1.0 INTRODUCTION

Air quality in an urban airshed is influenced by local, regional and transboundary sources as well as the prevailing geographical and meteorological conditions which transport and disperse air pollutants. Pollutants discharged into the atmosphere may be transported over long distances (hundreds of kilometres) by large-scale air flows and mixed by advective motion and turbulent fluxes created by a large number of eddies of all different sizes. Conversely, local air emissions such as from urban traffic may not be transported very far and stay within the urban airshed. An air quality model, or combination of models, must be capable of handling the different source combinations, the complex meteorology, and the transportation and dispersion of emissions to achieve realistic simulations of local impacts on air quality. The challenge is to determine the relevant set of sources and contaminants which influence air quality at a neighbourhood level and accurately account for their transport, transformation, dispersion, and deposition.

Air quality models predict air quality in terms of the concentration of specified pollutants in the air at a certain place and time. All air quality models need two kinds of input:

- information about the injection of pollutants into the atmosphere from one or more sources; and
- information about factors that influence the dispersion and transport of pollutants through the air such as wind speed and direction, solar radiation, topography, etc.

The models use this information to mathematically calculate and simulate how pollutants are transported, mixed and spread to give estimates of specific concentrations at specific places and times. Some models are very simple, while others are more complex, such as those that include ground level elevation data and chemical reactions taking place in the atmosphere that change the concentration of pollutants in the air. Increased complexity offers the advantages of more precise modelling results and ability to extract detailed information from the model about relative importance of each input. As the complexity increases so does the computer hardware capabilities, modelling time and financial resources.

There are many approaches to modeling, and each approach has its own strengths and weaknesses. Using a combination of different models or, even better, combining modeling with other assessment techniques, significantly improves the reliability of a modelling based analysis system.

The Toronto communities of South Riverdale-Leslieville-Beaches are situated adjacent to each other bordering Lake Ontario. Since the early 1970s, local residents of South Riverdale-Leslieville-Beaches (SRLB) have been concerned about the effects of local industries on the local environment and the health of residents. While some of the large industrial facilities had either closed or re-located by the end of the 1990s, the residents of these communities remain concerned about the effects of past and current exposures to pollutants from these industries.

To address concerns about the current cumulative exposure to pollution from multiple sources, the Toronto Environmental Office has undertaken “An All Sources Cumulative Air Quality Impact Study of the South Riverdale and The Beach”. The objective of the project is to evaluate the cumulative impact of both transboundary and local Criteria Air Contaminants (CACs) and Hazardous Air Pollutants (HAPs) emissions on the SRLB airshed.

1.1 Project Description

The focus of the airshed modelling project is to determine the contribution and nature of various local and background (transboundary) sources on the geographical distribution of ambient air concentrations that SRLB residents are exposed to. The following deliverables were identified as part of the project.

- Generate hourly three-dimensional mesoscale to microscale meteorological datasets which accurately demonstrates the transport of atmospheric emissions to Toronto for the year 2006.
- Creation of emission inventories of CACs and HAPs for the City of Toronto, Ontario and the parts of the US Great Lake States reflecting anthropogenic and natural activities.
- Create a geo-referenced and hourly varying inventory according to three (3) computational domains, namely US, Southern Ontario and Toronto.
- Prepare the emission inventory according to agreed upon source categories, namely industrial, residential / commercial, transportation (on-road and off-road) and biogenics.
- Prepare the three tiers of emissions for a select set of air contaminants in consultation with the TEO and Toronto Public Health.
- Identification of local contributors of CAC and Reported Substances (RS) including below the Reported Thresholds Source Emissions in the City of Toronto.
- Evaluation of contribution of transboundary and local sources to Criteria Air Contaminant and Reported Substances air quality levels in South Riverdale-Leslieville-Beaches (SRLB) airshed.
- Modelling local ozone ‘Production’ and Trans-boundary Ozone.
- Development of a Standard Neighbourhood Grouping Approach.
- Criteria to Identify Neighbourhood and Downwind Neighbourhood Impact Grouping Areas of Interest.
- Contribution of the Portland Energy Centre to air quality in SRLB.

The SRLB airshed is part of the larger Toronto airshed which is also part of the larger southern Ontario airshed. The influences on the local airshed include emissions from United States, south-western Ontario as well as the City of Toronto, each has a different emission profile with respect to contaminants, quantity of emissions, types (i.e., as from stacks, roadways, or areas) as well as the specific location of each.

1.1.1 Priority Air Contaminants

In 2008, Toronto Public Health established a list of 25 substances that are a priority concern for Toronto (Toronto Public Health 2008). This list of 25 priorities was combined with a complete CAC list to generate a set of “Priority Air Contaminants” for the City as a whole, to be used in the cumulative air modelling study. Toluene was also added to the list before it was finalized due to uncertainties in the ability to accurately capture modelling results for total volatile organic compounds (VOCs). Toluene is frequently used as a marker for VOCs, and is the most commonly released VOC in Ontario. Following consultation with the City of Toronto's Environment Office and

Toronto Public Health, thirty (30) Priority Air Contaminants (PAC) were selected for investigation in this study as identified in Table 1-1. These substances may be used or released in various operations around the city or beyond, including chemical manufacturing, food and beverage production, automotive repair and laboratories. For example, trichloroethylene and dichloromethane are common cleaning solvents that may be used in sectors such as manufacturing, chemicals distribution, and food and beverage production.

Table 1-1:Priority Air Contaminants (PACs)

	Class	PACs	Alternative Name	CAS Number*
1	CAC**	Nitrogen Dioxide		10102-44-0
2	CAC	Carbon Monoxide		630-08-0
3	CAC	Sulphur Dioxide		9/5/7446
4	CAC	$PM_{2.5}$		NA - M09
5	CAC	PM_{10}		NA - M10
6	CAC	VOCs		NA - M16
7	CAC	Ozone		10028-15-6
8	Mobile Toxics	Formaldehyde		50-00-0
9	Mobile Toxics	Acetaldehyde		75-07-0
10	Mobile Toxics	Acrolein		107-02-8
11	Mobile Toxics	1,3-Butadiene		106-99-0
12	Mobile Toxics	Benzene		71-43-2
13	Aromatics	Toluene		108-88-3
14	Aromatics	1,4-Dichlorobenzene		106-46-7
15	Aromatics	PAHs (as B[a]Ps)		50-32-8
16	Methane Halogens	Chloromethane	Methyl chloride	74-87-3
17	Methane Halogens	Dichloromethane	Methylene chloride	75-09-2
18	Methane Halogens	Chloroform		67-66-3
19	Methane Halogens	Carbon tetrachloride		56-23-5
20	Ethane Halogens	Vinyl Chloride		75-01-4
21	Ethane Halogens	1,2-Dichloroethane	Ethylene dichloride	107-06-2
22	Ethane Halogens	Trichloroethylene		79-01-6
23	Ethane Halogens	Tetrachloroethylene	Perchloroethylene	127-18-4
24	Ethane Halogens	Ethylene dibromide		106-93-4
25	Metals	Lead		7439-92-1
26	Metals	Cadmium		7440-43-9
27	Metals	Chromium		7440-47-3
28	Metals	Nickel compounds		7440-02-0
29	Metals	Mercury		7439-97-6
30	Metals	Manganese		7439-96-5

*CAS Registry Number (where CAS = Chemical Abstract Service of the American Chemical Society) universally used to identify chemical substance with unique identifier.

** CAC – Criteria Air Contaminant (using Ontario CAC list rather than the Federal CAC list)

1.1.2 Air Quality Modelling System

The CALPUFF modelling system was selected because past experience with the model has shown that it has the necessary capability to handle a variety of nested domains (i.e to handle different scales of the contributing upwind source areas) and it lends itself to subsequent layer-by-layer modification by the Toronto Environment

Office after this study is completed. The model's proven flexibility and capabilities of handling transboundary emissions as well as local sources and the model's robustness make it a very good system choice. CALPUFF was employed to address long-range transport of emissions from outside the City of Toronto including emissions from the United States and south western Ontario as well as incorporating the emissions from Toronto.

1.1.3 Modelling Domain and Sources of Emissions

The emissions which can impact an airshed can come from various different sources and operations as well as come from various distances. Three nested air emissions domains (or Tiers) with three different grid resolution scales, which increased with proximity and significance to the SRLB study area, were selected as shown on Figure 1-1. These are

- United States (Tier I - at 36km x 36 km grid resolution);
- Ontario (Tier II - at 12 km x 12 km grid resolution); and
- Toronto (Tier III - at 1 km x 1 km grid resolution).

The complete emission inventory includes local sources such as auto body repair, road traffic, residential and commercial heating, etc. as well as distance sources such as fossil fuel electricity generation, mining operations, airports, marine, and agricultural activities.

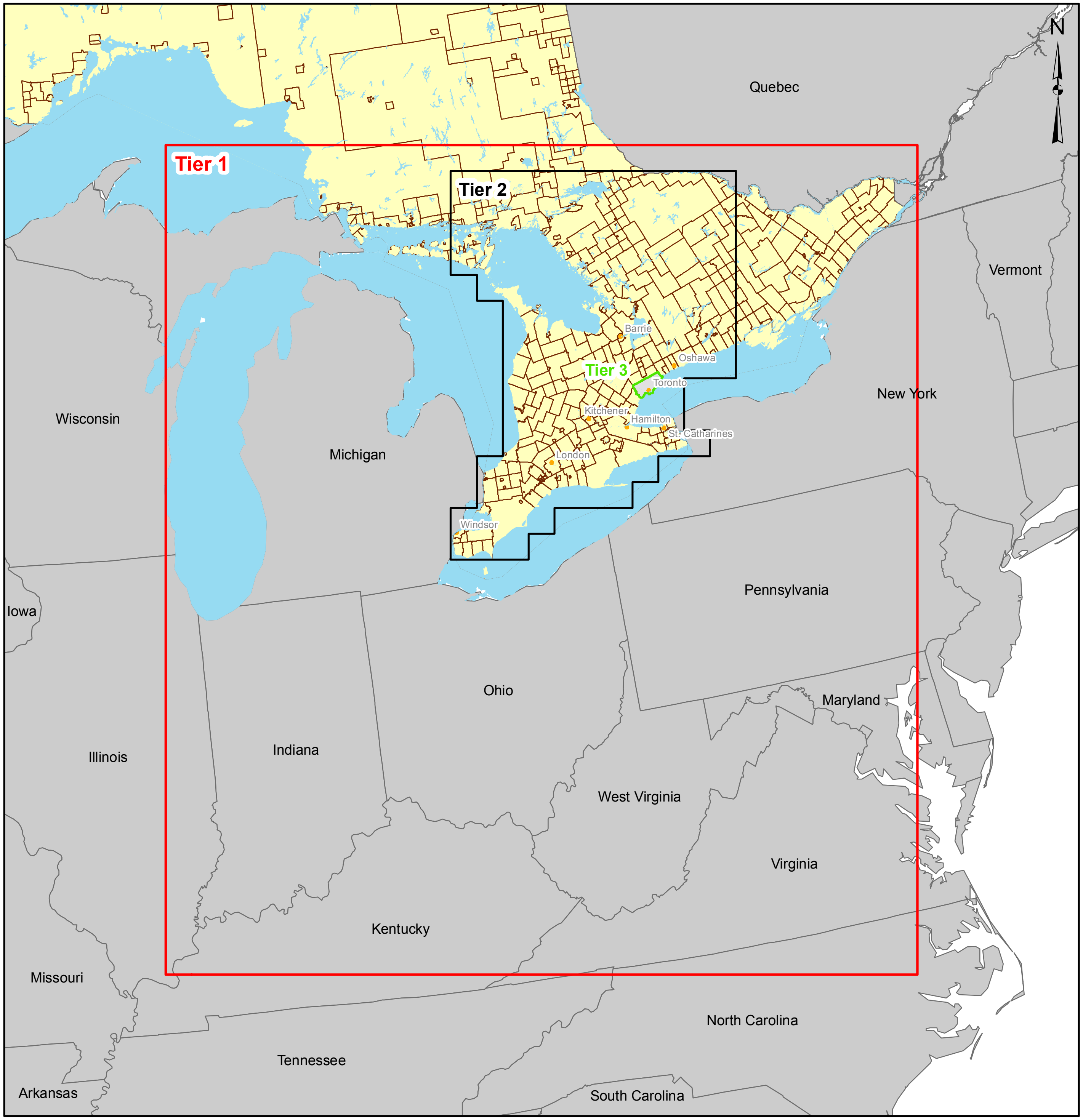
Determining the resulting concentration of the air emissions originating from each of the three domains to ambient levels in the SLRB was accomplished by setting up a detailed grid (50 metre x 50 metre resolution) of receptors over the SLRB area.

The emissions inventory for the PAC contaminants was developed from US EPA source inventory as well as Ontario and Canadian datasets including the National Pollutant Release Inventory (NPRI), city-wide and regional gas consumption rates, traffic data and city information. These emission data sets were integrated together to provide a cohesive and wide-ranging profile of emission contributions to air quality to the SLRB airshed.

1.2 Structure of the Report

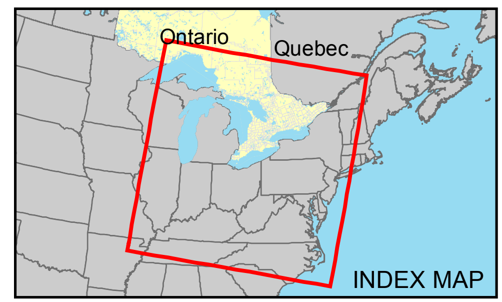
This report summarizes the development of the emissions inventory used in the model, the air quality modelling techniques employed and the results obtained from the modelling simulations. The model system predicts short-term (24-hr) and long-term (annual) ambient concentrations of 29 of the 30 PACs. The 30^{th} PAC, ozone is calculated from the other modelling results as a secondary product – since ozone is created from a chemical reaction as it is not a primary contaminant.

This report is structured as follows; Section 2.0 includes an overview of the airshed modelling system including the meteorological processor (CALMET) and the transport dispersion model (CALPUFF). Section 3.0 provides a description of the emission inventory and source configurations for the tiered system used. Descriptions of the modelling domain and the results of the meteorological modelling are described in Section 4.0. The CALPUFF dispersion modelling including inputs into the air quality model and results obtained are presented in Section 5.0. Section 6.0 presents the modelling method for ozone. The cumulative air quality levels in SLRB are presented in Section 7.0. Summary and Conclusions are provided in Section 8.0.



LEGEND

- Tier 3 (2km) Grid Outline
- Tier 2 (12km) Grid Outline
- Tier 1 (36km) Grid Outline



REFERENCE

Base Data - MNR NRVIS, obtained 2004, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: LCC Datum: NAD 83 Coordinate System: Ontario MNR Lambert

0 300 600 1,200 1,800 2,400 3,000

SCALE 1:8,000,000 KILOMETERS

PROJECT

TORONTO AIRSHED MODELLING

TITLE

THREE TIERED COMPUTATIONAL DOMAIN

PROJECT NO. 08-1112-0148			SCALE AS SHOWN	REV. 0.0
DESIGN	JMC	24 Mar. 2011		
GIS	JMC	24 Mar. 2011		
CHECK	AC	24 Mar. 2011		
REVIEW	AC	24 Mar. 2011		

Golder Associates
Mississauga, Ontario

FIGURE: 1-1

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