6.0 FUTURE MONITORING RECOMMENDATIONS

Our research as part of this project concludes that water quality and current monitoring appears never to have been undertaken in a systematic way at the mouth of the Nottawasaga River or in the near-shore regions of Nottawasaga Bay. Monitoring is certainly taking place at drinking water supply intakes (such as at Collingwood), but these data provide only limited information or near-shore water quality at one specific point. In addition, the drinking water quality analyses at intake points have detection limits which are often too high to confirm or verify that PWQO's are met for the protection of aquatic species.

A comprehensive long-term water quality monitoring program would be desirable. However, to design and establish such a program will take time and resources which may not be currently available. Nevertheless, it is important to initiate some data collection and it would be desirable to begin in the spring of 2006 with a modest program involving:

- three water quality monitoring stations in Nottawasaga Bay near the mouth
  - one within the plume region at the mouth
  - one near-shore to the northeast
  - one near-shore to the southwest
- periodic water quality monitoring at an offshore location in Nottawasaga Bay to enable characterization of the ambient waters (in the far-field, unaffected by measurable shoreline discharges)
- monitoring on a monthly basis at these stations and, when possible, to coincide with PWQO sampling the Klondike Park Road station in the river near the mouth
- water quality analyses to cover (as an absolute minimum) the parameters noted in Table 3-3. It would be most desirable to have more detailed water quality analyses to include the particulate / dissolved and organic / inorganic forms of phosphorus, as well as the forms of nitrogen. The same should be obtained at the Klondike Park Road Station in the river where there should also be periodic sampling for TSS particle size distribution. These data are commonly used in today's water quality models and add considerably to the strength of the modelled results.
- similar, periodic water quality analyses at the Collingwood intake. The advantage to that location is that no offshore work is required to obtain the samples, and they can be collected through all weather conditions and in all seasons.
- water temperature is a prime factor in determining mixing processes at a river mouth. River temperatures are measured monthly (during water quality monitoring) and lake temperatures are taken daily at the Collingwood intake. It is now possible to obtain inexpensive, reliable sensors for measuring water temperature and, to enhance future modelling, it is recommended that several be deployed in the river and in the lake at the locations outlined in the first bullet point above.

While it may be beyond the scope of recommendations which can be acted upon from this report, it would also be appropriate to make recommendations to Environment Canada to include additional meterological data collection (i.e., global solar radiation or bright sunshine data) at least one location representative of mean conditions for Georgian Bay. Tobermory and/or Parry Sound would be possibilities for consideration. What can be acted upon this year, however, is:

- collection of local radiation data using an "off-the-shelf" and relatively inexpensive pyrometer. It will provide local radiation data to eventually complement that collected at more distant stations for improving water temperature compilations.

The hydrodynamics of Nottawasaga Bay have only been monitored using drogues, and the model prepared for this study calibrates well to that data. The data are limited to eight brief surveys in relatively shallow water near the shore at the river mouth and, as a result, it is recommended that:

- continuous current monitoring be conducted for at least a month to provide a vertical profile of speed and direction at a 50 m depth (5 km – 10 km offshore) would provide opportunity to monitor currents at multiple depths and, for security, a bottom-mounted acoustic doppler current profiler is recommended for this work.

7.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Our principal objectives were to undertake hydrodynamic, water quality modelling of the mixing zone of the Nottawasaga River at its mouth, and to provide recommendations for future monitoring. These objectives were completed. In summary:

- the modelling system employed in this study is called GEMSS, which is an integrated system of hydrodynamic, transport and water quality models. The water quality component is based on the US EPA's EUTRO5 model, and the hydrodynamic module, called GLLVHT, was developed under the auspices of the US Army Corps of Engineers Waterways Experiment Station.

- the model computations are done on a three-dimensional horizontal and vertical grid. Although the focus of the modelling is at the southern tip of Georgian Bay, the model domain was extended to include the entire body of Georgian Bay. This ensured proper model set-up for detailed study at the mouth of the Nottawasaga River.

- the model was calibrated and verified using data from 2004 and 2005. The latter year included water quality and current measurements which were taken during a monitoring program put in place for this study.

- final modelling of the mixing zone was conducted using the CANWET STREAMPLAN results for existing land use and for future land use. Data for the years from 1995 to 2004 were scanned and, in both cases, the month of March 2003 proved to be the time when river discharge and loadings would combine to present a maximum loading / maximum plume condition.

- results of the mixing zone modelling show both the near-field and far-field concentrations for TP. The near-field, hydraulic mixing zone extends approximately 1200 m offshore and covers an area of about 2 km^2 at the river mouth. The far-field passive plume covers a larger area as the river waters are moved offshore and along the shore by currents in the bay. Modelling results indicate that there is a 10% probability that the 0.01 mg/L interim PWQO concentration for TP (in the worst case of maximum loading) would be found in an area extending from Georgian Sands Beach – roughly 23 km to the north-northwest of the river mouth to about 3 km east of Collingwood Harbour. Beyond that, there is little likelihood that the interim PWQO would be exceeded.

- modelling of the TN mixing zone was prepared for values exceeding 0.50 mg/L. This showed rapid mixing near the river mouth and that the full extent of the 10% probability plume reaches from Brocks Beach (10 km southwest of the river mouth) to Spratt Point and beyond (about 15 km along the near-shore to the north).

- results of the mixing zone modelling for the maximum loading case indicate that there is little difference in plume size between existing land use conditions and the future land use conditions.

- as mentioned above, field measurements were taken in 2005 to calibrate the model. These measurements are believed to be the first to have been taken to characterize the dynamics and water quality at the confluence of the Nottawasaga River in Nottawasaga Bay. It is most

- desirable to enhance this data set and Section 6.0 provides a number of additional monitoring recommendations.
- additional data from field monitoring or other sources should be used to progressively update and refine the GEMSS model. This information will simply enhance the model and, if the updating includes regular, daily meteorological inputs, the model could be employed as a tool for evaluating "real time" conditions. These might include spill or other emergency response, or storm runoff effects along the beach.
- a brief period of training with the existing model was a component of this project. We strongly recommend that one individual from those who were trained from the Conservation Authority be charged with becoming the local expert in its use. This would require frequent use of the model, development of new input data, and completion of a variety of regular simulations to maintain familiarity with the model. One set of simulations which would serve this purpose, as well as providing an abundance of useful information, would be a series of runs which would enable characterization of long-term general conditions and the pattern of temporal flow in the bay.

REFERENCES

Ambrose, R.B., T.A. Wool, and J.L.Martin. 1993. *The Water Quality Analysis Simulation Program. WASP5: Part A: Model Documentation: Part B: The WASP5 Model Input Dataset.* EPA, Athens, GA.

Boatman, C.D. 1997. *Field Parameter Evaluation for Budd Inlet Studies.* Aura Nova Consultants Inc., Seattle, Washington.

Buchak, E. M., G. J. Pelletier and S. C. Chapra, 2005. *Water Temperature Estimation Using Long-Term Climatological Records.* ERM-SMG Document Number 1.

Buchak, E. M. and J. E. Edinger. 1984. *Generalized, Longitudinal-Vertical Hydrodynamics and Transport: Development, Programming and Applications.* Contract No. DACW39-84-M-1636. Prepared for U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss.

Cerco, C. F. and Cole, T. 1995. *User's guide to the CE-QUAL-ICM Three-Dimensional Eutrophication Model,* release version 1.0. Technical report EL-95-15, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cressman, G. P.1959. *An Operational Objective Analysis System.* Mon. Wea. Rev., 87. 367-374.ERM,

Edinger, J. E., E. M. Buchak and V. S. Kolluru. 1998. *Modelling Flushing and Mixing in a Deep Estuary, Water, Air and Soil Pollution* 102: 345-353. 1998. Kluwer Academic Publishers, The Netherlands.

Edinger, J. E. and E. M. Buchak. 1995. *Numerical Intermediate and Far Field Dilution Modelling.* Journal Water, Air and Soil Pollution 83: 147-160,1995. Kluwer Academic Publishers, The Netherlands.

Edinger, J. E., E. M. Buchak, and M. D. McGurk. 1994. *Analyzing Larval Distributions Using Hydrodynamic and Transport Modelling. Estuarine and Coastal Modelling III.* American Society of Civil Engineers, New York.

Edinger, J. E., and E. M. Buchak. 1985. *Numerical Waterbody Dynamics and Small Computers.* Proceedings of ASCE 1985 Hydraulic Division Specialty Conference on Hydraulics and Hydrology in the Small Computer Age. American Society of Civil Engineers, Lake Buena Vista, FL.

Edinger, J. E. and E. M. Buchak. 1980. *Numerical Hydrodynamics of Estuaries in Estuarine and Wetland Processes with Emphasis on Modelling*, (P. Hamilton and K. B. Macdonald, eds.). Plenum Press, New York, New York, pp. 115-146.

Environment Canada. 2003. *Revised Technical Guidance on How to Conduct Effluent Plume Delineation Studies.* National Environmental Effects Monitoring Office. National Water Research Institute. Environment Canada.

Environmental Protection Agency (EPA). 1985. *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modelling* (Second Edition). EPA/800/3-85/040. Environmental Research Laboratory, Athens, GA, 30613.

EPA. 1994. *Water Quality Standards Handbook*: Second edition. August 1994 (EPA-823-B-94-005). (http://www.epa.gov/waterscience/standards/handbook/)

EPA. 1993. *The Water Quality Analysis Simulation Program*. WASP5: Part A: Model Documentation: Part B: The WASP5 Model Input Dataset. EPA, Athens, GA.

EPA. 1992 Technical Guidance Manual For Waste Load Allocations Book III: Estuaries. Part 3: *Use Of Mixing Zone Models In Estuarine Waste Load Allocations*. August 1992 (EPA-823-R-92-004)

EPA. 1991. Technical Support Document For *Water-Quality Based Toxics Control*. (EPA/505/2-90-001).

EPA. 1984. *Proceedings of Stormwater And Water Quality Model Users Group Meeting* April 12-13, 1984. January 1985 (EPA-600/9-85-003)

Environmental Resources Management Inc. 2005b. Technical Documentation of *GEMSS*. Exton, Pennsylvania.

Greenland International Consulting Ltd. 2006. *Assimilative Capacity Studies CANWET Modelling Project Lake Simcoe and Nottawasaga River Basins Final Report*. Lake Simcoe Region Conservation Authority and Nottawasaga Valley Conservation Authority.

Goetchius, Kristin M. and Haydee Salmun. 2002. *Modelling the Fate and Transport of Atrazine in the Upper Chesapeake Bay*. 15th ASCE Engineering Mechanics Conference. June 2-5, 2002. Columbia University, New York, NY.

Kolluru, V. S., E. M. Buchak and Philip. E. Brinkmann. 2003. *Hydrodynamic Modelling of Coastal LNG Cooling Water Discharge*. Journal of Energy Engineering, Vol. 129, No. 1.

Kolluru, V. S and M. Fichera. 2003. *Development and Application of Combined 1-D and 3-D Modelling System for TMDL Studies*. Proceedings of the Eighth International Conference on Estuarine and Coastal Modelling. Monterey, California, pp. 108 – 127. 2003.

Kolluru, V.S. and J. E. Edinger. 2002. *Combined Hydrodynamic and Water Quality Modelling*. 15th ASCE Engineering Mechanics Conference. Columbia University, New York, NY.

Mackay, D. 1980. *Solubility, partition coefficients, volatility and evaporation rates. In Reactions and Process Handbook*. Vol. 2, Part A. New York: Springer-Verlag.

MacLaren Plansearch Inc. 1992. *Wasaga Beach Floodline Mapping Study*, for Nottawasaga River Conservation Authority.

MacLaren Plansearch Inc. 1988. *Watershed Hydrology Study for Nottawasaga, Pretty and Batteaux Rivers Black Ash, Silver and Sturgeon Creeks, Volume 1* – Technical Report, Canada / Ontario Flood

Damage Reduction Program. Nottawasaga Valley Conservation Authority, Ontario Ministry of Natural Resources, Environment Canada.

National Geophysical Data Centre (NGDC). 2005. *http://www.ngdc.noaa.gov/mgg/greatlakes/huron.html*

Ontario Ministry of the Environment. 1978. *Water Management – Goals, Policies and Implementation Procedures of the Ministry of the Environment.* Ontario, Canada. November 1978 (revised May 1984).

Pamatmat, M.M. 1971. *Oxygen Consumption by the Seabed. IV. Shipboard and Laboratory Experiments.* Limnology and Oceanography, 16:536-550.

QUAL2Kw, 2005. Technical Documentation on QUAL2Kw – *A Modelling Framework for Simulating River and Stream Water Quality Version 5.1.* Prepared by Greg Pelletier and Steve Chapra. Department of Ecology Publications Distribution Office, P. O. Box 47600, Olympia, Washington 98504 – 7600.

Tomczak, M., 1998. *Spatial Interpolation and its uncertainty using automated anisotropic inverse Distance Weighting (IDW) – Cross – Validation / Jackknife approach.* Journal of Geographic Information and Decision Analysis, Volume 2, No. 2, PP 18 – 30.

Thomann, R. V., and J. F. Fitzpatrick. 1982. *Calibration and Verification of a Mathematical Model of the Eutrophication of the Potamac Estuary.* Report by HydroQual, Inc., Mahwah, NJ to DES, Washington DC.

Washington State Department of Ecology (WDOE). 1984. *Comprehensive Circulation and Water Quality Study at Budd Inlet, Southern Puget Sound Water Quality Assessment Study*, Prepared by URS Corporation for the Washington State Department of Ecology.

ACKNOWLEDGEMENT

The principal work on this project was undertaken from May 2005 to February 2006. Initially, field work was conducted under the direction of Paul Donahue. He was strongly supported by Glenn Switzer, Director of Engineering and Technical Services of the Nottawasaga Valley Conservation Authority, who provided his staff and a boat to assist in our work.

We also wish to acknowledge the modelling efforts of Dr. Venkat Kolluru, of ERM Inc., formerly J. E. Edinger & Associates. Without his assistance, the project could not have been completed.

We also appreciate the time, and effort, and constructive comments provided by the ACS Committee Members and the Peer Reviewers. A number of revisions have been made as a result of their questions and comments, and this final report benefited considerably from these reviews.

Last, we are most appreciative of the guidance, constructive comments and technical support received from the staff of the Lake Simcoe Region Conservation Authority. Particular thanks go to Rob Baldwin, who served as the LSRCA Project Manager for this study.

NOTICE TO READER

This document contains the expression of the professional opinion of SNC-Lavalin Engineers & Constructors Inc. ("SLEC") as to the matters set out herein, using its professional judgment and reasonable care. It is to be read in the context of the agreement dated May 24, 2005 (the "Agreement") between SLEC and the Lake Simcoe Region Conservation Authority (the "Authority"), and the methodology, procedures and techniques used, SLEC's assumptions, and the circumstances and constrains under which its mandate was performed. This document is written solely for the purpose stated in the Agreement, and for the sole and exclusive benefit of the Authority, whose remedies are limited to those set out in the Agreement. This document is meant to be read as a whole, and sections or parts thereof should thus not be read or relied upon out of context.

SLEC has followed methodology and procedures, and exercised due care consistent with the intended level of accuracy, using its professional judgment and reasonable care. Unless expressly stated otherwise, assumptions, data and information supplied by, or gathered from other sources (including the Authority, other consultants, government entities or agencies, testing laboratories and equipment suppliers, etc.) upon which SLEC's opinion as set out herein is based has not been verified by SLEC; SLEC makes no representation as to its accuracy and disclaims all liability with respect thereto.

To the extent permitted by law, SLEC disclaims any liability to the Authority and to third parties in respect of the publication, reference, quoting, or distribution of this report or any of its contents to and reliance thereon by any third party.