Stantec

Lake Ontario Collaborative Intake Protection Zone Studies

Volume 3: Toronto Water Supply System

City of Toronto

Intake Protection Zone Delineation and Vulnerability Assessment Studies for the R.L. Clark, Island, R.C. Harris, and F.J. Horgan Water Treatment Plants

Final Report

January 2008

Executive Summary

This Surface Water Vulnerability Analysis was undertaken by Stantec Consulting Ltd. for four (4) water treatment plants (WTP) in the Toronto Water Supply System (TWSS), including; R.L. Clark, Island, R.C. Harris, and F.J. Horgan WTPs. The analysis of the TWSS, as part of the Lake Ontario Collaborative, was undertaken to meet the requirements of the Ontario *Clean Water Act* (Government of Ontario, 2006). Using the guidance outlined in Ontario Ministry of Environment Draft Guidance Module 4 (MOE, 2006a) concerning Surface Water Vulnerability; the WTPs intakes and near areas were characterized, vulnerable areas about the intake known as Intake Protection Zones (IPZs) were determined and the vulnerability of raw intake water to contamination was scored.

Operator interviews were conducted for each of the four (4) WTPs in the TWSS. Major concerns outlined by operators are listed below for each WTP:

- R.L. Clark WTP: Pathogen fluctuations (*Escheria Coli (E.coli)*, *Cryptosporidium* and *Giardia*) related to discharge from Huron and Lakeview wastewater treatment plants (WWTP), pesticide and herbicide levels, sodium levels related to road de-icing, WWTP bypasses, combined sewer overflow (CSO), urban runoff discharged through storm sewers, and two (2) marinas;
- Island WTP: no known issues/concerns;
- R.C. Harris WTP: Pathogen fluctuations from Ashbridges Bay WWTP, Ashbridges Marina, Bluffers Point Marina, storm sewer outfalls, Don River, lake seiches, and annual upwelling and downwelling; and
- F.J. Horgan WTP: Bulk chemical storage and spills from industrial facilities, Canadian National (CN) rail line, and Highland Creek WWTP.

Raw water quality data at the intake was available in annual reports from 2003-2006 and information was provided by the operators.

Vulnerability zones for R.L. Clark, Island, R.C. Harris and F.J. Horgan WTPs are illustrated in Figure E.1, E.2, E.3, E.4, respectively. The IPZ-1 is a circle with a 1km radius around the intake crib. The uncertainty for accuracy of this zone is low (high confidence) as it is prescribed by Guidance Module 4. The IPZ-2 for each WTP was calculated using a hydrodynamic model which included data inputs from water movement, winds, currents and a time of travel factor. The uncertainty of the IPZ-2 delineation for the WTP is high due to the limitations in the modeling.

Vulnerability scores for the IPZ-1 and IPZ-2 are based on attributes of the source water, characteristics of the intake and area, possible local influences within the zones, and information on raw intake water quality. The vulnerability scores for IPZ-1 range from 5-7 (low-high) and the vulnerability scores for IPZ-2 range from 3.5-6.3 (low-high). Due to the qualitative nature of this study, all numbers are rounded to the next highest whole number. Vulnerability scores are summarized in Table E.1 for all TWSS WTPs. The delineation of the IPZ-2 for all WTPs is preliminary and may be revised based upon further information gathered in subsequent Phase 2 studies.

Table E.1: Vulnerability Score Summary

Intake Location	Zone Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_s)	Vulnerability Score[1] (V)	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
R.L. Clark WTP	10	9 HIGH	0.6 MODERATE	6 MODERATE	6 MODERAT E
Island WTP	10	7 LOW	0.5 LOW	5 LOW	4 LOW
R.C. Harris WTP	10	8 MODERATE	0.6 MODERATE	6 MODERATE	5 LOW
F.J. Horgan WTP	10	9 HIGH	0.5 LOW	5 LOW	5 LOW

[1] Vulnerability scores are rounded to the next highest whole number

The uncertainty level is a qualitative assessment of the confidence in the validity of delineation of the IPZs and their associated vulnerability scores. Table E.2 outlines the uncertainty scores.

Table E.2: Uncertainty Score Summary

WTP	Component	IPZ-1	IPZ-2
R.L. Clark	Zone Delineation Rating	LOW	HIGH
	Vulnerability Rating	LOW	LOW
	Combined Rating[1]	**LOW**	**HIGH**
Island	Zone Delineation Rating	LOW	LOW
	Vulnerability Rating	LOW	LOW
	Combined Rating[1]	**LOW**	**LOW**
R.C. Harris	Zone Delineation Rating	LOW	HIGH
	Vulnerability Rating	LOW	LOW
	Combined Rating[1]	**LOW**	**HIGH**
F.J. Horgan	Zone Delineation Rating	LOW	HIGH
	Vulnerability Rating	LOW	LOW
	Combined Rating[1]	**LOW**	**HIGH**

[1] Combined rating defaults to high

Information gathered in subsequent studies may decrease the uncertainty level for any factor that has received a high uncertainty score. At this time the IPZ delineations, along with the vulnerability scores are preliminary and have been produced at a scoping level, sufficient to meet the scope of work.

Figure E.1: R.L. Clark WTP Intake Protection Zones

Figure E.2: Island WTP Combined Intake Protection Zones

Figure E.3: R.C. Harris WTP Intake Protection Zones

Figure E.4: F.J. Horgan WTP Intake Protection Zones

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1.0 Introduction

1.1 BACKGROUND

The Ontario government introduced the *Clean Water Act* (the Act) in the fall of 2005 (Government of Ontario, 2006), establishing the legislative framework for undertaking watershed-based source protection to protect drinking water sources through preventative planning across the province. Protecting source water is the first step in a multi-barrier approach to ensuring the quality and sustainability of Ontario's drinking water supply. Source water protection will ensure that current and future sources of drinking water in Ontario are protected from potential contamination and depletion. This includes recognizing and reinforcing existing management practices that help protect source water quality and quantity.

A key focus of the legislation is the production of locally developed, science-based Assessment Reports that form the precursors to the development of Source Water Protection Plans. The reports will assess the current conditions of sources of drinking water and identify threats to their condition that will be addressed in the Source Water Protection Plans. Under the Act, the Source Protection Committees are responsible for the Assessment Reports.

Draft Guidance Module 4: Surface Water Vulnerability Analysis (Module 4) (MOE, 2006a) is one of a set of seven (7) Draft Guidance Modules designed by the Ontario Ministry of the Environment (MOE) to direct the completion of the technical components of the Assessment Reports and ensure a consistent approach is applied across the province. The latest versions of the Modules were issued in October 2006. The Draft Guidance Modules are listed below:

- Draft Guidance Module 1: Watershed Characterization (Module 1);
- Draft Guidance Module 2: Municipal Long Term Water Supply Strategy;
- Draft Guidance Module 3: Groundwater Vulnerability Analysis;
- Draft Guidance Module 4: Surface Water Vulnerability Analysis;
- Draft Guidance Module 5: Issues Evaluation and Threats Inventory (Module 5);
- Draft Guidance Module 6: Water Quality Risk Assessment (Module 6); and
- Draft Guidance Module 7: Water Budget and Water Quantity Risk Assessment.

The Collaborative Study to protect Lake Ontario Drinking Water consists of multiple phases. Round 1 consists of 2 (two) phases. Round 1, Phase 1 scope of work for this particular project considers the requirements of Module 4 on a preliminary scoping level. Round 1, Phase 2 considers Module 4 revision work that intends to reduce the overall uncertainty of vulnerable areas. Round 2 involves a single Phase that addresses the requirements of Module 5 and Module 6 on a preliminary level.

The Region of Peel has taken the role of lead municipality (for the purposes of this study) of the Collaborative Study to Protect Lake Ontario Drinking Water (the Collaborative). Municipal partners in the Collaborative include: the City of Hamilton, City of Toronto, Prince Edward

County, the Municipality of Port Hope, the Town of Cobourg, Region of Durham, Halton Region, and the Niagara Region (the Niagara and Halton Regions will be included in subsequent studies).

The Collaborative's Source Protection Regions (SPR), with associated member Conservation Authorities (CA) are listed below:

- CTC SPR –Credit Valley Conservation (CVC), Toronto and Region CA (TRCA), and the Central Lake Ontario CA (CLOCA);
- Trent Conservation Coalition SPR – Crowe Valley CA, Ganaraska Region CA, Kawartha Conservation, Lower Trent Conservation, and Otonabee Region CA;
- Halton-Hamilton SPR – Conservation Halton and Hamilton CA (HCA);
- Quinte Conservation SPR – Quinte Conservation; and
- Niagara Peninsula SPR – Niagara Peninsula CA.

Research partners include Environment Canada (EC), MOE, and several Ontario Universities. The Ontario Clean Water Agency (OCWA) provides coordination and project management for the Collaborative.

1.2 SCOPE OF WORK

Stantec Consulting Ltd. (Stantec) was retained by the Region of Peel to complete a Surface Water Vulnerability Analysis as described in Module 4 for sixteen (16) WTPs for the Collaborative Source Water Protection Studies. Reports are presented in volumes based upon owner municipalities. The Intake Protection Zones Studies Report for the TWSS (Toronto Water Supply System) intakes comprises Volume 3. Figure 1.1 illustrates the Lake Ontario WTPs as they relate to each other in a regional setting.

The TWSS WTPs included within this report are listed below:

- R.L. Clark WTP (Clark WTP);
- Island WTP;
- R.C. Harris WTP (Harris WTP); and
- F.J. Horgan WTP (Horgan WTP).

Module 4 differentiates between four (4) types of surface water intakes: Great Lakes intakes, Great Lakes Connecting Channels intakes, Inland Rivers and Streams intakes, and Inland Lakes intakes. The TWSS WTP intakes are Great Lakes intakes.

The primary purpose of this report is to characterize the aquatic and upland features of the area surrounding the WTP and intake, delineate IPZ boundaries around the WTP intake, and provide an assessment of the relative vulnerability of each of these zones.

The zones of concern to the Great Lake intakes include:

- **IPZ-1** – This zone represents the area immediately surrounding the drinking water intake, generally considered to be the most vulnerable given the geographic proximity and assumed lack of dilution time available for contaminants discharged within this area; and

- **IPZ-2** – This zone represents a modeled area based on an administratively determined 2-hr water particle time of travel (TOT). Contaminants entering this zone in large quantities will not have sufficient time to be diluted or filtered prior to reaching the intake.

Following the delineation of the IPZs, a semi-quantitative assessment of vulnerability to contamination for the IPZ-1 and IPZ-2 was completed. The relative vulnerability of a given zone is a function of the contributing area's inherent hydrological and environmental characteristics. The existence of natural and anthropogenic preferential pathways is also considered in the assessment of intake zone vulnerability. The vulnerability assessment is discussed in detail in Section 5.0.

The delineated vulnerable areas defined in this Module 4 report are used as a geographical guideline to the drinking water threats inventory and issues evaluation outlined in Module 5 (MOE, 2006b).

Figure 1.1: Regional Setting

1.3 REPORT OUTLINE

This report has been prepared based on Module 4 (MOE, 2006a) and the Region of Peel Terms of Reference (TOR) (Region of Peel, 2006). This report follows the specific work plan, methodology, and deliverables detailed in Stantec's proposal submission (Stantec, 2006).

The report is structured with the following sections:

1. Introduction;
2. Data Collection and Analysis;
3. Intake Protection Zones Delineation and Modeling;
4. Area Characterization;
5. Intake Protection Zones Vulnerability Analysis and Uncertainty Assessment;
6. R.L. Clark WTP;
7. Island WTP;
8. R.C. Harris WTP;
9. F.J. Horgan WTP;
10. Data Gap Analysis and Report Assumptions;
11. Data Management;
12. Conclusions; and
13. References.

1.4 PROJECT APPROACH

The consulting team is divided into two teams, centered on areas of expertise. These teams, along with their roles, are outlined below:

1. Stantec – Project Management, Environment, Infrastructure and Operations

   Infrastructure and Operations experts determined preferential pathways and point sources of pollutants by reviewing WTP operations information, storm and sewer outfall data, current land uses and area characterization, and other anthropogenic influences on the study area. Delineated the landward and up tributary components of the IPZ-2, determined the associated protection zone vulnerability scores and the related uncertainty level present in report findings, and identified significant gaps in critical information.

2. W.F. Baird and Associates (Baird) – Water Movement and Modeling

Water movement modelers accessed and analyzed wind, current, bathymetric, and influent watercourse data. Delineated the in-water and alongshore components of the IPZ-2.

2.0 Data Collection and Analysis

2.1 EXISTING INFORMATION

This project was based on a review of readily available, existing information. The consulting team located and assembled data for each site from various public data sources including municipalities and CAs involved in the study, the WTP operating staff, EC, MOE, and other databases.

2.1.1 Watershed Characterization Report

The TRCA as part of the CTC SPR, prepared a Module 1 report. This report was a primary source used to characterize the physiography, geology, soil characteristics and hydrology of the TWSS study area.

2.2 OPERATOR INTERVIEW

WTP operator's documented issues and concerns on a standardized interview form. Annual reports, engineering reports, as well as daily and weekly data logs were obtained for additional information.

Background information of the issues related to operational challenges was recorded. In the interests of raw water quality that would affect their treatment strategies, many potential sources of contamination of concern were documented. In consideration of the requirements of Module 4, the scope of this project does not include the analysis of contaminants. A summary of operator concerns can be found in the respective WTP sections.

3.0 Intake Protection Zones Delineation and Modeling

3.1 DELINEATION INTRODUCTION

For Great Lakes intakes, two vulnerability zones (IPZ) are required:

- A primary zone (IPZ-1) immediately about the intake with an administratively set minimum radius of 1km, representing the most vulnerable area; and
- A secondary zone (IPZ-2) with dimensions determined from calculations based upon characteristics of the local environment such as local water movement, and nearby shoreline and tributary watercourse features.

The purpose of these zones is to present an area within which contaminant threat sources (Threats) are to be inventoried in subsequent studies.

While the IPZ-1 is set at a minimum 1km radius about the intake, its radius can be increased. An increase in radius of IPZ-1 results from special or unique conditions, or other environmental situations that in good judgment suggest that this most vulnerable zone be increased in order to properly address the identified situations and/or conditions.

The IPZ-2 has two components:

- In-lake and alongshore (in-water) extent; and
- Landward and up-tributary (upland) extent.

The in-water component of the IPZ-2 can be calculated using numerical or hydrodynamic modeling to define the local water movement for a range of conditions. Inputs to the models may include but are not limited to:

- Wind and wave data;
- Bathymetry data;
- Water quality parameters at the intake; and
- An administratively set TOT of 2-hrs.

The upland component consists of the contributing area of watercourses located within the alongshore extent of the IPZ-2 (as determined above). The upstream limit of the IPZ-2 for each tributary within this zone is calculated using the residual time of the 2-hr TOT at the watercourse mouth and a standard “full bank” high flow event. The contributing areas off-bank in the main tributary and associated tributary branches downstream of this limit are determined as; the regulated limit or the administratively set limit of 120m, whichever is greater and includes constructed pathways such as storm sewersheds, drains and other surface water conveyances in addition to natural drainage.

In general, sources of information for the upland and watershed IPZ-2 components include the Module 1 report, Canadian Hydrographic Service stream flow data, other CA watershed data and reports and municipal stormshed network mapping.

3.2 APPLICATION OF NUMERICAL MODELS FOR PRELIMINARY IN-LAKE IPZ DELINEATION

W.F. Baird and Associates conducted numerical modeling in support of IPZ delineation for the eleven (11) WTPs located on the north shore of western Lake Ontario from Mississauga to Newcastle. This section provides a summary of the delineation of the in-water IPZ-2 for the TWSS WTPs: Clark, Island, Harris, and Horgan. The suggested approach to the modeling approach, description of input conditions, modeling and recommendations based on the modeling is provided in Appendix 3.1.

Hydrodynamic processes on the Great Lakes are in most cases 3-dimensional (3-D) with currents at the lakebed often flowing in the opposite direction from currents at the surface. The currents also vary temporally and are highly dependent on wind conditions. Field data, where it exists, defines the current patterns for the duration of the data set only, at the specific instrument location. It is useful in providing current information for a specific time and location, but it does not define the current patterns throughout the IPZ for the full range of conditions. Numerical modeling calibrated against field measurements is a recommended scientific approach to defining the IPZ-2. It allows for the evaluation and understanding of the flow patterns around the intake under a range of conditions.

Figure 3.1 illustrates the location of all intakes in the TWSS study area.

Figure 3.1: TWSS Study Area

3.2.1 Selected Models

Two numerical models were selected for use in this study: the Danish Hydraulic Institute (DHI) MIKE3 model was used to define the hydrodynamic conditions for western Lake Ontario and in the vicinity of the intakes while the National Oceanic and Atmospheric Administrations (NOAA) lakewide Princeton Ocean Model (POM) was used to provide the boundary conditions and external forcing mechanisms for the MIKE3 model.

DHI's MIKE3 can simulate un-steady 3-D flows in lakes, rivers and oceans taking into consideration density variations, bathymetry and external forcing functions including meteorology, tides, current velocity and surface elevation. The model has the ability to define several levels of nesting in order to provide the resolution necessary at specific locations within the computational domain. For this study, the MIKE3 model was used to evaluate hydrodynamic conditions in the lake and around the intakes for selected wind events. Model grid resolutions used for this study ranged from 2430m to 10m.

The version of the POM developed and used by NOAA for the Great Lakes Operational Forecast System (GLOFS) to forecast water levels, currents and temperatures on Lake Ontario was used to define the boundary conditions for the MIKE3 model including spatial wind fields, air temperature, surface elevation, and water temperatures. The Lake Ontario Operational Forecast System (LOOFS) is run with a 5km grid and 20 layers in the vertical. This grid setup is too coarse for defining the IPZ-2 and does not extend into the nearshore. The model output does however describe the large-scale hydrodynamic processes in the lake.

3.2.2 Modeling Approach and Setup

As previously discussed meteorological and hydrodynamic results from the LOOFS model were used to drive the MIKE3 model. The LOOFS could not be used directly to delineate the IPZ-2 for this project as the grid resolution is too coarse, does not extend to the nearshore where the intakes are situated, and does not resolve river inflow from tributaries. The LOOFS was developed to simulate lakewide hydrodynamics, water temperatures and variations in water level as part of their nowcasting/forecasting system. Historical data dating back to 2002 was available from NOAA's archived results. By utilizing the LOOFS data to define boundary conditions and external forcing mechanisms on a model with higher resolution grids, there was no need to develop a lakewide model. The outer grid of the MIKE3 model covers the western half of Lake Ontario with one open boundary along the eastern side of the model grid.

The model runs were event based, that is, the numerical model was run for historical wind events that occurred between 2002 and 2006. The simulation periods chosen for the runs were limited to this time period due to the availability of LOOFS results. Two wind events in 2003 were identified based on an analysis of data from Pearson International Airport; one, represented a strong east wind, the other, a strong west wind. These represent the two dominant wind directions that occur in western Lake Ontario. Test runs were also carried out, at 3 WTP locations in the Durham Region, to examine the impact of north winds particularly as it pertains to the potential for contaminants to be transported from shore to the intakes. Based on the time series data for Pearson Airport, the east event is less than a 1 year return period event. The west event is approximately a 3 year return period event. The POM data, which includes a spatially varied wind field developed from multiple wind stations, shows peak winds during both events, of 75 km/hr, which is closer to a 5 year return period event.

Local tributaries were defined in the model and a 2-year return period flow was used in all runs. It is important to note that in this phase of the study only gauged tributaries were defined in the model and that flows at the mouths of the rivers were based on the gauged data. Adjustment to the gauged river flows to represent conditions at the river mouth, and inclusion of non-gauged rivers is recommended in the next phase of work once hydrological data becomes available.

3.3 MODEL RESULTS

3.3.1 Current Patterns

The model results showed that nearshore current patterns are strongly correlated to wind direction; a similar response was evident throughout the lake. Current patterns within the lake are 3-D; encompassing reverse currents, upwelling, and downwelling, which are physical phenomena that occur. The intakes were generally located far enough offshore that they were not influenced by shoreline structures, and adjacent tributaries did not influence current patterns around the intakes under a two-year flow event. The results from the numerical modeling activities indicate that current patterns are most strongly influenced by wind conditions.

3.3.2 Reverse Particle Tracking for Preliminary In-lake IPZ Delineation

Reverse particle tracking was utilized to delineate the preliminary in-lake IPZ-2 for each intake. The particle model is driven with the simulated hydrodynamics from the MIKE3 model and run in reverse mode with the particles tracking the paths by which the currents would have transported neutrally buoyant particles to the intakes.

For each intake, the reverse particle tracking was run for the east and west events, described previously. These events each had durations of 3.5 days. The reverse particle tracking represents a location from which a particle could reach the intake within the 2-hr shut down time defined by the WTP operators. The location of the particles varies with the release time within the 3.5-day event. A conservative approach was taken for the preliminary delineation and the particles were released at the surface, rather than at the intake depth. This is conservative because the surface currents have higher speeds than the currents at depth.

3.3.3 Model Limitations

Numerical modeling undertaken in support of IPZ delineation during this phase of the project provides preliminary delineation of the IPZ-2 considering the hydrodynamic processes in the lake.

The key limitations of the modeling are as follows:

- The models used in this phase of the work are uncalibrated. A comparative validation of the model against available measured current and temperature data is recommended in order to evaluate the uncertainties associated with the numerical modeling results. Until this is done, it is not possible to say whether the results are conservative or not;

- Event based simulations were carried out in this phase of work for two events (east wind and west wind) of 3.5 day duration only. These are considered to be test runs and do not represent the full range of conditions that the intakes are exposed to. The time frames of these events were limited to the availability of the POM data, which covered a period from 2002 to 2006. Therefore wind events that may have occurred prior to 2002 cannot be modeled using this methodology;

- Cross-section data for the rivers was limited to the information (if any) supplied in the NOAA National Geophysical Data Centre (NGDC) hydrographic dataset. Due to lack of any additional upstream bathymetry, it has been assumed that the upstream river cross-sections are the same as the river mouth. Actual river cross-section data should be collected and used in Phase 2 to better define the velocities in the river and the IPZ-2 limits;

- In this phase of the study, only gauged tributaries were defined in the model and flows at the mouth of the rivers were represented by the gauged data. Adjustment to the gauged river flows to represent conditions at the river mouth, and inclusion of non-gauged rivers is recommended in the next phase of work once hydrological data becomes available;

- IPZ delineation was derived from lake hydrodynamics. The dispersion of contaminant plumes through natural diffusion movements as a result of density currents was not considered in this phase of work; and

- A conservative approach was taken in the reverse particle tracking. Particles were released at the surface where currents are stronger. Although this is a conservative approach, we cannot be certain if the model results are conservative, until the model is calibrated (as discussed above). In the next phase of the work, the particles will be released at the intake depth, closer to the lakebed.

3.4 PRELIMINARY DELINEATION OF THE INTAKE PROTECTION ZONES

As stated in Module 4, the purpose of delineating zones around the Great Lakes intakes is to protect them from immediate contaminants of concern that might enter from nearby areas or known sources. Drinking water intakes on the Great Lakes may be influenced by several environmental factors including: winds, waves, and currents. The modeling described above includes the effects of wind driven currents and currents generated by tributaries flowing into the lake.

For Great Lakes intakes, two zones are to be delineated: the IPZ-1 is a fixed radius around the intake crib; and the IPZ-2 acts as a secondary protection zone around the IPZ-1 and takes into account areas outside the IPZ-1 that have the potential to directly impact the intake such as streams, rivers or shoreline features.

3.5 UPLAND COMPONENT OF THE IPZ-2

While a considerable extent of the modeled in-lake IPZ-2 remains offshore, the modeling team advised extension of its extreme ends to shore to determine the alongshore extent of the IPZ-2. The upland vulnerability zones were determined from this alongshore extent.

The upland IPZ-2 was determined using the residual 2-hr TOT from the intake crib to the tributary mouth and estimated stream flow at full bank flow. Refer to Appendix 3.2 for the methodology used to aid in residual TOT determination and the upland extents of the IPZ-2.

3.6 MAPPING OF INTAKE PROTECTION ZONES

Based upon the numerical modeling and extensions of the IPZ-2, as well as the guidance outlined by Module 4, IPZ-1 and IPZ-2 boundaries were mapped for the four WTPs; Clark, Island, Harris, and Horgan. Figures 6.1, 7.1, 7.2, 8.1, and 9.1 illustrate the IPZ-2 areas for the WTPs. These zones will be refined on the basis of modeling results as they become available with future source water protection studies. They are presented here for use in the vulnerability assessment. The upland extents of the IPZ-2 are explained in detail within the respective WTP sections.

4.0 Area Characterization

4.1 UPLAND ENVIRONMENT

The City of Toronto is located entirely within the jurisdiction of the TRCA, which encompasses a total area of 3,467km^2. This area is comprised of nine watersheds including:

- Etobicoke Creek;
- Mimico Creek;
- Humber River;
- Don River;
- Highland Creek;
- Rouge River;
- Petticoat Creek;
- Duffins Creek; and
- Carruthers Creek.

The TRCA has six (6) participating, or member, municipalities: the City of Toronto; the Regional Municipalities of Durham, Peel, and York; the Township of Adjala-Tosorontio and the Town of Mono (TRCA, 2007). This report is concerned with the City of Toronto.

Figure 4.1 illustrates the TRCAs boundaries and applicable watersheds. This boundary defines the area in which the Module 1 report was generated for.

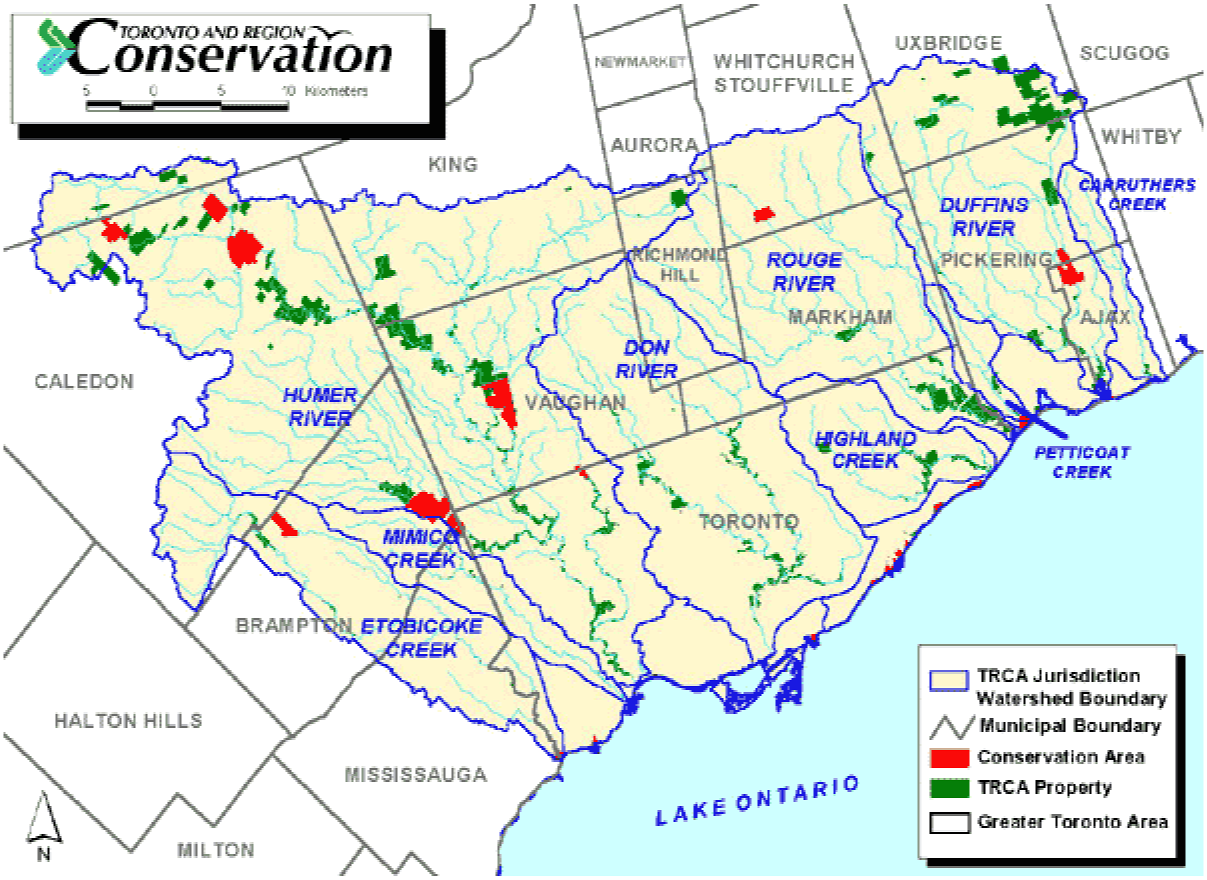

Figure 4.1: TRCA (TRCA, 2007b)

Table 4.1 summarizes the general upland environment of the City of Toronto study area.

Table 4.1: City of Toronto and York Region Area Characterization			
Description Item			
Physiographic Region		Lake Iroquois Plain (TRCA, 2007)	
Bedrock		Georgian Bay (TRCA, 2007)	
Soil Types	Clark WTP	Loam (TRCA, 2007)	
	Island WTP	No Data	
	Harris WTP	No Data	
	Horgan WTP	Sandy Loam (TRCA, 2007)	
Average Summer Air Temperature		14.6°C (EC, 2006)	
Average Winter Air Temperature		-1.8°C (EC, 2006)	
Average Annual Precipitation		834.0mm (EC, 2006)	
		Watershed Name	**Drainage Area**
Clark WTP		None	Drains directly to Lake Ontario
Island WTP		None	Drains directly to Lake Ontario
Harris WTP		None	Drains directly to Lake Ontario
Horgan WTP		None	Drains directly to Lake Ontario

Table 4.1: City of Toronto and York Region Area Characterization	
Description Item	
Local Recreational Uses of Source Water	Recreational boating, swimming.
Shoreline Modifications / Engineering Works	Extensive: piers, jetties, dykes, shoreline armouring.
Commercial Shipping Uses of Source Water	Transportation ferries, commercial shipping, Toronto Harbour.

4.2 RAW WATER QUALITY AT THE INTAKE

4.2.1 Data Reviewed

The following data source was reviewed in this report:

- **Annual Reports** – O. Reg. 170/03 of the *Safe Drinking Water Act* (MOE, 2002a) requires municipal drinking-water systems to file an annual report to the MOE as per form PIBS 4435E.

For the 2003 and 2004 sampling years, the Drinking Water Systems Annual Reports for the TWSS show the data for the four (4) WTP as a summary without individual sampling results. Tables 4.2 and 4.3 list these summarized results. Records specific to the individual WTPs were available for the 2005 and 2006 operating years and can be found in their respective sections.

Table 4.2: Microbiological Testing for 2003 Annual Report			
WTP	**Number of Samples**	**Range of *E.coli* and Fecal Results (counts/100mL)**	**Range of Total Coliform Results (counts/100mL)**
Clark, Island, Harris, Horgan	3,635	0 - 140	0 – 3,000

In regards to inorganic parameters of treated water, there was one exceedance across the TWSS, fluoride, with a peak value of 2.4mg/L. ODWQS states that the maximum allowable concentration (MAC) for fluoride is 1.5mg/L. There were no exceedances for organic parameters.

Table 4.3: Microbiological Testing for 2004 Annual Report			
WTP	**Number of Samples**	**Range of *E.coli* and Fecal Results (counts/100mL)**	**Range of Total Coliform Results (counts/100mL)**
Clark, Island, Harris, Horgan	3,915	0 - 110	0 – 1,400

In regards to inorganic parameters, there were two exceedances across the TWSS for sodium, with a peak value of 21.5mg/L. The two occurrences happened within 13 days and were attributed to the use of road salt. There was no sodium notification in the previous five years. There were no exceedances for organic parameters.

Drinking Water Surveillance Program (DWSP) and the Drinking Water Information System (DWIS) data are typically consulted in this section; however this information was not available at the time of writing, and is identified as a data gap. Thus only a small amount of information gathered from annual reports dating from 2003 to 2006 can be used. The information available at the time of writing is believed to be sufficient to conservatively characterize the source water and apply a vulnerability rating based on the criteria suggested in Module 4.

The Annual Reports for the TWSS are included in Appendix 4.2.

4.2.2 Water Quality Standards

Two sets of provincial criteria were selected as measures of water quality:

- **Ontario Drinking Water Quality Standards (ODWQS),** O.Reg 169/03 (MOE, 2002b) – ODWQS are made under the Safe Drinking Water Act and they prescribe the minimum drinking-water quality requirements for human consumption of *treated water* (not raw water) for; chemical parameters (metals, nutrients, organics, pesticides, etc.) microbiological groups, aesthetic parameters, and operational considerations. ODWQS toxicity standards are based on *human health* considerations, not environmental considerations. Aesthetic Objectives are set to guard against the impairment of odour, taste and colour. Operational Guidelines set to ensure water treatment operations are effective and efficient for treated and distributed water. The Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (MOE, 2006c) provides supporting documentation for ODWQS. There is no ODWQS for *Escherichia coli* (*E.coli*) and other microorganisms in raw surface water sources.

- **Provincial Water Quality Objectives (PWQO)** - PWQOs are set at a level of water quality that is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water (MOEE, 1999). The PWQOs are used to provide guidance in making water quality management decisions. They are used for raw water and discharges only and not for drinking water. Because aquatic life is continuously exposed to water, it is more sensitive to contaminants than humans periodically ingesting the same water, so with the exception of microbiological parameters, the PWQOs are stricter than the ODWQS. The PWQO for recreational water uses with an objective of 100 counts *E.coli* per 100mL, may be useful as indicator of quality of raw surface waters as a source for drinking water.

4.3 SEDIMENT QUALITY

Intake sediment quality is used in the vulnerability analysis section of this report, specifically in characterizing the source vulnerability modifying factor.

Data for sediment quality at the respective WTP intakes was not available at the time of writing of this draft report, and has been recorded as a data gap. The EC Lake Ontario tributary sediment report (Dove *et. al*., 2003) was consulted in order to provide sediment quality data near the respective WTP intake locations. Results for area watercourses are summarized below. A summary of Federal and Provincial sediment quality guidelines from the EC sediment quality report (Dove *et al*. 2003) is included in Appendix 4.3.

The Etobicoke Creek is located approximately 3km from the Clark WTP intake. Sediment quality in the Etobicoke Creek is summarized below:

- Total Dichlorodiphenyl Trichloroethane (DDT) and its metabolites were found in concentrations below Federal and Provincial guidelines;
- Polychlorinated Biphenyls (PCBs) were found in concentrations above Federal and Provincial guidelines. Aroclor 1242, Aroclor 1254 and Aroclor 1260 were detected;
- Total Polycyclic Aromatic Hydrocarbons (PAHs) were found in exceedance of Provincial guidelines (no Federal guidelines exist), however single PAH exceedances did occur with concentrations found above both the Federal threshold effect level (TEL) and probable effects level (PEL); and
- Metal exceedances included cadmium, copper, lead, and zinc with concentrations above the TEL.

Mimico Creek is located approximately 5km from the Clark WTP intake. Sediment quality from the mouth of Mimico Creek is summarized below:

- Total DDT and its metabolites were not sampled;
- PCBs were found in concentrations above Federal and Provincial guidelines. Aroclor 1254 and Aroclor 1260 were detected;
- PAHs were found in exceedance of Provincial guidelines (no Federal guidelines exist), however single PAH exceedances did occur with concentrations found above both the TEL and PEL; and
- Metal exceedances included manganese, which was found in concentrations exceeding the lowest effect level (LEL), zinc in concentrations above the PEL, and cadmium, chromium, copper, and lead in concentrations above the TEL.

The Humber River outfall is located approximately 6.5km from the Clarke WTP intake. Sediment quality in the Humber River is summarized below:

- Total DDT and its metabolites were found in concentrations above Federal and Provincial guidelines;
- PCBs were found in concentrations above Federal and Provincial guidelines. Aroclor 1254 and Aroclor 1260 were detected;
- Total PAHs were found in exceedance of Provincial guidelines (no Federal guidelines exist), however single PAH exceedances did occur with concentrations found above the TEL; and

- Metal exceedances included iron, manganese, and nickel found in concentrations exceeding the LEL, and arsenic, cadmium, copper, lead, and zinc in concentrations above the TEL.

The mouth of the Don River is approximately 5.2km to the closest Island WTP intake. Sediment quality in the Don River is summarized below:

- Total DDT and its metabolites were found in concentrations above Federal and Provincial guidelines;

- PCBs were found in concentrations above Federal and Provincial guidelines. Aroclor 1242, Aroclor 1254 and Aroclor 1260 were detected with Aroclor 1254 above the TEL;

- Total PAHs were found in exceedance of Provincial guidelines (no Federal guidelines exist), however single PAH exceedances did occur with concentrations found above the TEL and PEL; and

- Metal exceedances included manganese found in concentrations exceeding the LEL, and cadmium, chromium, copper, lead, and zinc in concentrations above the TEL.

The mouth of the Bellamy Ravine Creek is located approximately 4.5km from the Horgan WTP intake. Sediment quality in the Bellamy Ravine Creek is summarized below:

- Total DDT and its metabolites were found in concentrations below Federal and Provincial guidelines;

- PCBs were found in concentrations below Federal and Provincial guidelines. Aroclor 1254 and Aroclor 1260 were detected;

- Total PAHs were not found in exceedance of Provincial guidelines (no Federal guidelines exist), however single PAH exceedances did occur with concentrations found above the TEL; and

- Metal exceedances included manganese and lead found in concentrations exceeding the LEL, and cadmium and zinc in concentrations above the TEL

The mouth of the Highland Creek is located approximately 4km from the Horgan WTP intake. Sediment quality in the Highland Creek is summarized below:

- Total DDT and its metabolites were not sampled;

- PCBs were found in concentrations below Federal and Provincial guidelines. Aroclor 1254 and Aroclor 1260 were detected;

- Total PAHs were not found in exceedance of Provincial guidelines (no Federal guidelines exist), however single PAH exceedances did occur with concentrations found above the TEL; and

- Metal exceedances included zinc found in concentrations exceeding the LEL, and cadmium and copper in concentrations above the TEL.

The results summarized from the EC report do not indicate what would classify as poor sediment quality. The application of PCBs, DDT and other chlorinated pesticides has not occurred for some time. Detected concentrations are likely residuals from past commercial and industrial applications. Concentrations of metals detected in the Toronto study area watercourses are representative of intensive industrial and commercial uses. The presence of PAHs indicates fossil fuel combustion, and high concentrations can be expected in such a highly urbanized and industrialized area. Sediment contaminants are a potential concern to drinking water during shoreline construction, dredging activities or periods of resuspension in the intake area.

5.0 Intake Protection Zone Vulnerability Analysis and Uncertainty Assessment

5.1 INTRODUCTION

Vulnerability scores are derived for each intake protection zone. The vulnerability score (V) is derived from the formula, provided in Module 4, where:

$$V = Vf_z \times Vf_s$$

- Vf_z is the zone vulnerability factor relating to each zone; and
- Vf_s is the source vulnerability-modifying factor relating to location of the intake and influences affecting it.

The formula does not consider specific contaminants, their respective properties, or behaviours. The V and assigned scores of its respective factors, Vf_z and Vf_s, are unitless and are described in more detail in Sections 5.1.1 and 5.1.2. A summary of Great Lakes intakes vulnerability scores and factors is presented in Table 5.1 (MOE, 2006a).

Table 5.1: Vulnerability Score for Great Lakes Intakes

Intake Type	Zone Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_S)	Vulnerability Score (V)	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
Great Lakes	10	7 to 9	0.5 to 0.7	5 to 7	3.5 to 6.3

Vulnerability scores established for each intake are then assigned a ranking of vulnerability based on the following criteria:

- Low Vulnerability ($V \leq 5$);
- Moderate Vulnerability ($5 < V \leq 6$); and
- High Vulnerability ($V > 6$)

5.1.1 Zone Vulnerability Factor

A Vf_z score is assigned to each IPZ and relates to features and processes in the local environment that may impact the intake. Typical factors suggested by Module 4 in assigning a Vf_z score include, but are not limited to:

- Runoff generation potential (more runoff – higher Vf_z); and
- Transport pathways in the zone (faster transport potential or numerous pathways - higher Vf_z).

5.1.2 Source Vulnerability Modifying Factor

A Vf_s score is assigned to the intake, and is the same for each IPZ. Typical factors suggested by Module 4 in assigning a Vf_z score include, but are not limited to:

- Depth of intake from the top of water surface (deeper intake – lower Vf_s);
- Length of the intake from the shoreline (longer Great Lakes intake – lower Vf_s); and
- Historical water records indicating number of past incidences exceeding the water quality guidance/standards (no past incidence – lower Vf_s).

5.1.3 Related Source Vulnerability Considerations

The MOE Guidelines for the Design of Water Treatment Works (MOE, 1982) prescribe a minimum depth for drinking water intakes at 3m and a preferred depth of more than 10m. A recommended distance from shore is not provided.

For the purposes of comparison, this report has included State of Michigan surface water intake categorization criteria, in an effort to provide additional resources for qualifying selected intake vulnerability scores. The State of Michigan intake categories do not directly apply to Canadian Great Lakes WTP intakes, but it is assumed that Great Lakes intakes will have comparable vulnerability when viewed exclusively from the perspectives of distance offshore and depth parameters.

The State of Michigan, as part of its Source Water Protection Program (MDEQ, 2004), categorizes surface water intakes in four (4) ways according to distance offshore and depth to intake: nearshore, shallow-water intakes; near shore, deep-water intakes; offshore, shallow-water intakes; and offshore, deep-water intakes. The State of Michigan categories are included in further detail in Appendix 5.1. Table 5.2 provides a summary of the categories.

Table 5.2: Michigan Categories for Great Lakes Intakes

Category	Nearshore Shallow Water	Nearshore Deep Water	Offshore Shallow Water	Offshore Deep Water
Parameters	<~300m offshore <~6m depth	<~300m offshore >~6m depth	>~300m offshore <~6m depth	>~300m offshore >~6m depth
Vulnerability	High	High to Moderate	High to Moderate	Moderate

5.2 UNCERTAINTY ASSESSMENT

The uncertainty level as described in Module 4 is a qualitative assessment of the confidence in the validity of delineation of the IPZ and associated vulnerability scores. It relates to:

- Data used in the delineation of vulnerability zones and determination of vulnerability scores, its completeness (extent and density), quality, statistical validity, relevance and local content; and

- The numerical models or methods used to delineate the protection zones, their relevance, and suitability for the local condition.

The uncertainty level rating for each component is assessed as “high” (low confidence) or “low” (high confidence) for each of these components. An overall uncertainty level rating for each vulnerable area is the combination of the levels determined for each of the components. This overall high or low rating is used subsequently in Module 6 to modify risk scores.

6.0 R.L. Clark Water Treatment Plant

6.1 WATER TREATMENT PLANT DESCRIPTIONS AND PROCESSES

Table 6.1 summarizes the plant descriptions and processes for the Clark WTP.

Table 6.1: Clark WTP Description and Processes	
Treatment Plant	
Owner/Operator	City of Toronto
Location	45 Twenty Third Street, Etobicoke (NAD 83, Zone 17) 4827685m N, 619610m E
Drinking Water System Number	220002253
Unit Processes and Systems	• Chloramination • Chlorination • Clarifier - Sludge Blanket • Coagulation • Filtration • Flocculation • Fluoridation • Sedimentation • Taste And Odour Control • Zebra Mussel Control Five (5) low lift pumps, three (3) flash mixing chambers (three stage), three (3) flocculation tanks (two stage), three (3) sedimentation tanks, eighteen (18) filters (dual media), one (1) clear well, one (1) reservoir, and nine (9) high lift pumps (XCG, 2001a).
Distribution System	358km of trunk watermains, 5,525km of distribution watermains in twelve (12) pressure zones, ten (10) reservoirs, four (4) elevated tank, and eighteen (18) pumping stations with eighty-eight (88) pumps. (Toronto Water, 2006).
Rated Capacity	615ML/day (Toronto Water, 2006).
Servicing Population	A part of the TWSS servicing approximately 3.2 million residents in the City of Toronto and southern portion of York Region. (Toronto Water, 2006).
Intake	
Water Source	Lake Ontario
Geographical Location of Crib	(NAD 83, Zone 17) 4826219m N, 620691m E
Depth of Crib	18m below lake level (OCWA, 2007).
Length of Intake	1615m (OCWA, 2007).
Pipe Diameter	3275mm (OCWA, 2007).
Pipe Material	Concrete, steel lined (XCG, 2001a).

6.2 OPERATOR CONCERNS

Stantec conducted an interview with Clark WTP operators July 9, 2007 in an effort to identify known issues and concerns with plant operations. A standard interview form was used, as well as a study area map, to locate and discuss potential issues and areas of concern influencing or affecting the raw water quality at the intake. The completed interview form can be found in Appendix 2.1.

E.coli, Cryptosporidium, and *Giardia* are an identified concern. No sampling protocol currently exists for *Cryptosporidium* or *Giardia;* consequently samples are taken about four times a year. Fluctuations in pathogen concentrations have been linked to the two local WWTP. *E.coli* levels fluctuate during periods where WWTP effluent is unchlorinated. Operators have identified high nutrient levels, which can effect taste and odour in the treated water, and support algae growth. These events typically correlate with upwelling and downwelling associated to fall lake turnover events. Powdered Activated Carbon (PAC) is used in the treatment process to reduce negative taste and odour issues.

Raw water bacteria samples are taken weekly from May to October, during the zebra mussel control season, and daily from November to April.

Pesticides and herbicides are an area of concern. Periodic occurrences of atrazine have been observed in low concentrations. Tritium releases from the Pickering Generating Station has also been an issue in the past, the most notable being a release in the 1990's, which resulted in the plant being shut down for precautionary reasons. Other industrial discharges are a concern but locations for these point source discharges are not known.

WWTP bypasses, CSOs, and urban runoff discharged through storm sewer outfalls are additional issues of concern. De-icing salts infiltrating the storm network have been problematic in the past, resulting in adverse water quality ratings. Elevated levels usually occur during the spring melt as melting snow carries salt into the storm sewer network. Salt storage and disposal locations have been identified at the corners of Kipling and Horner Ave, and Queen Street and The Queensway.

The WTP operators identified two area marinas as a concern however both maintain environmental practices.

This WTP is perceived to be the most sensitive of the four (4) plants within the TWSS. It is most susceptible to high sodium levels and typically has higher bacteria levels than the others. However, the other three (3) plants act as indicators for this plant as it experiences changes in water quality after the other ones. Operators indicate the Clark WTP is a stable plant that operates well with no rapid changes required for water treatment.

6.3 RAW WATER QUALITY AT THE INTAKE

TWSS raw water quality data for the 2003 and 2004 operating years was provided as a whole for the supply system (refer to section 4.2.1). Records specific to the Clark WTP were available for the 2005 and 2006 operating years. Raw water quality data is used to determine the source vulnerability rating for the WTP intake. A summary of available data is provided below in Table 6.2 and 6.3.

Table 6.2: Microbiological Testing for 2005 Annual Report

WTP	Number of Samples	Range of *E.coli* and Fecal Results (counts/100mL)	Range of Total Coliform Results (counts/100mL)
Clark	649	0 - 98	0 - 6100

In 2005 the Clark WTP did not have any exceedances for either organic or inorganic parameters.

Table 6.3: Microbiological Testing for 2006 Annual Report

WTP	Number of Samples	Range of *E.coli* and Fecal Results (counts/100mL)	Range of Total Coliform Results (counts/100mL)
Clark	377	0 - 95	0 - 2000

In 2006 the Clark WTP did not have any exceedances for either organic or inorganic parameters.

6.4 INTAKE PROTECTION ZONE DELINEATION

The IPZ-1 consists of the area immediately surrounding the intake with an administratively set minimum radius of 1km. This represents the most vulnerable area about an intake.

The IPZ-2 includes all land area and stream mixing zones that could potentially influence the intake within the 2-hr TOT. The IPZ-2 consists of two primary components; the in-water IPZ-2 provided by the modeling team, and the upland IPZ-2 delineated with respect to the modeled IPZ-2, the methodology provided in Appendix 3.2, and specific local conditions.

6.4.1 In-lake and Alongshore IPZ-2

Refer to Section 3.0 for an explanation of the approach and modeling used in the delineation of the in-water IPZ-2. The approach used in this report is based on the numerical modeling with the reverse particle-tracking model run for east and west events, approximating 10-year return period winds.

The Clark WTP intake is illustrated in Figure 6.1. The intake is located 1.6km from shore. Currents in this area are predominantly parallel to shore, though there are some interesting circulation patterns indicated by the particle tracking. The in-water IPZ-2 extends approximately 3.6km northeast and 3km southwest of the intake. The particle tracking indicates that the IPZ-2 extends close to shore and the IPZ-2 has therefore been extended to include approximately 800m of shoreline. Further analysis should be undertaken early in Phase 2 to evaluate the potential for the IPZ-2 to reach the shoreline, as this has implications for the scope of the Phase 2 studies.

The in-water component of the IPZ-2 delineated in this phase of the work is preliminary due to the limitations discussed in Section 3.3.3 and Appendix 3.1.

6.4.2 Landward and Up-tributary Extent of the IPZ-2

The IPZ-2 was extended to the west to ensure that the site of the decommissioned Lakeview Generating Station was included ensuring potential threats associated with the site would be included in the vulnerability assessment. Sewershed data was only available from the Region of Peel, and as a result a conservative approach was applied to the delineation of the upland extent of the IPZ-2. The IPZ-2 travels northwest, following along Lakefront Promenade until it reaches the CN rail tracks. It follows the CN railway northeast line until it approaches the Etobicoke River and proceeds north and follows the river along, at a setback of 120m. It follows the river to the QEW/Gardner Expressway and then proceeds easterly following the highway. Upon reaching Wesley Street it turns south and follows the jogs over the railway tracks and proceeds along Queens Avenue. The IPZ-2 turns east following Mimico Avenue to Lakeshore Boulevard West and then finally to Summerhill Road where it meets the shoreline. The upland extent of the IPZ-2 was determined using assumptions summarized in Section 10.2.

Figure 6.1 illustrates the IPZ-1 and IPZ-2 for the Clark WTP. These zones will be refined on the basis of modeling results as they become available with future source water protection studies. They are presented here for use in the vulnerability assessment.

Figure 6.1: R.L. Clark WTP Intake Protection Zones

6.5 IPZ VULNERABILITY SCORES

Table 6.4 summarizes the vulnerability scores for the Clark WTP.

Table 6.4: Vulnerability Score Summary – Clark WTP

Intake Location	Zone Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_s)	Vulnerability Score[1] (V)	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
Clark WTP	10	9 HIGH	0.6 MODERATE	6 MODERATE	6 MODERATE

[1]Rounded to the next highest whole number.

6.5.1 Zone Vulnerability Factor (Vf_z)

The Clark WTP IPZ-1 Vf_z is assigned a value of 10 in accordance with Module 4.

The Clark WTP IPZ-2 Vf_z is determined to be 9 (high) based on natural and anthropogenic zcharacteristics within the study area.

The area surrounding the WTP is highly urbanized. The natural characteristics that drive the Vf_z estimation within the IPZ-2 extents consist of the slope of the upland environment and the Etobicoke Creek.

Anthropogenic pathways in the IPZ-2 include high surface runoff volumes from urban areas and transportation routes, and discharges from storm sewers and CSOs. Transportation routes to consider in this area include: Lakeshore Boulevard West, QEW/Gardner Expressway, Browns Line, Kipling Avenue, Islington Avenue, and Royal York Road, as well as various residential roads located within the IPZ-2 area. Urbanization of the area surrounding the WTP has resulted in large quantities of storm and surface water runoff. Surface water runoff may transport sediment, salt, oil and other contaminants into either the Etobicoke Creek or directly into Lake Ontario and the source water. Additional sites of concern located within the IPZ-2 include; the decommissioned Lakeview Generating Station, and the railway switching yards.

The Vf_z does not consider the nature of a contaminant but rather the ability of a contaminant to reach the source water body. The natural and anthropogenic characteristics provide for the discharge of contaminants into the lake. The Vf_z is assigned a high rating of 9 based on these findings.

6.5.2 Source Vulnerability Modifying Factor (Vf_s)

The Clark WTP Vf_s determined to be 0.6 (moderate).

The MOE guidelines for the Design of Water Treatment Works (MOE, 1982) prescribe that the preferred submergence for raw water intakes is 10m or deeper. The physical characteristics of the Clark intake pipe are described in Table 6.1. The surface water intake pipe is 18m below the water surface and therefore exceeds the MOE preferred depth. In comparison to the Michigan criteria for surface water intakes, the Clark WTP intake is classified as an offshore deepwater intake, and would receive a moderate vulnerability rating (refer to section 5.1.3).

The Annual Compliance reports, summarized in Section 6.3, indicate that there have been no exceedances of organic or inorganic parameters within the last two years. In the past sodium from de-icing salts has been a problem; this indicates potential influence from upland activities. Operators also indicated that pathogens in the source water are an issue of concern, especially during WWTP bypasses, despite the fact that raw water samples from 2005 and 2006 indicated that maximum *E.coli* levels were less than 100 counts/100mL (below the ODWQS).

This report also includes information from the Lakeview WTP (part of the Peel Water Supply System) operator interview (Stantec, 2007). The Lakeview operators indicated that the Lakeview WWTP discharge has the potential to effect various WTPs in close proximity to the WWTP. Effluent from the WWTP was modeled by KMK Consultants Limited (KMK, 2004). The effluent is discharged into Lake Ontario through a 1400m diffuser. The total phosphorus and ammonia plumes modeled by KMK, have been identified as directly overlapping a substantial portion of the projected IPZ-2.

With respect to Module 4, WTP intakes with influence from piped discharges, or rivers should receive a high source vulnerability rating. Overall it was noted that this WTP is the most sensitive of the four (4) WTPs in the TWSS. With the general drift of the lake, from east to west, the other three (3) WTPs can be used as indicators for this plant to prepare and make adjustments if necessary. As a result of these factors the Clark WTP was given a Vf_s score of 0.6.

6.6 UNCERTAINTY ASSESSMENT

Module 4 prescribes a conservative approach to assignment of an overall rating for each zone. Only where uncertainty is low for both components can an overall “low” uncertainty rating be assigned. Mixed low and high ratings would result in a default to a “high” uncertainty level for the zone (MOE, 2006a). Table 6.5 outlines the uncertainty level ratings for the Clark WTP.

Table 6.5: Uncertainty Level Ratings – Clark WTP

Component	IPZ-1	IPZ-2
Zone Delineation Rating	LOW	HIGH
Vulnerability Rating	LOW	LOW
Combined Rating[1]	LOW	HIGH

[1] Combined Rating defaults to highest level.

6.6.1 IPZ-1 Level of Uncertainty

Dimensions for IPZ-1 are prescribed in Module 4, and local conditions did not indicate a need to extend the zone beyond the prescribed minimum 1km radius. Local data contributing to factors for the vulnerability score are from recent studies and assessments, and ongoing monitoring programs. The resulting combined level of uncertainty is low for the IPZ-1, as shown in Table 6.5.

6.6.2 IPZ-2 Level of Uncertainty

Due to the quantity of data available at the time of writing of this report, the identified data gaps presented in Section 10.0, and the uncertainty associated with the numerical modeling used in determining the in-water component of the IPZ-2, the zone delineation must be assigned a high level of uncertainty.

The vulnerability rating assigned to the IPZ-2 was based upon available raw water quality data, sediment quality data, the characteristics of the upland environment, storm sewer and CSO information, and operator concerns. Although significant data gaps have been identified with respect to information used in the vulnerability assessment, the data available at the time of writing of this report is sufficient to assign the IPZ-2 vulnerability rating a low level of uncertainty.

The resulting combined uncertainty rating for the IPZ-2 is high, as shown in Table 6.5.

7.0 Island Water Treatment Plant

7.1 WATER TREATMENT PLANT DESCRIPTION AND PROCESS

Table 7.1 summarizes the plant description and processes for the Island WTP.

Table 7.1: Island WTP Description and Processes		
Treatment Plant		
Owner/Operator	City of Toronto	
Location	Centre Island, Toronto (NAD 83, Zone 17) 4830326m N, 630505m E	
Drinking Water System Number	220002244	
Unit Processes and Systems	• Chloramination • Chlorination • Coagulation • Filtration • Flocculation • Fluoridation • Taste And Odour Control • Zebra Mussel Control Four (4) low lift pumps, four (4) inline mixers, one (1) flocculation tank, six (6) filters (sand and granular activated carbon), two (2) clear wells, one (1) reservoir, and gravity feed to pumping station (Earth Tech, 2001a).	
Distribution System	358km of trunk watermains, 5,525km of distribution watermains in twelve (12) pressure zones, ten (10) reservoirs, four (4) elevated tank, and eighteen (18) pumping stations with eighty-eight (88) pumps (Toronto Water, 2006).	
Rated Capacity	410ML/day (Toronto Water, 2006)	
Servicing Population	A part of the TWSS servicing approximately 3.2 million residents in the City of Toronto and southern portion of York Region (Toronto Water, 2006).	
Intake		
Water Source	Lake Ontario	
Pipe 1	Status: **Operational**	
High Density Polyethylene (HDPE) (Enwave, 2007)	UTM Coordinates	(NAD 83, Zone 17) 4826148m N, 633111m E
	Length	5400m
	Diameter	1.6m
	Crib Depth	83m
Pipe 2	Status: **Operational**	
HDPE	UTM Coordinates	(NAD 83, Zone 17) 4826668m N, 633723m E
	Length	5400m
	Diameter	1.6m

Table 7.1: Island WTP Description and Processes		
	Crib Depth	83m
Pipe 3	Status: **Operational**	
HDPE	UTM Coordinates	(NAD 83, Zone 17) 4827099m N, 634374m E
	Length	5400m
	Diameter	1.6m
	Crib Depth	83m
Pipe 4	Status: **Non-operational**	
	UTM Coordinates	(NAD 83, Zone 17) 4829452m N, 630200m E
	Length	750m
	Diameter	1.8m
	Crib Depth	11m
Pipe 5	Status: **Non-operational**	
	UTM Coordinates	(NAD 83, Zone 17) 4829648m N, 630734m E
	Length	840m
	Diameter	1.8m
	Crib Depth	17m
Pipe 4 and Pipe 5 converge into a single 2.25m intake pipe (Earth Tech, 2001a).		

7.2 OPERATOR CONCERNS

Stantec conducted an interview with operators for the Island WTP on July 10, 2007 in an effort to identify known issues and concerns with plant operations. A standard interview form was used, as well as a study area map, to locate and discuss possible activities that could influence the quality of raw water entering the treatment plant. The completed interview form can be found in Appendix 2.1.

Operators did not indicate any issues or concerns with the operational intakes for the Island WTP. The water was identified as a consistently good source with virtually no variation. During the year the water temperature changes only slightly, varying from 3.8°C to 6.0°C. The higher temperature is a result of seasonal downwelling during the fall lake turnover, usually observed in November.

7.3 RAW WATER QUALITY AT THE INTAKE

TWSS raw water quality data for the 2003 and 2004 operating years was provided as a whole for the supply system. (Refer to section 4.2.1) Records specific to the Island WTP were available for the 2005 and 2006 operating years. Raw water quality data is used to determine the source vulnerability rating for the WTP intakes. A summary of available data is provided in Table 7.2 and 7.3.

Table 7.2: Microbiological Testing for 2005 Annual Report			
WTP	**Number of Samples**	**Range of *E.coli* and Fecal Results (counts/100)mL**	**Range of Total Coliform Results (counts/100)mL**
Island	1,062	0 - 23	0 - 690

In 2005 the Island WTP did not have any exceedances for either organic or inorganic parameters.

Table 7.3: Microbiological Testing for 2006 Annual Report			
WTP	**Number of Samples**	**Range of *E.coli* and Fecal Results (counts/100mL)**	**Range of Total Coliform Results (counts/100mL)**
Island	504	0 - 200	0 - 530

In 2006 the Island WTP did not have any exceedances for either organic or inorganic parameters.

7.4 INTAKE PROTECTION ZONE DELINEATION

The IPZ-1 consists of the area immediately surrounding the intake with an administratively set minimum radius of 1km. This represents the most vulnerable area about an intake.

The IPZ-2 includes all land area and stream mixing zones that could potentially influence the intake within the 2-hr TOT. The IPZ-2 consists of two primary components; the in-lake and alongshore IPZ-2 provided by the modeling team, and the landward and up tributary IPZ-2 delineated with respect to the modeled IPZ-2, the methodology provided in Appendix 3.2, and specific local conditions.

7.4.1 In-lake and Alongshore IPZ-2

Refer to Section 3.0 for an explanation of the approach and modeling used in the delineation of the in-water IPZ-2.

For Great Lakes intakes, Module 4 recommends using the average alongshore-current velocity during high wind and current period. The approach used in this report is based on the numerical modeling with a reverse particle-tracking model run for east and west events approximating 10-year return period winds.

The Island intakes are shown in Figures 7.1 and 7.2. The three intakes are located 5.4km from shore at a depth of 83m. These are the longest intakes, located in the deepest water in the Lake Ontario Collaborative (LOC) study area. The east and west intakes were modeled to develop an overall in-water IPZ-2 for all three intakes. As with the other intakes, a conservative approach was taken and surface currents were used to delineate the preliminary IPZ-2.

Currents at a depth of 83m would have significantly reduced velocities than surface currents. Currents in this area are predominantly parallel to the lakebed contours and the surface currents are strong. The IPZ-2 extends approximately 6km in the alongshore direction. The IPZ-2 is not connected to shore, indicating that contaminants are unlikely to be transported to the intake from shore within the 2-hr TOT.

The IPZ delineated in this phase of the work is preliminary due to the limitations discussed in Section 3.3.3 and Appendix 3.1.

7.4.2 Landward and Up-Tributary Extent of the IPZ-2

For the modeled intakes, Island intake 1 and Island intake 3, it was determined based on Module 4 criteria, that the upland component of the IPZ-2 was not necessary. Effects from study area tributaries and anthropogenic pathways do not influence the intake source water.

Figure 7.1: Island WTP In-Water IPZ-2 Modeling

Figure 7.2: Island WTP Combined Intake Protection Zones

7.5 IPZ VULNERABILITY SCORES

Table 7.4 summarizes the vulnerability scores for the Island WTP.

Table 7.4: Vulnerability Score Summary – Island WTP

Intake Location	Zone Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_S)	Vulnerability Score[1] (V)	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
Island WTP	10	7 LOW	0.5 LOW	5 LOW	4 LOW

[1] Rounded to the next whole number.

7.5.1 Zone Vulnerability Factor (Vf_z)

The Island WTP IPZ-1 Vf_z is assigned a value of 10 in accordance with Module 4.

The Island WTP IPZ-2 Vf_z is determined to be 7 (low).

The natural characteristics of the upland environment, and anthropogenic pathways within the study area were determined not to influence the Island WTP intakes. Significant issues or concerns do not exist related to the study area, which requires a low zone vulnerability rating.

7.5.2 Source Vulnerability Modifying Factor (Vf_S)

WTP Vf_S determined to be 0.5 (low).

The MOE guidelines for the Design of Water Treatment Works (MOE, 1982) prescribes a minimum submergence of 3m with a preference of 10m or deeper. The physical characteristics of the Island intake pipes are described in Table 7.1. The surface water intakes extend 5400m into Lake Ontario, 83m below the water surface. In comparison to the MOE guidelines the Island WTP intakes are excellent.

Operators described the raw water entering the plant as good with virtually no variation in characteristics. Operators also indicated that the intakes were isolated from shoreline influences. Slight temperature changes do occur as a result of seasonal upwelling and downwelling associated with normalization of lake water densities and subsequent turnover, which typically occurs in the fall, and occasionally spring seasons. Annual Reports for the last two years do not indicate exceedances for any of the testing parameters.

7.6 UNCERTAINTY ASSESSMENT

Module 4 prescribes a conservative approach to assignment of an overall rating for each zone. Only where uncertainty is low for both components can an overall “low” uncertainty rating be assigned. Mixed low and high ratings would result in a default to a “high” uncertainty level for the zone (MOE, 2006a). Table 7.5 outlines the uncertainty level ratings for the Island WTP.

Table 7.5: Uncertainty Level Ratings – Island WTP		
Component	**IPZ-1**	**IPZ-2**
Zone Delineation Rating	LOW	LOW
Vulnerability Rating	LOW	LOW
Combined Rating[1]	LOW	LOW

[1] Combined Rating defaults to highest level

7.6.1 IPZ-1 Level of Uncertainty

Dimensions for IPZ-1 are prescribed in Module 4, and local conditions do not indicate a need to extend the zone beyond the prescribed minimum 1km radius. Local data contributing to factors for the zone vulnerability score are from Federal and Provincial sources, recent studies and assessments, and ongoing monitoring programs. They are of sufficient density, frequency and quality to impart a moderate to high level of confidence in the vulnerability score resulting in low uncertainty. The resulting combined uncertainty rating is low for the IPZ-1, as shown in Table 7.5.

7.6.2 IPZ-2 Level of Uncertainty

The IPZ-2 level of uncertainty is directly affected by the level of confidence in which the in-water and upland IPZ-2 was delineated and the level of confidence associated with the vulnerability rating assigned to the IPZ-2.

The IPZ-2 delineation consists of two distinct parts, the upland component, and the in-water component. The in-water IPZ-2 has been delineated using numerical modeling. The model has a moderate to high uncertainty due to the limited period of available modeling and limited spatial resolution as well as it being uncalibrated with real-time data. The upland IPZ-2 was not required and therefore does not have a vulnerability rating.

Despite the constraints faced by the modeling teams and the data gaps present, a low level of uncertainty may be applied to the delineated IPZ-2. This is largely in part due to the local conditions of the Island WTP study area and an upland IPZ-2 not being required.

The vulnerability score assigned to the IPZ-2 consists of two distinct and necessary parts; the Vf_z and the Vf_s. The level of uncertainty associated with the vulnerability rating is a product of available information. Recognizing the data gaps identified in Section 10.0 while acknowledging the qualitative nature of the vulnerability rating, combined with the adherence to Module 4 criteria, a low level of uncertainty may be applied to the assigned vulnerability rating.

The combined low uncertainty ratings yield a low level of uncertainty for the Island WTP IPZ-2.

8.0 R. C. Harris Water Treatment Plant

8.1 WATER TREATMENT PLANT DESCRIPTION AND PROCESS

Table 8.1 summarizes the plant description and processes for the Harris WTP.

Table 8.1: Harris WTP Description and Processes		
Treatment Plant		
Owner/Operator	City of Toronto	
Location	2701 Queen Street East, Toronto (NAD 83, Zone 17) 4836984m N, 638731m E	
Drinking Water System Number	220002262	
Unit Processes and Systems	• Chloramination • Chlorination • Coagulation • Filtration • Flocculation • Fluoridation • Sedimentation • Taste and Odour Control • Zebra Mussel Control Six (6) low lift pumps, six flocculation tanks and sediment basins, forty (40) filters (sand and granular activated carbon), one (1) reservoir, and nine (9) high lift pumps. (XCG, 2001b)	
Distribution System	358km of trunk watermains, 5,525km of distribution watermains in twelve (12) pressure zones, ten (10) reservoirs, four (4) elevated tank, and eighteen (18) pumping stations with eighty-eight (88) pumps (Toronto Water, 2006).	
Rated Capacity	950ML/day (Toronto Water, 2006).	
Servicing Population	A part of the TWSS servicing approximately 3.2 million residents in the City of Toronto and southern portion of York Region (Toronto Water, 2006).	
Intake		
Water Source	Lake Ontario	
Pipe 1	Status: **Operational**	
Steel lined concrete pipe (XCG, 2001b)	UTM Coordinates	(NAD 83, Zone 17) 4836709m N, 641081m E
	Length	1300m (OCWA, 2007)
	Diameter	2.45m (OCWA, 2007)
	Crib Depth	15m (OCWA, 2007)
Pipe 2	Status: **Operational**	
Steel lined concrete pipe (XCG, 2001b)	UTM Coordinates	(NAD 83, Zone 17) 4836391m N, 640913m E
	Length	1300m (OCWA, 2007)
	Diameter	2.45m (OCWA, 2007)

Table 8.1: Harris WTP Description and Processes		
	Crib Depth	15m (OCWA, 2007)
Tunnel	Length	1000m (OCWA, 2007)
Common rock tunnel fed by intake pipes 1 and 2 (XCG, 2001b)	Diameter	3.05m (OCWA, 2007)

8.2 OPERATOR CONCERNS

Stantec conducted an interview with Harris WTP operators on July 10, 2007 in an effort to identify known issues and concerns relating to plant operations and the source water. A standard interview form was used, as well as a study area map, to locate and discuss areas of concern. The completed interview form is included in Appendix 2.1.

Operators identified the presence of pathogens in the source water; noting that occurrences are generally expected. The Ashbridges Bay WWTP is located approximately 4km west of the WTP. The WWTP discharge pipe extends 600m into Lake Ontario. The WWTP is the assumed source of occasionally high levels of free ammonia.

There is a marina located to the west, and to the east of the Harris WTP. These facilities are members of the Ontario Marina Operators Association (OMOA) and the Ontario Clean Marina Program, operated by the OMOA.

The area surrounding the Harris WTP is predominantly residential. Several parks and a golf course are located onshore. Operators identified and expressed concern regarding a large storm sewer outfall located at the bottom of Warden Avenue.

The only concern regarding river and creek influence is from the Don River, which discharges into Toronto Harbour. The water rotates and mixes in a circular pattern within the harbour and exits through gaps on either side of the island. Water exiting on the eastern side of the island is of concern.

The operators identified the primary influences on the Harris WTP source water as the Ashbridges WWTP, lake seiches, annual upwelling and downwelling, and influences from the Don River.

8.3 RAW WATER QUALITY AT THE INTAKE

TWSS raw water quality data for the 2003 and 2004 operating years was provided as a whole for the supply system. (Refer to section 4.2.1) Records specific to the Harris WTP were available for the 2005 and 2006 operating years. Raw water quality data is used to determine the source vulnerability rating for the WTP intake, a summary of available data is provided in Table 8.2 and 8.3.

Table 8.2: Microbiological Testing for 2005 Annual Report			
WTP	**Number of Samples**	**Range of *E.coli* and Fecal Results (counts/100mL)**	**Range of Total Coliform Results (counts/100mL)**
Harris	1,104	0 - 15	0 - 790

In 2005 the Harris WTP had three exceedances for sodium, all within a short period of time during the winter months. This can likely be attributed to de-icing salt making its way into the system. The Harris WTP did not have any organic exceedances.

Table 8.3: Microbiological Testing for 2006 Annual Report			
WTP	**Number of Samples**	**Range of *E.coli* and Fecal Results (counts/100mL)**	**Range of Total Coliform Results (counts/100mL)**
Harris	486	0 - 20	0 - 400

In 2006 the Harris WTP did not have any exceedances for either organic or inorganic parameters.

8.4 INTAKE PROTECTION ZONE DELINEATION

The IPZ-1 consists of the area immediately surrounding the intake with an administratively set minimum radius of 1km. This represents the most vulnerable area about an intake.

The IPZ-2 includes all land area and stream mixing zones that could potentially influence the intake within the 2-hr TOT. The IPZ-2 consists of two primary components; the in-water IPZ-2 provided by the modeling team and the upland IPZ-2 delineated with respect to the modeled IPZ-2, the methodology provided in Appendix 3.2, and specific local conditions.

8.4.1 In-lake and Alongshore IPZ-2

Refer to Section 3.0 for an explanation of the approach and modeling used in the delineation of the in-water IPZ-2.

For Great Lakes intakes, Module 4 recommends using the average alongshore-current velocity during high wind and current period. This is not a specific event with a defined return period. The approach used in this report is based on the numerical modeling with the reverse particle-tracking model run for east and west events approximating 10-year return period winds.

The Harris intake is shown in Figure 8.1. There are two intakes for this WTP, located approximately 360m apart. Based on information provided by the operator, both intakes are used equally, and there is no primary intake. The southwest intake was modeled and the IPZ-2 shown in Figure 8.1 is for the southwest intake. The intake is located 2km from shore. Currents in this area are predominantly parallel to shore and the in-water IPZ-2 extends approximately 4.5km northeast and 3.6km southwest of the intake. It is estimated that the IPZ-2 for the northeast intake would extend approximately 360m further to the northeast. The particle tracking indicates that the IPZ-2 does not extend to shore, potentially significantly reducing the threats within the 2-hr TOT.

The intake protection zones delineated in this phase of the work are preliminary due to the limitations discussed in Section 3.3.3 and Appendix 3.1.

8.4.2 Landward and Up-Tributary Extent of the IPZ-2

Sewershed data was available for the area surrounding the Harris WTP. The upland extent of the IPZ-2 will encompass entire sewersheds that outfall into Lake Ontario within the IPZ-2 projection as per the methodology provided in Appendix 3.2.

The western extent of the IPZ-2 was projected onto shore intersecting at Ashbridges Bay Park. The administratively set limit of 120m was used as the landward extent along this section of shoreline until Lakeshore Boulevard East. The IPZ-2 follows Woodbine Avenue north until turning east following a general line comprised of Milverton Boulevard, Doncaster Avenue, and Rosevear Avenue before turning south onto Victoria Park Avenue. The IPZ-2 turns east and follows Danforth Avenue, eventually connecting to Kingston Road, until Sharpe Street from which point the IPZ-2 winds through Pell Street Lane, Sandown Avenue, Leisure Lane, Midland Avenue, Kelsonia Avenue, Scarboro Crescent, Glenridge Road, and Cliffcrest Drive. From the end of Cliffcrest Drive the IPZ-2 follows the shoreline at a distance of 120m until Bluffers Park where it connects to the in-water component.

Figure 8.1: R.C. Harris WTP Intake Protection Zones

8.5 IPZ VULNERABILITY SCORES

Table 8.4 summarizes the vulnerability scores for the Harris WTP.

Table 8.4: Vulnerability Score Summary – Harris WTP

Intake Location	Zone Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_s)	Vulnerability Score[1] (V)	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
Harris WTP	10	8 MODERATE	0.6 MODERATE	6 MODERATE	5 LOW

1. Rounded to the next whole number.

8.5.1 Zone Vulnerability Factor (Vf_z)

The WTP IPZ-1 Vf_z is assigned a value of 10 in accordance with Module 4.

The WTP IPZ-2 Vf_z is determined to be 8 (moderate) based on natural and anthropogenic characteristics of the environment contained within the zone.

The Harris WTP is located on the edge of the Scarborough Bluffs, which is characterized by a gentle slope approaching the lake and a sharp drop-off close to the shoreline.

Anthropogenic pathways in the IPZ-2 consist of surface runoff from urban areas, transportation routes, storm sewers, and CSOs. Transportation routes to consider in this area include: Lakeshore Boulevard East, Queen Street East, Kingston Road, and the railway line farther inland.

High volumes of storm runoff occur as a result of the high level of urbanization in the study area. Storm runoff may transport sediment, salt, oil and other contaminants into the lake through the twelve (12) CSOs and five (5) storm sewers discharging in the study area.

The Vf_z does not consider the nature of a contaminant but rather the ability of a contaminant to reach the source water body. The natural and anthropogenic characteristic pathways, along with transportation routes, provide opportunity for contaminants to reach the lake. The Vf_z is assigned a moderate value of 8 based on these findings.

8.5.2 Source Vulnerability Modifying Factor (Vf_s)

The Harris WTP Vf_s is determined to be 0.6 (moderate).

The MOE guidelines for the Design of Water Treatment Works (MOE, 1982) prescribe that the preferred minimum submergence for raw water intakes is 10m or deeper. The physical characteristics of the Harris intake pipes are described in Section 8.1. The intakes are located 2300m into Lake Ontario and the intake crib for each pipe is located in approximately 15m of water. This exceeds the MOE preference for surface water intakes. With respect to the Michigan criteria for surface water intakes, the Harris WTP intakes are designated as; offshore, deep water intakes, and would receive a moderate vulnerability rating (refer to section 5.1.3).

The historical water quality records from the Annual Report indicate that on several occasions there have been issues with sodium in the water. This has been linked to de-icing salt, used on the roadways in the winter, discharging out the sewer outfalls during the spring melt, indicating onshore influences to the source water.

The Ashbridges WWTP is located to the west of the WTP. The WWTP has a capacity of 818,000m^3/day and discharges through a pipe extending 600m into Lake Ontario. As supported in the operator interview summarized in Section 8.2, WWTP effluent is a suggested source of excess free ammonia in the source water. Operators noted the effect of WWTP overflow on the WTP source water. While occasional WWTP influences to the source water have been identified, the length and depth of the Harris WTP intake pipe facilitate a moderate Vf_s of 0.6.

8.6 UNCERTAINTY ASSESSMENT

Module 4 prescribes a conservative approach to the assignment of an overall rating for each zone. Only where uncertainty is low for both components can an overall "low" uncertainty rating be assigned. Mixed low and high ratings would result in a default to a "high" uncertainty level for the zone (MOE, 2006a). Table 8.5 outlines the uncertainty level ratings for the Harris WTP.

Table 8.5: Uncertainty Level Ratings – Harris WTP

Component	IPZ-1	IPZ-2
Zone Delineation Rating	LOW	HIGH
Vulnerability Rating	LOW	LOW
Combined Rating[1]	LOW	HIGH

8.6.1 IPZ-1 Level of Uncertainty

Dimensions for IPZ-1 are prescribed in Module 4, and local conditions do not indicate a need to extend the zone beyond the prescribed minimum 1km radius. Local data contributing to factors for the Vf_z are from recent studies and assessments, and ongoing monitoring programs. They are of sufficient density, frequency and quality to impart a moderate to high level of confidence in the vulnerability score resulting in low uncertainty. The resulting combined uncertainty rating is low for the IPZ-1, as shown in Table 8.5.

8.6.2 IPZ-2 Level of Uncertainty

The delineated IPZ-2 is assigned a high level of uncertainty. Although an appropriate model was selected to conceptualize local water movement, local field data not available during modeling analysis is required to accurately calibrate the model. As well, limited data was available for use in establishing the model boundaries and therefore IPZ-2 is said to be preliminary. The upland component of the IPZ-2 was conservatively delineated in order to provide a scoping level study. With the absence of stream outflow data and storm sewershed data, the upland IPZ-2 was delineated with high uncertainty.

Site-specific data contributing to the vulnerability score is from ongoing provincial monitoring programs, federal monitoring programs, as well as input from the WTP operators and CA's. They are of sufficient quality and frequency to impart a moderate to low level of uncertainty in the vulnerability score.

As per Module 4 the combined uncertainty rating for the IPZ-2 is high.

9.0 F. J. Horgan Water Treatment Plant

9.1 WATER TREATMENT PLANT DESCRIPTIONS AND PROCESSES

Table 9.1 summarizes the plant descriptions and processes for the Horgan WTP.

Table 9.1: Horgan WTP Description and Processes	
Treatment Plant	
Owner/Operator	City of Toronto
Location	201 Copperfield Road, Toronto (NAD 83, Zone 17) 4846533m N, 647546m E
Drinking Water System Number	220004536
Unit Processes and Systems	• Chloramination • Chlorination • Coagulation • Filtration • Flocculation • Fluoridation • Taste And Odour Control • Zebra Mussel Control Six (6) low lift pumps, four (4) inline mixers, two (2) three stage mechanical flocculators and two (2) inline flocculators, eight (8) filters (dual media), two (2) clear wells, one (1) reservoir, and seven (7) high lift pumps. (Earth Tech, 2001b)
Distribution System	358km of trunk watermains, 5,525km of distribution watermains in twelve (12) pressure zones, ten (10) reservoirs, four (4) elevated tank, and eighteen (18) pumping stations with eighty-eight (88) pumps (Toronto Water, 2006).
Rated Capacity	570ML/day (Toronto Water, 2006)
Servicing Population	A part of the TWSS, which services approximately 3.2 million residents in the City of Toronto and southern portion of York Region (Toronto Water, 2006).
Intake	
Water Source	Lake Ontario
UTM Coordinates	(NAD 83, Zone 17) 4843721m N, 648453m E
Crib Depth	18m (OCWA, 2007)
Length of Intake	3200m (OCWA, 2007)
Pipe Diameter	3.35m (OCWA, 2007)
Pipe Material	Concrete lined (Earth Tech, 2001b)

9.2 OPERATOR CONCERNS

Stantec conducted an interview with Horgan WTP operators on July 10, 2007 in an effort to identify issues and concerns regarding plant operations. A standard interview form was used, as well as a study area map, to locate and discuss potential areas of concern influencing the quality of raw water entering the treatment plant. The completed interview form can be found in Appendix 2.1.

The area around the Horgan WTP consists of residential and industrial land uses. Operators expressed concern with the proximity of the Pickering Nuclear Generating Station, located approximately 5km from the intake, and the potential release of tritium into the water. Concern was also expressed with other industries within the vicinity of the WTP. Additionally a CN Rail line and the Highland Creek WWTP are located near the WTP study area.

Atrazine has been detected in trace amounts in the source water, however does not directly concern the operators. Operators expressed concern with respect to bulk chemical storage and spills from industrial facilities. Operators indicated a relative inability to test for specific contaminants in the event of a spill.

Sodium levels are stable year round, suggesting the source water may not be affected by onshore surface runoff. Highland Creek and the Rouge River discharge into Lake Ontario near the WTP and have not been mentioned as specific areas of concern.

High nearshore turbidity levels are typically recorded during the spring freshet. High turbidity events have not been observed at the intake. Operators indicated predictable conditions in the source water, presenting little difficulty in treatment.

9.3 RAW WATER QUALITY AT THE INTAKE

TWSS raw water quality data for the 2003 and 2004 operating years was provided as a whole for the supply system. (Refer to section 4.2.1) Records specific to the Horgan WTP were available for the 2005 and 2006 operating years. Raw water quality data is used to determine the source vulnerability rating for the WTP intake, a summary of available data is provided in Table 9.2 and 9.3.

Table 9.2: Microbiological Testing for 2005 Annual Report

WTP	Number of Samples	Range of *E.coli* and Fecal Results (counts/100mL)	Range of Total Coliform Results (counts/100mL)
Horgan	649	0 - 98	0 - 6100

In 2005 the Horgan WTP did not have any exceedances for either organic or inorganic parameters.

Table 9.3: Microbiological Testing for 2006 Annual Report

WTP	Number of Samples	Range of *E.coli* and Fecal Results (counts/100mL)	Range of Total Coliform Results (counts/100mL)
Horgan	504	0 – 17	0 - 260

In 2006 the Horgan WTP did not have any exceedances for either organic or inorganic parameters.

9.4 INTAKE PROTECTION ZONE DELINEATION

The IPZ-1 consists of the area immediately surrounding the intake with an administratively set minimum radius of 1km. This represents the most vulnerable area about an intake.

The IPZ-2 includes all land area and stream mixing zones that could potentially influence the intake within the 2-hr TOT. The IPZ-2 consists of two primary components; the in-water IPZ-2 provided by the modeling team, and the upland IPZ-2 delineated with respect to the modeled IPZ-2, the methodology provided in Appendix 3.2, and specific local conditions.

9.4.1 In-Lake and Alongshore IPZ-2

For Great Lakes intakes, Module 4 recommends using the average alongshore-current velocity during high wind and current period. This is not a specific event with a defined return period. The approach used in this report is based on the numerical modeling with the reverse particle-tracking model run for east and west events approximating 10-year return period winds.

The Horgan intake is located approximately 3.2km from shore at a depth of 18m. The preliminary in-water IPZ-2 is shown in Figure 9.1. Currents in this area are predominantly parallel to shore and the in-water IPZ-2 extends approximately 3.3km in either direction from the intake. The particle tracking indicates that the IPZ-2 does not extend to shore, potentially significantly reducing the threats within the 2-hr TOT.

The IPZ-2 delineated in this phase of the work is preliminary due to the limitations discussed in Section 3.3.3 and Appendix 3.1.

9.4.2 Landward and Up-Tributary Extent of the IPZ-2

Sewershed data was not available for the area surrounding the Horgan WTP. The WTP is situated in a narrow area in which overland flow enters into Lake Ontario either directly or via Highland Creek. A conservative approach was taken to delineate the upland component of the IPZ-2. Up-tributary extents were not required as the outlet of Highland Creek is located outside the projected in-water IPZ-2. A portion of Highland Creek was included in the landward extent in order to include the industrial area located near the WTP.

The modeled in-water IPZ-2 was projected onto shore, intersecting near Cathedral Bluffs Drive, which then extends north to Kingston Road. The IPZ-2 upland follows Kingston Road northeast to the railway tracks, proceeding until Manse Road. It extends north to the south branch of Highland Creek and then follows Highland Creek east until it reaches the creek mouth.

Figure 9.1: F.J. Horgan WTP Intake Protection Zones

9.5 IPZ VULNERABILITY SCORES

Table 9.4 summarizes the vulnerability scores for the Horgan WTP.

Table 9.4: Vulnerability Score Summary – Horgan WTP

Intake Location	Zone Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_s)	Vulnerability Score[1] (V)	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
Horgan WTP	10	9 HIGH	0.5 LOW	5 LOW	5 LOW

[1] Rounded to the next whole number.

9.5.1 Zone Vulnerability Factor (Vf_z)

The Horgan WTP IPZ-1 Vf_z is assigned a value of 10 in accordance with Module 4.

The Horgan WTP IPZ-2 Vf_z is determined to be 9 (high) based on natural and anthropogenic characteristics of the environment within the study area.

The natural characteristics that drive the Vf_z estimation around the Horgan WTP are minimal due to the amount of development in the area. It is highly urbanized with residential and industrial land uses. Approximately 3km of Highland Creek has been included in the upland extents to incorporate any overland flow that may have originated from the residential and industrial areas.

Highland Creek was also assumed to be the outfall for any sewersheds that are situated in the industrial or residential areas based on the general topography of the area. An administratively set limit of 120m was followed along on the north and east sides of the watercourse. Besides the creek, the remaining boundaries are formed through the transportation corridors of Kingston Road and Lawrence Avenue East.

The Vf_z does not consider the nature of a contaminant but rather the ability of a contaminant to reach the source water body. The natural and anthropogenic characteristics make contaminants available through transportation pathways, such as overland flow or Highland Creek, to the intake in Lake Ontario. The Vf_z is assigned a high value of 9 based on these findings.

9.5.2 Source Vulnerability Modifying Factor (Vf_s)

The Horgan WTP Vf_s is determined to be 0.5 (low).

The MOE guidelines for the Design of Water Treatment Works (MOE, 1982) prescribes a minimum submergence of 3m for drinking water intakes with a preferred submergence of 10m or greater. The physical characteristics of the Horgan WTP intake pipe are described in Table 9.1. The surface water intake pipe extends 3200m into Lake Ontario, 18m below the water surface. In comparison with the MOE guidelines the Horgan WTP is excellent. With respect to the Michigan criteria for surface water intakes, the Horgan WTP intakes are designated as;

offshore, deep water intakes, and would receive a moderate vulnerability rating (refer to section 5.1.3).

The historical water quality records from the Annual Report indicate that for the last two years there have been no issues with water quality. Operators have also indicated that the consistency of the water is very stable with the only small parameter changes during seasonal upwelling and downwelling. The water quality is very high and predictable, making it very easy to treat. Creek, river, and piped discharges were not identified influencing the source water. A low Vf_s score of 0.5 has been assigned.

9.6 UNCERTAINTY ASSESSMENT

Module 4 prescribes a conservative approach to assignment of an overall rating for each zone. Only where uncertainty is low for both components can an overall "low" uncertainty rating be assigned. Mixed low and high ratings would result in a default to a "high" uncertainty level for the zone (MOE, 2006a). Table 9.5 outlines the uncertainty level ratings for the Horgan WTP.

Table 9.5: Uncertainty Level Ratings – Horgan WTP

Component	IPZ-1	IPZ-2
Zone Delineation Rating	LOW	HIGH
Vulnerability Rating	LOW	LOW
Combined Rating[1]	LOW	HIGH

[1] Combined Rating defaults to highest level

9.6.1 IPZ-1 Level of Uncertainty

Dimensions for IPZ-1 are prescribed in Module 4, and local conditions do not indicate a need to extend the zone beyond the prescribed minimum 1km radius. Local data contributing to factors for the V score are from recent studies and assessments, and ongoing monitoring programs. They are of sufficient density, frequency and quality to impart a moderate to high level of confidence in the vulnerability score resulting in low uncertainty. The resulting combined uncertainty rating is low for the IPZ-1, as shown in Table 9.5.

9.6.2 IPZ-2 Level of Uncertainty

The level of uncertainty for the IPZ-2 delineation is high. An appropriate model was selected to conceptualize local water movement however due to the limited time period of available data and the model not being calibrated with real time data, the uncertainty is high. The IPZ-2 is preliminary and may be subject to change upon receiving more data.

Site-specific data contributing to the vulnerability score is from ongoing provincial monitoring programs, federal monitoring programs, as well as input from the WTP operators and CA's. They are of sufficient quality and frequency to impart a moderate to low level of uncertainty in the vulnerability score.

The resulting combined uncertainty rating for IPZ-2 is high, as shown in Table 9.5.

10.0 Data Gap Analysis and Assumptions

10.1 DATA GAPS

In general, the quality and quantity of data available from readily available public domain data sources has been sufficient to characterize the intakes and general setting of the Toronto study area, undertake preliminary delineation of the IPZ-2, and conduct a qualitative vulnerability analysis for zone and source factors. There are no gaps in data essential to completing a preliminary scoping IPZ and vulnerability assessment analysis. In order to complete a more comprehensive Module 4 assessment the data gaps identified in Table 10.1 should be filled. To indicate the relative importance of identified data gaps, priority ratings of high, moderate, and low have been assigned to each data gap listed in Table 10.1.

A gap analysis relating to water movement, modeling and IPZ-2 delineation is presented in Appendix 3.1.

Table 10.1: Data Gaps

Vulnerability Deliverable	**Data Set Name**	**Priority**	**Comment**
IPZ-2 Delineation	Storm Sewersheds	Medium	Needed to improve the accuracy of IPZ-2 delineation.
	Stream Properties	Medium	Needed to improve the accuracy of IPZ-2 delineation.
Intake and Area Characterization	Sediment Quality Data	Low	Provide additional intake vulnerability characterization.
	Harris and Horgan WTP intake characteristics	Low	Required to verify the characterization requirements outlined in Module 4.
	Raw Water Quality Data (DWSP and DWIS data)	Medium	Determine the characteristics of the raw water. Needed to fulfill characterization requirements outlined in Module 4.
Zones Vulnerability Score	Outfall data (storm water outfalls, CSO locations	Medium	Needed to provide additional source vulnerability characterization and to improve understanding of preferential pathways.

10.2 ASSUMPTIONS

In order to conservatively circumvent gaps in the IPZ-2 delineation, area characterizations, and vulnerability zones, assumptions were required in this report. By doing so, an area representing locations where contaminants and vulnerabilities exist that have the potential to affect the WTP and its intake has been developed. Below is a list of the assumptions that were made in deriving the upland and up-tributary extents of the landward IPZ-2.

- Overland flow and drainage patterns are based on topographical information;

- Stormsheds were assumed on the basis that large urban areas are drained by storm sewer networks;

- Projection of alongshore extent of IPZ-2 is assumed to provide some upland IPZ-2 extents. The level of modeling uncertainty is high and thus onshore and tributary outfall components are not explicitly represented;

- Residual time method was used in delineating inland IPZ-2 boundaries. Refer to Case A in Appendix 3.2 for method description and procedure;

- Transportation corridors are assumed to drain directly into natural pathways.

The assumptions listed above enabled the completion of the vulnerability analysis in light of the identified data gaps. These assumptions provided the means to delineate a conservative, scoping level IPZ-2 and assign a vulnerability rating acknowledging the presence of varying levels of uncertainty associated with the available data, the numerical modeling preformed to generate the in-water IPZ-2, and the methodology used to determine the upland component of the IPZ-2.

11.0 Data Management

The province has established detailed data standards for compilation of digital records. The current version is 3.0 and is dated October 26, 2006.

Upon approval of the final draft of this report, the following data classes related to Module 4 will be submitted in digital format:

- Surface Water Intakes
- Intake Protection Zones

The specified attributes are summarized in Appendix 11.1.

12.0 Conclusions

12.1 IPZ DELINEATIONS

Two vulnerability zones (IPZ) were delineated for each of the TWSS WTPs; Clark, Island, Harris, and Horgan:

- A primary zone (IPZ-1) centred on the intake crib was administratively set with a radius of 1km, representing the most vulnerable and immediate area around the intake;
- A secondary zone (IPZ-2) was delineated with in-lake dimensions determined using numerical modeling and upland IPZ-2 extents for three (3) of the four (4) WTPs were delineated using tributary watershed information and approximated TOT.

12.2 VULNERABILITY ASSESSMENT

Table 12.1 summarizes the vulnerability scores for each of the WTPs in the TWSS.

Table 12.1: Vulnerability Score Summary

Intake Location	Zone Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_s)	Vulnerability Score[1](V)	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
Clark WTP	10	9 HIGH	0.6 MODERATE	6 MODERATE	6 MODERATE
Island WTP	10	7 LOW	0.5 LOW	5 LOW	4 LOW
Harris WTP	10	8 MODERATE	0.6 MODERATE	6 MODERATE	5 LOW
Horgan WTP	10	9 HIGH	0.5 LOW	5 LOW	5 LOW

[1]Vulnerability score rounded to the next highest whole number.

12.3 UNCERTAINTY LEVEL ASSESSMENT

The uncertainty level is low for the IPZ-1 delineation and vulnerability assessment. The uncertainty level is high for IPZ-2 delineation due to the general lack of data to calibrate the model suites and the limited data inputs used to drive the model and reach steady state conditions. More data is required to run a variety of scenarios to effectively conceptualize water movement in the study area. Other than the detailed hydraulic data needed for model calibration, critical data necessary to delineate the vulnerability zones and score the intake vulnerability was sufficient. An IPZ-2 was delineated but the uncertainty in this delineation is high for all WTPs with the exception of the Island WTP. As a result, the combined uncertainty for the remaining three (3) WTPs is high.

Overall, the information available at the time of writing was of sufficient density, quality and quantity to characterize the aquatic and upland features of the area surrounding the WTP intakes, delineate IPZ boundaries around the WTP intakes and provide an assessment of the relative vulnerability of each of these zones. A final client comment review was provided to Stantec and is included in Appendix 12.1.

13.0 References

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APPENDIX 2.1:
OPERATOR INTERVIEWS

APPENDIX 3.1:
PRELIMINARY IN-LAKE PROTECTION ZONE DELINEATION REPORT- FINAL

APPENDIX 3.2: METHODOLOGY FOR THE DELINEATION OF LANDWARD AND UP-TRIBUTARY IPZ-2 EXTENTS

APPENDIX 4.1:
PLAN AND PROFILE DRAWINGS

APPENDIX 4.2:
ANNUAL COMPLIANCE REPORTS

APPENDIX 4.3:
FEDERAL AND PROVINCIAL SEDIMENT QUALITY GUIDELINES

APPENDIX 5.1:
STATE OF MICHIGAN CATEGORIES FOR GREAT LAKES INTAKES

APPENDIX 11.1:
DATA MANAGEMENT

APPENDIX 12.1:
CLIENT REVIEW COMMENTS