PERFORMANCE ASSESSMENT OF THE EASTERN BEACHES DETENTION TANK

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TORONTO, ONTARIO

a report prepared by the

STORMWATER ASSESSMENT MONITORING
AND PERFORMANCE (SWAMP) PROGRAM

for

Great Lakes Sustainability Fund
Ontario Ministry of the Environment
Toronto and Region Conservation Authority
Municipal Engineers Association of Ontario
City of Toronto

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An earlier version of this report and various memoranda on specific technical issues related to this project were prepared by SWAMP. Additional data analysis and interpretation, probabilistic modelling and report editing were undertaken by Lijing Xu and Barry J. Adams from the University of Toronto's Department of Civil Engineering under contract to the SWAMP program, as represented by the City of Toronto.

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THE SWAMP PROGRAM

The Stormwater Assessment Monitoring and Performance (SWAMP) Program is an initiative of the Government of Canada's Great Lakes Sustainability Fund, the Ontario Ministry of the Environment, the Toronto and Region Conservation Authority, and the Municipal Engineer's Association. A number of individual municipalities and other owner/operator agencies have also participated in SWAMP studies.

Since the mid 1980s, the Great Lakes Basin has experienced rapid urban growth. Stormwater runoff associated with this growth has been identified as a major contributor to the degradation of water quality and the destruction of fish habitats. In response to these concerns, a variety of stormwater management technologies have been developed to mitigate the impacts of urbanization on the natural environment. These technologies have been studied, designed and constructed on the basis of computer models and pilot-scale testing, but have not undergone extensive field-level evaluation in southern Ontario. The SWAMP Program was intended to address this need.

The SWAMP Program's objectives are:

* to monitor and evaluate new and conventional stormwater management technologies; and
* to disseminate study results and recommendations within the stormwater management industry.

Additional information concerning SWAMP and the supporting agencies is included in Appendix A.

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- the Government of Canada's Great Lakes Sustainability Fund,
- the Ontario Ministry of the Environment,
- the Toronto and Region Conservation Authority,
- the Municipal Engineers Association of Ontario.

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EXECUTIVE SUMMARY

Background and Objectives

The City of Toronto has a long history in combating wet weather flow pollution in the form of combined sewer overflows and separated stormwater runoff. Particularly, much effort has been spent to improve the recreational value of the beaches within the City area by protecting the near-shore water from the pollution of uncontrolled discharges from storm sewers and combined sewer overflows. One of the many measures employed by the City to mitigate this source of water pollution is that of detention facilities. The Maclean Avenue detention tank (Figure 1), which was put into operation in 1995, is one such measure implemented to decrease the adverse impacts of both stormwater and CSOs in the Eastern Beaches area.

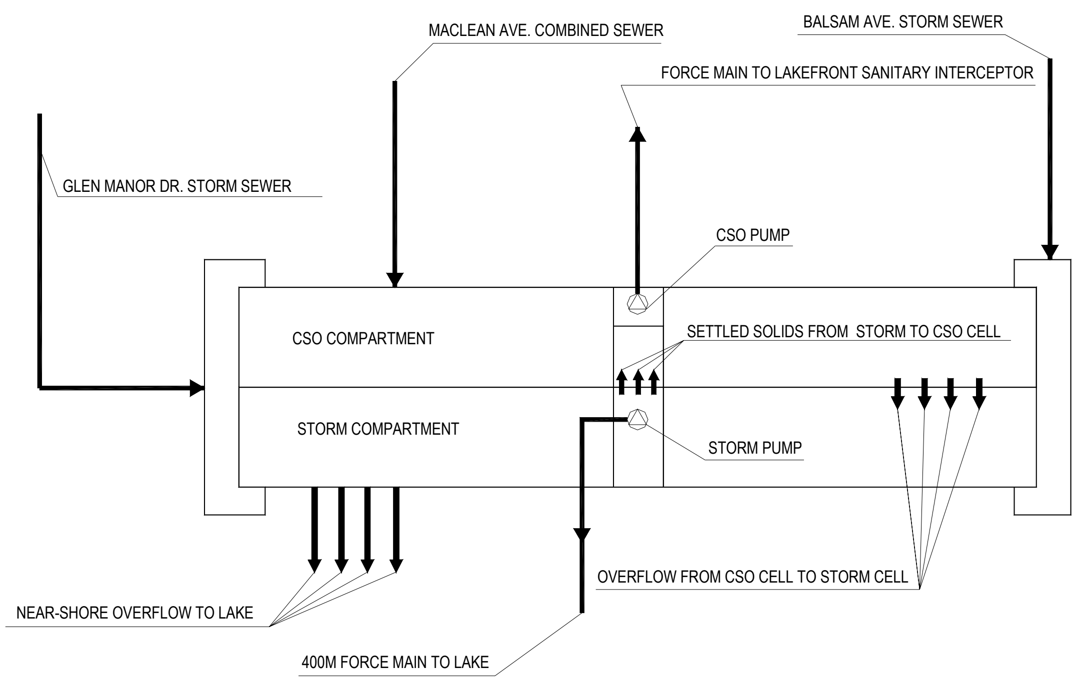

Figure 1: Schematic of the Maclean Avenue detention tank

The Tank is located at the south end of Maclean Avenue in the Eastern Beaches area between Glen Manor Drive and Balsam Avenue and has a total storage volume of 8000 m^3. Currently, the total tank storage volume of 8000 m^3 is equally divided into two compartments: a combined sewer overflow (CSO) control compartment and a stormwater control compartment. The CSOs are collected and detained in the CSO compartment and pumped to the Lakefront Interceptor (LFI) when capacity in the interceptor is available to convey them to the treatment plant. An overflow from the CSO compartment to the storm compartment may occur if the CSO volume is greater than the storage volume. The storm compartment receives and detains stormwater for an 8-hour period after the runoff event ceases. After detention, the supernatant is pumped 400 m off-shore to Lake Ontario and the subnatant is drained to the CSO compartment and eventually conveyed to the treatment plant. When the water level in the storm compartment rises to a certain height during the runoff event, the storm pump is initiated to pump the excess runoff 400 m off-shore to the Lake. If the water level rises to the weir height then a near-shore overflow is triggered through the weir to the Lake. In the future, when the Kingswood Trunk Relief Sewer (KTRS) along Queen Street East is constructed, the proposed KTRS will be oversized to provide in-line storage for the CSOs currently discharged to the tank. As a result, the Maclean Avenue detention tank would ultimately receive stormwater only. The two compartments would be interconnected, and the settled sludge after the detention would be pumped to the LFI for further treatment at the Ashbridges Bay treatment plant.

Since field data on the performance of underground detention facilities are scarce, a monitoring program was undertaken under the auspices of the Stormwater Assessment Monitoring and Performance (SWAMP) program on the Maclean Avenue tank from July 1995 to December 1996, to collect inlet and outlet water samples from the tank for analysis of the influent and effluent water chemistry. Monitoring equipment installed in the tank by the City recorded water depths every five minutes in the tank during a runoff event after the tank was put into operation. In order to bring the Eastern Beaches detention tank study to a conclusion, the present work has the following objectives:

- Based on the data available, conduct an assessment of the pollution control performance of the Eastern Beaches Detention Tank, both on an event-by-event basis as well as on a continuous basis.
- Ascertain whether the facility is sized appropriately in relation to its control frequency requirements.

Monitoring Program and Data Analysis Protocol

After the tank was put into operation in 1995, equipment was installed to record water depths in the tank every 5 minutes during each runoff event year-round, with data records maintained by City staff. Based on these data and the system geometry, quantities such as the total runoff volume, the detained runoff volume, and the overflowed runoff volume can be calculated event-by-event; consequently, tank performance measures on runoff quantity control can be obtained either on event basis or yearly basis.

With the City providing the flow monitoring data, SWAMP staff focused on other monitoring components that include influent and effluent water chemistry, water toxicity and sediment analysis. Since the 1995 water quality data were judged to be invalid, water quality data monitored for the entire year in 1996 are used in this study. Influent and effluent Event Mean Concentrations (EMCs) of pollutants are obtained and tabulated. Statistical analyses are conducted with consideration of seasonal factors. According to the influent and effluent pollutant EMCs and runoff quantity monitoring data in 1996, pollutant mass loads into the system and out of the system are calculated and the tank performance effectiveness for pollutant removal can be subsequently obtained. Performance of the storm compartment of the Maclean Avenue detention tank is evaluated based on two scenarios: a "system" performance scenario and a "tank" performance scenario. The "system" scenario considers the influence of overflows on the tank performance while the "tank" scenario only evaluates the pollutant mass removal of the portion of runoff captured and detained by the tank. Therefore, the "tank" scenario allows an evaluation of the performance of detention tank itself, which is widely considered to be one of the most effective stormwater management practices. In both of the scenarios, two methods of expressing the pollutant removal efficiency are used: one is based on the evaluation of each individual event which is called individual event performance (IEP); the other method is to calculate the total pollutant load reduction for the entire year, summer season, and winter season, respectively, which is called the total load performance (TLP).

Data Analysis Results

Runoff Quantity Control

A total of 73 rainfall-runoff events were detected in 1996 in the storm compartment. Twenty-two of those generated either near-shore or off-shore overflows to the Lake and 7 of those were near-shore overflows. The total near-shore overflow volume was 3,939 m^3 which represents 1.4% of the 1996 total inflow volume to the tank. The 400 m off-shore overflow volume was 117,397 m^3, which represents 41% of the total inflow volume. The system pumped out almost half of the total inflow runoff, without detention, to the Lake 400 m off-shore in 1996. It might be concluded that the substantial decrease in beach posting frequency is due to a large fraction of undetained runoff directly pumped to the Lake 400 m off-shore. In the CSO compartment, a total of 18 events occurred and only 2 events triggered overflows to the storm compartment. Since both the number of CSO events and the CSO volume captured by the CSO compartment are not large, a likely future strategy is to store the CSO volumes in-line by oversizing the proposed KTRS in the future.

Pollutant Removal

The pollutant removal efficiencies calculated from the "system" scenario and the "tank" scenario are obviously different. The performance of the "tank" itself is noticeably better than for the "system" due to the overflows considered in the "system" scenario. In the "tank" scenario, the TSS removal is 50.5% for the yearly average IEP and 68.5% for the yearly TLP. These values might represent the pollutant removal efficiency of the Maclean Avenue detention tank itself under the 8-hour detention period. In the "system" scenario, the yearly average IEP for TSS removal is 30.6% and the yearly TLP for TSS removal is 56.9%. Most of the heavy metals show obvious removal by the tank. The greatest heavy metal reduction is 94.7% for chromium, and most of the other heavy metals are removed by about 50%. These heavy metals are often attached to TSS and removed by sedimentation during the detention period. Ironically, the removal of bacteria (E. coli) is negative after detention, although the main objective in the implementation of the tank was to reduce the number of beach postings due to the public health concerns posed by elevated concentrations of bacteria. The removal of microbiological pollutants can usually be achieved through biological decay which requires a longer detention time. It is obvious that the 8-hour detention time does not help with bacterial reduction. Other measures, such as ultraviolet radiation or chemical disinfection might be options to satisfy the Provincial Water Quality Objective of 100 coliforms/100 ml.

Modelling Results

Analytical probabilistic models are developed according to the Maclean Avenue detention tank operational features and the principles of model development to predict and optimize the current and future tank performance. In the current stage, tank performance on runoff quantity control in terms of the average annual number of overflows obtained from the five-year observed data is 10.2, from the simulation of the QQS model is 4.5, and from the prediction of derived analytical probabilistic model is 13.3. The modeling results suggest that the optimal operation condition in the future stage might be: the tank storage volume is 8000m^3 (equivalent to 9800m^3 of combined tank and submerged pipe storage), the pumping rate is 2280 m^3, and the detention time is 8 hours, then, the average annual number of overflows (from March to November) is 9.6.

Conclusions and Recommendations

- The tank performance analysis results based on the data monitored in 1996 suggest that the current storage volume of the storm compartment is insufficient due to the large fraction of undetained urban runoff overflow to the Lake. The CSO volumes captured by the CSO compartment are not large, thus, it might be reasonable for the City to convert the CSO compartment to detain stormwater runoff in the future which would improve the tank performance for stormwater control.
- The set points for the overflow pumping process during the event need careful consideration. The study suggests that the pump removed undetained runoff to the Lake more than is necessary, which substantially decreases the tank performance for pollution control.
- The detention time is a key factor governing the pollutant removal efficiency of the detention tank. For the purpose of bacterial removal, either a longer detention time or other disinfection techniques are required.