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Application of a Three-dimensional Wind Driven Circulation Model to Assess the Locations of New Drinking Water Intakes in Lake Ontario

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ABSTRACT. *A 3D transport model is used to perform a comparative analysis of several potential drinking water intakes located along the northwest shore of Lake Ontario between Toronto and Oshawa. The model is specifically used to assess each intake under both long- and short-term transport of a potential pollutant release from the Pickering Nuclear Generating Station and potential and actual pollutant releases from local land sources respectively. A model based on a 500 m grid resolution is calibrated using data collected in the aftermath of the 1992 tritium spill at the Pickering Nuclear Generation Station and subsequently used to simulate long-term transport. A model based on a 100 m grid resolution is verified using drogue studies and used to simulate short-term transport events. Both models are used to assess pollutant levels at each of nine potential intake locations under different wind scenarios and pollutant releases. Field data for the study included water quality and flow measurements from local sewers and rivers, and estimates of pollutant levels from the local waste water treatment plants. This paper describes the model setup for both the long-term and short-term transport models, calibration using field data, long-term transport modeling, short-term transport modeling, and the comprehensive analysis approach used to evaluate the nine potential intake locations proposed. Results indicated that four intakes in particular outperformed other intake locations by maintaining bottom pollutant levels within governmental standards and warning times that exceeded 20 hours.*

INDEX WORDS: *Model calibration, current meter, drogue, water quality, three-dimensional pollutant transport.*

INTRODUCTION

The Great Lakes form an important freshwater drinking source for many urban areas surrounding the lakes but also provide a sink for pollutants and runoff. Consequently introducing new drinking water intakes into any of these water bodies requires investigation into both local pollutant sources and their transport in order to determine the most appropriate location and depth of any new intake. In recent years, considerable interest has evolved in determining new alternatives for providing safe drinking water to communities. One obvious aspect to this is locating new intakes in the Great Lakes, particularly Lake Ontario. To investigate this possibility, a new drinking water intake to be located in the northwest part of Lake Ontario (Toronto/Durham) was investigated. The proposed intake envelope is actually defined by several potential intake points located between 2 and 5 km from the northern shoreline of Lake Ontario, east of the City of Toronto as shown in Figure 1. Intake depths, as determined from Canadian Hydrographic Chart 2077, range from approximately 14 m to 30 m as summarized in Table 1. Part of the assessment was to identify a preferred intake or intake zone from the several designated within the intake envelope. The basis for this exercise involved an evaluation of pollutant levels that might occur at the different intakes under contaminants released from local sources which included waste water treatment plant outfalls (WWTP), rivers, and sewers as well

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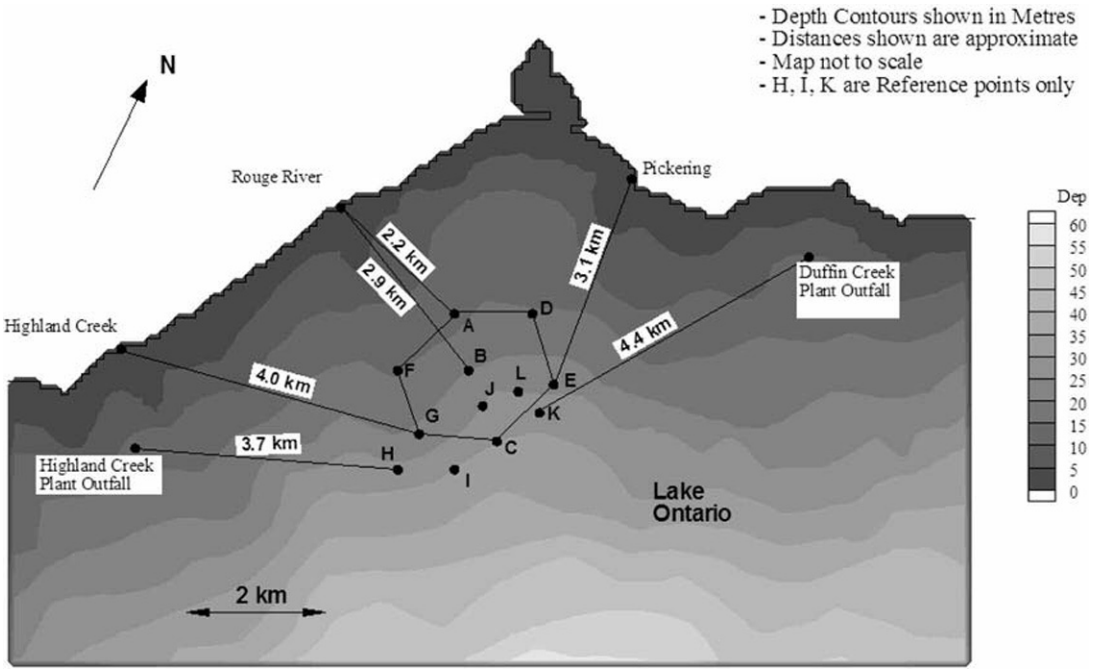

FIG. 1. Lake Ontario proposed intake locations.

as a potential release of tritiated water from the Pickering Nuclear Generating Station (PNGS). This paper describes the modeling study carried out to evaluate the pollutant levels at each of the intakes, as well as the field study performed to support such a modeling study.

Local pollutant sources identified for the modeling process included several major storm sewers, local rivers including Highland Creek, Rouge River, Petticoat Creek, and Duffins Creek and waste water treatment plant outfalls from the Highland Creek and York Durham Duffins Creek plants as shown in Figure 2. The Pickering Nuclear Generating Station (PNGS), also considered a potential pollutant source, is located about 3 km north east of the intake envelope, as shown in Figures 1 and 2. The impacts of non point sources were considered to be significantly smaller than the point sources identified and were not accounted for in the modeling exercise.

Each of the potential intakes was evaluated using a three-dimensional wind driven transport model under various wind conditions and pollutant release scenarios as follows:

1) Long-term transport of a historic spill from the PNGS under the variable wind conditions at the time of the spill.
2) Short-term transport of a potential spill from the PNGS under historic and theoretical wind conditions which can move the plume in the direction of the intake.
3) Short-term transport of a combination of pollutants from creeks, sewers and WWTPs in the vicinity of the potential intake envelope under historic and theoretical wind conditions.

MODELING BACKGROUND

In 1992 there was an accidental spill of tritiated water from the PNGS; this spill extended over 15 km east and 15 km west of the PNGS over a period of 4 weeks. In order to capture the full extent of the long-term plume movement a large computational

TABLE 1. Estimated intake depth (m) in Lake Ontario.

Intake	A	B	C	D	E	F	G	J	L
Depth (m)	13.45	19.75	29.75	15.56	23.72	14.40	21.45	25.10	24.85