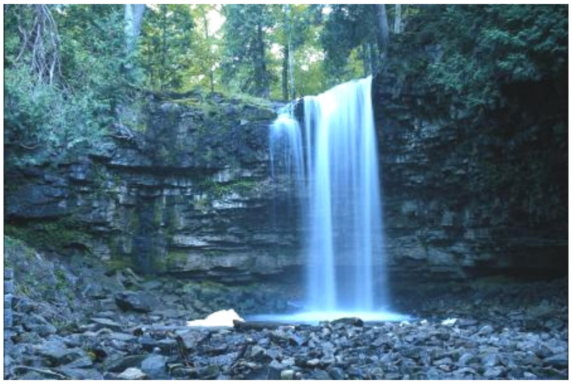
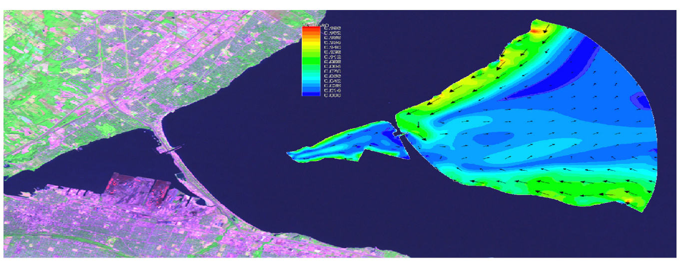
Source Water Protection



Collaborative Study to Protect Lake Ontario Drinking Water

Final Phase 1 Report
(MOE Module 4)
for the
City of Hamilton



March 2008

This report was developed for the City of Hamilton by Stantec Consulting Ltd. with the following contributors:

Lake Ontario Collaborative Intake Protection Zone Studies

Volume 1: City of Hamilton

Intake Protection Zone Delineation and Vulnerability Assessment Study for the Woodward Avenue Water Treatment Plant

FINAL REPORT

March 2008

Executive Summary

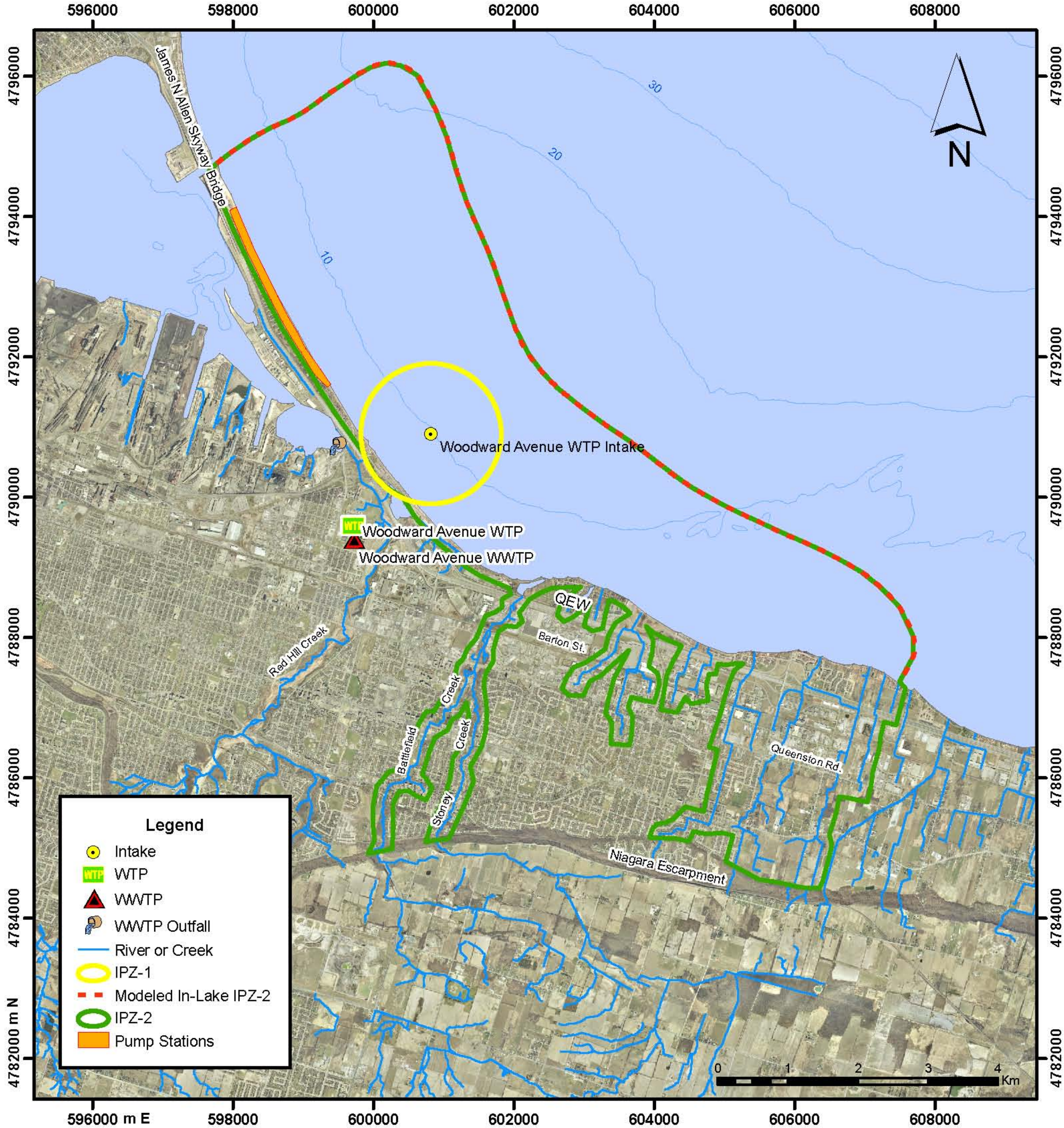
This Surface Water Vulnerability Analysis was undertaken by Stantec Consulting Ltd. for the Woodward Avenue Water Treatment Plant (WTP) under the Lake Ontario Collaborative to meet the requirements of the Ontario *Clean Water Act* (Government of Ontario, 2006). Using the guidance outlined in Ontario Ministry of Environment Draft Guidance Module 4 concerning Surface Water Vulnerability; the WTP intake and near areas were characterized, vulnerable areas about the intake known as Intake Protection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.

Major concerns raised by operators at the Woodward Avenue WTP include; the presence of pathogens in the source water, taste and odour issues, industrial wastewater discharges, the QEW and Skyway bridge, urban runoff and, storm sewer discharge. Local marina's, commercial shipping, wildlife, spills and dredging are also concerns.

Raw water quality data at the intake was available in annual reports from 1998-2000 and information was provided in the Engineer's Report.

The vulnerability zone for the Woodward Ave WTP is illustrated in Figure E.1. 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). The IPZ-2 was calculated using a 3D-ADCIRC hydrodynamic model which included data inputs from water movement, winds, currents and a time of travel factor. The uncertainty for the accuracy of the delineated vulnerability zones is high (low confidence).

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. For the Woodward Avenue WTP these factors produce a vulnerability score of 6 (moderate) for the IPZ-1 and 5 (low) for the IPZ-2. The delineation of the IPZ-2 for WTP is preliminary and may be revised based upon further information gathered in subsequent Phase 2 studies.



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DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

HCCL
Coastal & River Engineering
Water Resources & Environmental Hydraulics

Project
Lake Ontario Collaborative Intake Protection Zone Studies

Figure No.	Revision No.	Date
E.1	2	Jan. 8, 2008

Title
Woodward Avenue WTP Intake Protection Zones

Imagery and public works data © City of Hamilton.
Waterflow © Hamilton Conservation Authority.
Topographic data © Natural Resources Canada.
Bathymetry courtesy of NOAA.
Projection: UTM Zone 17N, NAD 1983

Table of Contents

List of Figures

List of Tables

List of Appendices

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 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 these 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 scoping level.

The Region of Peel has taken the role of lead municipality (for the purposes of this study) within 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 CA; and
- Niagara Peninsula SPR – Niagara Peninsula CA

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

With the exception of discussions with water treatment plant (WTP) staff, the current study is generally limited to a desktop analysis of existing information, with a summary of data gaps provided to help develop a future fieldwork program that could be completed to address the information deficiencies.

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 Woodward Avenue WTP intake comprises Volume 1. Figure 1.1 illustrates the Lake Ontario intakes as they relate to each other in a regional setting.

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 Woodward Avenue 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 Intake Protection Zone (IPZ) boundaries around the WTP intake, and provide an assessment of the relative vulnerability of each of these zones.

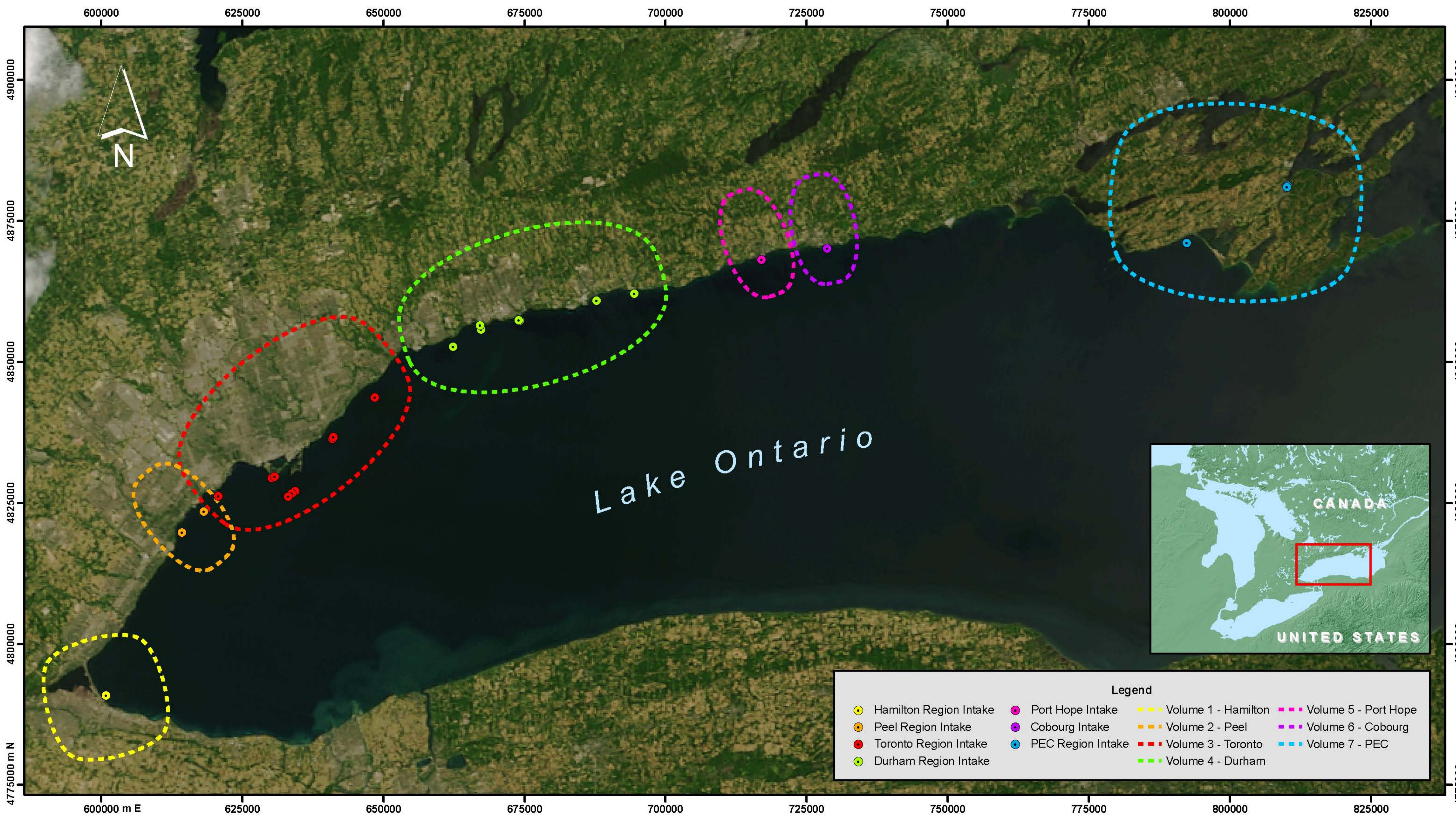
The zones of concern to the Great Lake intakes include:

- **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-hour (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 Module 4 are used as a geographical guideline to the drinking water threats inventory and issues evaluation outlined in Module 5 (MOE, 2006b).



Stantec

Baird
NAVIGATING NEW HORIZONS

HCCL
Coastal & River Engineering
Water Resources & Environmental Hydraulics

SOURCE WATER PROTECTION

0 9 18 27 36 Km

Inset data © ESRI Inc.

Project
Lake Ontario Collaborative Intake Protection Zone Studies

Figure No.	Revision No.	Date
1.1	2	Jan. 7, 2008

Title
Regional Setting

1.2.1 Report Outline

This report has been prepared based upon Module 4 (MOE, 2006a) and the Region of Peel's Terms of Reference (TOR) (Region of Peel, 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. Intakes Characterization;
6. Intake Protection Zones Vulnerability Analysis;
7. Uncertainty Assessment;
8. Data Gap Analysis and Assumptions;
9. Data Management Table;
10. Conclusions; and
11. References.

1.3 PROJECT APPROACH

The consulting team for the Woodward Avenue WTP 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 within the study area. Delineated the landward and up-tributary components of the IPZ-2 and determined vulnerability scores and associated uncertainty levels.

2. Hall Coastal Canada Limited (HCCL) – Water Movement Modeling

   Water movement modelers accessed and analyzed wind, current, bathymetric, and influent watercourse data. Delineated the in-lake 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 Module 1 Report

The HCA as part of the Halton-Hamilton Source Water Protection Region (HHSWPR) has prepared the Draft Watershed Characterization report in accordance with Module 1 (MOE, 2006d). The Module 1 report was the primary source used to characterize the physiography, geology, soil characteristics and hydrology of the study area.

2.2 OPERATOR INTERVIEW

In July 2007, Stantec conducted an operator interview with the Woodward Avenue WTP operations staff where issues and concerns were documented. The operator interview is included in Appendix 2.1. Operators identified treatment challenges, raw water quality knowledge, and identification of potential sources of contamination and concern within the area. This information will be discussed within Section 4.2 of this report.

3.0 Hydrodynamic Modeling and Intake Protection Zone Delineation

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 and immediate area about an intake; 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 Module 5.

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 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 CA 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 – Watershed Characterization Reports, Canadian Hydrographic Service stream flow data, other CA watershed data and reports and municipal stormshed network mapping.

3.2 HYDRODYNAMIC MODELING AND IPZ-2 DELINEATION

Appendix 3.1 includes the recommended approach for the delineation of the IPZ-2.

Details of the approach to available information review, hydrodynamic models evaluation and selection, and IPZ delineation are detailed in the July, 2007 "Lake Ontario Collaborative (Hamilton, Port Hope, Cobourg, Wellington and Picton) In-Water Intake Protection Zone Delineation - Hydrotechnical Analyses" Final Report by HCCL, included in Appendix 3.2. The following is a summary of the detailed information provided in that report.

3.3 APPROACH

The approach to defining the in-water component of the IPZ-2 boundary for the intakes mentioned above is varied due to limitations in available resources (relevant information and budgetary) for the Phase 1 work. The approach to each intake was selected in order to maximize the benefit of the existing information available, while addressing the local hydrodynamic characteristics as best as possible given the available resources. A general approach was taken to background information review and interpretation of the hydrodynamic environment.

Although there is a significant volume of current monitoring information from the Western Lake Ontario region as well as occasional historic deployments in other regions of Lake Ontario, it generally involves deployment periods of a few months at a time, and not necessarily within proximity to municipal water intakes. As a result, this information is not particularly well suited to defining extreme current conditions within the region, and potentially less appropriate for defining such conditions near the intake. This information does however provide for a reasonable understanding of the regional hydrodynamic processes and in some cases supports the development of regional hydrodynamic models.

The delineation of the IPZ-2 requires the ability to have some control over the conditions that are considered for the development of the zone. Specifically, it is desirable to define the zone for a "standard" event condition, and preferably one associated with a given design event such that some assessment of risk can be made. Probabilistic analysis of extremes typically requires a considerably longer data record than is available from the existing current monitoring data. Such records are generally available for wind and water levels, which are more regionally homogeneous. For these reasons, it is desirable and beneficial to provide for hydrodynamic modeling of the region such that the input boundaries of the model can be forced with extreme "event" conditions for which probabilistic estimates can be made.

The IPZ-2 boundary is also a function of the currents over a region that may extend some distance from the intake, and may not be well represented by only a few point measurements of current time series. The modeling approach accounts for this spatial variability in hydrodynamic conditions as the model domain provides for prediction of currents over a larger domain at a pre-defined level of discretization. This representation of the spatial variation in physical characteristics can better accommodate the inherent complexities of the region.

Finally, the modeling approach provides for the opportunity to investigate the sensitivity of predicted velocities to changes in environmental variables and therefore permits a better assessment of the confidence of the results given expected confidence in the measured input variables. For this reason, hydrodynamic modeling is proposed where resources support its development in Phase 1. Where such resources do not exist, alternative methods of estimating the preliminary IPZ-2 have been selected.

A specific approach to defining the in-water extents of the IPZ-2 were defined by region on the basis of the general overview, as detailed in Section 3.4 below.

3.4 HYDRODYNAMIC PROCESSES IN STUDY AREA

There is a relatively significant volume of research into Lake Ontario hydrodynamic processes on the regional level, especially focused on the western end of Lake Ontario. Existing hydrodynamic research generally focuses on the lakewide circulation processes and associated phenomena; there is unfortunately little emphasis on episodic and localized processes in the nearshore area, which are very important to the definition of the IPZ-2 boundary.

In general, a review of relevant literature published by National Water Resources Institute (NWRI) and others in various publications highlights a number of important factors with regard to the hydrodynamics in western Lake Ontario. Although literature specific to Central Lake Ontario is limited, some processes discussed in relation to Western Lake Ontario are relevant to Lake Ontario processes in general. Those processes are:

- The annual development of a spring thermal bar is expected to have an impact on nearshore water movements and associated water quality during this period, as dissolved and suspended materials are expected to be moved alongshore, with little offshore exchange. This thermal bar development and progression is relatively complex from a modeling perspective;
- Westerly winds typically generate upwelling in the western Lake Ontario region and associated offshore drift in the surface levels while easterly winds generate stronger currents and typically induce downwelling of surface waters;
- A strong alongshore current is observed within a few kilometres of the shoreline, generally flowing counterclockwise in western Lake Ontario, with occasional reversals under strong opposing wind conditions;
- In general, spring circulation is focused in the alongshore direction and cross shore mixing is limited by the presence of the thermal bar, while in the summer and fall, the period of entire lake stratification, mixing in the cross shore direction is more common;
- Coastal processes differ significantly between winter and summer conditions, largely due to thermally generated vertical density gradients in the summer compared to a typically isothermal condition in the winter;

- In general, the literature focuses on lake wide processes (including wind, temperature and density driven currents), which are complicated to some degree by the proximity of the region to the western end of Lake Ontario and the associated abrupt change in shoreline direction at Burlington; and

- Typically, the currents generated by the lake-wide processes are relatively small (<0.1m/s) but they are important from an overall long-term water quality and circulation perspective.

Although daily raw water quality data was not provided for the Hamilton intakes at the time of report preparation, a review of available current monitoring information in relation to wind data, wave hindcast information and intake raw water quality at other western Lake Ontario sites suggest further generalizations.

- Turbidity spikes, expected to be indicative of poor water quality conditions, and active hydrodynamic conditions are predominantly observed in the late fall through early spring months, when the water temperature is relatively uniform, and thermal stratifications are not a major consideration in the hydrodynamic processes;

- The turbidity events appear to correlate well with significant wind and wave conditions in the record. It is typical of the Great Lakes for the most active wave and wind conditions to be experienced in the late fall and winter months;

- Given the apparent significance of the wind driven events, and the need to establish an IPZ boundary on the basis of maximum average velocities (or some other similarly representative condition) it is evident that the ability to represent wind driven circulation is critical of any modeling effort; and

- Although thermal considerations are important with respect to water quality modeling and more general circulation conditions, they do not appear to be critical with respect to the more significant currents observed in the Acoustic Doppler Current Profiler (ADCP) data.

3.4.1 Review of Local Current Monitoring Information

Current monitoring during the summer and fall of 2000 near Hamilton was completed as part of a significant current monitoring program in support of general investigations of physical processes in Lake Ontario. The deployment in 12m depth is outside the typical zone of significant wave influence, but the location of the deployment in the extreme western end of the lake suggests that both alongshore and cross-shore processes may be of considerable importance.

A detailed review of the measured currents shows a predominance of alongshore currents at depth, with increased diversity in the direction of the surface layers. Current magnitudes are generally much greater in the extreme upper layer than in immediately underlying and lower layers; although the ADCP records indicate good data quality in this extreme upper layer, it is not consistent with the majority of the current profile. The tendency for sustained easterly winds to generate onshore currents near the surface with offshore currents at depth is evident.

Conversely, sustained westerly winds generate offshore currents near the surface with onshore currents at depth. Generally, these currents are relatively small (0.2m/s ±). Alongshore currents show a similar range of magnitudes with significant velocities in the very-near surface area and considerably smaller velocities with depth.

It is evident that the current patterns in this region are relatively complex, and influenced by the situation of this site in the extreme western end of the lake.

3.5 HYDRODYNAMIC MODEL REVIEW AND SELECTION OF PREFERRED APPROACH TO HYDRODYNAMIC ANALYSES

Due to the spatial and temporal variability of the regional and local currents, as well as the desire to simulate currents associated with a significant probabilistic event for which measurements are not likely to be available, hydrodynamic models are valuable tools for IPZ delineation. There are a multitude of hydrodynamic models available, ranging from simplistic 1-Dimensional single process models through 3-Dimensional (3-D) multi process models. These models may be available freely in the public domain with little technical support and documentation, or may be integrated within complex and costly commercial modeling suites.

Experience with in-water IPZ-2 delineation to date confirms that the general hydrodynamic processes would be best represented through 3-D modeling of the nearshore area due to the variability of velocity, magnitude and direction with depth under the wide range of wind, wave, temperature and hydrologic conditions which may influence a particular site. On an open coast, with significant fetches in both alongshore directions, it has been found that under extreme wind conditions (those deemed suitable for derivation of the in-water IPZ-2 boundary), the alongshore velocity profile can be relatively well represented through 2-DH (2-Dimensional Horizontal, i.e. vertically averaged) modeling, especially where the intake is in relatively shallow water. This is due to the fact that the wind and wave generated velocities in the nearshore area become relatively well distributed with depth, and the alongshore current is free to move downdrift along the shoreline.

The physical characteristics of the western Lake Ontario sites (including Hamilton) are expected to generate relatively complex hydrodynamic conditions within the area because predominant winds along the axis of the lake tend to move the water towards the end of the lake where it may generate upwelling and downwelling circulation currents that are relevant to the preliminary IPZ delineation. Northeast and southeast winds are expected to generate more significant alongshore currents locally.

The selection of an appropriate model or analysis approach has been made on the basis of the available resources (time, budget and data) and a review of the relevant hydrodynamic information and associated environmental variables that are available. A general review of the available information and interpretation of the issues of significance was also completed to assist in the assessment of an appropriate approach, as discussed below.

3.5.1 General

- A review of pertinent literature and background information regarding the lake and nearshore processes within the region of interest was completed;

- Existing environmental data (winds, waves, hydrologic inputs, water levels, raw water quality at intake) and relevant current monitoring information (where available) were collected and reviewed;

- Existing environmental data was interpreted with regard to significant local and regional processes and their expected relative hydrodynamic influence; and

- Potential approaches to IPZ-2 delineation were reviewed on the basis of the existing understanding of regional hydrodynamic processes, including analytical and desktop approaches, interpretation of existing modeling results and potential numerical hydrodynamic modeling. Where numerical modeling is proposed, potential modeling approaches were considered and appropriate models selected on the basis of the characteristics of the site and complexity of conditions.

3.5.2 City of Hamilton

- Due to availability of current monitoring data and the relative complexity and development density of this region, hydrodynamic modeling was proposed in association with existing efforts at Burlington, Burloak, Oakville (Halton Region) and Grimsby (Niagara Region);

- Preliminary 2-D Advanced Circulation (ADCIRC) modeling was completed as originally proposed for Halton Region with the model domain extending to incorporate the Halton, Grimsby and Hamilton intakes;

- Due to the complexity of this region with respect to its location at the western end of Lake Ontario, and the associated potential influence of regional lakewide processes as well as local wave induced currents, and the expected importance of 3-D flow conditions within this physical setting, 3-D hydrodynamic modeling is considered to be necessary; and

- Moderate resolution 3-D modeling was completed using the POK2k model. The influence of waves has been considered in the modeling through the introduction of wave-induced stresses through the domain, distributed with depth.

The 2-D ADCIRC model followed by 3-D modeling approach provides the following benefits:

- Finite element approach in ADCIRC provides for a flexible mesh, permitting smooth transitions from areas of coarse model definition (offshore) to areas of refined definition (intake, shoreline and hydrologic inputs);

- ADCIRC model permits various forcing functions including surface wind stress, long wave (water level fluctuation) and normal boundary flux;

- Wave radiation stresses can be imposed on ADCIRC over the model domain to reflect the effect of breaking waves in the nearshore zone during periods of high winds;

- The ADCIRC model is cost effective and supported by a comprehensive user interface should the presiding authority wish to maintain the model;

- As wind and waves approach the shore perpendicular in direction (onshore), the 2-D ADCIRC approach is not capable of resolving the theoretical condition of onshore currents on the surface with return currents near the lakebed. For this case, a 2-DV (2-Dimensional Vertical) analytical model that considers wind stress and wave mass and radiation fluxes in the cross-shore direction has been employed where 3-D Princeton Oceanic Model (POM) modeling is not yet proposed;

- Refinement of 3-D POM modeling provides for improved representation of the onshore and offshore phenomena and provides boundary information for future 3-D model refinements with waves and more detailed representation of shoreline features as deemed necessary; and,

- The majority of uncertainty in this approach is in the prediction of combined offshore and alongshore conditions in the presence of waves. Given the MOEs objectives for Phase 1 in-water IPZ-2 investigations, the approach presented for this region is considered appropriate providing that the results are interpreted in a conservative manner.

3.6 2-D HYDRODYNAMIC MODELING

The hydrodynamic modeling process required the processing of local and regional physical data such as bathymetry (lake bed elevations) and shoreline locations as well as environmental variables, which are used to force the model at its boundaries (lateral and surface). Bathymetric information was derived from Canadian Hydrographic Service navigational charts and field sheets while the shoreline was derived from Ontario Ministry of Natural Resources Ontario Base Map themes.

The modeling was completed for a range of wind and wave conditions with extreme flows imposed at relevant watercourse outlets (Stoney Creek, Fifty Point Creek, Forty Mile Creek, Hamilton Harbour contributions, Bronte Creek and Sixteen Mile Creek) within the model domain. The modeling domain was selected such that boundaries are well removed from the area of interest (expected IPZ-2 limits). A 2-hr TOT and 100 year return period for boundary inputs was assumed in the development of the IPZ-2. However, model runs were also performed assuming 2-hr TOT with 10-year return period input conditions. Boundary conditions imposed on the model are discussed further in the following section.

3.6.1 Development of Boundary Conditions

The imposed 2-D model boundary conditions include steady state wind stress, wave stress, static water level, hydrologic inputs and boundary fluxes (velocities). These conditions were derived from various environmental data sources discussed in the hydrodynamic modeling report (Appendix 3.2). Critical orientations of wind stress and wave conditions were combined with a regional boundary flux to define the alongshore velocities and the resulting IPZ-2 boundary.

The critical combinations of wind and wave stresses used in the Hamilton ADCIRC modeling to establish the IPZ-2 defining velocities included:

- 100-year winds from N and 100 year waves from N;

- 100-year winds from SE and 100 year waves from SE;
- 10-year winds from N and 10 year waves from N; and
- 10-year winds from SE and 10 year waves from SE.

Hydrologic inputs from various watercourses of relevance are discussed further in the hydrodynamic modeling report available in Appendix 3.2.

The assumed lakewide boundary input is considered to be conservative but is a source of uncertainty in the modeling due to the limited period of available modeling and the limited spatial resolution of the lakewide model. The velocities modeled at the intake are not particularly sensitive to the lakewide input, however, and as a result the conservative assumption is considered appropriate. Lakewide influences were modeled by imposing current velocities ranging from 0.3 – 0.6m/s on the offshore model boundary.

3.6.2 Interpretation of Monitoring and Modeling Results

A detailed discussion of modeling results is provided in the hydrodynamic modeling report (Appendix 3.2); the various results are not discussed individually here. In general, the 2-D modeling assumes a steady-state approach with extreme (probabilistic) forcing variables imposed on the model boundary, and assumes that these conditions will persist for a sufficiently long period to establish such a steady state condition. The current velocities established under these conditions generally maintain a well-mannered pattern where bathymetric features are not abrupt. This approach to modeling and interpretation is generally a conservative approach and is typical of planning level investigations.

Given the relatively limited data set available in this area and lack of resources to provide for a comprehensive review of the environmental forcing functions (persistence, dependence, etc.) the IPZ-2 boundaries provided herein are considered preliminary in nature. It is expected that increased certainty in the lines could be achieved by improving the understanding of environmental data trends and the associated nearshore water current response. Sources of uncertainty are discussed in the hydrodynamic modeling report (Appendix 3.2).

3.7 3-D HYDRODYNAMIC MODELING

3-D hydrodynamic modeling was completed at a moderate scale resolution in order to provide for improved ability to capture the 3-D nature of the wind and wave generated flows in western Lake Ontario. The POM2k model was used with a curvilinear grid structure, with mesh resolution as low as approximately 80m near the intakes. The resolution of the modeling did not permit consideration of the hydrologic inputs in the 3-D assessment, but did include the influence of waves via imposed wave induced radiation stresses distributed in depth throughout the domain. As in the case of the 2-D modeling, the hydrodynamic modeling process required the processing of local and regional physical data such as bathymetry (lake bed elevations) and shoreline locations as well as environmental variables which are used to force the model at its boundaries (lateral and surface).

The modeling was completed for 100-year wind conditions from 8 compass directions with consideration of wave-induced influences for 100-year wave conditions from the north and east. The modeling domain was selected such that boundaries are well removed from the area of interest (expected IPZ-2 limits). A 2-hr TOT was assumed in the development of the IPZ-2. Boundary conditions imposed on the model are discussed further in the following section.

3.7.1 Development of Boundary Conditions

The imposed 3-D model boundary conditions for IPZ determination include steady state wind stress, wave stress and static water level. These conditions were achieved with a 12-hour spin-up period where wind and wave conditions were ramped to the design condition, which was held steady for 2 hours at the design event condition. A more detailed discussion of boundary conditions is provided in the hydrodynamic modeling report (Appendix 3.2).

Due to the limited resolution of the lakewide POM model and the "event-based" nature of this modeling effort, it was not possible to impose a realistic flux or water level control on the offshore model boundary. Instead, a radiation boundary condition on elevation was imposed. Performance of the model was assessed at two locations within the model with reasonably good agreement between ADCP measurements and modeling results.

3.7.2 Interpretation of Monitoring and Modeling Results

Although the 3-D modeling approach improves on the ability to assess the 3-D nature of the flows in western Lake Ontario, it has not been developed to a sufficient resolution to provide adequately for hydrologic inputs to the grid, and could possibly benefit from further refinement of the grid in areas of abrupt shoreline change and additional consideration of additional wave directions in order to improve on the nearshore results. As with the 2-D modeling, the 3-D modeling assumes a steady-state approach with extreme (probabilistic) forcing variables imposed on the model boundary, and assumes that these conditions will persist for a sufficiently long period to establish such a steady state condition. A relatively simplistic approach to statistical analysis of the boundary conditions and their coincidence and persistence has been taken to date. It remains, that increased certainty in the IPZ-2 boundary could be achieved by improving the understanding of environmental data trends and the associated nearshore water current response.

It is also recognized that neither the 2-D or 3-D approaches discussed herein are particularly well suited to represent the complexities of the hydrodynamic conditions in the nearshore zone under the influence of large waves. Sources of uncertainty are discussed further in the hydrodynamic modeling report.

3.8 INTAKE PROTECTION ZONE DELINEATION (IPZ-2)

Preliminary IPZ-2 model boundaries are mapped on georeferenced satellite imagery (Appendix 3.2, Figure 3.1) on the basis 2D-H particle tracking and cross-shore travel time calculations. The approximate extents of the 2-hr 100 year return period zones are:

- Northwest 4300m;

- Southeast 4100m; and
- Offshore 3600m.

The IPZ-2 has been extended to the shoreline at the lateral extents of the IPZ-2 boundaries based on the uncertainties and limitations in the Phase 1 analyses as discussed in detail in the hydrodynamic modeling report.

The 3-D modeling derived line is also provided in (Appendix 3.2, Figure 3.1. The 3-D results suggest that the line enclosing the particle tracking paths would extend approximately:

- Northwest 4900m;
- Southeast 7500m; and
- Offshore 1800m.

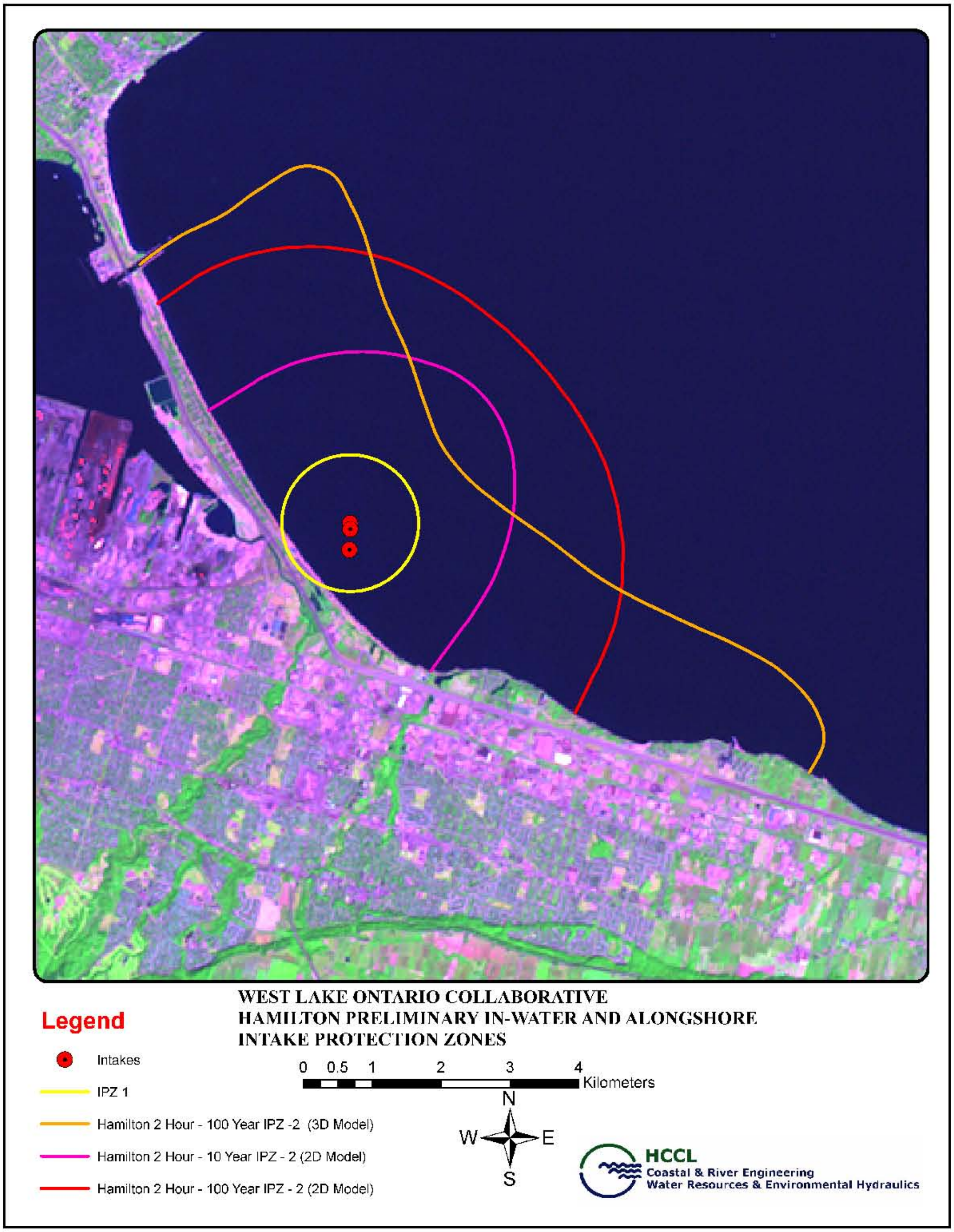


Figure 3.1: Woodward Avenue WTP Preliminary In-Lake and Alongshore IPZ-2 Delineations

3.9 LANDWARD AND UP-TRIBUTARY EXTENT OF THE IPZ-2

Data required for delineation of landward and upland extents of the IPZ-2 includes but is not limited to:

- Delineated lake IPZ-2;
- Location and outfalls of local watercourses;
- Storm sewer outfalls; and
- Suggested methodology for determining landward and upland extents (Appendix 3.3).

The Woodward Avenue WTP IPZ-1 and IPZ-2 are depicted in Figure 3.2.

While a considerable extent of the modeled in-water 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 extents were determined from the projected shoreline boundaries.

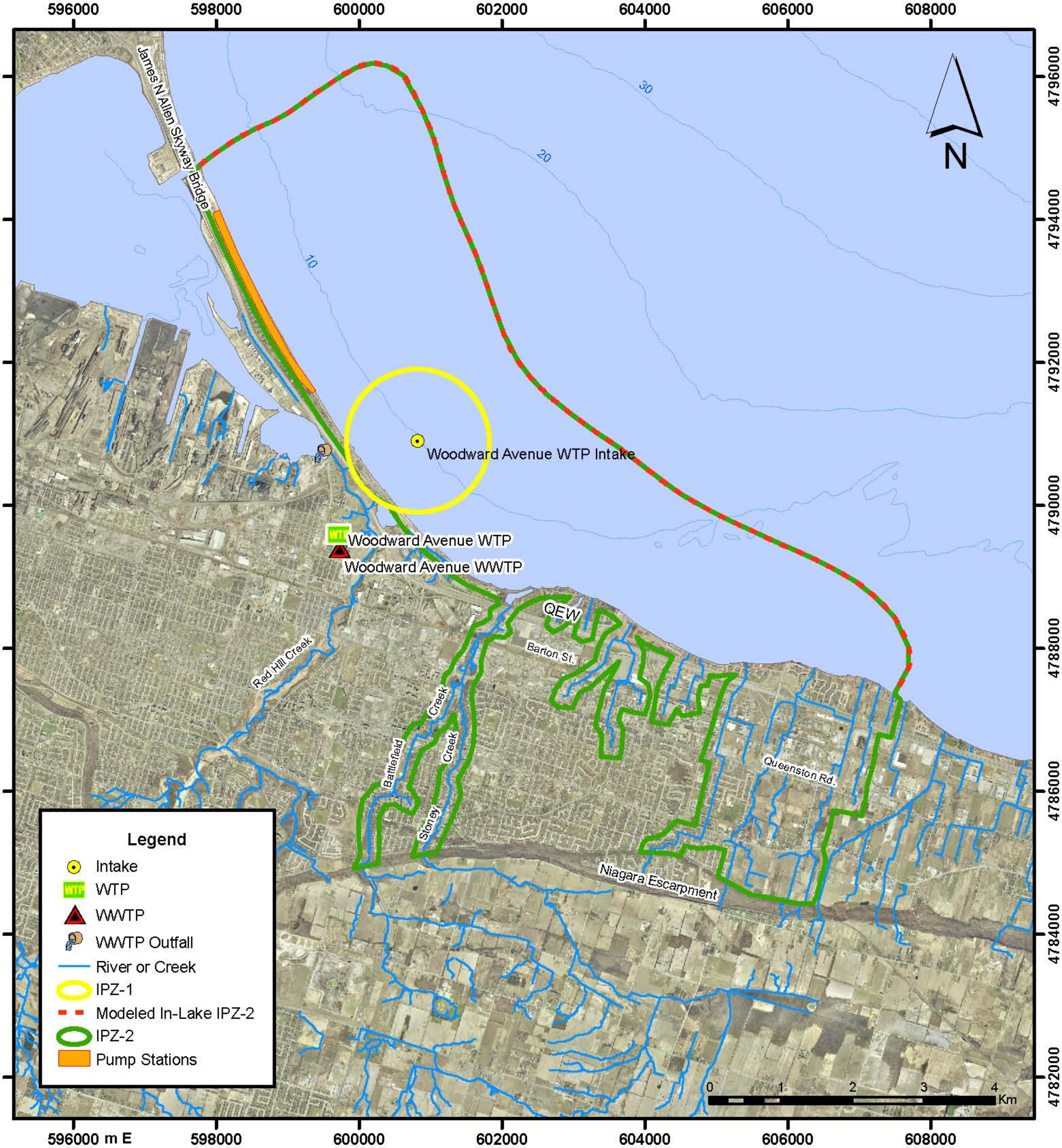
The upland extent of the IPZ-2 includes portions of Stoney Creek, Battlefield Creek, and several smaller municipal drains to the foot of the Niagara Escarpment. Red Hill Creek and its watershed were excluded from the IPZ-2 area as it discharges to Hamilton Harbour. The IPZ-2 does not extend into Hamilton Harbour.

While induced currents from shipping, re-suspended sediments, and temperature fluctuations occur within the mouth of the shipping channel, Hamilton Harbour is not included within this study since it is located outside the 2-hr TOT associated with the delineated IPZ-2. The entrance to Hamilton Harbour is considered a transportation corridor for the purposes of this study and is discussed in that context in the vulnerability section of this report. Additionally; operator concerns have not indicated that the shipping channel has a direct impact on the quality of water at the Woodward Avenue WTP intake. The operations staff noted that combined sewer overflows (CSO) and the Woodward Avenue Urban Pollution Control Plant (UPCP) discharge to the Red Hill Creek, which ultimately discharges to Hamilton Harbour. As this is a preliminary scoping study there may be discussion and study review related to the influence of the shipping channel and potential impacts upon the raw water quality at the intake.

The landward extent of the IPZ-2 consists of the administratively determined limit of 120m applied along the shoreline, and along the length of area tributaries. From the storm outfall locations provided by the City of Hamilton the administratively set 120m limit was determined sufficient to include the identified outfalls along the banks of the area tributaries. Refer to Figure 2 in Appendix 3.4 for additional detail.

Tributary watercourses were included to their full length, or to the foot of the Niagara Escarpment as watercourse characteristics, specifically streamflow velocities were not available at the time of writing of this report. As a result, residual TOTs, as determined using the methodology described in Appendix 3.3, could not be applied, and therefore an up-tributary distance could not confidently be determined. To maintain a conservative IPZ-2 delineation the Niagara Escarpment was used as the up tributary limit.

These zones may be refined on the basis of further modeling results and relevant information as they become available with future source water protection studies.



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DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

HCCL
Coastal & River Engineering
Water Resources & Environmental Hydraulics

Project
Lake Ontario Collaborative Intake Protection Zone Studies

Figure No.	Revision No.	Date
3.2	2	Jan. 8, 2008

Title
Woodward Avenue WTP Intake Protection Zones

Imagery and public works data © City of Hamilton.
Waterflow © Hamilton Conservation Authority.
Topographic data © Natural Resources Canada.
Bathymetry courtesy of NOAA.
Projection: UTM Zone 17N, NAD 1983

4.0 Area and Intake Characterization

4.1 AREA CHARACTERIZATION SUMMARY

The Woodward Avenue WTP is within the jurisdiction of the HCA. The HCA includes most of urban Hamilton, Hamilton Harbour, a section of the Niagara Escarpment, and several small creek watersheds (HHSWPR, 2006). Table 4.1 provides general characteristics of the study area.

Table 4.1: Woodward Avenue WTP Area Characterization	
Description Item	
Physiographic Region	Iroquois Sand Plain (HHSWPR, 2006)
Bedrock	Queenston, Clinton, Lockport, Guelph (HHSWPR, 2006)
Soil Types	Silty clay loam, silty loam, sand loam, loam (HHSWPR, 2006)
Average Air Temperature April – November	14.68°C (EC, 2006)
Average Air Temperature December – March	-1.45°C (EC, 2006)
Average Annual Air Temperature	9.3°C (EC, 2006)
Average Annual Precipitation	864mm (EC, 2006)
Local Influencing Watercourses	Stoney Creek & Battlefield Creek (HHSWPR, 2006)
	Stoney Creek area watercourses (HHSWPR, 2006)
Watershed Name	Stoney Creek watershed (HHSWPR, 2006)
Drainage Area	29.18km² (HHSWPR, 2006)
Commercial Shipping Uses of Source Water	Hamilton Harbour approach

4.1.1 Runoff Generation and Pathways

Runoff will reach the surface water body from a catchment area via an instance or combination of the following:

- Overland flow;
- Natural streams and rivers;
- Storm sewers;
- Combined sewers (sanitary and storm sewers in older urban areas); and,
- Runoff pathways in the IPZ-2 area include the Queen Elizabeth Way (QEW), urban transportation corridors, storm sewer outfalls, impervious land, and industrial runoff.

The upland IPZ-2 area, specifically north of Barton Street, contains a high percentage of industrial land uses. Runoff generation in these areas is high, as a result of a high percentage of impervious surfaces. Impervious surfaces force overland flow to nearby water courses resulting in peak flow conditions during storm events. Overland flow and storm sewer surge conditions may incur high flow velocities towards outfalls at the shoreline of Lake Ontario.

Several storm sewer discharges have been located within the up-tributary extents of the IPZ-2. These storm sewers discharge into Stoney Creek, area municipal drains and along the lakeshore and have the potential to convey runoff contaminants to the intake source water. Figure 2 in Appendix 3.4 illustrates the locations of the storm sewer outfalls within the study area.

Several sanitary sewer-pumping stations are located along Beach Boulevard, three others are located within the up-tributary IPZ-2 extents. Sanitary sewer pumping station bypass discharges may occur during peak flow conditions. During these events untreated sanitary sewage may be conveyed directly into Lake Ontario and more importantly the source water. Figure 1 in Appendix 3.4 illustrates the locations of the sanitary sewer pumping stations.

Principal transportation routes produce large volumes of storm runoff and have the potential to convey spills and other contaminants to the source water. Ditches and drains along transportation corridors may connect to storm sewer networks and/or watercourses at bridges and culverts. The QEW crosses area watercourses at culvert crossings. It is assumed that QEW storm water is discharged to Lake Ontario.

4.2 INTAKE CHARACTERIZATION

Table 4.2 summarizes the plant processes and intake. The Woodward Avenue WTP Certificate of Approval (C of A) is included in Appendix 4.1. The Engineer's Report indicates three intake pipes; the WTP operators and the Engineer's Report have identified two intakes as non-operational and sealed. The non-operational intake pipes are not considered in this analysis.

Table 4.2: Woodward Avenue WTP Description and Processes			
Water Treatment Plant			
Owner/Operator	City of Hamilton		
Location	700 Woodward Avenue, City of Hamilton		
Certificate of Approval Number	1343-725PZD (Amended May 17th 2007)		
Unit Processes and Systems	The water treatment process consists of pre-chlorination, screening, coagulation, sedimentation; filtration with (24) dual media filters using sand and granular activated carbon (GAC), fluoridation. Plant is equipped with SCADA monitoring systems.		
Distribution System	The distribution system supplies all communities in the City of Hamilton, parts of the Regional Municipalities of Haldimand-Norfolk and Niagara, and Parts of Halton Region. (City of Hamilton, 2007a)		
Rated Capacity	10.72 m^3/s 926 000 m^3/day (MOE, 2007)		
Servicing Population	467 800 (City of Hamilton, 2007a)		
Intake			
Source Water: Lake Ontario			
Pipe 1		Status	**Operational**
Concrete intake pipe		UTM coordinates	600 817.929m E 4 790 970.247m N

Table 4.2: Woodward Avenue WTP Description and Processes		
At 926ML/day flow rate pipe produces pipe velocities of 2.29m/sec	Length	945m
	Diameter	2.44m
	Crib depth (lake bottom)	9.8m
Pipe 2	Status	Non Operational
Concrete and steel pipe	UTM coordinates	600 819.396m E 4 790 990.578m N
	Length	915m
	Diameter	1.52m
	Crib depth (lake bottom)	10.4m
Pipe 3	Status	Non Operational
Concrete and steel pipe	UTM coordinates	600 812.971m E 4 790 603.556m N
	Length	640m
	Diameter	1.22m
	Crib depth (lake bottom)	8.0m
Notes: Pipe 2 and Pipe 3 connect to a common intake chamber, which is currently closed. Future plans for the WTP include using either Pipe 2 or Pipe 3 as a back up intake.		

Above information provided from the Woodward Ave WTP Engineer's Report by Hargrave & Burdick, 2001, unless where noted otherwise.

4.2.1 Operator Concerns

The following is a summary of the completed operator interview available in Appendix 2.1.

Primary operator concerns and contaminant sources of concern identified by the WTP operators include:

- The presence of pathogens in the source water;
- Taste and odour issues associated with geosmin producing microbes;
- Industrial wastewater discharges;
- Urban runoff and storm sewer discharge;
- Contaminated sediment disrupted by dredging activities and bank and shoreline modifications;
- The QEW and Skyway bridge;
- Local marinas;
- Wildlife;
- Spills; and

- Commercial shipping.

Operators identified possible commercial ship anchorages perpendicular to the Harbour sandbar near the intake. Supporting data such as annual ship travel and cargo was not available at the time of writing.

Operators noted that high turbidity during the winter and spring seasons is common typically driven by high wind events from the northeast and east.

4.2.2 Local Bathymetry

In general, the bathymetry is gently sloping with an approximate slope of 1.11%. No significant bathymetric features have been identified within proximity to the intake (Hargrave *et al*., 2001).

Refer to Appendix 4.2 for the Woodward Avenue WTP bathymetric plan.

4.3 RAW WATER QUALITY AT THE INTAKE

4.3.1 Data Reviewed

The following data sources were reviewed in this report:

- **Woodward Avenue WTP Engineers' Report 2001** – Required under the new Drinking Water Protection Regulations, it provides a description of the waterworks, characterization of the raw water supply source as well as other additional assessments.

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

- **LOSAAC Progress Report 2002-2003** – Lake Ontario Shoreline Algae Action Committee (LOSAAC, 2003). Halton Region report focused on nutrient loadings from storm sewer discharges and wastewater treatment plant effluent.

4.3.2 Water Quality Standards

Two sets of provincial criteria were selected as relative 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; and,

- **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.

4.3.3 Raw Water Quality at the Intake

Table 4.3 illustrates microbiological data for the Woodward Avenue WTP between October 1998 and September 2000.

Table 4.3: October 1998 to September 2000 Raw Water Microbiological Data[1]

	Number of Samples	Number of Samples 0-100 counts/100mL	Number of Samples >100 counts/100mL	Maximum count/100mL
Total Coliforms	48	44	4	274
E.coli	48	48	0	10*

[1]Hargrave *et al*., 2001
*Maximum *E.coli* is for 1999-2000 only; actual counts for 1998 not available

WTP operators indicated that high turbidity events typically occur in the winter or during the spring freshet, and typically occur under northeasterly or easterly wind events. Average turbidity conditions are low at the Woodward Avenue WTP however periodic high turbidity events do occur, usually as a result of high-energy wind and wave events.

No inorganic or volatile organics exceedances occurred from 1998 to 2000. Samples were taken annually. Information on the following parameters was not included: dichloromethane, monochlorobenzene, toluene, and mercury (Hargarve *et al*., 2001).

Few samples existed for PCBs and pesticides between 1998 and 2000. Of the parameters tested no exceedences were detected (Hargarve *et al*., 2001).

4.3.4 Beach Water Quality

Beach data available from the City of Hamilton provides geometric mean data for *E.coli* levels for Beach Boulevard, Confederation Park Beach, and Van Wagner's Beach from May 25th, 2004 to July 17th, 2007. Refer to Appendix 4.3 for the full data set. Confederation Park Beach is the nearest to the Woodward Avenue WTP intake. One (1) PWQO exceedence occurred in 2007 with a recorded *E.coli* concentration of 173 counts/100mL (City of Hamilton, 2007b). This information does not support beach contamination as a potential threat to the source water.

4.3.5 Algae

Operators have identified the presence of algal blooms in the study area. Algae can present taste and odour issues in treated water and blooms can negatively affect the water treatment process. Existing algal concerns and associated information is presented below.

Cyanobacteria blooms may contain algae species that produce toxins that are harmful to humans (MOE, 2005). Cyanobacteria blooms have caused the closure of a number of Hamilton area beaches. Many of these beaches are within Hamilton Harbour and are outside the IPZ-2.

Phosphorus loadings in Lake Ontario are an area of concern as it can promote algal growth in the lake. The average annual total phosphorus (TP) loading from the Woodward Avenue UPCP in 2006 was 176kg/day. The average annual TP concentration for 2006 was 0.41mg/L (City of Hamilton, 2006).

The Hamilton UPCP discharges into Hamilton Harbour, which for the purpose of this report is considered outside of the IPZ-2. Area watercourses conveying storm sewer discharge, as discussed in Section 4.1.1, may contain concentrations of phosphates and other substances that may promote algae growth. For comparison, Halton Region TP loadings from storm sewers roughly doubled that from the nearby Halton wastewater treatment plants (LOSAAC, 2003). Numerous storm sewer outfalls have been located in the study area as supported by Figure 2 of Appendix 3.4.

Excessive algae in the source water leads to air binding in the water treatment process. Filters require additional backwashing during these events, which results in a reduced plant supply capacity.

4.4 SEDIMENT QUALITY NEAR THE INTAKES

EC sampled sediments at the mouths of Lake Ontario tributaries and published the results in 2003 (Dove *et al*., 2003). While sediment quality for the Woodward Avenue WTP at the intake was not available and is recognized as a data gap, information for the mouth of Stoney Creek, located approximately 2700m from the intake, within the IPZ-2, was available.

Results indicate that the Stoney Creek sediment has low levels of inorganic and organic contaminants. A summary of Federal and Provincial sediment quality guidelines from the EC report (Dove *et al.,* 2003) is included in Appendix 4.4.

- Cadmium, chromium, copper, and iron were found in concentrations exceeding the Provincial Lowest Effect Level (LEL);

- Lead and zinc were present in concentrations exceeding the Federal Probable Effect Level (PEL);

- Manganese was detected in concentrations exceeding the Provincial Severe Effect Level (SEL);

- Total Dichlorodiphenyl Trichloroethane (DDT) and its metabolites were found in concentrations in exceedence of the LEL;

- Polychlorinated Biphenyls (PCB) were detected exceeding the Federal Threshold Effect Level (TEL); and
- Total Polycyclic Aromatic Hydrocarbons (PAHs) were found in exceedence of the LEL.

Metals and PAHs detected in the area sediment may be attributable to primary steel manufacturing and coking operations in Hamilton Harbour to the east, and other supporting and heavy industries west at Stoney Creek. These contaminants may have been transported by atmospheric deposition and there presence does not directly indicate dumping or in-area use. PCBs are not necessarily specific to one type of industry, but may indicate past industrial activities.

Halogenated pesticides, such as DDT, are classified as persistent organic pesticides (POPs) and can be detected long after there use has desisted. Concentrations found in Stoney Creek may result from historical agricultural land uses prior to large-scale urban and industrial development and the ban of the use of many POPs.

5.0 Intake Protection Zones Vulnerability Analysis

5.1 INTRODUCTION

The vulnerability score as defined in Module 4 is a numerical expression of the susceptibility of the intake to contaminants. It is based on attributes of the intake (length and depth), type of water body, the physical characteristics of the environment it is situated in, and the influences affecting intake water. It is essentially qualitative, based upon low, moderate or high scores assigned to the contributing factors. 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.

Module 4 outlines vulnerability scoring for intakes in all types of surface water sources, the following discussion will be limited to the Great Lakes. Vulnerability scores for Great Lakes intakes are derived for the IPZ-1 and IPZ-2 (MOE, 2006a). A summary of Great Lakes intakes vulnerability scores and factors is presented in Table 5.1.

Table 5.1: Vulnerability Score for Drinking Water Intakes Using Surface Water Sources

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. For Great Lakes intakes the Vf_z ranges from 7 to 10 in whole increments representing low, moderate and high vulnerability. 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 $Vf_{Z.}$).

The ranges of Vf_z scores assigned to Great Lakes intakes are as follows;

- IPZ-1: 10 (fixed due to inherent vulnerability of close proximity to intake); and
- IPZ-2: 7, 8, 9 (low, moderate, or high depending on the nature and density of factors influencing the intake).

5.1.2 Source Vulnerability Modifying Factor

A Vf_s score is assigned to the intake. For Great Lakes intakes the Vf_s scores can range from 0.5 to 0.7, representing low, moderate, and high vulnerability. Typical factors suggested by Module 4 in assigning a Vf_s score include, but are not limited to:

- Depth of intake from the top of water surface (deeper Great Lakes 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 (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 that the minimum submergence for raw water intakes is 3m however the guidelines prefer a submergence of at least 10m. MOE guidelines do not prescribe a minimum or suggested distance from shore.

For the purposes of comparison, this report has included State of Michigan surface water intake categorization criteria (Table 5.2), in an effort to provide additional resources for qualifying selected intake vulnerability scores.

The State of Michigan, as part of its Source Water Protection Program (MDEQ, 2004), categorizes surface water intakes in four 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 Michigan categories for Great Lakes intakes are summarized in Table 5.2.

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

The State of Michigan categories are included in further detail in Appendix 5.1.

5.2 WOODWARD AVENUE WTP IPZ VULNERABILITY SCORES

Table 5.3 summarizes the vulnerability scores for the Woodward Avenue WTP.

Table 5.3: Vulnerability Score Summary

Intake Type	Zone Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_s)	Vulnerability Score[1] (V)	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
Great Lakes	10	9 HIGH	0.6 MODERATE	6 MODERATE	5 LOW

[1]Vulnerabilty score rounded to next highest whole number

5.2.1 Zone Vulnerability Factor (Vf_z)

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

Woodward Avenue WTP IPZ-2 Vf_z is determined to be 9 (high) based on natural and anthropogenic characteristics of the upland environment.

The natural characteristics driving the zone vulnerability estimation within the IPZ-2 area include: soil features, slope of the upland environment, and tributary watercourses conveying the runoff influenced by the aforementioned factors into Lake Ontario. The soil within the study area consists primarily of well-drained sands and loams. The gradient present in the area below the Escarpment does not support large runoff volumes.

Anthropogenic pathways in the IPZ-2 area include transportation routes, storm sewers, and waste water discharges. The upland extents of the IPZ-2 include residential and industrial land uses where storm sewer systems may be subject to contaminated runoff, and consequently discharge into the Lake Ontario source water.

Several sanitary sewer-pumping stations have been identified along the Hamilton Harbour sandbar and further east within the IPZ-2 area. Storm sewer outfall locations are also identified and a map of their locations as well as sanitary pumping stations is included in Appendix 3.4. Sanitary pumping stations may overflow in times of peak system demand. In these events untreated sewage may be discharged into the source water.

The QEW is of concern as a major highway that carries high volumes of traffic and crosses several waterways that discharge to the lake near the intake. Highway culvert crossings along this route have the potential to convey spills and contaminated runoff into the source water.

The in-water IPZ-2 delineated by hydrodynamic modeling does not include explicit analysis of Hamilton Harbour. The delineation includes the shipping channel in the breakwall that connects Lake Ontario with Hamilton Harbour. For the purposes of this study the shipping channel is assumed to be constructed pathway. The influence of Hamilton Harbour on Lake Ontario by means of the shipping channel is observed as a point source discharge. Further discussion is provided in Appendix 3.2.

Based on the density and significance of the anthropogenic pathways present in the IPZ-2 the zone vulnerability factor was determined to be 9 (high).

5.2.2 Source Vulnerability Modifying Factor (Vf_s)

The Woodward Avenue WTP Vf_s was determined to be 0.6.

The in-service intake pipe extends 834m into Lake Ontario with a crib depth of 9.8m. The in-service intake pipe is considered to be adequate as the intake crib is submerged at the approximate MOE preferred depth of 10m. In comparison with the Michigan standards discussed in Section 5.1.3 the Woodward Avenue WTP intake qualifies as an offshore, deepwater intake and would therefore receive a moderate vulnerability rating.

Using the provided historical raw water quality records from 1998-2000, it was found that there were no specific parameters (inorganic, organic, metal) that were exceeded. The aesthetic and operational considerations have the potential to impact treatment processes and the quality of water that is delivered via the distribution system: algal blooms and high turbidity events.

Based on the satisfactory location but limited amount of available raw water quality data the Vf_s for the Woodward Avenue WTP receives a moderate score of 0.6.

6.0 Uncertainty Assessment

The uncertainty level as described by Module 4 is a qualitative assessment in the confidence of 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.

6.1 UNCERTAINTY ANALYSIS WOODWARD AVENUE WTP INTAKE

Table 6.1 outlines the uncertainty level ratings for the Woodward Avenue WTP.

Table 6.1: Uncertainty Level Rating

Component	IPZ-1	IPZ-2
IPZ Delineation	Low	High
Vulnerability Score	Low	Low
Combined Rating[1]	Low	High

[1]Combined rating defaults to high level with presence of high uncertainty in any component

6.1.1 IPZ-1 Level of Uncertainty

Dimensions for IPZ-1 are prescribed in Module 4, and local conditions and local operator concerns do 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 reliable, ongoing provincial, federal monitoring programs and the treatment plant. 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 6.1.

6.1.2 IPZ-2 Level of Uncertainty

The overall IPZ-2 level of uncertainty is high.

The 3D-ADCIRC modeling preformed by HCCL has provided a comprehensive in-water component of the IPZ-2 however some uncertainties with the model do exist. There is uncertainty in: the prediction of combined offshore and alongshore conditions in the presence of waves; the limited period of available modeling and limited spatial resolution to the lake-wide model; and the lack of resources available to provide for a comprehensive review of the environmental forcing functions. Due to this, the confidence in the accuracy of the in-water delineation is low; therefore the uncertainty for this component is high.

The uncertainty regarding the accuracy of the upland component of the IPZ-2 is high. Information was provided regarding point source discharges including the Hamilton Harbour breakwall and storm sewers however specific watercourse information, such as flow data, was unavailable at the time of writing. The upland delineation would benefit from precise residual TOT information at study area creek mouths, and specific study area watercourse characterization information. A conservative approach to defining both upland IPZ-2 components was taken to encompass most of the total water contributing areas of the tributary watercourses and associated constructed pathways.

Site-specific data contributing to the vulnerability factor are 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.

7.0 Data Gap Analysis

Table 7.1 outlines the data gaps that were identified throughout this report.

Table 7.1: Data Gap Analysis Table

Key Deliverable	Data Set Name	Purpose & Description	Priority
IPZ Delineation	Watercourse characteristics	Flow data and velocities to determine up-tributary extents of the IPZ-2	Moderate
	Storm sewer network maps	For use with TOTs and watercourse characteristics to delineate a more accurate IPZ-2.	Moderate (some data provided)
Source Vulnerability Score	Specific algae bloom information	Relationship to source water quality.	Moderate
Intake Characterization	Sediment quality at the intake	Sediment data for most influential sediment zone.	Low
Zone Vulnerability Score	Shoreline structures	Characterization and historical use information	Low
	Commercial shipping anchorages and information	Potential ballast water contaminant source	Low

In general, the quality and quantity of information available from readily accessible public domain data sources are sufficient to characterize the intake and setting, undertake preliminary delineation of IPZ-2, and conduct primary qualitative vulnerability analyses for zone and source factors. To indicate the relative importance of identified data gaps, priority ratings of high, moderate, or low have been assigned to each data gap listed.

8.0 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; and
- Intake Protection Zones.

The specified attributes are summarized in Appendix 8.1.

9.0 Conclusions

9.1 IPZ DELINEATIONS

Two vulnerability zones (IPZ) were delineated for the Woodward Avenue WTP intake:

- A circular primary zone (IPZ-1) centered on the intake crib was administratively determined with a radius of 1km;
- A secondary zone (IPZ-2) was delineated with dimensions determined using 3D-ADCIRC hydrodynamic modeling and up-tributary IPZ-2 extents were delineated using the administratively set 120m limit, and available tributary watercourse information. Stormshed information provided by the City of Hamilton and included in Appendix 3.4 was consulted to support the up-tributary extents the length of influencing watercourses or to a limit of the Niagara Escarpment.

9.2 VULNERABILITY ASSESSMENT

The Vf_z is scored as 10 (high) for IPZ-1 as prescribed by Module 4. The Vf_z for IPZ-2 was determined to be 9 (high) due to the presence sanitary sewer pumping stations and anthropogenic pathways such as transportation routes (QEW) and storm sewers. The Vf_s was assigned a score of 0.6 (moderate) due to the adequate depth and length of the intake and the minimal amount of raw water quality data available for historical analysis. The calculated vulnerability score was determined to be 6 (moderate) for the IPZ-1 and 5 (low) for IPZ-2.

9.3 UNCERTAINTY LEVEL ASSESSMENT

The uncertainty level assigned to the IPZ-1 is low. The IPZ-1 is an administratively determined radius and local conditions present the need to increase this zone.

The uncertainty level assigned to the IPZ-2 has been determined as high. Despite the presence of data gaps directly relating to the delineation of the upland component of the IPZ-2, and the uncertainty within the hydrodynamic modeling, it was determined that the conservative approach to defining the IPZ-2 was sufficient in order to confidently assess the vulnerability of the zone. A final client comment review was provided to Stantec and included in Appendix 9.1.

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APPENDIX 2.1: OPERATOR INTERVIEW

Collaborative Study to Protect Lake Ontario Drinking Water

Interview form for municipal water intakes in the study area of the Collaborative

Stantec

Interviewees: Ian Routeledge, Tony Robles, Chris Shrive

Plant Information

Name of WTP: Woodward WTP

MOE SWDA #: 220003118

Intake GIS coordinates: 599872.00E, 4789964.00N

Intake length: 945m

Intake depth: 9.8m
Dimensions are for the 96” intake. The smaller 48” and 60” join to a common pipe and are not in service.

Any special conditions at the intake?
2.44m diameter crib with zebra mussel control. Installed in 1992

Interview Questions

Please indicate your level of concern (Very, Somewhat, Low, Don't Know) for each of the following Contaminant Groups and Contaminant Sources with comments where appropriate.

Contaminants of Concern

Pathogens (E Coli, Cryptosporidium, etc.) : Very concerned. Pathogens not always present.

Inorganics (Metals etc.) : Low

Nutrients (P, N, etc.): Low

Organic Compounds (Benzene, TCE, PCBs etc.): Low

Pesticides/Herbicides (Atrazine, etc.): Low

Radioactivity/Radionuclides (Tritium, etc.): Low

Disinfection Byproducts : Somewhat

Taste & Odour: Very Concerned (see Geosmin)

Other: Zebra mussel control is year round to aid in CT.

Contaminant Sources of Concern *(complete only those that apply to intake)*

Crop Related Agriculture: n/a

Livestock Related Agriculture: n/a

Municipal Wastewater Discharges (during normal flows): n/a. WWTP discharges to the harbour. Numerous ps and 6 CSOs but outfall to the harbour as well.

Industrial Wastewater Discharges (point sources): Yes but unknown locations.

Wastewater Treatment Bypasses: n/a

Combined Sewer Overflows: 6 in the area but outfall to the harbour.

Urban Runoff/Storm Sewers: Yes. Unknown locations and outfalls. Overland flow exists.

Construction Runoff: n/a

Contaminated Sediments/Dredging: Yes.

Bank or Shoreline Modifications: Yes.

Drainage/Filling of Wetlands:n/a. May be a storm pond. Dredging may occur out of the zone near the ship channel.

Highway Runoff: n/a. QEW and Skyway would be transport pathways of concern.

Land Disposal of Sludge/Manure: n/a

Landfills: n/a

Leaky Underground Storage Tanks: n/a

Marinas: Yes. Fifty and Centennial Park.

Wildlife: Yes. Ducks and geese in the area. Health unit would have further information.

Salt Storage/disposal: n/a

Spills: Yes.

Shipping: Yes. Commercial ships have been seen to anchor off the harbour breakwall. Unknown of the ballast water discharge and requirements.

River/Creek Influences: n/a

Nuclear Power Facilities: Possibly. McMaster University reactor.

Bulk Chemical Storage:n/a. All known to be contained in the harbour.

Algal blooms: Yes. LOSAAC report may have data on this.

Other:

Past Raw Water Qualities (5 Years)

	Normal	Poorest conditions	Season with worst water quality
Turbidity	0.3 NTU	149 NTU	Winter/Spring. E/NE winds.
E Coli	0-100 counts/100mL		
Geosmin	Less than 0.0005	0.025	Summer
Chlorides	23.69-26.82	33.77.	Spring. Increasing in the last 5 yrs
pH	8.06-8.14	8.32	summer
Color	n/a	n/a	Not tested
Alkalinity	n/a	n/a	Not tested
Total Organic Carbon	n/a	n/a	Not tested
Ammonia	0.00-0.01	0.03	

Temperature (what is the normal range): average is 8 deg C. Range 0-24 deg C

Other

Comments on Raw Water Quality Fluctuations
-Strong wave action and NE/E winds cause high turbidities in the raw water.
-major algae blooms

General Comments from Operator/Owner of Treatment Plant
-Lake provides excellent source of raw water for treatment/distribution. Lake is utilized for commercial shipping/industrial discharge and nuclear pland discharge.

Data Sources/Reports
-City of Hamilton Environmental Lab, Annual reports

Interviewer Information

Gary Deonarine, E.I.T.
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Gary.Deonarine@stantec.com

APPENDIX 3.1: APRIL 19TH SUMMARY MEMO ON MODELING RECOMMENDATIONS

Deonarine, Gary

From: Holly Wirth [HWirth@ocwa.com]
Sent: Thursday, September 20, 2007 2:09 PM
To: Langan, John
Cc: Andrew Valickis; LMoore@ocwa.com; Greg.Aickele@peelregion.ca; Deonarine, Gary; Tyrrell, John
Subject: FW: Memo 3-D Proposal-
Attachments: Memo 3-D Proposal-12Sep07.pdf

John,

We have reviewed Stantec's Memo: 3-D Modeling and Re-definition of In-Water and Upland IPZ-2 for Western Lake Ontario Intakes (attached) and discussed it with the Sub and Steering committees. Approval has been granted for the additional work outlined in the memo. Please proceed with the work.

Sincerely,

Holly

From: Langan, John [mailto:john.langan@stantec.com]
Sent: Wednesday, September 12, 2007 4:16 PM
To: Andrew Valickis
Cc: Holly Wirth
Subject: Memo 3-D Proposal-

Draft memo outlining Western Lake Ontario 3-D re-modelling and costs with supporting images.

It's in pdf to attach the images.

Your comments will be appreciated for finalization.

Best regards,

John S. Langan
Project Manager Environmental
Stantec Consulting Ltd.
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London ON N6A 5J7
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Please consider the environment before printing this email.

Memo

Stantec

To: Andy Valickis
OCWA, Toronto

From: John S. Langan
London

File: 165500512

Date: April 19, 2007

Reference: Recommended Approach to Modelling and Delineation of the In-Water IPZ-2 for Lake Ontario Collaborative Intakes

W.F. Baird & Associates (Baird) and HCCL are using hydrodynamic modelling to conceptualize nearshore water movement for determination of the in-water and alongshore IPZ-2s. Available hydrodynamic models were reviewed and suites of models are recommended to conceptualize nearshore water movement in area of intakes that will provide in-water IPZ-2 components. Baird and HCCL have prepared technical detailed memos outlining their perceptions of needs and costs for a thorough modelling of water movement for each of the intakes (attached).

The following is a summary of their recommended approaches and identified needs for Phase 1 IPZ-2 delineation work. They wish to proceed with the recommended approaches and seek Collaborative Steering Committee approval to do so.

DRAFT

GTA Intakes – Baird

The Baird assignment includes intakes for 11 water plants located in Peel (2), Toronto (4) and Durham (5). All intakes are in relatively unconstrained open shoreline situations and within the same or side-by-side lake cells and can be treated uniformly in approach to modelling to conceptualize the in-water IPZ-2.

<u>Recommendation</u>

-a suite of models consists of the lake-wide **Princeton Oceans Model** (POM) to establish coarse large-lake and nearshore boundary conditions and **DHI-MIKE 3D** (MIKE 3) model to conceptualize detailed water movements about the intakes,

-POM is well established and maintained for Lake Ontario by NOAA and is the large-lake model of choice due to this,

-Toronto has a license for MIKE 3 and has applied to watershed and shoreline modelling across the City waterfront.

-MIKE 3 is a versatile and well-developed and supported model suitable for conceptualization of nearshore water movement with many features and applications,

-Baird has a MIKE 3 license that can be used in application of the model to conceptualize fine nearshore water movement about intakes in Durham and Peel, too.

Reference: Recommended Approach to Modelling and Delineation of the In-Water IPZ-2

Outputs
-preliminary Phase 1 report outlining

- initial IPZs generated from *uncalibrated* POM & MIKE 3 models suite out puts using readily available data, only
- identification of deficiencies & limitations in above analysis and resulting IPZ-2s,
- identification of significant GAPs in critical data needed for models to generate IPZ-2s having a *moderate* level of confidence, and
- programs and costs to close above GAPs

Benefits
-POM and MIKE 3 permit consideration of lakewide and nearshore influences,
-3D outputs to readily conceptualize surface, mid-water and bottom water movements,
-MIKE 3 already owned and in use across Toronto waterfront for other applications,
-consultant (Baird) has license to apply MIKE 3 in Peel and Durham

Intakes in Western, Central and Eastern Lake Ontario – HCCL
The HCCL assignment includes intakes for 5 water plants located in Hamilton (i), Cobourg (1), Port Hope (1), Wellington (1) and Picton (1). The intakes are not together in a common stretch of Lake Ontario (as for Baird). As such hydraulic and hydrodynamic environments for the respective geographic groups are quite different. In addition, the amount of information for the areas varies from intensive and good quality (western Lake Ontario) to moderate (Port Hope and Cobourg) and virtually non-existent (Wellington and Picton). Of necessity, the approaches, data requirements, and costs will be different for each geographic grouping.

Recommendation
-a suite of models consists of the lake-wide **Princeton Oceans Model** (POM) to establish coarse large-lake and nearshore model boundary conditions and **ADCIRC 2D** (ADCIRC) model to conceptualize detailed water movements about the intakes, with progression to moderate resolution 3-D nearshore model by the end of Phase 1.
-POM has been described above,
-ADCIRC is an economical and U.S.A.C.E. supported model and has been used to conceptualize nearshore water movement and delineate IPZ-2 at 3 western Lake Ontario intakes for Collaborative member, Halton Region.
- ADCIRC permits the consideration of wave stresses in the nearshore region, with many additional features and applications.
-HCCL has used ADCIRC to generate Great Lakes IPZ-2s at Grimsby and Fort Erie for Niagara Region, Port Stanley and Grand Bend for London, and Thunder Bay.

DRAFT

Reference: Recommended Approach to Modelling and Delineation of the In-Water IPZ-2

Outputs
-preliminary Phase 1 report outlining

- initial IPZs generated from *uncalibrated* POM & ADCIRC models suite out puts (Hamilton and Port Hope/Cobourg) using readily available data only,
- Interpretation of possible in-water IPZ-2 limits based on limited available information (without modelling) at Wellington and Picton,
- identification of deficiencies & limitations in above analysis and resulting IPZ-2s,
- identification of significant GAPs in critical data needed for models to generate IPZ-2s having a *moderate* level of confidence, and
- programs and costs to close above GAPs

Benefits
-POM and ADCIRC permit consideration of lakewide and nearshore influences,
-it has had wide application in delineating IPZ-2 for Great Lakes intakes,
-consultant (HCCL) has license for ADCIRC and supporting SMS model Suite,
-readily convertible to 3D, where needed.

DRAFT

STANTEC CONSULTING LTD.

J. Langan

John S. Langan
Project Manager Environmental
john.langan@stantec.com

Attachment: Baird Technical Memorandum on Modelling,
HCCL Technical Memorandum on Modelling

March 23, 2007

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Baird

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John S. Langan,
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oceans
engineering
lakes
design
rivers
science
watersheds
construction

Re: Intake Protection Zone Technical Studies for Western Lake Ontario – Phase 1 and 2 Work

Dear John:

Below is the information you have requested, specifically:

1. Summary of Phase 1 work – what will be delivered;
2. Additional Phase 2 work to bring IPZ2 delineation to a moderate level of confidence (scope, data needs, costs for data and budget for work);
3. Additional Phase 2 work to further refine IPZ2's where specific issues are identified as part of the threats analysis;
4. Discussion of consistency of approaches between Baird and HCCL work.

Phase 1 Summary

1. Assembled and reviewed relevant literature on the physical coastal processes in western Lake Ontario; and isolated specific field investigations that may potentially be used to support numerical modelling activities. Environment Canada completed two comprehensive field studies of currents and temperatures along the north shore of Western Lake Ontario for discrete periods from 2000 to 2003. The field program completed in 2000 was quite detailed as several current meters were deployed along the waterfront from Hamilton to Cobourg in close proximity to various intakes (including each of the groups if intakes in Peel, Toronto and Durham). The time frame of this particular study was one month (August to September); similar time periods were used in 2002 and 2003 (only for Oakville area in 2003). Baird has formally requested this information from Environment

Baird

Canada and anticipates delivery of the data in early April 2007. It is our understanding that the City of Toronto will be undertaking ADCP measurements for the GTA in 2007, we have requested information on this from Bill Snodgrass and are awaiting feedback.

2. Hydrographic data used to support the development of model grids that define the bathymetry within the computational domain were obtained from the National Oceanographic and Atmospheric Administration (NOAA), which manage the data through the National Geophysical Data Center (NGDC). This information has been reviewed and prepared in GIS for development of model girds. Additional hydrographic data sources have been obtained and reviewed including Canadian Hydrographic Survey data sets and SHOALS (airborne bathymetric LIDAR) collected for the IJC Lake Ontario Study that Baird worked on).

3. Historical Flow data has been obtained from Water Survey of Canada for a number of key tributaries that discharge to Lake Ontario, from Peel to Durham Region. An extreme value analysis has been carried out to evaluate flow conditions as a function of return period. This data will be used to identify specific events of interest that may be analysed numerically to aid in the delineation of IPZ2. This information will also be used in Phase II to evaluate representative conditions for further modeling activities. Environment Canada indicated at the 23 February 2007 Technical Committee meeting that they can provide additional information on flows and loadings – we are awaiting this data.

4. A model selection assessment and modeling strategy task was completed. The results of this task are summarized in a letter to Stantec dated 9 March 2007. In summary, the recommendation is to use the POM model to provide lakewide boundary conditions and to develop a single nearshore MIKE3 model for Peel, Toronto and Durham intakes. We are awaiting feedback from the technical committee on this recommendation.

5. Once feedback is received from the steering committee on the proposed model approach, and providing it is in agreement, the MIKE3 model will be setup. A coarse outer grid with a uniform grid spacing of 810m will extend from Halton Region east to Northumberland and offshore to a depth of approximately 50m, however the extents of the

Baird

model domain as well as grid resolution are subject to change pending further analysis of the lake wide POM model. Several levels of nesting are then required to achieve the appropriate resolution (10m to 30m) at intakes situated near creeks and rivers.

6. Initially, correlations between the available intake water quality data (turbidity in NTUs) and available hydrodynamic data (currents, waves and flows) will be undertaken with due consideration of seasonal and environmental conditions. This analysis will assist in providing preliminary information on environmental conditions that are important in the determination of IPZ-2 vectors.

7. A preliminary IPZ2 will be developed for each intake using the un-calibrated MIKE3 model linked to the un-calibrated POM model for extreme conditions during the period of record available for the POM model (August 1, 2002 to December 31, 2006).

8. Recommendations for additional work will be provided (to a large extent these are summarized below).

Phase 2a – Initial Work to Improve IPZ2 Delineation

The following tasks are proposed for the initial part of the Phase 2 study of Source Water Protection for Western Lake Ontario.

1. Consideration of return periods (and combined probability) of river flows and wind-generated currents to define uncertainty associated with IPZ2. Many of the intakes are nearby to river and creek mouths and a key consideration will be the combined probability of high river flows and high winds. Both the river flows and the wind-generated lake circulation act to deliver possible contaminants to the intakes. In other words, a 10-year river flow combined with a 10-year wind speed may represent something significantly less than a 100-year condition if there is dependency between the winds and river flow (which is likely, particularly for east winds that accompany extra-tropical storms and associated precipitation events).

Baird

2. Model/Analysis:
    a. Evaluate model bathymetry near intakes based on CHS field sheet and other relevant data sources (such as SHOALS) and update where required. Therefore, this task consists of taking the recent data and revising the model grids generated in Phase I.
    b. Although the field investigations carried out by NWRI in 2000 were very good spatially, the period covered was only one month in late summer. Another concern is that there is no archived lakewide data for this period. Deployment of at least 3 ADCPs and temperature meters for each of the three regions (Peel, Toronto and Durham) for a period of at least two months in the fall of 2007 is proposed to capture stronger meteorological events. It is anticipated that this data will be used as part of the model calibration/verification and to aid in the analysis of the impact of waves on nearshore currents.
    c. Evaluate the influence of not including the lakewide boundary in the evaluation of circulation in the inner domain (to define IPZ2). Under this task, it will be determined whether IPZ2 delineation is conservative or not (and to what extent) when the lakewide boundary conditions are ignored. Model simulations will be based on representative conditions developed from a statistical analysis of current conditions and flows from local tributaries.
    d. Preliminary consideration of the influence of wave-driven currents at selected representative sites.
    e. Limited calibration of the nearshore MIKE3 model domain will be completed with the available ADCP data collected from August to September 2002 at a location offshore of Mississauga. The objective of this task is to define the uncertainty in model delineation due to model inaccuracy, to the extent possible with the available data near intakes.

Baird

f. Additional model runs based on results of the tasks described above to complete the definition of IPZ2 and uncertainty definition.

3. Reporting

We also recommend as part of Phase 2a, the collection of ADCP and temperature (FTP) data at three sites (one each in Peel, Toronto and Durham) for the period of two months. This recommendation may be adjusted pending receipt of information on the planned City of Toronto deployment of ADCPs.

Phase 2b – Additional Refinements to IPZ2 Delineation

1. More detailed calibration of the nearshore MIKE3 model domain will be completed using field data collected by NWRI in 2000. This will require the lakewide model (POM, ELCOM, or MIKE3) to be run for this time period as archived POM model results are not available from NOAA for 2000. Baird has developed and archived spatial wind fields for Lake Ontario from approximately 1960 to 2000. It is possible Environment Canada could contribute to the lakewide model component of this phase.
2. Pending availability, more detailed calibration/verification will be completed with the City of Toronto ADCP (and temperature?) data collected in 2007.
3. Depending on the outcome of Phase2a/Task2b, and Phase 2b/Tasks 1 and 2, review of available ADCP data further offshore will be undertaken and a limited calibration of the lakewide model will be completed provided suitable data exist. If justified, this task could be undertaken by Environment Canada.
4. Complete refinements to the IPZ2 delineation for significant threats identified in the Threats Inventory.
5. Reporting.

Baird

Consistency of Approaches being Followed by Baird and HCCL

We have reviewed each other's approach and found that although we are taking slightly different paths through Phase 1 and Phase 2a, we generally reach the same level of detail at the completion of Phase 2a. Baird has concentrated more on setting up a consistent 3D model (more complex than a 2D model) for all 11 sites in Peel, Toronto and Durham, given that 3D hydrodynamic modeling has been applied here in the past for similar investigations of intakes and outfalls. On the other hand, Baird has invested less effort in Phase 1 on delineation of IPZ2s with extreme events. In contrast, HCCL are relying on existing coarse resolution or new fine resolution 2D models on the one hand, but have invested more effort in evaluating extreme events. Moving through to the end of Phase 2a, both groups aim to have 3D (or in some cases 2D) models setup with a limited degree of calibration and consideration for uncertainty associated with combinations of events. Therefore, there will be consistency in the IPZ2s delineated for each intake coming out of the completion of Phase 2a.

Sincerely,
Baird & Associates

Fiona Duckett, P.Eng.
Associate

cc:: Dr. Rob Nairn, P.Eng.
Principal

File No. 11065

Mr. John Langan
Stantec Consulting
800-171 Queens Avenue
London, Ontario N6A 5J7

March 27, 2007

Dear Mr. Langan:

Re: Lake Ontario Collaborative – IPZ 2 Work Program Recommendations

This letter is provided in support of recommendations to provide for a moderate level of confidence in Phase IPZ 2 delineation needs for the Lake Ontario Collaborative. Preliminary recommendations are provided for further refinement of IPZ analyses and delineation if deemed necessary.

1 Introduction

HCCL is currently working on the delineation of IPZ boundaries in Lake Ontario for intakes at Hamilton, Port Hope, Cobourg, Wellington and Picton areas. The funding of the Phase 1 Lake Ontario Collaborative Intakes was relatively small (on an intake by intake basis) in comparison to others in the Great Lakes region. Proposed IPZ delineation tasks were proposed in accordance with the available budget. In total, $53,000 is available for IPZ delineation (information review, data collection, analyses, modelling and documentation) at these intakes, or in essence, about $10,000 per site (3 Hamilton intakes considered as one site).

The available information associated with each of these sites has been reviewed with due consideration of available resources, location of the intakes and the associated potential for developing meaningful IPZ boundaries at each of the sites given the available resources. It was concluded, on the basis of intake groupings, field data availability, budget limitations and expected IPZ uncertainty, that the approach would focus modelling efforts (and associated budget) at Hamilton, Port Hope and Cobourg, with preliminary assessments only at Picton and Wellington until field data was available to support more detailed investigations. Due to this differential approach to the various sites, each is discussed individually herein.

In summary the current approach includes:

a) 3 Hamilton Intakes will be evaluated within a modelling domain which includes Halton (Burlington, Oakville, Burloak) and Grimsby Intakes as well in order to provide some economy of shared resources and to improve overall regional integration of hydrotechnical analyses. The proposed evaluation approach (in progress) involves the development of a 2-D hydrodynamic model (ADCIRC), with progression to 3-D modelling using selected data from a relatively significant regional current monitoring data base (largely NWRI) to guide the model development and performance assessment.

b) Port Hope and Cobourg Intakes will be analyzed together within a single model domain using a 2-D modelling approach (ADCIRC). There is a single data set at this location available from NWRI. The quality of the data is unknown at this time as NWRI scientists are presently processing the data request. This data set was also collected in the summer of 2000, and therefore may not have captured any significant circulation events given that summer conditions are typically relatively quiet. Therefore, the value of this data set to the analyses is uncertain.

c) There is expected to be no relevant field current data at Wellington. There is a potential for some single point 2-D current meter data availability in this region, but it is quite dated and the quality and extent of the data and exact location of the mooring is uncertain until the data has been reviewed. The data has been requested from NWRI, but it is possible that the data will not be of sufficient coverage to support numerical model development. For this reason, and given the budget constraints, formal modelling is not planned for this area until supporting information is available. IPZ considerations will be identified based on existing lakewide modelling results until a more detailed effort is supported through additional budget availability and supporting local field data. It is cautioned that the existing lakewide modelling is relatively coarse in spatial definition and is not developed for the purpose of estimating nearshore velocities.

d) There is expected to be no relevant data at Picton. There is a potential for some single point 2-D current meter data in the Bay of Quinte region, but it is quite dated and the quality and extent of the data and exact location of the moorings are uncertain until the data has been reviewed. The data has been requested from NWRI, but it is not expected that the data will be sufficient to support numerical model development. For this reason, and given the budget constraints, formal modelling is not planned for this area until supporting information is available. IPZ considerations will be identified, as possible, based on an existing habitat modelling effort by Environment Canada (in or about 2003), and through simplistic empirical techniques. It is cautioned that the existing Environment Canada modelling efforts are preliminary in nature and do not include the expected primary forcing functions within Picton Bay.

2 Technical Discussion

2.1 General

Our experience with IPZ delineation to date confirms that the general hydrodynamic processes would be best represented through 3-Dimensional modelling of the nearshore area due to the variability of velocity magnitude and direction with depth under the wide range of wind, wave, temperature and hydrologic conditions which may influence a particular site. On an open coast, with significant fetches in both alongshore directions, it has been found that under extreme wind conditions (those deemed suitable for derivation of the IPZ boundary), the alongshore velocity profile can be relatively well represented through 2-DH (2-Dimensional Horizontal, i.e. vertically averaged) modelling, especially where the intake is in relatively shallow water. This is due to the fact that the wind and wave generated velocities in the nearshore area become relatively well distributed with depth, and the alongshore current is free to move downdrift along the shoreline. In the event that the wind is onshore, there is theoretically a significant potential return flow along the bed that cannot be accommodated in the 2DH model. In this case, we have employed a 2-DV (2-Dimensional Vertical) analytical model in some cases. The major uncertainty in this approach is in prediction of combined offshore and alongshore conditions, but given our understanding of the MOE's objectives with the Phase 1 IPZ investigations, it is felt that the 2-D approach is sufficient if the results are interpreted in a conservative manner and if the combined influence of wind stresses, waves (radiation stress and mass flux) and hydrologic inputs are included.

In cases where the intake is not located on the open coast, and the alongshore currents are not permitted to move freely downdrift along the shoreline, the situation becomes more complex; such situations may occur at the extreme ends of the Great Lakes or in long embayments. Assuming an east/west lake orientation, the alongshore currents generated by wind blowing over the length of the length may generate alongshore currents along the north and south shorelines, which possibly converge as they are turned by the rapidly changing shoreline orientation at the end of the lake. It is expected that return flow along the bed may be significantly increased in this region, and as a result, the 3-Dimensional nature of the flow becomes increasingly important in defining the direction of velocities which define the IPZ. The Hamilton intakes at the eastern end of Lake Ontario, and the Picton intake in Picton Bay are examples of situations where 3-D considerations are expected to be more important in the definition of the preliminary IPZ.

The L.O.C. request for proposal for Phase 2 studies suggests that additional focus may be necessary for extreme conditions such as maximum tributary and sewer flows, thermal bar conditions and upwelling and downwelling events. Our review of existing information and modelling to date indicate that these events are not necessarily the "extreme" conditions which define a 2 hour IPZ-2 in a Great Lakes setting. Flow velocities are generally dissipated quickly in the nearshore environment, and thermal bar conditions typically are not associated with the large wind events (which are typically in the late fall) which generate the strongest nearshore velocities. However, it is agreed that these conditions may be very important to threat delivery to an intake, as such conditions may deposit (or contain) contaminants released in the spring in the nearshore area under certain conditions. These contaminants may be subsequently driven to the intake by a significant wind driven condition. Under such conditions, however, the 2 hour delineation would appear to be less relevant from a threats perspective.

Ultimately, the IPZ line is based on a somewhat subjective definition of the time required for facility shutdown (2 hours) and to date no definition of an acceptable level

of risk. It is suggested that detailed modelling refinements to provide fine adjustments to the scientific derivation of the IPZ line in order to refine the threats assessment should be considered in association with a more critical evaluation of the more subjective factors involved in the line derivation. Refined modelling does provide for better understanding of the threats and possible delivery vectors under a wide range of conditions (not just those influential in defining the IPZ2 boundary) and for that reason may be well justified from the standpoint of understanding the threats in general. Given the focus on a 2 hour IPZ, our proposed tasks as defined herein focus largely on improved understanding of the "extreme" conditions. Improved understanding of more complex regionally-driven processes or those driven by more moderate forcing functions (i.e. thermal process – hydrologic interactions) would require more intensive monitoring (than proposed herein) in order to ensure that models accurately represent the conditions of interest.

2.2 Hamilton Intakes

2.2.1 Present Approach

The Hamilton intakes benefit from the local presence of Grimsby and Halton intakes with respect to overall available funding for IPZ delineation. This area is currently being modeled in 2-DH with progression to a 3-D approach following the 2-D model completion. As previously noted, there is also a relatively large amount of current monitoring data in this region to support the model development and evaluation.

2.2.2 Phase 2a – Needs to provide moderate certainty

Phase 2a recommendations to provide for a moderate certainty in IPZ delineation include:

- Refinement of coarse 3-D modelling grid near Hamilton Intake.

The existing level of analysis is expected to provide for a relatively well refined 2-D modelling approach (due to flexible mesh abilities). Given the budget limitations, the 3-D modelling effort at the Hamilton intakes is expected to be relatively coarse in nature. Refinement of the grid in the vicinity of the intakes would improve the definition of IPZ and permit the physical representation of more detailed shoreline features and contaminant threat vectors to provide a moderate level of certainty.

2.2.3 Phase 2b - Refining Analysis to Reduce Uncertainty

Suggested tasks to refine the Phase 1 analysis to reduce uncertainty if deemed necessary include:

- Re-visit environmental boundary conditions and statistical dependence issues.
- Re-visit lakewide boundary for improved definition.
- Further refinement of 3-D approach to include more detailed representation of local watercourses and their potential influence on the Hamilton Intakes.

With regard to the IPZ delineation in accordance with the guidance documents, possibly the most influential factor in providing for a refined IPZ boundary is the accuracy of the boundary conditions. A more detailed statistical assessment of the input boundary conditions (consideration of the multivariate statistical nature and potential dependence of one variable on another) could provide for increased certainty of the IPZ line location for a given level of acceptable risk (time of response and probability of excedence).

The existing lakewide boundary condition is relatively coarse in spatial definition and does not necessarily provide for a good representation of the typical IPZ defining events, and therefore is expected to provide for increased uncertainty. It is expected that the conditions well removed from the offshore boundary, especially under IPZ defining conditions, are more significantly influenced by the local processes which are better represented in the nearshore model than the lakewide model due to improved definition.

The effect of the lakewide model is expected to be more significant in deep water areas and where regional currents are focused by the lakebed and shoreline geometries. Therefore, improved spatial representation of the lakewide boundary is expected to provide a moderate degree of benefit to the nearshore modelling in the Hamilton area due to its situation at the end of Lake Ontario, and the relatively deep conditions. There is a possibility of improved lakewide modelling definition through current initiations at Environment Canada. Should this improved lakewide modelling be available, nearshore model boundaries will be revisited to refine the input conditions.

Due to the heavily urbanized characteristics of the area and the large population served, further refinement of the model would provide an improved understanding of the threat delivery vectors in general, and may serve to highlight the potential threat associated with more chronic delivery vectors under the wider range of potential nearshore conditions.

2.3 Port Hope / Cobourg

2.3.1 Present Approach

The Port Hope and Cobourg intakes are on a relatively open stretch of shoreline, and are therefore expected to be relatively well represented by a 2-DH modelling approach for the purpose of Phase 1 IPZ delineation. As previously noted, this approach can provide a relatively good representation of alongshore velocities under well mixed conditions, and is supplemented by a 2-DV analytical model for the cross shore condition. The interpretation of the results will be completed with modelling limitations in mind.

As noted, the existing data set associated with the summer 2000 current monitoring deployment has been requested from NWRI. The summer deployment period, and the situation of this meter approximately 3 km offshore, however, will make the data less relevant to the IPZ defining conditions and associated local currents at the existing intakes. The quality of the data will not be known until the information requests have been processed by NWRI.

2.3.2 Phase 2a – Needs to provide moderate certainty

Phase 2a recommendations (pending review of NWRI field data) to provide for a moderate certainty in IPZ delineation include:

- Current monitoring in nearshore region (near Port Hope intake)
- Consideration of field data in 2-D model approach

The need for relevant field data cannot be fully assessed until the existing 2000 NWRI field data has been reviewed. We have included this item in the Phase 2a needs at this time, but should relevant data be available from the 2000 NWRI meter, this deployment could be shifted to Phase 2b. The potential lack of relevant field data at this site provides for increased uncertainty in the modelling results and the model's success in reflecting significant current events.

2.3.3 Phase 2b - Refining Analysis to Reduce Uncertainty

Suggested tasks to further refine the Phase 1 analysis to reduce uncertainty if deemed necessary include:

- Progression of model to 3-D approach
- Additional current monitoring deployment (near Cobourg intake)
- Re-visit environmental boundary conditions and statistical dependence issues
- Re-visit lakewide boundary for improved definition.

Given the approximations associated with the 2-D modelling approach, a 3-D approach would provide for improved certainty in the ability of the model to represent a wider range of boundary conditions and the associated return flows from the shoreline under varying wind and wave approach conditions. As the results of the 2-D modelling are to be interpreted in a conservative manner, it is possible that the 3-D modelling results will provide for a reduced IPZ boundary with increased certainty, while at the same time provide for a better overall interpretation of the general physical processes not necessarily associated with the IPZ definition, but associated with more chronic conditions delivering contaminants to the intake area. The inclusion of key threat delivery vectors (eg. Ganaraska River mouth) in the refined modelling is important.

The progression to 3-D modelling would benefit from the collection of field data in the vicinity of the Cobourg intake as well given that the Port Hope deployment is in the order of 12 km away, and the one deployment is not expected to represent the other's local conditions well.

The existing lakewide boundary condition is relatively coarse in spatial definition and does not necessarily provide for a good representation of the regional input to typical IPZ defining events. Therefore this is expected to provide for some degree of uncertainty in the modelling. It is expected that the conditions well removed from the offshore boundary, especially under IPZ defining conditions, are more significantly influenced by the local processes which are better represented in the nearshore model than the lakewide model due to improved definition. Improved spatial representation of the lakewide boundary is expected to improve overall modelling certainty, but is expected to be less critical at this location due to the relatively open shoreline configuration. Where such refined lakewide modelling results are available, they would be considered in the refinement of the nearshore model boundary.

2.4 Wellington

2.4.1 Present Approach

The Wellington Intake is situated on a relatively open shoreline, but there is expected to be no directly relevant field data for this intake. Given the lack of model supporting information and limited modelling budget, formal modelling is not planned for this area until supporting information is available. IPZ considerations will be identified based on existing lakewide modelling results until a more detailed effort is supported through additional budget availability and supporting local field data.

As previously noted, the existing lakewide modelling is relatively coarse in spatial definition and is not developed for the purpose of estimating nearshore velocities, and therefore, there would be considerable uncertainty in any IPZ definition on this basis.

2.4.2 Phase 2a – Needs to provide moderate certainty

Phase 2a recommendations to provide for a moderate level of certainty in IPZ2 delineation at this site:

- Current monitoring near the intake
- 2-D model development for the site

In order to provide for a basic understanding of the typical hydrodynamics in the vicinity of the intake, and in order to provide some confidence in any modelling effort, field data collection is recommended in the vicinity of this intake. This data should be collected during spring or preferably fall conditions where there is increased potential for monitoring during high wind conditions. Should data collection in Phase 2a be economically unfeasible forcing this task into Phase 2b, it is possible to develop a model without the data; however, a moderate level of certainty would not be achievable.

Given the relatively open shoreline in this location, the generalized 2-DH modelling approach is expected to be suitable for the purposed of Phase 1 IPZ delineation. As previously noted, this approach can provide a relatively good representation of alongshore velocities under well mixed conditions, and is supplemented by a 2-DV analytical model for the cross shore condition. The interpretation of the results is completed with modelling limitations in mind.

Refining Analysis to Reduce Uncertainty

Suggested tasks to further reduce uncertainty in the IPZ delineation, if deemed necessary, include:

- Progression of model to 3-D approach
- Re-visit environmental boundary conditions and statistical dependence issues
- Re-visit lakewide boundary for improved definition.

As with the Port Hope and Cobourg modelling effort, given the approximations associated with the 2-D modelling approach, a 3-D approach would provide for improved certainty in the ability of the model to represent a wider range of boundary conditions and the associated return flows from the shoreline under varying wind and wave approach conditions. As the results of the 2-D modelling are to be interpreted in a conservative manner, it is possible that the 3-D modelling results will provide for a reduced IPZ boundary with increased certainty, while providing for a better overall interpretation of the general physical processes. The relatively remote location of this site may not warrant further investigation should limited threats be identified.

Should more detailed modelling be required, refinement of the existing lakewide boundary condition would also improve overall modelling certainty. Again, given the relatively open shoreline configuration in this area, the influence of the lakewide boundary is expected to less critical, but should be refined where more comprehensive lakewide modelling results are available.

2.5 Picton

2.5.1 Present Approach

The Picton Intake is situated deep in Picton Bay in relatively shallow water. The hydrodynamic conditions at this location are inconsistent with those on the open coast, but are expected to be strongly influenced by coastal driving forces (winds and waves). Given the lack of model supporting information and limited modelling budget, formal modelling is not planned for this area until supporting information is available. IPZ considerations will be identified based on review of an existing Environment Canada temperature model and on simplified empirical techniques to assess wind and wave generated velocities in a 2D vertical sense.

The expected limited relevance of the Environment Canada model to Picton Bay, and the lack of spatial ability associated with the empirical approach will result in considerable uncertainty in the IPZ delineation at this location.

2.5.2 Phase 2a – Needs to provide moderate certainty

Phase 2a recommendations to provide for a moderate level of certainty in IPZ2 delineation at this site:

- Current monitoring near the intake

- Development of 3-D hydrodynamic model for Picton Bay and boundary region

In order to provide for a basic understanding of the typical hydrodynamics in the vicinity of the intake, and in order to provide some confidence in any modelling effort, field data collection is recommended in the vicinity of this intake. This data should be collected during spring or fall conditions where there is increased potential for monitoring during high wind conditions. Should data collection in Phase 2a be economically unfeasible forcing this task into Phase 2b, it is possible to develop a model without the data; however, a moderate level of certainty would not be achievable.

The confined bay geometry suggests that 3-D processes are more critical at this location. The critical condition is expected to be associated with a wind condition aligned along the axis of the bay, generating a response that varies considerably with depth. For this reason, a 3-D modelling approach is suggested initially. The confined geometry may simplify the required modelling efforts to some degree.

2.5.3 Refining Analysis to Reduce Uncertainty

Suggested tasks to further reduce uncertainty in the IPZ delineation, if deemed necessary, would include:

- Re-visit environmental boundary conditions and statistical dependence issues

The isolated location and associated reduction in critical forcing conditions is expected to provide for more confidence in the initial modelling effort. The initial modelling stage would be completed assuming conservative combinations of forcing conditions (water levels, winds, hydrologic inputs, etc.). Therefore, a refinement of these conditions through consideration of dependence of the various parameters and an associated adjustment to boundary conditions may permit a reduction of the initial IPZ with increased confidence.

3 Summary

In summary, the recommended priorities for provision of moderate certainty in the IPZ delineation and further refinements to improve confidence and refine IPZ boundaries if necessary are summarized in Table 1.

Table 1 : Lake Ontario Collaborative Workplan (HCCL)

Task
Hamilton
Phase 2a – Refine 3-D model at Hamilton
Phase 2b - Revisit environmental boundary conditions and refine lakewide boundary conditions (if available), consider further refinement of threat source areas (river mouths, etc.)

Port Hope & Cobourg Intakes
Phase 2a – ADCP Field Data Collection (Port Hope), refine 2-D model with field data
Phase 2b – Progress to 3-D Modelling, deployment of current meter at Cobourg, revisit environmental boundary conditions and refine lakewide boundary conditions
Wellington
Phase 2a – ADCP Field Data Collection, develop 2-D modelling
Phase 2b - Progress to 3-D Modelling, revisit environmental boundary conditions and refine lakewide boundary conditions 3-D modelling
Picton
Phase 2a – ADCP Field Data Collection, develop 3-D modelling
Phase 2b – Revisit environmental boundary conditions

With regard to differences in approach to IPZ delineation within different regions of the Great Lakes, it is realistic to expect varying degrees of effort and modelling approaches as necessary to address the site specific complexities in a manner consistent with the ultimate needs of the MOE. In short, given the objective to define an IPZ with moderate confidence such that preliminary threats assessment can be undertaken and analyses refinements identified, the approach must suit the complexities of the site with respect to hydrodynamics and threats. Furthermore, given the budgetary constraints, the approach should undoubtedly make best use of the existing and available resources.

Should analyses progress through to the end of Phase 2b, it is expected that the majority of sites will employ some level of 3-D modelling or well refined 2-D modelling supported by field data and would be provided relatively consistent confidence in the results as would be expected. The potential for additional analyses to be deemed unnecessary at some sites is testament to the acceptability of differential approaches.

I trust this discussion provides sufficient information for work plan submission at this point in the project. Please do not hesitate to call should you require additional information.

Sincerely,

Stu Seabrook, P.Eng.
HCCL

APPENDIX 3.2: HCCL HYDROLOGICAL FINAL MODELING REPORT

1 Hydrodynamic Modelling and IPZ Delineation (Lake Ontario Collaborative)

1.1 Introduction

Details of the approach to available information review, hydrodynamic models evaluation and selection, and IPZ delineation are detailed in the July, 2007 "Lake Ontario Collaborative (Hamilton, Port Hope, Cobourg, Wellington and Picton) In-Water Intake Protection Zone (IPZ-2) Delineation - Hydrotechnical Analyses" Draft Final Report by HCCL, included in Appendix 3.2. The following is a summary of the detailed information provided in that report.

1.2 Approach

The approach to defining the in-water and alongshore component of the IPZ-2 boundary for these municipal water intakes is varied due to limitations in available resources (relevant information and budgetary) for the Phase 1 work. The approach to each intake was selected in order to maximize the benefit of the existing information available, while addressing the local hydrodynamic characteristics as best possible given the available resources. A general approach was taken to background information review and interpretation of the hydrodynamic environment.

Although there is a significant volume of current monitoring information from the Western Lake Ontario Region as well as occasional historic deployments in other regions of Lake Ontario, it generally involves deployment periods of a few months at a time, and is not necessarily local to areas of municipal water intakes. As a result, this information is not particularly well suited to defining extreme current conditions within the region, and potentially less appropriate for defining such conditions near the intake. This information does however provide for a reasonable understanding of the regional hydrodynamic processes and in some cases supports the development of regional hydrodynamic models.

The delineation of the IPZ requires the ability to have some control over the conditions that are considered for the development of the zone. Specifically, it is desirable to define the zone for a "standard" event condition, and preferably one associated with a given design event such that some assessment of risk can be made. Probabilistic analysis of extremes typically requires a considerably longer data record than is available from the existing current monitoring data. Such record lengths are generally available for wind and water levels which are more regionally homogeneous. For these reasons, it is desirable and beneficial to provide for hydrodynamic modelling of the region such that the input boundaries of the model can be forced with extreme "event" conditions for which probabilistic estimates can be made.

The IPZ boundary is also a function of the currents over a region that may extend some distance from the intake, and may not be well represented by only a few point measurements of current time series. A modelling approach accounts for this spatial variability in hydrodynamic conditions as the model domain provides for prediction of currents over a larger domain at a pre-defined level of discretization. This representation of the spatial variation in physical characteristics can better accommodate the inherent complexities of the region.

Finally, the modelling approach provides for the opportunity to investigate the sensitivity of predicted velocities to changes in environmental variables and therefore permits a better assessment of the confidence of the results given expected confidence in the measured input variables. For this reason, hydrodynamic modelling is proposed where resources support its development in Phase 1. Where such resources do not exist, alternative methods of estimating the preliminary IPZ-2 have been selected.

A specific approach to defining the in-water and alongshore extents of the IPZ-2 was defined by region on the basis of the general overview, as detailed in Section 1.4 below.

1.3 Hydrodynamic Processes in Study Area

There is a relatively significant volume of research into Lake Ontario hydrodynamic processes on the regional level, especially focused on the western end of Lake Ontario. Existing hydrodynamic research generally focuses on the lakewide circulation processes and associated phenomena; there is unfortunately little emphasis on episodic and localized processes in the nearshore area which are very important to the definition of the IPZ-2 boundary.

In general, a review of relevant literature published by NWRI and others in various publications highlights a number of important factors with regard to the hydrodynamics in western Lake Ontario. Although literature specific to Central Lake Ontario is limited, some processes discussed in relation to western Lake Ontario are relevant to Lake Ontario processes in general.

- The annual development of a spring thermal bar is expected to have an impact on nearshore water movements and associated water quality during this period, as dissolved and suspended materials are expected to be moved alongshore, with little offshore exchange. This thermal bar development and progression is relatively complex from a modelling perspective.
- Westerly winds generally generate upwelling in the western Lake Ontario region and associated offshore drift in the surface levels while easterly winds generate stronger currents and typically induce downwelling of surface waters.
- A strong alongshore current is observed within a few kilometers of the shoreline, generally flowing counterclockwise in western Lake Ontario, with occasional reversals under strong opposing wind conditions.
- In general, spring circulation is focused in the alongshore direction and cross shore mixing is limited by the presence of the thermal bar, while in the summer and fall, the period of entire lake stratification, mixing in the cross shore direction is more common.
- Coastal processes differ significantly between winter and summer conditions, largely due to thermally generated vertical density gradients in the summer compared to a typically isothermal condition in the winter.

- In general, the literature focuses on lake wide processes (including wind, temperature and density driven currents) which are complicated to some degree by the proximity of the region to the western end of Lake Ontario and the associated abrupt change in shoreline direction at Burlington.
- Typically, the currents generated by the lake-wide processes are relatively small (<0.1 m/s) but they are important from an overall long-term water quality and circulation perspective.

Although daily raw water quality data was not provided for the Hamilton intakes at the time of report preparation, a review of available current monitoring information in relation to wind data, wave hindcast information and intake raw water quality at other western Lake Ontario sites suggest further generalizations.

- Turbidity spikes, expected to be indicative of poor water quality conditions, and active hydrodynamic conditions are predominantly observed in the late fall through early spring months, when the water temperature is relatively uniform, and thermal stratifications are not a major consideration in the hydrodynamic processes.
- The turbidity events appear to correlate well with significant wind and wave conditions in the record. It is typical of the Great Lakes for the most active wave and wind conditions to be experienced in the late fall and winter months
- Given the apparent significance of the wind driven events, and the need to establish an IPZ boundary on the basis of maximum average velocities (or some other similarly representative condition) it is evident that the ability to represent wind driven circulation is critical of any modelling effort.

Although thermal considerations are important with respect to water quality modelling and more general circulation conditions, they do not appear to be critical with respect to the more significant currents observed in the ADCP data.

1.3.1 Review of Local Current Monitoring Information

Current monitoring during the summer and fall of 2000 near Hamilton was completed as part of a significant current monitoring program in support of general investigations of physical processes in Lake Ontario. The deployment in 12 m depth is outside the typical zone of significant wave influence, but the location of the deployment in the extreme western end of the lake suggests that both alongshore and cross-shore processes may be of considerable importance.

A detailed review of the measured currents shows a predominance of alongshore currents at depth, with increased diversity in direction in the surface layers. Current magnitudes are generally much greater in the extreme upper layer than in immediately underlying and lower layers ; although the ADCP records indicate good data quality in this extreme upper layer, it is not consistent with the majority of the current profile. The tendency for sustained easterly winds to generate onshore currents near the surface with offshore currents at depth is evident. Conversely, sustained westerly winds generate offshore currents near the surface with onshore currents at depth. Generally, these currents are relatively small (0.2 m/s ±). Alongshore currents show a similar range of magnitudes with significant velocities in the very-near surface area and considerably smaller velocities with depth.

It is evident that the current patterns in this region are relatively complex, and influenced by the situation of this site in the extreme western end of the lake.

1.4 Hydrodynamic Model Review and Selection of Preferred Approach to Hydrodynamic Analyses

Due to the spatial and temporal variability of the regional and local currents, as well as the desire to simulate currents associated with a significant probabilistic event for which measurements are not likely to be available, hydrodynamic models are valuable tools for IPZ delineation. There are a multitude of hydrodynamic models available, ranging from simplistic 1-Dimensional single process models through 3-Dimensional multi process models. These models may be available freely in the public domain with little technical support and documentation, or may be integrated within complex and costly commercial modelling suites.

HCCL experience with in-water IPZ-2 delineation to date confirms that the general hydrodynamic processes would be best represented through 3-Dimensional modelling of the nearshore area due to the variability of velocity magnitude and direction with depth under the wide range of wind, wave, temperature and hydrologic conditions which may influence a particular site. On an open coast, with significant fetches in both alongshore directions, it has been found that under extreme wind conditions (those deemed suitable for derivation of the in-water IPZ-2 boundary), the alongshore velocity profile can be relatively well represented through 2-DH (2-Dimensional Horizontal, i.e. vertically averaged) modelling, especially where the intake is in relatively shallow water. This is due to the fact that the wind and wave generated velocities in the nearshore area become relatively well distributed with depth, and the alongshore current is free to move downdrift along the shoreline.

The physical characteristics of the western Lake Ontario sites (including Hamilton) are expected to generate relatively complex hydrodynamic conditions within the area because predominant winds along the axis of the lake tend to move the water towards the end of the lake where it may generate upwelling and downwelling circulation currents that are relevant to the preliminary IPZ delineation. Northeast and southeast winds are expected to generate more significant alongshore currents locally. Conditions within the Bay of Picton are also expected to be relatively complex in nature due to its situation deep within the bay and the relatively shallow waters at the intake.

Conditions at Port Hope, Cobourg and Wellington are expected to be more dominated by the alongshore processes, although onshore winds would be expected to generate increased variance in the distribution of velocities (magnitude and direction) with depth.

The selection of an appropriate modelling or analysis approach has been made on the basis of the available resources (time, budget and data) and a review of the relevant hydrodynamic information and associated environmental variables that are available. A general review of the available information and interpretation of the issues of significance was also completed to assist in the assessment of an appropriate approach, as discussed below.

1.4.1 General

- A review of pertinent literature and background information regarding the lake and nearshore processes within the region of interest was completed.
- Existing environmental data (winds, waves, hydrologic inputs, water levels, raw water quality at intake) and relevant current monitoring information (where available) were collected and reviewed.
- Existing environmental data were interpreted with regard to significant local and regional processes and their expected relative hydrodynamic influence.
- Potential approaches to IPZ delineation were reviewed on the basis of the existing understanding of regional hydrodynamic processes, including analytical and desktop approaches, interpretation of existing modelling results and potential numerical hydrodynamic modelling. Where numerical modelling is proposed, potential modelling approaches were considered and appropriate models selected on the basis of the characteristics of the site and complexity of conditions.

1.4.2 Hamilton

- Due to availability of current monitoring data and the relative complexity and development density of this region, hydrodynamic modelling was proposed in association with existing efforts at Burlington, Burloak, Oakville (Halton Region) and Grimsby (Niagara Region).
- Preliminary 2-D (ADCIRC) modelling was completed as originally proposed for Halton Region with the model domain extending to incorporate the Halton, Grimsby and Hamilton Intakes.
- Due to the complexity of this region with respect to its location at the western end of Lake Ontario, and the associated potential influence of regional lakewide processes as well as local wave induced currents, and the expected importance of 3-D flow conditions within this physical setting, 3-D hydrodynamic modelling is considered to be necessary.
- Moderate resolution 3-D modelling was completed using the POK2k model. The influence of waves has been considered in the modelling through the introduction of wave induced stresses through the domain, distributed with depth.
- The 2-D ADCIRC followed by 3-D POM modelling approach provides the following benefits:
    - finite element approach in ADCIRC provides for a flexible mesh, permitting smooth transitions from areas of coarse model definition (offshore) to areas of refined definition (intake, shoreline and hydrologic inputs),
    - ADCIRC model permits various forcing functions including surface wind stress, long wave (water level fluctuation) and normal boundary flux,

- wave radiation stresses can be imposed on ADCIRC over the model domain to reflect the effect of breaking waves in the nearshore zone during periods of high winds, and
- the ADCIRC model is cost effective and supported by a comprehensive user interface should the presiding authority wish to maintain the model.
- as wind and waves approach the shore perpendicular direction (onshore), the 2-D ADCIRC approach is not capable of resolving the theoretical condition of onshore currents on the surface with return currents near the lake bed. For this case, a 2-DV (2-Dimensional Vertical) analytical model that considers wind stress and wave mass and radiation fluxes in the cross-shore direction has been employed where 3-D POM modelling is not yet proposed.
- refinement of 3-D POM modelling provides for improved representation of the onshore and offshore phenomena and provides boundary information for future 3-D model refinements with waves and more detailed representation of shoreline features as deemed necessary.

The majority of uncertainty in this approach is in the prediction of combined offshore and alongshore conditions in the presence of waves. Given the MOE's objectives for Phase 1 in-water IPZ-2 investigations, the approach presented for this region is considered appropriate providing that the results are interpreted in a conservative manner.

1.5 2-D Hydrodynamic Modelling

The hydrodynamic modelling process required the processing of local and regional physical data such as bathymetry (lake bed elevations) and shoreline locations as well as environmental variables which are used to force the model at its boundaries (lateral and surface). Bathymetric information was derived from Canadian Hydrographic Service navigational charts and field sheets while the shoreline was derived from Ontario Ministry of Natural Resources Ontario Base Map themes.

The modelling was completed for a range of wind and wave conditions with extreme flows imposed at relevant watercourse outlets (Stoney Creek, Fifty Point Creek, Forty Mile Creek, Hamilton Harbour contributions, Bronte Creek and Sixteen Mile Creek) within the model domain. The modelling domain was selected such that boundaries are well removed from the area of interest (expected IPZ-2 limits). A 2 hour time of travel (TOT) and 100 year return period for boundary inputs was assumed in the development of the IPZ-2. However, model runs were also performed assuming 2 hour TOT with 10 year return period input conditions. Boundary conditions imposed on the model are discussed further in the following section.

1.5.1 Development of Boundary Conditions

The imposed 2-D model boundary conditions include steady state wind stress, wave stress, static water level, hydrologic inputs and boundary fluxes (velocities). These conditions were derived from various environmental data sources discussed in the hydrotechnical modelling report (Appendix ***). Critical orientations of wind stress and wave conditions were combined with a regional boundary flux to define the alongshore velocities and the resulting IPZ 2 boundary.

The critical combinations of wind and wave stresses used in the Hamilton ADCIRC modelling to establish the IPZ-2 defining velocities included:

- 100 Year winds from N and 100 year waves from N
- 100 Year winds from SE and 100 year waves from SE
- 10 Year winds from N and 10 year waves from N
- 10 year winds from SE and 10 year waves from SE

Hydrologic inputs from various watercourses of relevance are discussed further in the hydrotechnical modelling report.

The assumed Lakewide boundary input is considered to be conservative but is a source of uncertainty in the modelling due to the limited period of available modelling and the limited spatial resolution of the lakewide model. The velocities modeled at the intake are not particularly sensitive to the lakewide input, however, and as a result the conservative assumption is considered appropriate. Lakewide influences were modeled by imposing current velocities ranging from 0.3 – 0.6 m/s on the offshore model boundary.

1.5.2 Interpretation of Monitoring and Modelling Results

Detailed discussion of modelling results is provided in the Hydrotechnical modelling report; the various results are not discussed individually here. In general, the 2-D modelling assumes a steady-state approach with extreme (probabilistic) forcing variables imposed on the model boundary, and assumes that these conditions will persist for a sufficiently long period to establish such a steady state condition. The current velocities established under these conditions generally maintain a well mannered pattern where bathymetric features are not abrupt. This approach to modelling and interpretation is generally a conservative approach and is typical of planning level investigations.

Given the relatively limited data set available in this area and lack of resources to provide for a comprehensive review of the environmental forcing functions (persistence, dependence, etc.) the IPZ-2 boundaries provided herein are considered preliminary in nature. It is expected that increased certainty in the lines could be achieved by improving the understanding of environmental data trends and the associated nearshore water current response. Sources of uncertainty are discussed in the hydrotechnical modelling report.

1.6 3-D Hydrodynamic Modelling

3-D hydrodynamic modelling was completed at a moderate scale resolution in order to provide for improved ability to capture the 3 dimensional nature of the wind and wave generated flows in western Lake Ontario. The POM2k model was used with a curvilinear grid structure, with mesh resolution as low as approximately 80 m near the intakes. The resolution of the modelling did not permit consideration of the hydrologic inputs in the 3-D assessment, but did include the influence of waves via imposed wave induced radiation stresses distributed in depth throughout the domain. As in the case of the 2-D modelling, the hydrodynamic modelling process required the processing of local and regional physical data such as bathymetry (lake bed elevations) and shoreline locations as well as environmental variables which are used to force the model at its boundaries (lateral and surface).

The modelling was completed for 100 year wind conditions from 8 compass directions with consideration of wave induced influences for 100 year wave conditions from the north and east. The modelling domain was selected such that boundaries are well removed from the area of interest (expected IPZ-2 limits). A 2 hour time of travel (TOT) was assumed in the development of the IPZ-2. Boundary conditions imposed on the model are discussed further in the following section.

1.6.1 Development of Boundary Conditions

The imposed 3-D model boundary conditions for IPZ determination include steady state wind stress, wave stress and static water level. These conditions were achieved with a 12 hour spin-up period where wind and wave conditions were ramped to the design condition which was held steady for 2 hours at the design event condition. A more detailed discussion of boundary conditions is provided in the hydrotechnical modelling report (Appendix ***).

Due to the limited resolution of the Lakewide POM model and the "event-based" nature of this modelling effort, it was not possible to impose a realistic flux or water level control on the offshore model boundary. Instead, a radiation boundary condition on elevation was imposed. Performance of the model was assessed at two locations within the model with reasonably good agreement between ADCP measurements and modelling results.

1.6.2 Interpretation of Monitoring and Modelling Results

Although the 3-D modelling approach improves on the ability to assess the 3-D nature of the flows in Western Lake Ontario, it has not been developed to a sufficient resolution to provide adequately for hydrologic inputs to the grid, and could possibly benefit from further refinement of the grid in areas of abrupt shoreline change and additional consideration of additional wave directions in order to improve on the nearshore results. As with the 2-D modelling, the 3-D modelling assumes a steady-state approach with extreme (probabilistic) forcing variables imposed on the model boundary, and assumes that these conditions will persist for a sufficiently long period to establish such a steady state condition. A relatively simplistic approach to statistical analysis of the boundary conditions and their coincidence and persistence has been taken to date. It remains, that increased certainty in the IPZ-2 boundary could be achieved by improving the understanding of environmental data trends and the associated nearshore water current response.

It is also recognized that neither the 2-D or 3-D approaches discussed herein are particularly well suited to represent the complexities of the hydrodynamic conditions in the nearshorezone under the influence of large waves. Sources of uncertainty are discussed further in the hydrotechnical modelling report.

1.7 Intake Protection Zone Delineation (IPZ-2)

Preliminary IPZ-2 model boundaries are mapped on georeferenced satellite imagery (Figure ***) on the basis 2D-H particle tracking and cross-shore travel time calculations. The approximate extents of the 2-hour 100 year return period zones are:

- Northwest4300 m
- Southeast 4100 m
- Offshore 3600 m

The IPZ-2 has been extended to the shoreline at the lateral extents of the IPZ-2 boundaries based on the uncertainties and limitations in the Phase 1 analyses as discussed in detail in the hydrotechnical modelling report.

The 3-D modelling derived line is also provided in Figure ***. The 3-D results suggest that the line enclosing the particle tracking paths would extend approximately:

- Northwest4900 m
- Southeast 7500 m
- Offshore 1800 m

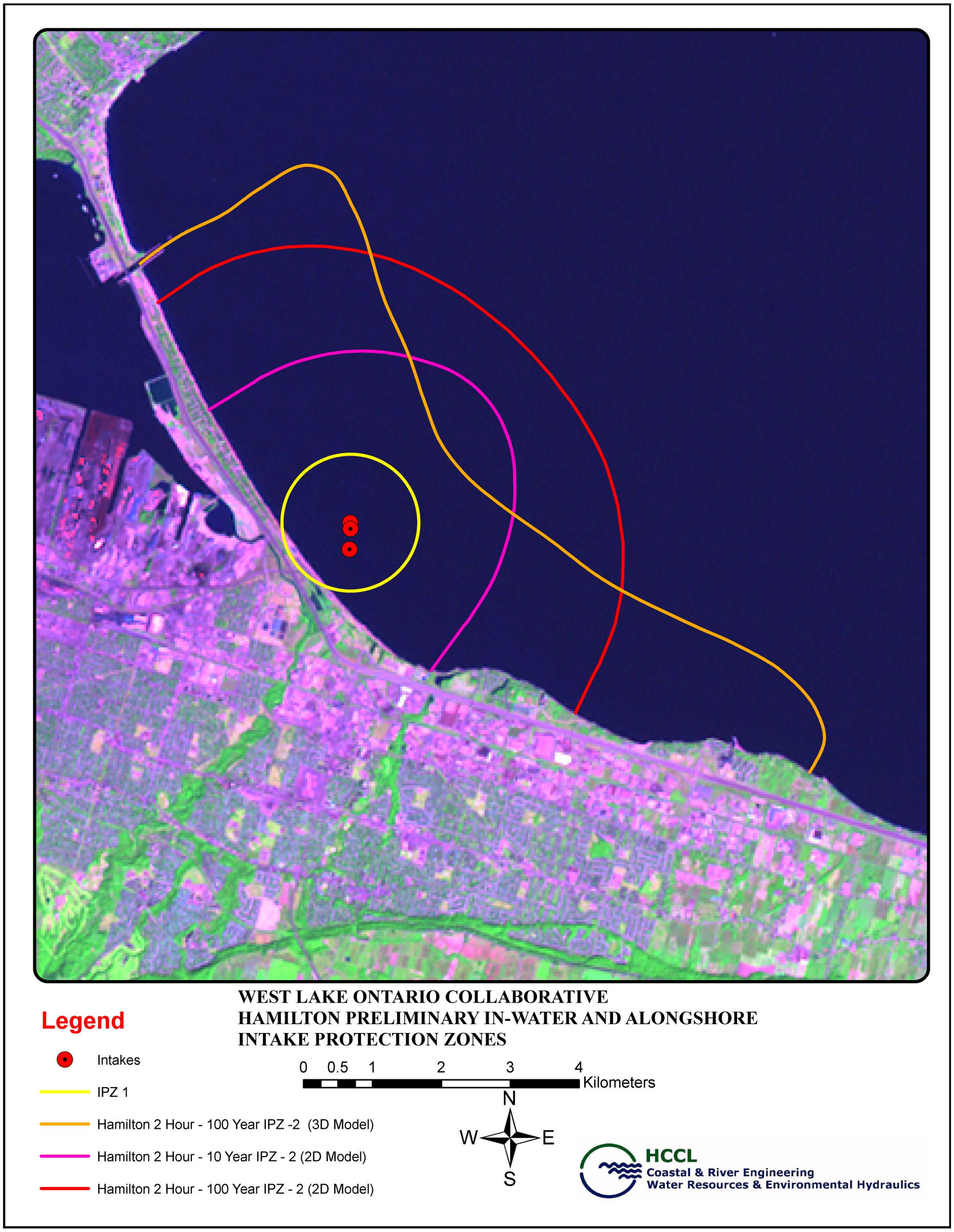


Figure *: Hamilton – Preliminary In-Water and Alongshore IPZ-2**

APPENDIX 3.3:
LANDWARD AND UPTRIBUTARY IPZ-2 DELINEATION METHODOLOGY

Landward and Up-Tributary IPZ-2 Extent Methodology

INTRODUCTION

Where intersections between preliminary IPZ-2 areas, provided by the subcontracted modelers, and study area shorelines do not exist, it becomes necessary for the completion of this phase of work and the initiation of subsequent phases, to apply conservative qualitative methodologies to determine a preliminary IPZ-2 delineation.

CASE A

Case A methodology for the delineation of landward and upland IPZ-2 extents is intended for use with Lake Ontario modeling performed by Baird and Associates.

Baird applied POM and DHI MIKE-3 numerical models using 10-year wind and 2-year current events, for a 3.5-day period, to ascertain a two-hour time of travel.

Methodology and Procedure

The methodology described below is applied to determine time of travel residuals for watercourse outlets, including; storm sewer and combined sewer overflow outfalls, municipal drains, creeks, or rivers. Where data regarding watercourse characteristics is not available this method is used to provide a landward, or upland, IPZ-2 area.

Initially utilizing the extents of the IPZ-2, a radial arm was measured from the intake point to the farthest extent of the in-lake IPZ-2. This was repeated for the opposite side of the in-lake IPZ-2.

Using the determined radial arms, arcs were projected onshore. One arc projected from either end of the IPZ-2. Ideally arcs were projected with similar angles, however local study area conditions may in some cases have required the use of increased or decreased arc angles. Where these arcs meet, an approximation was used to smoothly incorporate both radii with conservative estimates in consideration.

With the radial arms determined and the respective arcs projected, an extension line was plotted from the extents of the in-water IPZ-2 to a point on-shore. Ideally the extension line was either a tangential extension of IPZ-2 perimeter, or a line, which intersected the shoreline at approximately 90 degrees. This extension was approximate and may have been altered to accommodate local study area conditions. From that point an administratively determined limit of 120m or the respective Conservation Authority regulated limit (refer to Guidance Module 4) was applied as the upland extent until connecting with the previously determined arcs. This delineation will be known as the initial perimeter.

Where information regarding watercourses, or storm sewer networks was present, the up-tributary and upland IPZ-2 was extended to include influencing stormsheds or watersheds if determined influential. Stormsheds were included if they overlapped, partially or entirely, the initial perimeter; or if it was determined the flow could be transferred quickly enough to warrant inclusion. Entire stormsheds were included as a result of general uncertainty and the necessity to maintain conservative estimations.

The Figure 1 example illustrates the methodology as applied to the Lakeview WTP intake.

Uncertainty

Uncertainty associated with this IPZ-2 delineation methodology resulted largely from the quality and quantity of information available to characterize study area watercourses, stormsheds, watersheds, and other applicable factors. In general the uncertainty is recognized to be high due to the application of conservative estimates and loosely defined procedures, along with the relative absence of detailed numerical and hydrodynamic tributary modeling. This does not however reduce the ability of this methodology to provide a conservative, preliminary delineation of upland and up-tributary IPZ-2 extents.

CASE B

Case B methodology for the delineation of landward and upland IPZ-2 extents was utilized for HCCL modeled in-water IPZ-2 delineations.

HCCL delineations utilize 10 and 100-year wind and current events modeling in 3D-ADCIRC to present a conservative initial in-water IPZ-2.

Methodology and Procedure

The methodology described below is applied to determine time of travel residuals for use at watercourse outlets, which may include storm sewer and combine sewer overflow outfalls, municipal drains, creeks, or rivers. Where data regarding watercourse characteristics is not available this method is used to provide a landward, or upland, IPZ-2 area.

The methodology used to derive landward and up-tributary IPZ-2 areas is initiated with an extension of the in-water IPZ-2 perimeter to an on-shore “intersect” point. The extension is effectively a straight line projected tangentially from the in-water IPZ-2 perimeter, or orthogonally from a point on the shoreline. This extension is approximate and its determination in any event may be altered to accommodate local study area conditions.

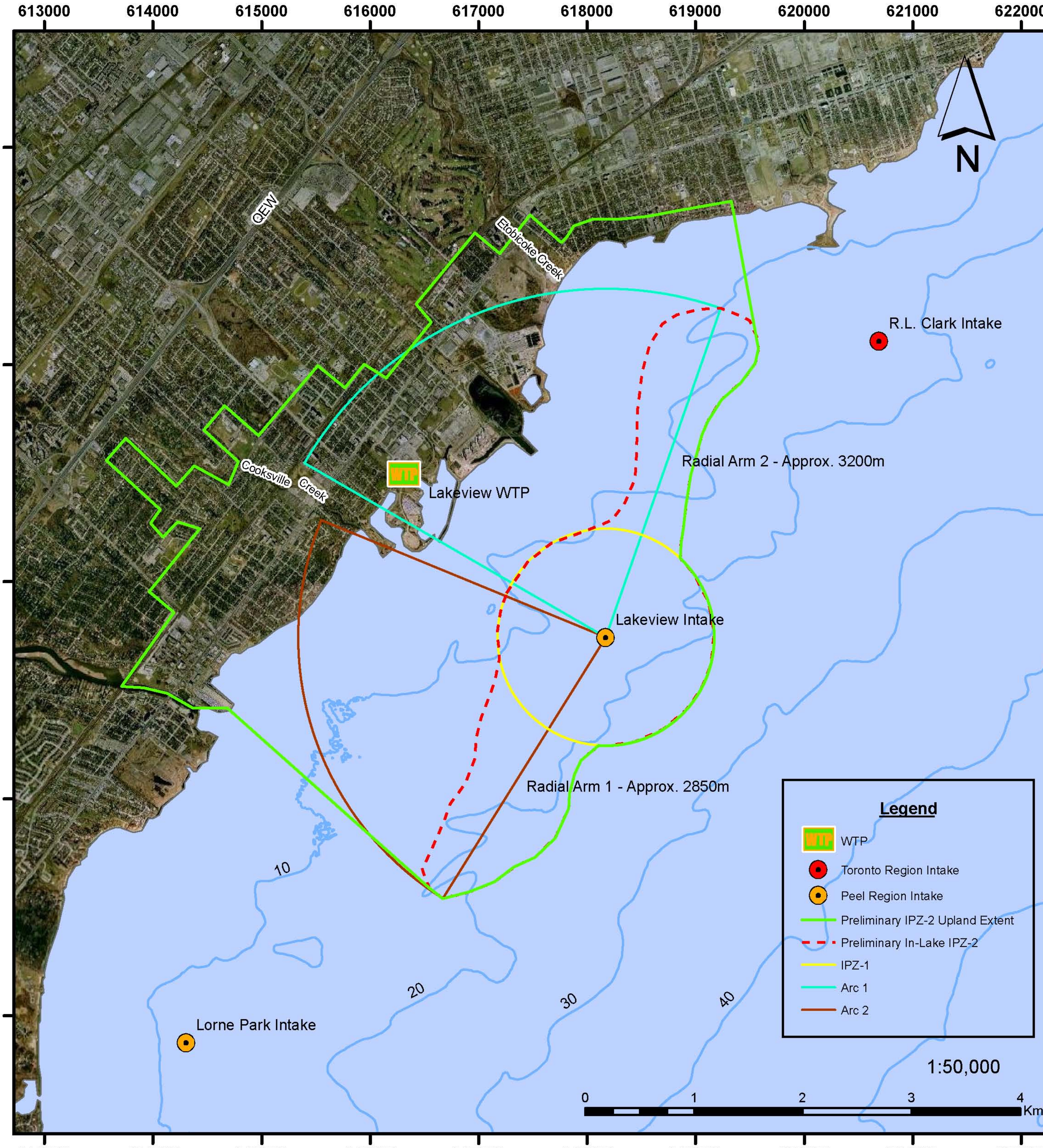
The time of travel estimation is determined after the IPZ-2 is extended to the shoreline. Time of travel to area watercourse outfalls are required in order to determine the residual of the established two-hour travel time for a particular watercourse. This residual is then applied to watercourse characteristics; specifically flow velocity, in order to determine the up-tributary extent of the IPZ-2.

Time of travel estimations are determined by assuming the distance from the intake to the extent of the in-water IPZ-2 perimeter represents two hours. With this convention established, distances to watercourse mouths are measured and converted to a proportion of the established two-hour TOT distance.

The landward extent of the IPZ-2 was determined with consideration to the up-tributary extents. Either the administratively determined limit of 120m or the established Conservation Authority regulated limit is used in areas where no pathway influence is present. Where storm shed and watershed information was available the landward IPZ-2 was delineated to account for those effects.

Uncertainty

Uncertainty associated with the IPZ-2 delineation methodology results largely from the quality and quantity of information available to characterize study area attributes. In general the uncertainty is recognized as high due to the application of conservative estimates and loosely defined procedures, along with the relative absence of detailed numerical and hydrodynamic modeling. This does not however reduce the ability of this methodology to provide a conservative, preliminary delineation of upland and up-tributary IPZ-2 extents.



Stantec

Baird
NAVIGATING NEW HORIZONS

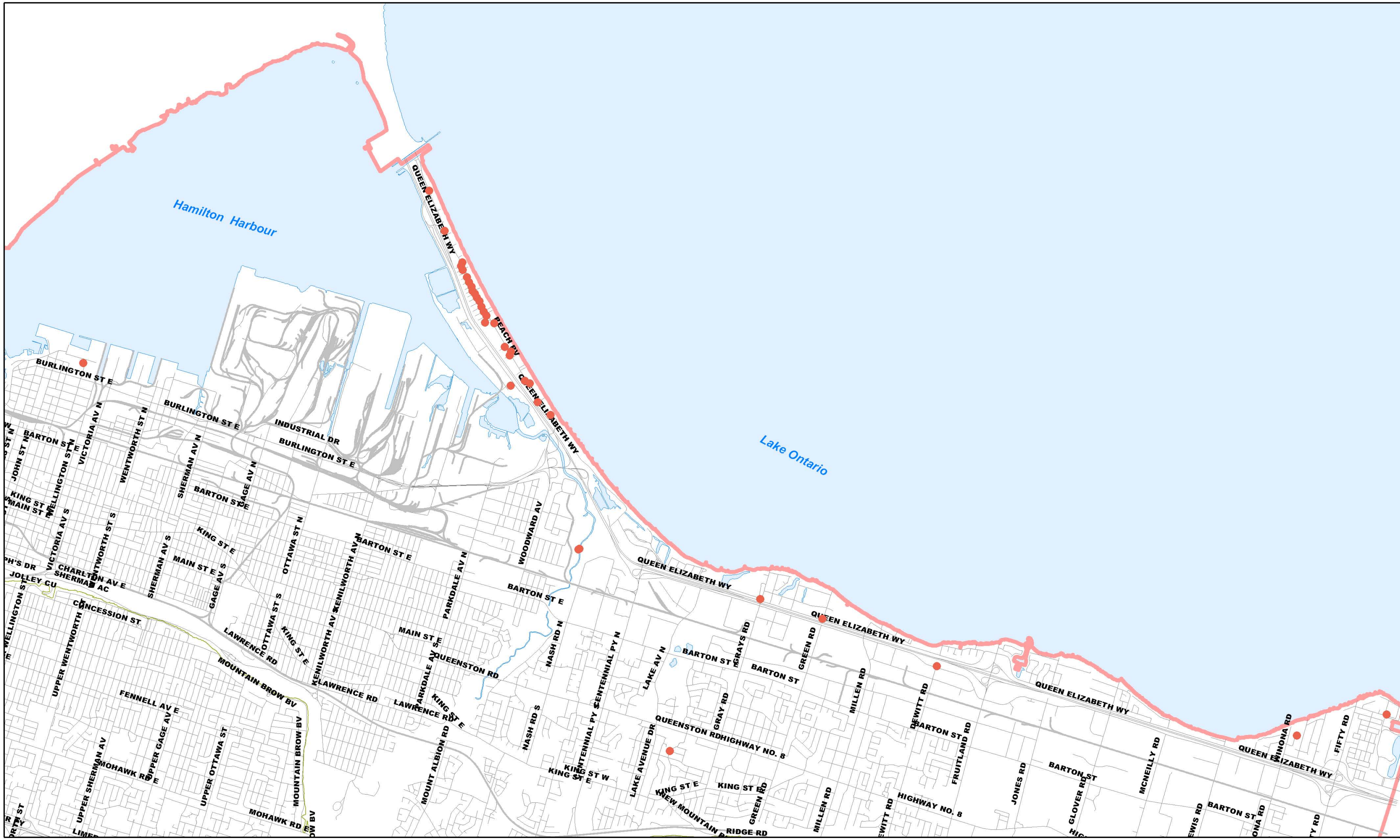
Project
Lake Ontario Collaborative Intake Assessments

Figure No.
1

Title
Lakeview WTP IPZ-2 Delineation Methodology

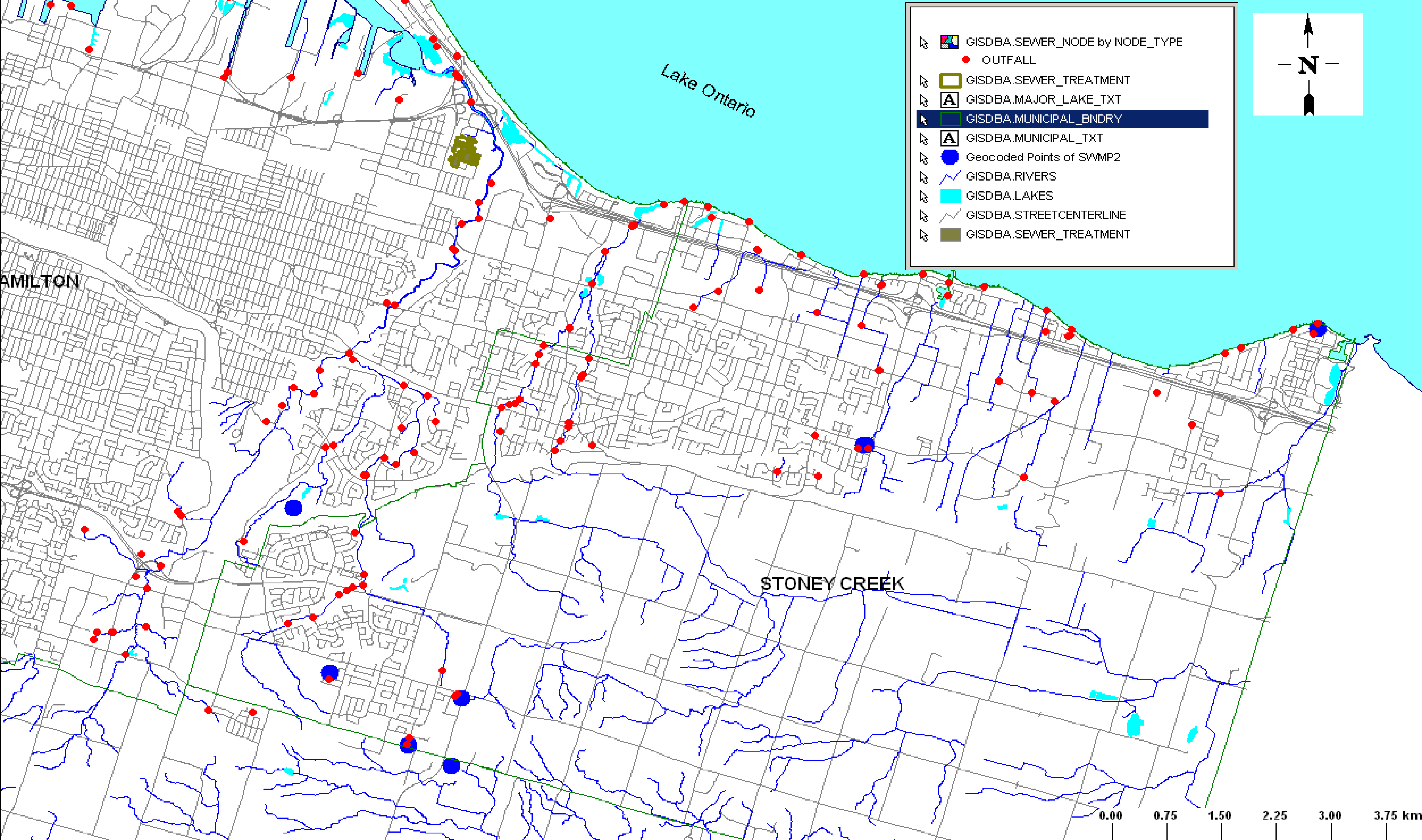
APPENDIX 3.4:
STORM SEWER OUTFALL & SANITARY SEWER PUMPING STATION LOCATIONS

FIGURE 1:
SANITARY SEWER PUMP STATION LOCATIONS
AS PROVIDED BY THE CITY OF HAMILTON



Hamilton Harbour
Lake Ontario
QUEEN ELIZABETH WY
PEACH AV
BURLINGTON ST E
INDUSTRIAL DR
BARTON ST E
KING ST E
MAIN ST E
CHARLTON AV E
CONCESSION ST
LAWRENCE RD
MOUNTAIN BROW BV
FENNELL AV E
MOHAWK RD E
QUEENSTON RD
HIGHWAY NO. 8
BARTON ST
KING ST W
RIDGE RD
VICTORIA AV N
WENTWORTH ST N
SHERMAN AV N
GAGE AV N
OTTAWA ST N
KENILWORTH AV N
PARKDALE AV N
WOODWARD AV
NASH RD N
CENTENNIAL PY N
LAKE AV N
GRAYS RD
GREEN RD
MILLEN RD
DEWITT RD
FRUITLAND RD
JONES RD
GLOVER RD
MCNEILLY RD
WINONA RD
FIFTY RD
UPPER WENTWORTH
UPPER SHERMAN AV
UPPER GAGE AV
UPPER OTTAWA ST
MOUNT ALBION RD
LAKE AVENUE DR
NASH RD S
GRAY RD
OTTAWA ST S
KENILWORTH AV S
GAGE AV S
SHERMAN AV S
VICTORIA AV S
JOHN ST N
JOLLEY CU
SHERMAN AC
NEW MOUNTAIN RD

FIGURE 2:
STORM SEWER OUTFALL LOCATIONS
AS PROVIDED BY THE CITY OF HAMILTON


GISDBA.SEWER_NODE by NODE_TYPE
OUTFALL
GISDBA.SEWER_TREATMENT
GISDBA.MAJOR_LAKE_TXT
GISDBA.MUNICIPAL_BNDRY
GISDBA.MUNICIPAL_TXT
Geocoded Points of SWMP2
GISDBA.RIVERS
GISDBA.LAKES
GISDBA.STREETCENTERLINE
GISDBA.SEWER_TREATMENT
N
Lake Ontario
AMILTON
STONEY CREEK
0.00
0.75
1.50
2.25
3.00
3.75 km

APPENDIX 4.1: CERTIFICATE OF APPROVAL WOODWARD AVENUE WTP

CONTENT COPY OF ORIGINAL

Ontario

Ministry of the Environment	**Ministère de l'Environnement**	*AMENDED CERTIFICATE OF APPROVAL MUNICIPAL DRINKING WATER SYSTEMS NUMBER 1343-725PZD Issue Date: May 17, 2007*

City of Hamilton
55 John St N 6th Floor
Hamilton, Ontario
L8R 3M8

Site Location: Woodward Avenue Water Treatment Plant
700 Woodward Ave
Hamilton City,
L8H 6P4

Pursuant to the Safe Drinking Water Act, 2002, S.O. 2002, c. 32, and the regulations made thereunder and subject to the limitations thereof, this approval is issued under Part V of the Safe Drinking Water Act, 2002, S.O. 2002, c. 32 to:

City of Hamilton
55 John Street North, 6th Floor
Hamilton, Ontario
L8R 3M8

PART 1 - DRINKING-WATER SYSTEM DESCRIPTION

1.1 for a drinking-water system serving the City of Hamilton, rated as set out in Part 4, consisting of the following:

Proposed Works
(As per application dated March 19, 2007)

Up-country Estates Water Booster Station and Re Chlorination System
Construction of a new booster pumping station, located on the south side of Parkside Drive, opposite the south end of Robson Road, boosting pressure from an existing 400mm diameter watermain on Parkside drive, serving the community of Waterdown, as follows:

approximately 14.5 m x 11 m brick building housing booster pumps, generator room, electrical room, chemical room, equipped with the following:

- two (2) inline pumps each rated at 50 L/s at 28 m total dynamic head (TDH);
- two (2) inline pumps each rated at 80 L/s at 28 m total dynamic head (TDH);
- re-chlorination system consisting of:
- three (3) chemical pumps (one as standby) each rated at 2 L/h ;
- two (2) 560 L chemical tanks with containment facilities;
- five (5) analysers, measuring free chlorine, total chlorine and free ammonia on the inlet side and free chlorine, total chlorine on the discharge side;
- one (1) standby generator set, having a rating of 125 kilowatts, to provide power for the booster pumping station during emergency situations, together with noise attenuation, complete with two (2) double walled fuel tanks, having a total capacity of 2045 L;
- associated piping, heating system, ventilation system, electrical mechanical and control system.

Completed Works
(as per application dated September 7, 2006)

<u>Permanent Disinfection System</u>
A disinfection system consisting of primary disinfection by free chlorination followed by secondary disinfection by chloramination;

for primary disinfection, "CT" (concentration in mg/L * Time in minutes) is achieved, upstream and/or downstream of the filtration, by chemical dosing of chlorine at one or multiple locations, namely: intake, rapid mixing area and post filtration;

the secondary disinfection utilizing chloramines by dosing ammonium hydroxide to the outlet boxes of the two existing clear wells. A control system providing a ratio dosage or flow proportional dosage of ammonium hydroxide. Together with instrumentation to monitor free chlorine residual just upstream of the ammonia feed and monitoring free ammonia, total chlorine residual and free chlorine residual in the high lift pump discharge;

including two (2) 30,000 L storage tanks, one (1) 1, 360 L tank for a vent water bath scrubber, three (3) chemical metering pumps (two duty, one standby), piping and appurtenances;

<u>residual chlorine analyzers for the purpose of regulatory control</u>:

for primary disinfection, real time "CT" calculated with input from continuous monitoring equipment located, as follows:
- free chlorine at the low lift pumping station;
- free chlorine at module 1 pre treatment processes, settled water conduit;
- free chlorine at module 2 pre treatment processes, settled water conduit;
- free chlorine at the outlet of clear well No.1;
- free chlorine at the outlet of clear well No.2;

for secondary disinfection, from continuous monitoring equipment located, as follows:
- free chlorine at high lift pumping station east discharge or west discharge;
- total chlorine at high lift pumping station east discharge or west discharge;

<u>residual ammonia analyzers for the purpose of process control</u>:
- Free ammonia analyzers for the high lift pump east and west discharge pipes

Completed Works
(as per letter dated July 28, 2006 from Hargrave & Burdick, Environmental Inc.,)

- stand by chlorinators;
- modifications to chlorination system at:
- Kenilworth Access pumping station
- Osler Drive pumping station
- Lee Smith reservoir
- backflow prevention devices for tank flushing lines;
- overflow pipe from the fluoride day tank back to the bulk storage tank; and
- filter building flood protection system

Proposed Works
Application dated March 27, 2006)

<u>Modifications to Trash Pumps at Low Lift Pumping Station</u>

replacement of motors of newly installed two (2) trash pumps each equipped with a 30 kW motor rated at 5,000 m3/d at 20.5 m total dynamic head with two new motors, each 18.6 kW, rated at 4,320 m^3/d at 8 m TDH, and associated modifications to the electrical and controls system;

Completed Work
Abandoned the existing 300mm diameter trash emergency discharge piping to the Red Hill Creek discharge system.

all in accordance with the Application dated March 27, 2006, from KMK Consultants Ltd.

Proposed Works
(As per applications dated May 30, 2006)
Modifications to Dundas Water Tower-Mixing System

installation of a mechanical mixing system, by extending the existing 300mm diameter inlet riser pipe to the top water level and fitted with four (4) 200 mm diameter nozzle valves, at two different elevations (two at each level), together with associated modifications to the piping system and complete with miscellaneous maintenance and safety works;

all in accordance with the applications submitted by KMK consultants Ltd.

Proposed Works
(As per applications dated January 6, 2006)
Replacement of Emergency Scrubber

replacement of an existing "wet" type chlorine gas scrubber used in emergency with a new "dry" type scrubber system, to be used in emergency conditions in the chlorine room, complete with associated modifications to mechanical, structural, electrical and controls;

all in accordance with the application dated January 6, 2006 prepared by R.V Anderson and associates.

Proposed Works
(As per applications dated November 15, 2005 and April 12, 2006)

residual chlorine analyzers for the purpose of process control:

miscellaneous residual chlorine analyzers for the purpose of process control are provided including. but not limited to measure:

- free chlorine at the beginning of modules 1 and module 2 of pre treatment processes;
- free chlorine at the inlets of clearwell No.1 and clearwell No.2;
- free chlorine at high lift pump discharge

Note: the analyzers located within the distribution system are for the purpose of process control.

the above full scale alternate disinfection is to be extended from January 6, 2006 to February 9, 2007;

all in accordance with the applications dated November 15, 2005 and April 12, 2006 prepared by Hargrave and Burdick Environmental Inc.

Proposed Works
(As per letter dated August 4, 2005)

- modifications to the supervisory control and data acquisition system (SCADA)

Proposed Works
(As per application dated June 19, 2005)

modifications to the existing Fifty Road Reservoir Pumping station, to incorporate a new rechlorination system, as follows:

- replacement of the existing temporary re chlorination system to feed sodium hypochlorite solution to both inlet and outlet pipe of the reservoir, comprising of :

- two (2) chemical pumps (duty and standby) each rated at 1.5 L/hr, feeding inlet pipe, complete with free chlorine residual analyzer, a flow monitor, and controls;

- one (1) chemical pump feeding outlet pipe, rated at 1.5 L/hr, complete with free chlorine residual analyzer, a flow monitor, and controls;

- one (1) 60 L capacity solution tank complete with a secondary containment tank; and

associated modifications to the station inlet/outlet piping system, electrical and controls system.

Existing Fifty Road Reservoir Pumping Station is located on Reservoir Park Road on the west side of Fifty Road South of old Hwy 8, east of Grimsby, within pressure district 10 of the City of Hamilton's water distribution system, consisting of a single cell reservoir with an approximate capacity of 1,100 cu.m, equipped with two (2) high lift pumps each rated at 2 L/s at a total dynamic head of 36m, and a temporary top up chlorination feed system consisting of one (1) sodium hypochlorite pump rated at 6.3 L/hr, one (1) 60L capacity chemical storage tank and one (1) residual chlorine analyzer, together with controls, electrical, mechanical and associated piping system.

Proposed Works
(As per application dated February 14, 2005)

<u>Full Scale Testing of Alternate Disinfection System - Project Date Extension</u>
Full scale testing of alternate disinfection system consisting of primary disinfection by free chlorination followed by secondary disinfection by chloramination. The chloramination is performed by feeding ammonium hydroxide to the outlet boxes of the two existing clear wells, together with instrumentation to monitor free chlorine residual just upstream of the ammonia feed and monitoring free ammonia, total chlorine residual and free chlorine residual in the high lift pump discharge;

together with operating the system that would allow chemical dosing of chlorine at locations, namely: intake, rapid mixing area, post filtration, post clear well with the view of achieving at least 99 percent removal or inactivation of Cryptosporidium oocysts, at least 99.9 per cent removal or inactivation of Giardia cysts and at least 99.99 per cent removal or inactivation of viruses by the time water enters the distribution system, at all times.

The above full scale alternate disinfection is to be extended to January 6, 2006;

all in accordance with the application dated February 14, 2005, prepared by Hargrave and Burdick Environmental Inc.

Proposed Works
(As per application dated February 9 2005)

<u>Coagulation System Upgrades</u>

Upgrading of the existing coagulation system for improved and optimized performance by constructing the following:

- refurbishing of two (2) existing coagulant wood stave storage tanks each 54 cu.m capacity, to be used for polyaluminum chloride (PACl) or aluminum sulphate (Alum);
- decommission and replace the existing coagulant system by providing five (5) new coagulant metering pumps each capable of dosing up to 400 L/hr maximum and 4.15 L/hr minimum together with associated works including discharge piping and appurtenances for use with polyaluminum chloride (PACl) or aluminum sulphate (Alum);
- chemical containment facilities for the two coagulant storage tanks;
- associated piping, valving, electrical, instrumentation;
- four (4) new coagulant (PACl) or aluminum sulphate (Alum) discharge lines from the storage area to the rapid mixer of each of the four (4) pre-treatment trains; and
- addition of electric actuators to eleven (11) manual sluice gates associated with the sedimentation basins;

all in accordance with the Report entitled " Design Brief City of Hamilton Woodward Avenue WTP Coagulation System Upgrades" dated February 2005, prepared by Acres and Associated Environmental Limited

Proposed Works
(As per application dated January 28, 2005)

Upgrading the Existing Chlorine Handling Facility

Upgrading the existing chlorine handling facility at the existing chlorine building located at the Woodward water treatment plant by replacing liquid chlorine process piping system, replacing emergency gas scrubber, upgrading the controls system and miscellaneous building upgrades, consisting of the following:

- replacement of wet type emergency gas scrubber with new dry-type scrubber complete with associated controls;
- refurbishing of the existing gas analyzer and two sensors;
- installation of a second new gas analyzer with two sensors;
- replacement of liquid chlorine process piping;
- controls and necessary instrumentation associated with the new scrubber and new chlorine gas detector; and
- miscellaneous electrical, mechanical and structural works.

all in accordance with the report entitled "City of Hamilton Design Brief for Woodward Avenue Water Treatment Plant Chlorine Building Upgrade" dated January 28 2005, prepared by R.V.Anderson Associates Limited

Proposed Works
(As per application dated July 13, 2004)

Modifications to Low Lift Trash Screen Removal System

modifications to the existing Low Lift Pumping Station Screening Removal system, as follows:

- replacement of existing two (2) trash pumps (used for the purpose of removing debris in raw water), each rated at 11,224 m3/d with two (2) new vertical dry pit chopper pumps, with 30 kW motors, each rated at 5,000 m3/d and 20.5 m total dynamic head (TDH), to remove debris from the trash chamber;

- approximately 1200m of 250mm diameter insulated forcemain from the low lift pumping station, connecting an existing man hole on Nash Road North (MH3A), at an elevation of 74.5m, approximately 40m south of an existing 3600 mm x 1500mm concrete box culvert, complete with a 1600mm x 1200 mm air release chamber; and

- modifications to the existing 300mm trash discharge piping system to allow the existing Red Hill Creek discharge system to be operated during emergency event (s).

all in accordance with the application dated July 13, 2004, design brief entitled "City of Hamilton Woodward Avenue LLPS Screenings Removal System" dated July 2004, prepared by KMK Consultants Limited, correspondence dated August 3, 2004, August 4, 2004 and August 31, 2004 and engineering drawings submitted with the letter dated September 17, 2004

Proposed Works
(as per application dated August 17, 2004)

New Raw Water Conduit between Low Lift PS and WTP

- Construction of a new 2,700 mm diameter raw water transmission main in tunnel, located at the QEW highway crossing at Burlington Street from the existing Low Lift Pumping Station (NAD 83: UTM Zone 17, 599871.00 m E. and 4790512.00 m N), to the Woodward Avenue Water Treatment Plant site, together with two (2) tunnel shafts, associated appurtenances and connections to the existing raw water supply system; and

- all works necessary to abandon the existing 1524 mm diameter raw water transmission main between the Low Lift Pumping Station and the Water Treatment Plant site.

all in accordance with the application dated August 17, 2004, and drawings prepared by Totten Sims Hubicki Associates consulting engineers.

Proposed Works
(as per application dated June 9, 2003)

Rechlorination / Recirculation Upgrades to Water Storage Facilities
Modifications to the existing water storage facilities located in the City of Hamilton water distribution system, serviced by the Woodward Avenue Water Treatment Plant, providing rechlorination and recirculation, as follows:

Kelly Street Water Tower
Installation of the following at Kelly Street Water Tower servicing pressure district WH16, consisting of a reinforced concrete standpipe with 16.76m diameter and 34.75m water depth providing a maximum volume of 7,682 m^3 , located on the north side of Kelly and Main Street, having UTM coordinates: 589158 Easting, 4798890 Northing, :

- sodium hypochlorite feed system consisting of two (2) chemical feed pumps (one duty, one standby) each having a rated capacity of 2.8 L/hr;
- two (2) 200 L solution tanks (one duty, one standby) complete with containment basin;
- two (2) chlorine residual analyzers (one measuring free and one measuring total);
- one (1) magnetic flow meter;
- modifications to water main providing a separate inlet and outlet pipe; and
- associated piping and control equipment.

Dundas Water Tower upgrades
deleted as per application dated February 16, 2006 from TSH Associates

Woodley Lane Reservoir upgrades
deleted as per application dated February 16, 2006 from TSH Associates

Garner Road Reservoir and Booster Station
Installation of the following at Garner Road Reservoir and Booster Station, servicing pressure district WH18, consisting of a two celled reinforced concrete underground reservoir providing a maximum volume of 33,260 m^3 , located on the northwest side of Garner and Glancaster Roads, having UTM coordinates: 586982 Easting, 4784778 Northing:

- sodium hypochlorite feed system consisting of two (2) chemical feed pumps (one duty, one standby) each having a rated capacity of 5.6 L/hr;
- one (1) 600 L solution tank (duty) complete with containment basin;
- one (1) 200 L solution tank (standby)
- one (1) chlorine residual analyzer;
- modifications to water main providing a separate inlet and outlet pipe to the reservoir; and
- associated piping and control equipment.

Highland Road Reservoir and Booster Station upgrades
deleted as per application dated February 16, 2006 from TSH Associates

all in accordance with the application dated June 9, 2003, Design brief entitled " Rechlorination and Recirculation of Water Storage Tanks" dated March 2003, contract documents entitled " Rechlorination and Recirculation of Water Storage Tanks Contract No." dated March 2003 and engineering drawings all prepared by Totten Sims Hubicki Associates (1997) Limited.

Proposed Works
(as per application dated July 16, 2003)

Filter Building Upgrades
Modifications to the existing Filter building located in the Woodward Avenue Water Treatment Plant, comprising of installation of filter surface agitator system for the existing 24 filters, including surface agitator water supply booster system complete with associated controls, as follows:

- surface agitator assemblies for the existing 24 filters complete with associated piping;
- two (2) vertical inline centrifugal booster pumps each rated at 6,530 m^3 /d, providing agitator water supply in the filter building backwash pump room, complete with associated valves and controls;

- one (1) reduced pressure type back flow prevention device on the existing 250mm diameter plant service water pipe entering the south side of filter building;
- one (1) reduced pressure type back flow prevention device on the existing 150 mm diameter plant service water pipe at the west end of Module #1's (Filter 1 to 12) pipe gallery;
- two (2) reduced pressure type back flow prevention devices on 50mm diameter bypass lines around both the 150mm and 250mm backflow preventers;
- upgrading of the existing Module No.1's 100mm diameter surface agitator water supply pipe and valves with 150 mm diameter;
- isolation valves, modifications to the associated piping system, controls, electrical and mechanical system for a complete operable system.

all in accordance with the application dated July 16, 2003, report entitled "The City of Hamilton Woodward Avenue Water Treatment Plant Technical Specifications for Contract #1: Gates and Valves Replacement With Controls and Electrical Upgrades" dated July 2003, and engineering drawings all prepared by Hargrave & Burdick consulting engineers.

Proposed Works
(as per application dated August 12, 2003)

<u>Full Scale Testing of Alternate Disinfection System - Project Date Extension</u>
Extension of the full scale pilot facility of an alternate disinfection system at the Woodward Avenue Water Treatment Plant approved under Certificate of Approval No.0949-5AUQ8E dated August 21, 2002. The alternate disinfection system consisting of changing the primary chloramination facility to a system consisting of primary chlorination followed by ammonium hydroxide addition for the maintenance of a combined chlorine residual in the distribution system.

Extend the validity of the certificate as per condition 5 of the certificate No.0949-5AUQ8E dated August 21, 2002, from August 21, 2003 to February 21, 2005.

all in accordance with the application dated August 12, 2003 and supporting documents submitted by Hargrave & Burdick consulting engineers.

Proposed Works
(as per application date April 2, 2003)

<u>Rechlorination / Recirculation Upgrades to Water Storage Facilities</u>
Replacement of the existing manually adjusted chlorination system with a flow and or residual paced disinfection system at the following re-chlorination facilities:

1. <u>Kenilworth Access Pumping Station</u>

- replacement of existing two (2) manually adjusted hypochlorite metering pumps with two (2) residual and or flow paced metering pumps (one duty, one standby), each rated at 108 L/hr;

- installation of two (2) new chlorine residual analyzers, one to measure total chlorine and the other one to measure free chlorine;

- upgrading the existing injection system;

- associated modifications including controls necessary to adjust chemical dosing in relation to flow and residual chlorine levels; and

- modifications to the alarm system and the Supervisory Control and Data Acquisition (SCADA) system.

2. <u>Osler Drive Pumping Station</u>

- replacement of existing two (2) manually adjusted hypochlorite metering pumps with two (2) residual and or flow paced metering pumps (one duty, one standby), each rated at 10.5 L/hr;

- installation of two (2) new chlorine residual analyzers, one to measure total chlorine and the other one to measure free chlorine;

- upgrading the existing injection system;

- associated modifications including controls necessary to adjust chemical dosing in relation to flow and residual chlorine levels; and

- modifications to the alarm system and the Supervisory Control and Data Acquisition (SCADA) system.

3. Lee Smith Reservoir

- replacement of existing two (2) manually adjusted hypochlorite metering pumps with two (2) residual and or flow paced metering pumps (one duty, one standby), each rated at 3.6 L/hr;

- installation of two (2) new chlorine residual analyzers, one to measure total chlorine and the other one to measure free chlorine;

- installation of one (1) 100mm diameter magnetic flow meter;

- upgrading the existing injection system;

- associated modifications including controls necessary to adjust chemical dosing in relation to flow and residual chlorine levels; and

- modifications to the alarm system and the Supervisory Control and Data Acquisition (SCADA) system.

all in accordance with the application for approval dated April 2, 2003, Design Brief, Drawings and report entitled " City of Hamilton Project No. 5140167153 Mandated Plant Improvements Re-Chlorination Systems for HD011-Osler Drive Booster Station HDR00-Lee Smith Reservoir HD005-Kenilworth Booster Station" dated March 2003, all prepared by AWS Engineers and Planners Corp.

Proposed Works
(as per application dated December 3, 2002)

Filter Building Upgrades
1. installation of two (2) 100 mm backflow prevention assemblies in parallel, on Pre-treatment building service water line;

2. twenty four (24) level sensors including transmitters and controls, mounted one at each filter, measuring filter water levels, transmitting information to the existing plant PLC/SCADA system and controlling water levels in each filter during filtering/back-washing operations and protecting against any potential flood condition in filter gallery ;

3. a new 50mm diameter overflow pipe from the hydroflurosilicic acid solution day tank connecting the existing overflow pipe of the bulk storage tank; and

4. re-installation of surface agitators (previously removed during filter media replacement) complete with necessary modifications to the water supply piping system.

all in accordance with the application for approval dated December 3, 2002 and attached documents, dated November 27, 2002, all prepared by Hargrave and Burdick, Environmental Inc.

Proposed Works
(as per application dated March 25, 2002)

Modifications to Flocculation Tank Draining System
- Installation of a diversion gravity sewer c/w flap gate for emptying the existing flocculation tanks in the existing Woodward Avenue Water Treatment Plant for cleaning and inspection and diverting the drainage flows to existing inlet wet

well ahead of the headworks at the Woodward Avenue Wastewater Treatment Plant;
- - Abandoning and capping of the existing discharge piping to the Red Hill Creek;

all in accordance with the design brief and enclosed plans prepared by Dillon Consulting Limited, Consulting Engineers.

Proposed Works
(as per application dated June 12, 2001)

Full Scale Testing of Alternate Disinfection System
installation and operation of a full scale testing of an alternate disinfection system at the Woodward Avenue Water Treatment Plant serving the City of Hamilton, Haldimand and the southern portion of the Region of Halton.

conversion of the existing primary chloramination facility to a system consisting of primary chlorination followed by chloramination facility along with the maintenance of combined chlorine residual in the drinking water distribution system. The new system will be equipped with the following:

Chlorine Applications

- two (2) Gas Chlorine Disinfection Systems, converted from on-site and redundant sulphonator units, each rated 909 kg/d with separate feed lines discharging chlorine solution to the filtrate of each treatment train;

- one (1) Gas Chlorine Disinfection System (standby for both pre and post chlorination systems), new installation, rated 909 kg/d with feed lines discharging chlorine gas to the pre and post chlorine injectors;

- two (2) Chlorine Residual Analyzers, measuring the concentration of the free chlorine residuals, each supplied with continuous water supply from a separate clearwell cell upstream of the proposed ammonium hydroxide application point (near cell effluent) described below, quality control band not to exceed +/- 0.05 mg/L at a chlorine concentration of 1.0 mg/l in the solution or a proportionately wider band where the stream being monitored routinely contains a higher concentration of chlorine and each analyzer complete with 4-20 mA output to ammonium hydroxide metering pumps/SCADA;

- one (1) Chlorine Residual Analyzer, measuring the concentration of total chlorine residuals, connected to one of the two high lift pump discharge headers (the other discharge header is installed with a similar device described below), complete with 4-20 mA output to SCADA and

- two (2) of the existing Chlorine Residual Analyzer units measuring the concentration of total chlorine residuals, each connected to a separate clearwell cell influent, to be converted to measure the concentration of free chlorine residuals at same location, complete with 4-20 mA output to the post disinfection system described above.

Ammonium-hydroxide Application

- two (2) Chemical Solution Tanks for the above ground storage of ammonium hydroxide solution with a total usable volume of approximately 30,200 L, storage facilities complete with a secondary spill containment device, including a scrubber;

- three (3) or more Chemical Metering Pumps (two or more duty and one standby) with feed lines discharging ammonium hydroxide solution to each of the two clearwell cells and/or the high lift pump suction line(s) or the high lift pump discharge header(s) and

- a Control System providing a flow proportional dosage of ammonium hydroxide.

Existing Disinfection System
Note: The following description supersedes the description of disinfection system appended under the heading "*Existing Works (as per First Engineers' Report...dated January 2001..)*"

- one (1) Gas Chlorine Disinfection System for pre-chlorination, rated 2,720 kg/d consisting of a gas injector and eductor system, two in-line centrifugal booster pumps, three V-notch chlorinators each rated 909 kg/d and each complete with a rotameter device, with chemical lines discharging a chlorine solution to the intake as well as upstream of the flocculator device;

- one (1) Gas Chlorine Disinfection System for post-chlorination, rated 450 kg/d and consisting of two V-notch chlorinators, each rated 225 kg/d and two rotameters, with feed lines discharging a chlorine solution to the filtrate of each treatment train;

- three (3) Chlorine Evaporator Devices (two duty and one standby), connected to both the pre- and post-disinfection systems (Woodward Avenue Water Treatment Plant) as well as to the chlorination system at the neighboring Wastewater Treatment Plant, complete with rail car supply and an automatic switch-over system with manual override;

- two (2) Cylinder Weigh Scales, each rated 1,182 kg, complete with vacuum regulator-check valves and automatic cylinder switch-over system (abandoned to be removed);

- a Dechlorination System consisting of two sulphur dioxide evaporator devices (one duty and one standby), each complete with a sulphonator device and a rotameter, rated 800 kg/d, with chemical feed lines discharging sulphur dioxide solution upstream of each clearwell (to be converted to chlorinators);

Note: Each of the two sulphonator units and appurtenances to be converted to a gas chlorine disinfection system (ref. '*Proposed Disinfection System*' above).

- a Anhydrous Ammonia Storage and Dosage consisting of one 12.1 m^3 bulk storage tank, two direct feed ammoniator units each complete with a 136.4 kg/d rotameter, with chemical feed lines discharging the process chemical to upstream and/or downstream of the old sulphur dioxide application points;

- three (3) Chlorine Residual Analyzer (CRA) units measuring the concentration of total chlorine residuals, each connected to a clearwell cell influent and one of the two high lift pump common discharge headers, respectively;

> Note: two of the three CRAs measuring the concentration of total chlorine residuals to be converted to measure the concentration of free chlorine residuals (ref. '*Proposed Disinfection System*' above).

- one (1) Clearwell consisting of two interconnected cells, each baffled, Cell No.1 86.6 m by 33.8 m by 3.1 m side water depth (SWD) with a usable volume of approximately 9,090 m^3, baffled, and Cell No.2 "L" shaped with a usable volume of 18,180 m^3;

- associated equipment, instrumentation and controls, including gas detector and alarm system.

all in accordance with the application dated June 12, 2001, and report entitled 'City of Hamilton, Woodward Avenue Water Treatment Plant Post Chlorination Modifications' prepared by Hargrave & Burdick, Environmental Inc., dated June 13, 2001, as well as additional information and documentation provided in support of the Application.

Proposed Works
(as per application dated March 22, 2000)

Binbrook Water Booster Pumping Station
Installation of an aboveground water booster pumping station located on the East side of Highway 56, approx. 100 m North of Cemetary Road, housing three (3) inline water booster pumps each having a rated capacity of 37.5 L/s at a TDH of approx. 31 m (two duty, one 50 % standby), internal and external piping and valves, pressure gauges, switches and transmitters, bypass piping and valves and an 80 kW natural gas standby generator set together with a separated Chemical Room housing a chlorination system for supplementary chlorination (topping-off) consisting of two (2) metering pumps (one duty, one standby) and one (1) solution tank within containment enclosure, chlorine residual analyzer and sample pump together with piping and valves and sample tap, control panels; forced air venting, heating, control panel; exterior piping and valves including watermeter within an inground chamber with access hatchway inside booster pumping station;

all in accordance with the design brief, plans, and specifications prepared by Aldworth Engineering Inc., Consulting Engineers;

Existing Works
(as per First Engineer's Report entitled, "City of Hamilton, Woodward Avenue Water Treatment Plant Engineer's Report", prepared by Hargrave & Burdick, Environmental Inc. and dated January, 2001, and any additional information and documentation that may have been provided in support of the Report)

a surface water treatment plant located on Woodward Avenue in Hamilton (NAD 83: UTM Zone 17, 599871.00 m E. 4789964.00 m N.) capable of producing 926,000 m^3/d (gross) and 909,000 m^3/d (net), consisting of the following:

Intake Facilities

- one (1) 945 m long, 2440 mm diameter raw water concrete intake pipe at a depth of approximately 9.8 m with a concrete crib at the opening complete with fibreglass bar screens;

- one (1) 640 m long, 1220 mm diameter raw water steel and concrete intake pipe at a depth of approximately 8.0 m with a wooden crib at the opening ;

- one (1) 915 m long, 1520 mm diameter, raw water steel and concrete intake pipe at a depth of approximately 10.4 m with a concrete crib at the opening ;

- a concrete intake conduit chamber into which the 1220 mm and 1520 mm diameter intake pipes join and from which a 1830 mm diameter concrete pipe runs east to the Low Lift Pumping Station intake chamber reducing to a 1520 mm diameter pipe and connecting to the intake chamber with a 1520 mm sluice gate;

Low Lift Pumping Station

- a Low Lift Pumping Station (NAD 83: UTM Zone 17, 599871.00 m E. and 4790512.00 m N.) to transfer water to the Stelco Raw Water Pumping Station and the Woodward Avenue Water Treatment Plant, located approximately 548m north of the Water Treatment Plant (Filter Enclosure Building) just off of Lakeland Beach on Van Wagners Beach Road, having a firm capacity of 1,009,088 m^3/d and consisting of an inlet chamber, bar screens, screen chambers, wet wells, electrical switch-gear and mechanical room, pump room and instrumentation as follows:

- one (1) 15.32 m by 6.1 m inlet chamber into which the 2440 mm diameter intake pipe connects with a 2440 mm sluice gate (north wall), a 2440 mm diameter connection is provided for a future intake (north wall) and the 1830 mm diameter intake pipe from the intake conduit chamber reduces to a 1520 mm pipe and connects with the 1520 mm sluice gate (west wall),

- one (1) set of bar screens, 15.29 m by 5.79 m high, in front of three (3) 2440 mm by 1830 mm sluice gates in the wall between the intake well and water screens,

- three (3) 3.05 m wide, 6.35 mm stainless steel travelling water screens (each with a minimum capacity of 454,000 m^3/d and driven by 1.125 kW motors) each sitting in a screen well 3.4 m wide and 8.53 m deep, with one (1) water screen connected to the west wet well, one (1) water screen connected to the east wet well, and the centre screen connected to both the east and west wet wells,

- two (2) wet wells including an east wet well approximately 31.22 m by 3.96 m by 6.86 m side water depth at maximum water level and a west wet well approximately 26.82 m by 3.96 m by 6.86 m side water depth at maximum water level,

- a 24.69 m by 24.69 m electrical switch-gear and mechanical room which includes a 24.31 m by 4.54 m area with electrical switchgear for the travelling water screens and pumping equipment relocated to a new confined room, (a 3.87 m by 3.30 m boiler room not in use), a 14.22 m by 4.65 m transformer and high voltage room, a 5.26 m by 4.34 m dehumidification equipment room (dehumidification equipment not in use), housing and drives for the three (3) travelling water screens and two (2) intake chlorination system booster pumps each rated at 911 m^3/d at 21.94 m Total Dynamic Head (TDH) with 3.75 kW motors; and

- a 67.94 m by 7.77 m pump room containing three (3) low lift centrifugal pumps with 262.5 kW motors each rated at

227,272 m^3/d at 8.53 m TDH, one (1) low lift centrifugal pump with a 262.5kW motor rated at 260,000 m^3/d at 8.53 m TDH, two (2) low lift centrifugal pumps with 187.5 kW motors each rated at 163,636 m^3/d at 8.53 m TDH, provision for two (2) future low lift centrifugal pumps, two (2) trash pumps with 11.25 kW motors each rated at 11,224 m^3/d at 10.97m TDH to remove any debris in the raw water, two (2) travelling screen jet pumps with 30 kW motors to remove wastewater from the travelling screens, a residual analyzer measuring free chlorine, a pH/ORP (oxidation reduction potential) analyzer, a turbidimeter and a bubble trap regulator located at the raw water intake chamber for testing raw water quality parameters;

Low Lift Pumping Station Transmission Mains and Piping

- a 2130 mm diameter low lift pump discharge collection header along the outside of the south wall of the pumping station to transfer water to the treatment plant, with connections provided for the existing 1520 mm and 2130 mm, and a future 2740 mm, diameter raw water mains;

- a 2130 mm diameter discharge pipe that wyes off of the discharge header and crosses under the Queen Elizabeth Highway, under Burlington Street, and under Red Hill Creek;

- a 1520 mm diameter discharge pipe that wyes off of the discharge header and runs parallel to the 2130mm diameter discharge pipe crossing under the Queen Elizabeth Highway, under Burlington Street, and under Red Hill Creek, into a valved cross fitting;

- a valved cross fitting which allows connection from the 2130 mm discharge pipe to a 1370 mm suction pipe for the Stelco Raw Water Pumping Station;

- associated valves and piping to feed the two modules of the water treatment plant and allow sections of the piping to be isolated for maintenance;

- two (2) venturi flow meters to monitor flow to each water treatment plant module;

- a 1200 mm diameter carrier pipe (abandoned intake) running easterly to the Low Lift Pumping Station, used to carry the two intake chlorine solution lines, that increases in size at a manhole to a 1520mm diameter corrugated metal pipe just west of the Low Lift Pumping Station;

- a 300 mm diameter trash chamber discharge line that runs from the Low Lift Pumping Station adjacent to the 1200 mm diameter carrier pipe and discharges to Red Hill Creek;

Pre-treatment

- a pretreatment system located underground upstream of the main Water Treatment Plant (Filter Enclosure Building) into which raw water from the Low Lift Pumping Station enters, including a raw water inlet well for each of the two (2) pretreatment modules which, combined, consist of four (4) rapid mixing tanks, four (4) primary and secondary stage flocculation tanks and four (4) sedimentation tanks as follows:

Rapid Mix Tanks

- four (4) three (3) stage concrete rapid mix tanks (two sets for each pretreatment module), with a combined capacity of 926,300 m^3/d, consisting of three (3) 3.20 m long by 3.05 m wide by 3.96 m side wall depth cells per rapid mix tank and 18.75 kW vertical turbine mixers in the first two stages of each section of the rapid mix tanks, with provision for a future mixer in the third stage;

Flocculation Tanks

- four (4) two (2) stage concrete flocculation tanks (two flocculation tanks for each pretreatment module) with a combined capacity of 926,300 m^3/d, each stage baffled into three (3) parallel cells 10.97 m long by 11.05 m wide by 5.76 m side water depth, the first stage having three (3) 7.5 kW vertical turbine mixers in each flocculation tank (one in each cell) the second stage having 3.75 kW turbine mixers in each flocculation tanks (one on each cell);

Sedimentation Tanks

- four (4) concrete sedimentation tanks (two sedimentation tanks for each pretreatment module), each tank 80.46 m long by 33.83 m wide by 4.11 m side water depth, having a combined rated capacity of 926,300 m^3/d;

Main Plant Enclosure Building

- a Filter Enclosure Building located on Woodward Avenue in Hamilton (NAD 83: UTM Zone 17, 599871.00 m E. and 4789964.00 m N.) that houses filters, backwash water pumps and associated control room, offices, staff and laboratory facilities as follows:

Filters and Backwash Facilities

- twenty-four (24) dual media (granular activated carbon/sand) rapid rate filters having a total rated filtration capacity of 926,300 m^3/d, consisting of two (2) 13.72 m long by 4.88 m wide concrete cells for each filter (providing 133.9 m^2 filter area per filter), clay block under-drains, one (1) 2.44 m by 2.13 m high filtered water concrete conduit from Module 1 (Filters 1-12) exiting the filter building in the area between the two filter modules and extending south to Clearwell No.1, where a weir at the inlet to Clearwell No. 1 controls the low water level in the filter, along with a Clearwell No.1 bypass conduit to the High Lift Pumping Station suction conduit, one (1) 3.05 m by 2.13 m high filtered water concrete conduit from Module 2 (Filters 13-24) exiting the filter building on the east end and extending south and south-east to the Clearwell No.2 inlet structure (which is also connected to Clearwell No.1), where a weir at the inlet to Clearwell No. 2 controls the low water level in the filters, four (4) split case centrifugal backwash pumps to fill the backwash tower including two (2) centrifugal pumps with 112.5 kW motors operating at 302.8 L/s at 27.44 m TDH and two (2) double suction centrifugal pumps operating at 87.89 L/s at 21.34m TDH and one (1) 760 m^3 backwash water storage tower;

Clearwells

- two (2) clearwells downstream of the Filter Enclosure Building providing finished water storage including one (1) 9,090 m^3 concrete reservoir (Clearwell No. 1), 86.56 m long by 33.83 m wide by 3.05m side water depth with a baffle wall running north to south from the north wall at the centre of the clearwell and an interconnecting gated opening with Clearwell No.2 and one (1) 18,180 m^3 "L" shaped concrete reservoir (Clearwell No. 2), 89 m long by 36.57 m wide by 3.05 m side water depth along one side and 64.61 m long by 42.67 m wide by 3.05 m side water depth with an intra-basin baffle wall;

High Lift Pumping Station

- a High Lift Pumping Station which pumps treated water to Pressure District 1, located west of the Filter Enclosure Building, having a firm capacity of 569,400 m^3/d with provision for future expansion, equipped with one (1) centrifugal pump rated at 68,000 m^3/d at 80.16 m TDH with a 750 kW motor, three (3) centrifugal pumps rated at 114,400 m^3/d at 80.16 m TDH with 1312.5 kW motors, one (1) centrifugal pump rated at 159,000 m^3/d at 71.62 m TDH with a 1500 kW motor and one (1) centrifugal pump rated at 158,200 m^3/d at at 71.62 m TDH, equipped with a 1500 kW motor;

Other Plant Enclosure Buildings

Chlorine Building

- a Chlorine Building, located on the south side of the Filter Enclosure Building that includes a chlorine scrubber room and a feed equipment room (with a crawl space) that houses chlorination feed equipment for both the water and wastewater treatment plants.

Pre-Chlorination/Coagulant Enclosure Building

- a Pre-chlorination/Coagulant Enclosure Building, located on the northwest corner of the water plant site, housing coagulant storage and feed equipment as well as the intake system chlorine injector;

Fluoride System Enclosure Building

- a Fluoride System Enclosure Building located south of the Chorine Building, housing hydrofluosilicic acid day storage and feed and transfer equipment;

Surge Suppressor Valve Enclosure Building

- a Surge Suppressor Valve Enclosure Building, located at the southwest corner of the High Lift Pumping Station, housing two (2) 1200 mm diameter water mains that pass through the basement, two (2) 355 mm surge relief valves, one (1) air/vacuum relief valve, 500 mm diameter surge pipe and associated valves, piping, and fittings;

Disinfection Systems
Note: The following description, superseded by the 'Existing Disinfection System" described under the heading "***Proposed Works*** *(as per application dated June 12, 2001) Full Scale Testing of Alternate Disinfection System"*

- one (1) gas chlorine disinfection system for intake and pre-chlorination, located in the Chlorine and Sulphur Dioxide Enclosure Building, able to inject chlorine at the mouth of 2440 mm diameter intake via a 2720 kg/d chlorine gas injector and eductor located in the Pre-chlorination/Coagulant Enclosure Building, two (2) in-line centrifugal booster pumps with 3.75 kW motors located in the Low Lift Pumping Station and diffusers at the intake and to both pretreatment modules via injectors, eductors and diffusers located upstream of each module, consisting of three (3) V-Notch chlorinators with 909 kg/d rotameters with one (1) chlorinator feeding the intake system and one (1) chlorinator alternatively capable of augmenting post-chlorination capacity;

- one (1) gas chlorine disinfection system for post chlorination located in the Chlorine and Sulphur Dioxide Enclosure Building, able to inject chlorine via injectors, eductors and diffusers upstream of each clearwell, consisting of two (2) V-notch chlorinators with 225 kg/d rotameters;

- three (3) 3636 kg/d chlorine evaporators (two duty and one stand-by), located in the Chlorine and Sulphur Dioxide Enclosure Building, connected to the Wastewater Treatment Plant chlorinators for chlorination of Wastewater Treatment Plant effluent and interconnected with the Water Treatment Plant pre-treatment and post-treatment chlorinators to augment the pre-chlorination capacity, along with piping and appurtenances to connect the evaporators to two (2) 90 tonne rail cars containing liquid chlorine, complete with a manual switch-over system (automatic switch-over system is installed switch-over);

- two (2) cylinder weigh scales with a capacity of 1182 kg, located in the Chlorine and Sulphur Dioxide Enclosure Building, complete with vacuum regulator-check valves and automatic cylinder switch-over system;

- two (2) 3636 kg/d sulphur dioxide evaporators (1 duty, 1 stand-by) for chlorine concentration control, located in the Chlorine and Sulphur Dioxide Enclosure Building, able to inject sulphur dioxide via injectors, eductors and diffusers upstream of each clearwell, complete with two (2) sulphonators with 800 kg/d rotameters.;

- one (1) anhydrous ammonia disinfection system for conversion of free chlorine to monochloramine, able to inject ammonia immediately upstream (one module only) and downstream (modules 1 and 2) of the sulphur dioxide feed points, consisting of one (1) 12.1 m^3 capacity bulk storage steel tank located on the east side of the Filter Enclosure Building, one (1) direct feed ammoniator located at the loading bay in the center of the Filter Enclosure Building for Filter Module No. 1, equipped with a 136.4 kg/d rotameter, 25mm ammoniator and diffusers and one (1) direct feed ammoniator located at the east end of the Filter Module No. 2 Pipe Gallery for Filter Module No. 2, equipped with a 136.4 kg/d rotameter, 50 mm ammoniator and diffusers;

- two (2) post chlorine residual analyzers for continuous measurement of total chlorine residual in treated water;

- associated equipment, instrumentation and controls, including gas detector and alarm system;

Chemical Storage and Feed Systems

- a coagulant feed system consisting of two (2) 4.27 m diameter wood stave coagulant storage tanks having a capacity of 54.7 m^3, two (2) coagulant feed metering pumps (one duty; one stand-by), with 0.25 kW motors each rated at 75.6 L/hr at 690 kPa, one (1) coagulant feed metering pump, with a 0.375 kW motor rated at 83 L/hr at 1030 kPa and two (2) 18 mm coagulant feed pipes through the east-west tunnel to 38 mm diffusers just upstream of the rapid mixers;

- a fluoridation system, capable of injecting hydrofluosilicic acid via diffusers installed upstream of the both clearwells, consisting of one (1) 45.0 m^3 insulated heat-traced hydroflurosilicic acid storage tank installed outside within a containment structure with handrail, adjacent to the existing Fluoride System Enclosure Building together with all associated piping and valves, one (1) 1894 L fibre-reinforced plastic day tank together with piping, valves, containment curb and exhaust fan, one (1) transfer pump with a 0.75 kW motor; three (3) chemical feed pumps each rated at 156 L/hr at 600 kPa with 0.56 kW motors and all associated safety equipment;

Chlorine Scrubber System

- a chlorine scrubber system, located in the chlorine scrubber room of the Chlorine and Sulphur Dioxide Enclosure Building, consisting of one (1) 2780 L wood stave tank for storage of potassium hydroxide, one (1) 594 L plastic tank, one (1) pump with a 5.63 kW motor, 50 mm PVC suction and discharge piping and one (1) scrubber unit;

Surge Protection System

- a surge protection system, located approximately 125 m west of the High Lift Pumping Station, approximately 25 m north of the private access road and approximately 15 m north of the 2250 mm watermain consisting of one (1) approximately 700 m^3 elevated standpipe with two concentric tanks approximately 28.5 m above grade, 11.0 m diameter outer tank and approximately 6.25 m diameter inner tank, with a common overflow weir box and 500 mm stainless steel overflow pipe and both with side water depths of 7.42 m, two (2) sets of riser pipes (one for each tank), each equipped with an altitude valve, associated valves and piping, flow meters, and pressure sensors and two (2) sets of check valves which sense the loss of pressure in the system and open to fill the system with water to prevent column separation and cavitation.

Waste Treatment

- wastewater transfer facilities to transfer backwash water and settled sludge to the adjacent wastewater treatment plant;

- together with all associated piping, electrical and mechanical equipment, ventilation, monitoring, control, metering , alarm systems and instrumentation;

Re-chlorination Facilities

- a re-chlorination system serving the same service area as the water treatment plant, comprised of the following:

Facilities To Re-chlorinate and Transfer Water From Pressure District 1

- Kenilworth Access Pumping Station (NAD 83: UTM Zone 17, 595750.00 m E., 4787338.00 m N.), adjacent to Kenilworth Access Reservoir and equipped with one (1) 34,100 m^3/d pump and three (3) 45,500 m^3/d pumps, complete with a re-chlorination system, located in a separate room within the pumping station, consisting of one (1) 7600 L polyethylene sodium hypochlorite storage tank and two (2) 78.8 L/hr chemical metering pumps (one duty; one standby) along with associated valves, piping, injection point and diffuser;

- Greenhill Avenue Pumping Station (NAD 83: UTM Zone 17, 599397.00 m E., 4784945.00 m N.), adjacent to Greenhill Avenue Reservoir and equipped with one (1) 22,700 m^3/d pump and two (2) 75,000 m^3/d pumps, complete with a re-chlorination system, located in two separated rooms adjacent to the pumping station consisting of a chlorine storage room capable of storing ten (10) 909 kg cylinders and with three (3) 909 kg cylinder weigh scales with vacuum regulators and an automatic cylinder switch-over system and a chlorinator room with one (1) duty 45.4 kg/d chlorinator and one (1) stand-by 90.8 kg/d chlorinator, feeding chemical to the pump suction line, along with associated valves, piping and total chlorine residual analyzer;

Facilities To Re-chlorinate and Transfer Water From Pressure District 2

- Osler Drive Pumping Station (NAD 83: UTM Zone 17, 586069.00 m E., 4790104.00 m N.), equipped with three (3) 7845 m^3/d pumps, complete with a re-chlorination system, located in the pumping station, consisting of four (4) 1200 L polyethylene storage tanks and one (1) 3.6 L/hr metering pump along with associated valves, piping, injection point and diffuser;

- York Road Pumping Station (NAD 83: UTM Zone 17, 587075.00 m E., 4793551.00 m N.), equipped with four (4) in-line pumps, two rated at 4,530 m^3/d and two rated at 8,880 m^3/d, complete with a re-chlorination system, located in an enclosure within the pumping station building, consisting of one (1) 200 L polyethylene storage tank and two (2) 8.4 L/hr chemical metering pumps (one duty and one stand-by) along with associated valves, piping, injection point, diffuser and chlorine analyzer with automatically controlled chlorine addition;

Facilities To Re-chlorinate Water In Pressure District 22

- Lee Smith Reservoir, a 270 m^3 storage reservoir (NAD 83: UTM Zone 17, 581689.00 m E., 4787031.00 m N.), complete with a re-chlorination system consisting of two (2) 400 L sodium hypochlorite storage tanks and one (1) chemical metering pump along with associated valves, piping, and injection point and diffuser immediately upstream of the reservoir;

Miscellaneous

portable chlorinators for use as required throughout the entire system, all associated piping, electrical and mechanical equipment, ventilation, monitoring, control, metering, alarm systems and instrumentation;

1.2 all in accordance with the applications and plans and other supporting documents listed in Schedule "A", and all other Schedules, which are attached to, and form part of this approval, except as specified in the conditions contained herein.

PART 2 - DEFINITIONS AND INFORMATION

2.1 Words and phrases not defined in this approval shall be given the same meaning as those set out in the *Safe Drinking Water Act, 2002*, S.O. 2002, c. 32 and any regulations made in accordance with that act, unless the context requires otherwise.

2.2 In this approval

“adverse effect”, "contaminant", “impairment” and “natural environment” shall have the same meanings as in the *Environmental Protection Act*, R.S.O.1990, c. E.19 and the *Ontario Water Resources Act,* R.S.O.1990, c. O.40;

"approval" means this entire approval document, issued in accordance with section 36 of the *SDWA,* and includes any schedules to it;

"Director" means a Director appointed pursuant to s. 6 of the *SDWA* for the purposes of Part V of the *SDWA*;

"drinking-water system" includes the works set out in Part 1;

"operating authority" and "owner" mean, in addition to the respective meanings given in the Act, City of Hamilton;

"provincial officer" means a provincial officer appointed pursuant to s. 8 of the *SDWA*;

“rated capacity” means the maximum flow rate of water which can be treated when operating the drinking-water system under design conditions;

"*SDWA"* means the *Safe Drinking Water Act, 2002, S.O. 2002, c. 32,* as amended.

"Equipment" means the diesel generator set described in the Owner's application, this Certificate and in the supporting documentation submitted with the application, to the extent approved by this Certificate;

“Publication NPC-205" means Ministry Publication NPC-205, Sound Level Limits for Stationary Sources in Class 1 & 2 Areas (Urban), October, 1995; and

“Publication NPC-232" means Ministry Publication NPC-232, Sound Level Limits for Stationary Sources in Class 3 Areas (Rural), October, 1995.

PART 3 - GENERAL

Compliance

3.1 The owner and operating authority shall operate the drinking-water system in accordance with the *SDWA*, any applicable regulations made thereunder, and this approval.

3.2 Despite any condition of this approval to the contrary, the owner and operating authority set out in Part 2 are jointly and severally liable to comply with all conditions of this approval.

3.3 The owner and operating authority shall ensure that any person authorized to carry out work on or operate any aspect of the drinking-water system has been informed of the *SDWA*, all applicable regulations made in accordance with that act, and this approval and shall take all reasonable measures to ensure any such person complies with the same.

3.4 A copy of this approval shall be kept in a conspicuous place so that it is available for reference by all persons responsible for all or part of the operation of the drinking-water system.

Build, etc. in Accordance

3.5 Except as otherwise provided by this approval, the drinking-water system shall be designed, developed, built, operated and maintained in accordance with Part 1 above and the documentation listed in Schedule “A".

Interpretation

3.6 Where there is a conflict between the provisions of this approval and any other document, the following hierarchy shall be used to determine the provision that takes precedence:

i. The *SDWA*;

ii. a condition imposed in this approval in accordance with s. 38 of the *SDWA*;

iii. any regulation made under the *SDWA*;

iv. this approval;

v. any application documents listed in Schedule "A" from most recent to earliest; and

vi. all other documents listed in Schedule "A" from most recent to earliest.

3.7 The requirements of this approval are severable. If any requirement of this approval, or the application of any requirement of this approval to any circumstance, is held invalid or unenforceable, the application of such requirement to other circumstances and the remainder of this approval shall not be affected thereby.

3.8 Nothing in this approval shall be read to provide relief from the need for strict compliance with the *Environmental Assessment Act,* R.S.O. 1990, c E.18.

Other Legal Obligations

3.9 The issuance of, and compliance with the conditions of, this approval does not:

i. relieve any person of any obligation to comply with any provision of any applicable statute, regulation or other legal requirement; or

ii. limit in any way the authority of the Ministry to require certain steps be taken or to require the owner to furnish any further information related to compliance with this approval.

3.10 For greater clarity, nothing in this approval shall be read to provide relief from regulatory requirements in accordance with section 38 of the *SDWA*, except as provided in Part 9.

Adverse Effects

3.11 Nothing in this approval shall be read as to permit: i) the discharge of a contaminant into the natural environment that causes or is likely to cause an adverse effect; or ii) the discharge of any material of any kind into or in any waters or on any shore or bank thereof or into or in any place that may impair the quality of the water of any waters.

3.12 All reasonable steps shall be taken to minimize and ameliorate any adverse effect on the natural environment or impairment of the quality of water of any waters resulting from the operation of the drinking-water system including such accelerated or additional monitoring as may be necessary to determine the nature and extent of the effect or impairment.

3.13 Fulfillment of one or more conditions imposed by this approval does not eliminate the requirement to fulfill any other condition of this approval or the requirements of any applicable statute, regulation, or other legal requirement resulting from any act or omission that causes or is likely to cause an adverse effect on the natural environment or the impairment of water quality.

Change of Owner

3.14 The owner or the operating authority, as the case may be, shall notify the Director, in writing, of any of the following changes within 30 days of the change occurring:

i. change of owner or operating authority;

ii. change of address;

iii. change of partners where the owner is or at any time becomes a partnership, and a copy of the most recent declaration filed under the Business Names Act, R.S.O. 1990, c. B17; or

iv. change of name of the corporation where the owner or operating authority is or at any time becomes a corporation, and a copy of the most current information filed under the Corporations Information Act, R.S.O. 1990, c. C.39.

3.15 In the event of any change in ownership of the drinking-water system, other than change to a successor municipality, the owner shall notify the successor of and provide the successor with a copy of this approval, and the owner shall provide a copy of the notification to the district manager of the local office of the Ministry and the Director.

Inspections

3.16 No person shall hinder or obstruct a provincial officer in the performance of his or her duties, including any and all inspections authorized by the *SDWA*.

Information

3.17 Any information requested, by the Ministry, concerning the drinking-water system and its operation under this approval, including but not limited to any records required to be kept by this approval shall be provided to the Ministry, upon request.

3.18 Records required by or created in accordance with this approval, unless specifically referenced in s. 12 of O. Reg. 170/03, shall be retained for at least 5 years in a location where a provincial officer who is inspecting the treatment system can conveniently view them.

PART 4 - PERFORMANCE

Rated Capacity

4.1 The drinking-water system shall not be operated to exceed the rated capacity for the maximum flow rate into the treatment system of 10.72 m^3/s (926,000 cu.m/d)

Increase to Rated Capacity

4.2 Despite condition 4.1, the drinking water system may be operated at a rate above the rated capacity set out in condition 4.1 where necessary for:

i. fighting a large fire; or

ii. the maintenance of the drinking-water system.

4.3 Condition 4.2 shall not be construed to allow drinking-water to be supplied that does not meet all other applicable standards and legal requirements.

4.4 The Owner shall ensure that the noise emissions from the Equipment comply with the limits set out in Publication NPC-205 or NPC-232, as applicable.

PART 5 - MONITORING AND RECORDING

Flow measuring devices

5.1 Install a sufficient number of flow-measuring devices within the drinking-water system to permit continuous measurement and recording of:

i. the flow rate and daily volume of water conveyed into the treatment system; and

ii. the flow rate and daily volume of water conveyed from the treatment system to the distribution system.

5.2 Records shall be maintained that set out the parameters recorded in accordance with condition 5.1, and where a measured flow rate into a treatment system, train, or stage exceeds the maximum flow rate set out for that treatment system, train, or stage in Part 4, the amount, date, time and duration of the exceedence shall also be recorded.

Calibration of flow measuring devices

5.3 All flow measuring devices must be checked and calibrated in accordance with the manufacturer's instructions.

5.4 If the manufacturer's instructions do not indicate how often to check and calibrate the flow measuring devices, the equipment must be checked and calibrated at least once every year during which the drinking-water system is in operation.

Additional Sampling - Management of Residue

5.5 In addition to any other sampling and analysis that may be required, sampling and analysis shall be undertaken for the parameters listed in **Table 1**, in the event the Red Hill Creek discharge takes place.

Table 1 Management of Residue Sampling

Item	Parameter	Type	Location
1.	Suspended Solids	Grab	Point of discharge
2.	Residual Chlorine	Grab	Point of discharge

PART 6 - OPERATIONS AND MAINTENANCE

Chemical standards

6.1 All chemicals and materials used in the operation of the drinking-water system that come into contact with water within the system shall meet all applicable standards set by both the American Water Works Association ("AWWA") and the American National Standards Institute ("ANSI") safety criteria standards NSF/60 and NSF/61.

6.2 The most current chemical and material product registration documentation from a testing institution accredited by either the Standards Council of Canada or by the American National Standards Institution shall be available at all times for each chemical and material used in the operation of the drinking-water system that comes into contact with water within the system.

6.3 Condition 6.2 does not apply in the context of any particular chemical or material where the Owner has written documentation signed by the Director that indicates that the Ministry is satisfied that the chemical or material is acceptable for use within the drinking-water system and that chemical or material is only used as permitted by the documentation.

Operations manual

6.4 An up-to-date operations manual shall be maintained and available for reference by all persons responsible for all or part of the operation of the drinking-water system.

6.5 The operations manual shall include at a minimum:

i. the requirements of this approval and associated procedures;

ii. the operation and maintenance recommendations from the most recent engineers' report;

iii. procedures for the monitoring and recording of in-process parameters necessary for the control of the treatment system and assessing the performance of the drinking-water system;

iv. procedures for the operation and maintenance of monitoring equipment;

v. contingency plans and procedures for the provision of adequate equipment and material to deal with emergencies, upset and equipment breakdown;

vi. procedures for the dealing with complaints related to the drinking-water system, including the recording of the nature of the complaint and any investigation and corrective action taken in respect of the complaint;

6.6 Procedures necessary to the operation of any physical alterations of the drinking-water system shall be incorporated into the operations manual prior to the alterations coming into operation and other sections in the operations manual shall be updated within one year of the substantial completion of the alteration and shall be retained and made available readily for inspection by the ministry staff.

Drawings

6.7 Up-to-date Process Flow Diagrams (PFD) and Process and Instrumentation Diagrams (P&ID) for the treatment system shall be kept on site at the drinking water system.

6.8 All drawings and diagrams in the possession of the owner or operating authority that show the treatment system as constructed shall be retained.

6.9 An alteration to the treatment system shall be incorporated into Process Flow Diagrams (PFD), Process and Instrumentation Diagrams (P&ID), and record drawings and diagrams within one year of the substantial completion of the alteration and shall be retained and shall be made readily available for inspection by Ministry staff.

Equipment (Diesel Generator Set)

6.10 The Owner shall ensure that the Equipment is properly operated and maintained at all times.

i. The Owner shall prepare, not later than three (3) months after the date of this Certificate or the date of commissioning of the Equipment, and update, as necessary, a Manual outlining the operating procedures and a maintenance program for the Equipment, including:

(a) routine operating and maintenance procedures in accordance with good engineering practices and as recommended by the Equipment suppliers;

(b) emergency procedures;

(c) procedures for any record keeping activities relating to operation and maintenance of the Equipment;

(d) all appropriate measures to minimize noise and odorous emissions from all potential sources;

ii. implement the recommendations of the Manual; and

iii. retain, for a minimum of two (2) years from the date of their creation, all records on the maintenance, repair and inspection of the Equipment, and make these records available for review by staff of the Ministry upon request.

PART 7 - FUTURE ALTERATIONS

Approved future alterations

7.1 *Not Applicable*

Certificate of compliance

7.2 *Not Applicable*

PART 8 - STUDIES AND UPGRADES REQUIRED

8.1 Subject to Condition 8.2 below, on or before October 31, 2006, the Owner shall implement the following physical improvements to the works, in keeping with the recommendations of the Engineer's Report and related correspondence:

(i) provide automatic switch over and alarm to ensure continuous chlorination.

Requirement not an approval

8.2 The owner shall not construct any works required by this part until all associated approvals, licenses and permits have been obtained from the Ministry.

PART 9 - RELIEF FROM REGULATORY REQUIREMENTS

Relief from regulatory requirements

9.1 Notwithstanding the provisions of O. Reg. 170/03, amended by O.Reg 253/05
the Owner is not required to comply with the following:

- Record the minimum and maximum of test readings taken by a residual chlorine analyzer for a period of 5 minutes required in accordance with Schedule 6, section 6-5 (1) 2.i;

- Record the minimum and maximum of test readings taken by a turbidity meter installed on the effluent line of a filter for a period of 15 minutes required in accordance with Schedule 6, section 6-5 (1) 2.i;

- Minimum alarm standard of 0.1mg/L less than the concentration of free/combined chlorine residual that is required to achieve primary disinfection required by a residual analyzer measuring primary disinfection, in accordance with Schedule 6, section 6-5 (1) 5;

- Maximum alarm standard of 1 NTU required for turbidity meter in accordance with Schedule 6, section 6-5 (1) 5; and

- A consecutive reading of 1 NTU measured in a filter effluent, described in paragraph 6, Section 16-3 of Schedule 16, defining adverse result.

Conditions in exchange for relief from regulatory requirements

9.2 For the purposes testing, recording and setting alarms for continuous monitoring equipments required under Section 6-5 (1), the owner shall install chlorine residual analyzer and turbidity meter, as follows:

a chlorine residual analyzer that monitors primary disinfection:
- is capable of polling every 1 minute but averages the reading for every 5 minutes interval and records the reading;
- a "Low" alarm is set at 20% higher than the concentration of free/combined chlorine residual that is required to achieve primary disinfection;
- a “Low Low” alarm is set at the concentration of free/combined chlorine residual that is required to achieve primary disinfection and reported to MOE SAC as an “adverse reading”;
- a “High” alarm is set at 3 mg/L and a “High High” alarm is set at 4 mg/L

A turbidity meter measuring turbidity of the filter effluent:
- is capable of polling every 1 minute and averaging the readings for every 15 minutes and records the reading.
- a "High" alarm is set at 0.8 NTU;
- a “High High” alarm is set at 0.9 NTU;

9.3 For the purpose Schedule 6, section 6-5 (1) 5, the following are considered as minimum / maximum alarm standards for the continuous monitoring equipment:

i. Minimum alarm standard required by a residual chlorine analyzer measuring primary disinfection is set at a concentration equal to free/combined chlorine residual that is required to achieve primary disinfection; and

ii. Maximum alarm standard required by a turbidity meter measuring filter effluent is set at 0.9.

9.4 For the purposes of Section 18 of the SDWA, in addition to the instances identified by Section 16-3 of Schedule 16, and subject to condition 9.2 above, if a report under subsection 18(1) of the Act has not been made in respect of turbidity in the preceding 24 hours, the following shall be considered as adverse results of a drinking-water test:

i. A result indicating that turbidity exceeds 0.9 Nephelometric Turbidity Unit (NTU) in two samples of water from a filter effluent line that are tested by continuous monitoring equipment, if the two samples were taken 15 minutes or more apart and the latter of the two samples was the first sample that was taken 15 minutes or more after the earlier sample.

The following supporting documents form part of this approval.

1. Application dated March 19, 2007
Design Brief entitled " Upcountry Estates Water Booster Pumping Station" dated February 2007, prepared by Hatch Mott MacDonald
- Correspondence dated March 20, 2007 from Hatch Mott MacDonald
- E-mail dated May 2, 2007 from Hatch Mott MacDonald

2. Application dated September 7, 2006
- Correspondence dated September 25, 2006, from Hargrave and Burdick
- Report entitled "City of Hamilton Woodward Avenue Water Treatment Plant Alternate Disinfection System Monitoring Report for the Ministry of Environment" dated September 2006, prepared by Hargrave & Burdick.
-E mail dated October 16, and 17, 2006, from Chuck R.Burdick, Hargrave and Burdick

3. Application dated November 15, 2005
- Correspondence dated October 26, 2005, from Hargrave and Burdick
- E mails dated December 4, 2005, December 7, 2005 and December 8, 2005 from Chuck R.Burdick, Hargrave and Burdick
- Email dated December 8, 2005, from Dan Chauvin, City of Hamilton
-E mail dated May 18, 2006, from Chuck R.Burdick, Hargrave and Burdick

- Correspondennce dated December 19, 2005, from the City of Hamilton
- Correspondennce dated December 22, 2005, from the City of Hamilton
- Email from Abdul Khan, M.Sc. Eng., MBA., P.Eng., dated February 24, 2006
- Email from Abdul Khan, M.Sc. Eng., MBA., P.Eng., dated March 14, 2006

Application dated January 25, 2006 for a dry type scrubber
- Correspondennce dated January 25, 2005, from the City of Hamilton

Application dated February 16, 2006
- Correspondennce dated February 21, 2006, from Totten Sims Hubicki Associates-

Application dated March 27, 2006
- Correspondence dated April 24, 2006, from KMK Consultants Ltd.
- Design brief entitled " Hamilton Elevated Tanks Repairs and Upgrades" dated April 6, 2006, by KMK Consultants Limited
- E mails dated August 30, 2006 and September 5, 2006 from Arbinder Hundal, P.Eng., KMK Consultants Ltd.

Application dated April 12, 2006
- Correspondence dated April 11, 2006, from Hargrave and Burdick
- E mails dated June 29, 2006, July 14, 2006 and July 28, 2006 from Hargrave and Burdick
- Correspondence dated July 28, 2006, from Hargrave and Burdick
- E mail dated July 31, 2006 from Hargrave and Burdick attaching:
- Correspondence dated July 31, 2006; and
- P&IDs of regulatory instruments

Application dated May 30, 2006
- Correspondence dated June 1, 2006, from KMK Consultants Ltd.
- Design brief dated April 2006 prepared by KMK Consultants Ltd.
- Drawings dated April 2006 prepared by KMK Consultants Ltd.

- Email from Abdul Khan, M.Sc. Eng., MBA., P.Eng., dated September 13, 2006

4. Application dated November 29, 2004
- Correspondence dated November 29, 2004 signed by Dan Chauvin, C.E.T., City of Hamilton

Application dated January 28, 2005

- Correspondence dated January 27, 2005, signed by W.H. Don, P.Eng., R.V.Anderson Associates Limited
- Correspondence dated February 23, 2005, signed by Pierre Solda, C.E.T, City of Hamilton
- Correspondence dated March 7, 2005, signed by W.H. Don, P.Eng., R.V.Anderson Associates Limited
- Report entitled "City of Hamilton Design Brief for Woodward Avenue Water Treatment Plant Chlorine Building Upgrade" dated January 28, 2005, prepared by R.V.Anderson Associates Limited

Application dated February 9, 2005
- Correspondence dated February 14, 2005, signed by Caroline Korn, P.Eng, Associated Engineering (ONT) Ltd.
- Report entitled " Design Brief City of Hamilton Woodward Avenue WTP Coagulation System Upgrades" dated February 2005, prepared by Acres and Associated Environmental Limited
- Specifications dated February 2005, prepared by Acres and Associated Environmental Limited
- Drawings dated February 2005, prepared by Acres and Associated Environmental Limited

Application dated February 14, 2005
- Correspondence dated February 14, 2004, signed by Chuck R. Burdick, M.Eng., P.Eng.,
- E Mail dated May 25, 2005 from Dan Chauvin, City of Hamilton

Application dated June 19, 2005
- Correspondence dated August 2, 2005, signed by Mike Elliot, project Manager, KMK Consultants
- Report entitled City of Hamilton Fifty Road Pumping Station Rechlorination Upgrades Design Report" dated July 2005, prepared by KMK Consultants
- Specifications and drawings dated July 2005, prepared by KMK Consultants
- Email dated August 29, 2005, from Mike Elliot, KMK Consultants

- Correspondence dated August 4, 2005, from Jim Harnum, Senior Director, Water and Wastewater Division, City of Hamilton
- E mails dated August 12, 18, 19 and 25 from Abdul Khan Director, Water and Wastewater Division, City of Hamilton

5. The original applications for approval, including design calculations, engineering drawings and reports, and other supporting documents prepared in support of any previous certificate(s) of approval issued for any works now approved and replaced by this approval, unless this approval states otherwise.

This Certificate of Approval revokes and replaces Certificate(s) of Approval No. 7697-6UGKWB issued on October 19, 2006

All or part of this decision may be reviewable in accordance with the provisions of Part X of the SDWA. In accordance with Section 129(1) of the Safe Drinking Water Act, Chapter 32 Statutes of Ontario, 2002, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this notice, require a hearing by the Tribunal. Section 129(2) sets out a procedure upon which the 15 days may be extended by the Tribunal. Section 129(3) of the Safe Drinking Water Act, Chapter 32 Statutes of Ontario, 2002, provides that the Notice requiring the hearing shall state:

1. The aspect of the decision, including the portion of the permit, licence, approval, order or notice of administrative penalty in respect of which the hearing is required; and
2. The grounds for review to be relied on by the person at the hearing.

Except with leave of the Tribunal, a person requiring a hearing in relation to a reviewable decision is not entitled to,
(a) a review of an aspect of the decision other than that stated in the notice requiring the hearing; or
(b) a review of the decision other than on the grounds stated in the notice

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary*
Environmental Review Tribunal
2300 Yonge St., Suite 1700
P.O. Box 2382
Toronto, Ontario
M4P 1E4

AND

The Director
Part V, *Safe Drinking Water Act, 2002*
Ministry ofthe Environment
2 St. Clair Avenue West, Floor 12A
Toronto, Ontario
M4V 1L5

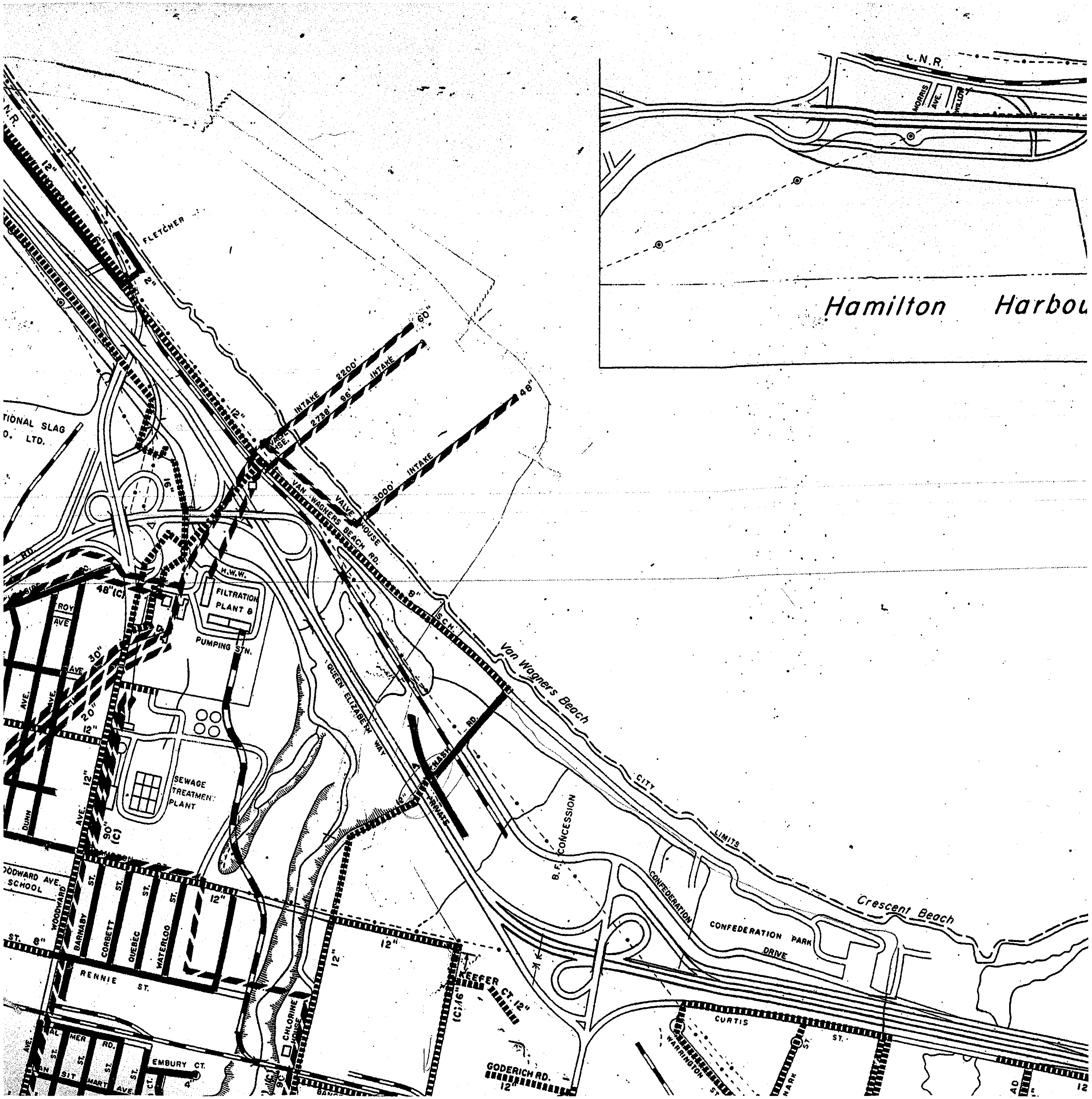
*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted water works are approved under Part V of the Safe Drinking Water Act.

DATED AT TORONTO this 17th day of May, 2007

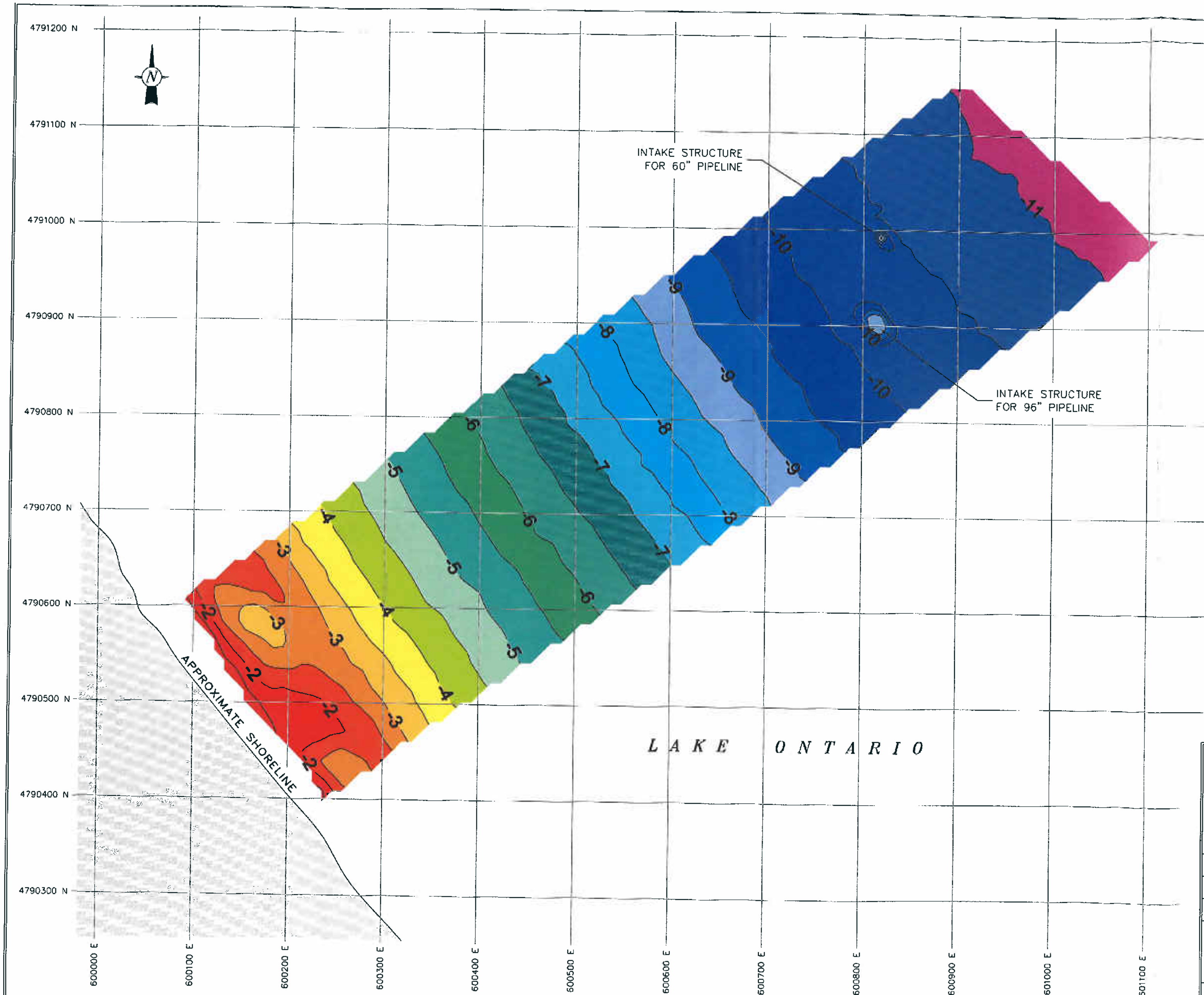
Aziz Ahmed, P.Eng.
Director
Part V *of the Safe Drinking Water Act, 2002*

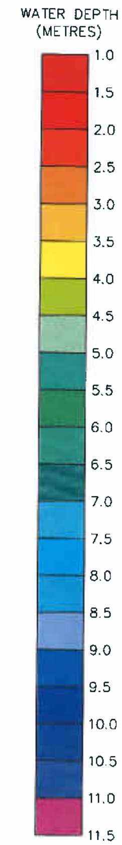
RM/
c: District Manager, MOE Hamilton - District
Mark Stirrup, Hatch Mott MacDonald



C.N.R.
MORRIS AVE.
WILLOW
Hamilton Harbou
FLETCHER
INTAKE 2200' 60"
2738' 96" INTAKE
48"
3000' INTAKE
VALVE HOUSE
VAN WAGNERS BEACH RD.
Van Wagners Beach
CITY LIMITS
Crescent Beach
CONFEDERATION PARK
DRIVE
CONFEDERATION
B.F. CONCESSION
QUEEN ELIZABETH WAY
PRIVATE
H.W.W.
FILTRATION PLANT &
PUMPING STN.
SEWAGE TREATMENT PLANT
TIONAL SLAG
O. LTD.
48"(C)
ROY AVE.
30"
20"
12"
8"
90" (C)
DUNN
AVE.
WOODWARD AVE. SCHOOL
WOODWARD
BARNABY ST.
CORBETT ST.
QUEBEC ST.
WATERLOO ST.
RENNIE ST.
KEEFER CT. 12"
CHLORINE HOUSE
EMBURY CT.
GODERICH RD.
CURTIS ST.
WARRINGTON ST.

APPENDIX 4.2: INTAKE BATHYMETRY





NOTES:

CO-ORDINATE SYSTEM – UTM (ZONE 17)

HORIZONTAL DATUM – NAD83 (WGS84)

CHART DATUM (IGLD85) FOR LAKE ONTARIO IS 74.2 METRES

WATER DEPTH (METRES) CORRECTED TO IGLD85

SHORELINE APPROXIMATED FROM CANADIAN HYDROGRAPHIC CHART No. 208601

0 50m 100m (APPROXIMATE)

ASI Group

PROJECT: D20362	SCALE: AS SHOWN
DR. BY: MJF	DATE: MAY 2002
CLIENT: CITY OF HAMILTON	

COLOUR–FILLED BATHYMETRIC PLAN

FIGURE 1–1

APPENDIX 4.3
BEACH *E.COLI* LEVELS: AS PROVIDED BY CITY OF HAMILTON PUBLIC HEALTH SERVICES

Beach Name	Sample Date	Geo mean
Beach Boulevard	25-May-04	14
Beach Boulevard	01-Jun-04	5
Beach Boulevard	08-Jun-04	1
Beach Boulevard	15-Jun-04	3
Beach Boulevard	22-Jun-04	10
Beach Boulevard	30-Jun-04	10
Beach Boulevard	07-Jul-04	54
Beach Boulevard	14-Jul-04	33
Beach Boulevard	21-Jul-04	13
Beach Boulevard	28-Jul-04	118
Beach Boulevard	04-Aug-04	7
Beach Boulevard	11-Aug-04	1
Beach Boulevard	18-Aug-04	3
Beach Boulevard	25-Aug-04	103
Beach Boulevard	01-Sep-04	4
Beach Boulevard	25-May-05	19
Beach Boulevard	29-May-05	4
Beach Boulevard	01-Jun-05	16
Beach Boulevard	08-Jun-05	87
Beach Boulevard	14-Jun-05	6
Beach Boulevard	22-Jun-05	97
Beach Boulevard	27-Jun-05	12
Beach Boulevard	04-Jul-05	35
Beach Boulevard	11-Jul-05	21
Beach Boulevard	18-Jul-05	28
Beach Boulevard	25-Jul-05	2
Beach Boulevard	02-Aug-05	12
Beach Boulevard	08-Aug-05	3
Beach Boulevard	15-Aug-05	13
Beach Boulevard	22-Aug-05	3
Beach Boulevard	29-Aug-05	3
Beach Boulevard	22-May-06	2
Beach Boulevard	31-May-06	2
Beach Boulevard	06-Jun-06	2
Beach Boulevard	12-Jun-06	50
Beach Boulevard	19-Jun-06	2
Beach Boulevard	26-Jun-06	261
Beach Boulevard	04-Jul-06	4
Beach Boulevard	11-Jul-06	3
Beach Boulevard	17-Jul-06	24
Beach Boulevard	24-Jul-06	3
Beach Boulevard	31-Jul-06	11
Beach Boulevard	08-Aug-06	9
Beach Boulevard	14-Aug-06	4
Beach Boulevard	21-Aug-06	12
Beach Boulevard	28-Aug-06	55
Beach Boulevard	23-May-07	17
Beach Boulevard	29-May-07	13
Beach Boulevard	05-Jun-07	13

Beach Boulevard	12-Jun-07	17
Beach Boulevard	19-Jun-07	70
Beach Boulevard	26-Jun-07	14
Beach Boulevard	04-Jul-07	21
Beach Boulevard	10-Jul-07	22
Beach Boulevard	17-Jul-07	15
Confederation	25-May-04	3
Confederation	01-Jun-04	12
Confederation	08-Jun-04	2
Confederation	15-Jun-04	1
Confederation	22-Jun-04	10
Confederation	30-Jun-04	11
Confederation	07-Jul-04	37
Confederation	14-Jul-04	22
Confederation	21-Jul-04	22
Confederation	28-Jul-04	162
Confederation	04-Aug-04	200
Confederation	11-Aug-04	40
Confederation	18-Aug-04	40
Confederation	25-Aug-04	58
Confederation	01-Sep-04	68
Confederation	25-May-05	11
Confederation	01-Jun-05	1
Confederation	08-Jun-05	49
Confederation	14-Jun-05	4
Confederation	22-Jun-05	1000
Confederation	27-Jun-05	17
Confederation	04-Jul-05	25
Confederation	11-Jul-05	68
Confederation	18-Jul-05	87
Confederation	25-Jul-05	36
Confederation	02-Aug-05	39
Confederation	08-Aug-05	2
Confederation	08-Aug-05	10
Confederation	15-Aug-05	10
Confederation	22-Aug-05	5
Confederation	29-Aug-05	4
Confederation	22-May-06	2
Confederation	31-May-06	4
Confederation	06-Jun-06	10
Confederation	12-Jun-06	10
Confederation	19-Jun-06	5
Confederation	26-Jun-06	214
Confederation	04-Jul-06	4
Confederation	11-Jul-06	209
Confederation	17-Jul-06	22
Confederation	24-Jul-06	103
Confederation	31-Jul-06	21
Confederation	08-Aug-06	81
Confederation	14-Aug-06	8
Confederation	21-Aug-06	38

Confederation	28-Aug-06	80
Confederation	23-May-07	10
Confederation	29-May-07	10
Confederation	05-Jun-07	11
Confederation	12-Jun-07	29
Confederation	19-Jun-07	83
Confederation	26-Jun-07	11
Confederation	04-Jul-07	16
Confederation	10-Jul-07	173
Confederation	17-Jul-07	44
Van Wagner's	25-May-04	8
Van Wagner's	01-Jun-04	21
Van Wagner's	08-Jun-04	5
Van Wagner's	15-Jun-04	11
Van Wagner's	22-Jun-04	7
Van Wagner's	30-Jun-04	16
Van Wagner's	07-Jul-04	76
Van Wagner's	14-Jul-04	23
Van Wagner's	21-Jul-04	17
Van Wagner's	28-Jul-04	114
Van Wagner's	04-Aug-04	27
Van Wagner's	11-Aug-04	15
Van Wagner's	18-Aug-04	10
Van Wagner's	25-Aug-04	88
Van Wagner's	01-Sep-04	6
Van Wagner's	25-May-05	54
Van Wagner's	01-Jun-05	9
Van Wagner's	08-Jun-05	98
Van Wagner's	14-Jun-05	14
Van Wagner's	22-Jun-05	1000
Van Wagner's	27-Jun-05	250
Van Wagner's	05-Jul-05	62
Van Wagner's	12-Jul-05	1
Van Wagner's	18-Jul-05	126
Van Wagner's	25-Jul-05	6
Van Wagner's	02-Aug-05	3
Van Wagner's	08-Aug-05	11
Van Wagner's	08-Aug-05	2
Van Wagner's	15-Aug-05	3
Van Wagner's	22-Aug-05	18
Van Wagner's	29-Aug-05	6
Van Wagner's	23-May-06	1
Van Wagner's	31-May-06	2
Van Wagner's	06-Jun-06	7
Van Wagner's	12-Jun-06	19
Van Wagner's	19-Jun-06	7
Van Wagner's	26-Jun-06	235
Van Wagner's	04-Jul-06	8
Van Wagner's	11-Jul-06	74
Van Wagner's	17-Jul-06	4
Van Wagner's	24-Jul-06	208

Van Wagner's	31-Jul-06	9
Van Wagner's	08-Aug-06	18
Van Wagner's	14-Aug-06	17
Van Wagner's	21-Aug-06	13
Van Wagner's	28-Aug-06	137
Van Wagner's	23-May-07	15
Van Wagner's	29-May-07	18
Van Wagner's	05-Jun-07	14
Van Wagner's	12-Jun-07	46
Van Wagner's	19-Jun-07	39
Van Wagner's	26-Jun-07	20
Van Wagner's	04-Jul-07	16
Van Wagner's	10-Jul-07	32
Van Wagner's	17-Jul-07	14

APPENDIX 4.4: FEDERAL AND PROVINCIAL SEDIMENT QUALITY GUIDELINES

Appendix B: Summary of Federal and Ontario Sediment Quality Guidelines

Compound	Unit	Federal TEL	Federal PEL	Provincial LEL	Provincial SEL
Hexachlorobenzene	ug/g			0.02	24
Endrin aldehyde	ug/g	0.00267	0.0624		
Toxaphene	ug/g	0.0001			
Aldrin	ug/g			0.002	8
a-BHC	ug/g			0.006	10
b-BHC	ug/g			0.005	21
Lindane	ug/g	0.00094	0.00138	0.003	1
Total Chlordane	ug/g	0.0045	0.00887	0.007	6
p,p'-DDD	ug/g			0.008	6
p,p'-DDE	ug/g			0.005	19
Total DDD	ug/g	0.00354	0.00851		
Total DDE	ug/g	0.00142	0.00675		
Total DDT	ug/g	0.00119	0.00477	0.008	71
DDT & Metabolites	ug/g			0.007	12
Dieldrin	ug/g	0.00285	0.00667	0.002	91
Endrin	ug/g	0.00267	0.0624	0.003	130
Heptachlor epoxide	ug/g	0.0006	0.00274	0.005	5
Mirex	ug/g			0.007	130
Aroclor 1016	ug/g			0.007	53
Aroclor 1248	ug/g			0.03	150
Aroclor 1254	ug/g	0.06	0.34	0.06	34
Aroclor 1260	ug/g			0.005	24
Total PCB	ug/g	0.0341	0.277	0.07	530
Naphthalene	ug/kg	34.6	391		
Acenaphthylene	ug/kg	5.87	128		
Acenaphthene	ug/kg	6.71	88.9		
Fluorene	ug/kg	21.2	144	190	
Phenanthrene	ug/kg	41.9	515	560	
Anthracene	ug/kg	46.9	245	220	
Fluoranthene	ug/kg	111	2355	750	
Pyrene	ug/kg	53	875	490	
Benz(a)anthracene	ug/kg	31.7	385	320	
Chrysene	ug/kg	57.1	862	340	
Benzo(k)fluoranthene	ug/kg			240	
Benzo(a)pyrene	ug/kg	31.9	782	370	
Indeno(1,2,3-cd)pyrene	ug/kg			200	
Dibenzo(a,h)anthracene	ug/kg	6.22	135	60	
Benzo(ghi)perylene	ug/kg			170	
Total PAH	ug/kg			4,000	
As (Arsenic)	µg/g	5.9	17	6	33
Cd	µg/g	0.6	3.5	0.6	10
Cr	µg/g	37.3	90	26	110
Cu	µg/g	35.7	197	16	110
Fe	pct			2	4
Mn	µg/g			460	1100
Ni	µg/g			16	75
Pb	µg/g	35	91.3	31	250
Zn	µg/g	123	315	120	820
Mercury	ng/g	170	486	200	2000

APPENDIX 5.1:
STATE OF MICHIGAN: SOURCE WATER PROTECTION PROGRAM

The State of Michigan, as part of its Source Water Protection Program (MDEQ, 2004), categorizes surface water intakes in four 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 following are descriptions of these categories:

***Nearshore, shallow-water intakes** are those that, generally, are less than 1,000 ft (~300m) from shore and in less than 20 ft (~6m) of water. These intakes are most likely to be categorized as highly sensitive and highly susceptible. Lake currents and passing boat traffic can disturb bottom sediments, causing high turbidity. Storms and changes in wind patterns can disrupt the flow of water over these intakes, causing rapid changes in water quality, which in turn create treatment difficulties for operators. Overland runoff and shoreline discharges are more likely to affect these intakes because of their limited isolation from land and smaller water volumes available for dilution.*

***Nearshore, deep-water intakes** are those that, generally, are less than 1,000 ft (~300 m) from shore, and in more than 20 ft (~6 m) of water. These intakes are most often categorized as highly sensitive though, if deep enough, they might be only moderately sensitive. They are under hydrologic conditions similar to those of near shore, shallow-water intakes, except that they are less likely to be under the full range of conditions of shallower intakes. Overland runoff and shoreline discharges are the most prevalent issues, followed by atmospheric changes and recreational water uses.*

***Offshore, shallow-water intakes** are those that, generally, are greater than 1,000 ft (~300 m) from shore, and in less than 20 ft (~6m) of water. These intakes are most often categorized as highly sensitive though, if far enough from shore, they might be only moderately sensitive. These intakes are not as susceptible to overland runoff and shoreline discharges because of their distance from shore. Their location, however, can result in higher susceptibility to discharge from inland rivers. Discharge from inland rivers generally enter a lake and is incorporated in the prevailing lake current. These currents occasionally carry river water over an intake prior to dilution and absorption of a contaminant into lake water. This action causes change in turbidity, temperature, general chemistry, and biologic conditions of the source-water, especially during times of high overland runoff and discharge from inland rivers.*

***Offshore, deep-water intakes** are those that, generally, are greater than 1,000 ft (~300m) from shore, and in more than 20 ft (~6m) of water. These intakes usually are categorized as moderately sensitive. Because of their distance from shore, they are isolated from overland runoff and shoreline discharges. They generally are located such that lake currents and lake volume provide the potential for large volumes of dilution in the event of a spill or contaminant event and of inland river discharge. Atmospheric conditions are less likely to affect water quality at these depths and distances from shore. The greatest potential for change to water quality is from occasional shifts or changes in currents.*

The Michigan categories for Great Lakes intakes are summarized in Table 5.2.

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

APPENDIX 8.1:
DATA MANAGEMENT TABLE

Data Management

The province of Ontario has established detailed data standards for compilation of digital records to be used as a companion to the Assessment Report: Guidance Modules for Source Water Protection. Table 1.1a contains the specified attributes for Surface Water Intakes, and Table 1.1b summarizes those attributes as they pertain to the Woodward Avenue WTP intake. Table 1.2a contains the specified attributes for Intake Protection Zones, and Table 1.2b summarizes those attributes as they pertain to the Woodward Avenue WTP intake.

Table 1.1a: Surface Water Intake Attributes	
Attribute	**Notes**
Municipality	The official name of the Municipality associated with the location of the intake.
Data Supplier	The individual or group providing information on the intake location and description.
Study Date	The date at which the intake information was collected.
Intake ID	A unique intake identifier. The intake ID must be unique with the geographic area of a municipality.
Intake Type	A classification of the intake based on the type of waterbody from which the intake is drawing water.
Representation Type	Cases may exist where mapping cannot be provided for a cluster of private intakes. In this case more than one intake may be represented by a single point feature.
Waterbody ID	The ID of the waterbody from which the intake is drawing water, as defined in the Ontario Land Information Warehouse (OLIW).
Response Time	The minimum amount of time in hours the water treatment plant operator needs to respond to adverse conditions or an emergency.
Collection X	The horizontal map coordinate specifying the intake location in decimal degrees (Longitude of the Geographic coordinate system).
Collection Y	The vertical map coordinate specifying the intake location in decimal degrees (Latitude of the Geographic coordinate system).
Pipe Depth	The depth of the intake below the water surface in metres.
Pipe Infrastructure ID	An optional possible link to engineering data.
Pipe Diameter	The diameter of the intake pipe in metres.
Pipe Material	The material type of the intake pipe.
Comment	Additional information to describe the intake. This may include a brief description of related features (lake, river or shoreline features related to the intake), or other pertinent intake information.

Table 1.1b: Summary of Surface Water Intake Attributes for the Woodward Ave WTP intake.

Municipality	City of Hamilton
Data Supplier	Stantec Consulting Ltd.
Study Date	August 2007
Intake ID	LOC-V1.I1
Intake Type	GREAT LAKE
Representation Type	INDIVIDUAL
Waterbody ID	
Response Time	2 hours
Collection X	-79.7577
Collection Y	43.2648
Pipe Depth[1]	9.8m
Pipe Infrastructure ID	
Pipe Diameter[1]	2.44m
Pipe Material[1]	Concrete
Comments	[1]The pipe depth, diameter, and material are taken from the Woodward Avenue WTP Engineers Report (Hargrave & Burdick, 2001) and refers to the operational pipe only.

Table 1.2: Surface Water Intake Protection Zone Attributes	
Attribute	**Notes**
Municipality	The official name of the Municipality associated with the location of the intake. In cases of municipal intakes, the Municipality name will correspond to the Municipality who owns and operates the intake.
Data Supplier	The individual or group providing information on the intake location and description. This may be an intake manager, municipality or consulting company.
Study Date	The date at which the intake information was collected.
Intake ID	A unique intake identifier. The INTAKE ID must be unique to each municipality.
IPZ Type	The type of Intake Protection Zone depicted by the polygon feature. Valid values: IPZ1 -- Intake Protection Zone 1, IPZ2 -- Intake Protection Zone 2
Source Vulnerability Factor	A decimal number ranging between 0 and 1 indicating the vulnerability of the intake with respect to the particular waterbody from which the intake is drawing water. Intakes located on inland rivers and lakes are generally more vulnerable to contamination than intakes situated on the Great Lakes.
Zone Vulnerability Factor	An integer value ranging from 1 to 10 which is applied to each Intake Protection Zone indicating the degree of vulnerability based on the proximity of the zone to the intake. Intake protection zones closest to the intake will have the highest degree of vulnerability and thus will have a higher vulnerability score. The vulnerability score chosen will be based on a number of site-specific factors to reflect the vulnerability of the zone to contamination.
Vulnerability Score	The ranked vulnerability score based on multiplying the Zone Vulnerability Factor and the Source Vulnerability Factor.
Vulnerability Ranking	A ranking of the Vulnerability Scores. Valid values: Low -- Vulnerability Score < 5, Medium -- Vulnerability Score > 5 and Vulnerability Score <= 6, High -- Vulnerability Score > 6.
Uncertainty Level	The degree of uncertainty associated with the vulnerability assessment. Valid values: HIGH or LOW. These depend on the detail of information or data used to delineate the zones and calculate the vulnerability score.
Date Compiled	The date at which the Intake Protection Zones and Vulnerability Scoring was completed.
Delineation Method Description	A textual description of how polygon dimensions and location were determined. This must be sufficiently detailed that that the polygon's level of complexity and uncertainty can be evaluated. For IPZ1, this can be as simple as "Buffer of [distance] meters generated around the intake point using GIS." For IPZ2, there needs to be a description of the tools used to calculate the average maximum water velocity to the intake and the source data used to determine the characteristics of the cross-section and floodplain upstream of the intake for delineating the extent and width.

Table 1.2b: Summary of Surface Water Intake Protection Zone Attributes for the Woodward Ave WTP intake.	
Municipality	City of Hamilton
Data Supplier	Stantec Consulting Ltd.
Study Date	August 2007
Intake ID	LOC-V1.I1
IPZ Type	IPZ-2
Source Vulnerability Factor	0.6
Zone Vulnerability Factor	9
Vulnerability Score	5
Vulnerability Ranking	LOW
Uncertainty Level	HIGH
Date Compiled	August 16th 2007
Delineation Method Description	3D Hydrodynamic Modeling

APPENDIX 9.1:
CLIENT REVIEW COMMENTS

CLIENT REVIEW COMMENTS			STATUS	CONSULTANT COMMENTS
ID	NAME OF REVIEWER	CLIENT/PARTNER COMMENT		
1	***Vol 1 – Hamilton*** Mike Bingham **General Comments**	Upland area to be considered. Time of Travel (TOT) shouldn't be used to limit the IPZ where there are known threats to the drinking water intake just outside the IPZ2	Noted	In the Module 4 study, threats were not inventoried nor used to justify the extent of IPZ-2. The IPZ-2 delineation may be refined with input from threats analysis as part of the Module 5 work.
2		We identified significant data gaps that affect the output of the study. One of the major gaps are related to lack of information on raw water quality at the intake, sediments quality at the WTP intake, pathways and watercourse flows. These will be made available upon request as part of Phase 2 work.	Noted	Data requests for the Module 5 study include these parameters.
3		Fill in the information gaps in order to obtain a reliable science based IPZ2, Vulnerability and Threats Assessment.	Noted	Module 4 revision modeling and Module 5 analysis involves potential refinement to the IPZ-2 on the basis of threats inventory, the vulnerability scores may be impacted. This will be addressed as an addendum or appendix item.
4		Considering the significant difference in IPZ2 extension as per 2-D and 3-D modeling (page 3.9), complete 3D hydrodynamic modeling instead of moderate resolution 3D modeling would give a more accurate interpretation for the extension of the IPZ2.	Pending	HCCL
5		The present up-land IPZ-2 conservative boundary for watercourses is preferred to residual TOT;	Noted	
6		Residual TOT calculations at outfalls would be more accurate as the City can provide catchment boundaries using in-house stormwater modeling technology;	Noted	Modeling refinement in Module 4 extension work may provide representation of residual TOT at outfalls that have been identified within Module 4 work to date.
7		The report contains security sensitive information that should not be made available to the public (please see Table 4.2. Woodward Avenue WTP Description and Process; Appendix 8.1., Data Management Table);	Noted	This information is confidential and is only disclosed to the client and those under their discretion.
8		As per MOE Module 4, Assessing the Vulnerability of Future Supplies, particularly Intake Pipe 2 and possible Intake Pipe 3 should be taken into consideration as future drinking water intakes.	Addressed	Appropriate changes made accordingly.
9	**Specific Comments**	*Page 1.2, Scope of Work*. IPZ-1 should be defined in terms of minimum 1km radius;	Addressed	Changes made accordingly.
10		*Page 3.1, Delineation Introduction, 3rd paragraph*. IPZ-2 should include the 2 hours TOT;	Noted	2-hour TOT is discussed within this section.
11		*Page 3.1, Delineation Introduction, last paragraph*. "as" instead of "as;";	Addressed	Changes made accordingly.
12		*Page 3.4, Hydrodynamic Processes in Study Area*. The daily raw water quality data, once available, should be incorporated in the model;	Addressed	Daily raw water data is not a direct input for the model. This information may help draw some trends and create a better understanding of processes in the area.
13		*Page 3.4, Hydrodynamic Processes In Study Area, last paragraph.* Define the ADCP acronym;	Addressed	Changes made accordingly.
14		*Page 3.6., 3.5.2. Hamilton.* Define the POK and 3-D POM	Pending	HCCL

CLIENT REVIEW COMMENTS			STATUS	CONSULTANT COMMENTS
ID	NAME OF REVIEWER	CLIENT/PARTNER COMMENT		
		acronym;		
15		*Page 3.7., 1st paragraph.* Further clarification is needed on the offshore and alongshore conditions.	Pending	HCCL
16		*Page 3.7., Development of Boundary Conditions.* Considering the fact that 2D model was use for a combination of 10 and 100-year return period, could you distinguish which return period was the dominant one in establishing the IPZ2?	Addressed	Revised with 10-year return in Module 4 extension work.
17	**Hamilton cont'd**	• *Page 4.5, Algae.* Please do not refer to the Total Phosphorus (TP) data from 2000. More recent data is now available. As per Woodward Treatment Plant 2006 Report the average annual TP was 0.45 mg/L.	Addressed	Changes made from annual report.