TORONTO

STAFF REPORT
ACTION REQUIRED

Toronto's Future Climate: Study Outcomes

Date:	October 26, 2012
To:	Parks and Environment Committee
From:	John Livey, Deputy City Manager, Cluster B
Wards:	All Wards
Reference Number:	P:\2012\Cluster B\TEO\PE12003

SUMMARY

In 2005, Toronto was severely impacted by a one-hour rainstorm that cost the City of Toronto $47 million in repairs to its infrastructure (including the washout and re-construction of Finch Avenue at Black Creek and damage to the trunk sewer in the Highland Creek valley) and cost the insurance industry $600 million in payments to clients for damages to personal property. The 2005 storm is one of many record weather events that have impacted Toronto over recent years.

Faced with impacts of this magnitude and billion dollar projections for expenditure in public transit, roads, energy and public works infrastructure, a study was commissioned to specifically examine the projected climate conditions Toronto would experience in the period 2040-2049 . The purpose of the study is to provide a window on the conditions that our public infrastructure will be operating in over the course of its service life.

In particular, a focus was given to extreme weather events – including rainfall and heat waves – that are key concerns in connection with the need to maintain public infrastructure and service provision responsibilities.

This staff report describes the outcomes of the climate modelling study undertaken by the Toronto Environment Office with SENES Consultants Ltd.

RECOMMENDATION

The Deputy City Manager, Cluster B, recommends that:

1. This report be received for information purposes.

Financial Impact

There are no financial impacts resulting from the receipt of this report for information purposes.

There are financial implications for capital works and operating budgets due to changing weather patterns in the Toronto area resulting from climate change. Key points of concern are public transit, roads, energy, water supply, sewage treatment, storm water management and for those members of our community who are vulnerable to heat waves and cold winter temperatures.

As public infrastructure is built, renewed or replaced, it is important that it be designed to operate under the escalating extreme weather conditions we are currently experiencing and those that are anticipated during the cycle of its service life. The key goal is to maintain the serviceability of our public infrastructure in a cost effective manner in order to deliver the public services mandated to our municipality and work to avoid costly infrastructure repairs that also carry social and economic costs.

This report will be distributed to key corporate staff to help inform and support their planning processes for building and maintaining public infrastructure that will be increasingly impacted by weather related stresses.

The Deputy City Manager and Chief Financial Officer has reviewed this report and agrees with the financial impact information.

DECISION HISTORY

This report describes the work undertaken, the results obtained and the benefits achieved in connection with directives contained in: Climate Change Adaption Strategy (Staff Report to Executive Committee: May13, 2008) http://www.toronto.ca/teo/pdf/climate_change_adaptation_strategy_staff_report.pdf .

Recommendation No. 6 specifically calls for the establishment of a process to develop a comprehensive, long term adaptation strategy, which is clarified within the report as having several component processes, including using "science to analyze how climate is changing locally and what the future is likely to bring" (p. 8 identified process #4).

ISSUE BACKGROUND

In addition to the record rainstorm of 2005, Toronto has been impacted by numerous record weather events in recent years. Table 1, attached at Appendix A, provides a summary of local record weather events for 2000-2012.

COMMENTS

Why conduct a Toronto-specific climate study?

To date, global and regional climate modelling has focused on identifying board trends across wide areas and over long periods of time. These studies help to provide a strategic understanding of climate change, but do not provide specifics of the type of change in climate conditions and increased extreme weather events that Toronto is projected to experience.

The standard approach to climate modelling has been to use Global Climate Models linked to 30-year time periods. These models operate at course spatial resolution (i.e. with very large grid cells) typically using a 300 km x 300 km global grid.

Although regional climate models of medium resolution (typically in the range of 80 km x 80 km to 40 km x 40 km) refine the results found in global climate models, the global and regional models do not adequately account for the following key features:

i. non-inclusion of locally significant natural features such as the Great Lakes and the Niagara Escarpment;

ii. insufficient mapping and focus on urban land use influences; and

iii. the need to include more recent base data and more rapidly escalating climatic change.

We therefore identified a gap in climate change modelling work undertaken by the Federal Government in connection with urban areas, including Toronto. Specifically, Environment Canada's adaptive climate research has focused on six subject areas (agriculture, coasts, economic, forests, hydrology, and human health) that do not include a city or urban infrastructure focus or component. The Working Groups of Natural Resource Canada's Adaptation Platform primarily focuses on coastal zone management, mining, forestry and Northern Canada.

Whose help did we rely on?

Toronto's adopted process of assessing future weather and weather extremes has been done in close consultation with climatologists, meteorologists, hydrologists and climate adaptation specialists from Environment Canada, the Ontario Ministry of the Environment and Toronto Region Conservation Authority. These experts provided key input to our study approach, the specifics of our Request for Proposals for consultant selection, the selection of the consultant and review of study work and results.

This level of engagement reflects the recognized need to conduct climate modelling at a city-region level in order to attain information not available through global, national or regional climate modelling.

Who undertook the modelling for the City? And what model did they use?

The study was undertaken by SENES Consultants from Richmond Hill, Ontario. SENES created a predictive weather modelling system (called "FReSH") that was specific to southern Ontario based on the Weather Research and Forecasting Model previously developed in the United States.

What report was produced?

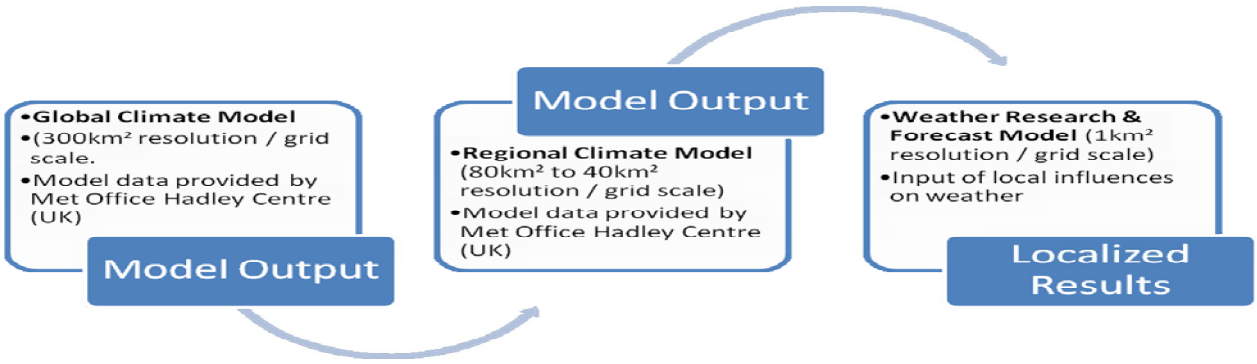
SENES produced a report of their work for the City titled "Toronto's Future Weather and Climate Driver Study" (hereinafter referenced as the "SENES Study"). A complete copy of the SENES Study can be found at http://www.toronto.ca/teo/pdf/tfwcds-full-report.pdf

An executive summary of the SENES Study has been prepared by Toronto Environment Office staff and can be found at http://www.toronto.ca/teo/pdf/tfwcds-summary.pdf

Did we use or look at the climate model output of others?

We benefitted greatly from adopting and incorporating the prior work of others. We combined global and regional model output to drive a Weather Research and Forecasting model of much finer resolution to provide detailed parameter estimates of Toronto's future local weather. The following diagram provides the linkage between global, regional and local climate modelling to derive localized results.

Diagram of Toronto's Model Integration



The Weather Research and Forecasting model was used to provide not just weather averages or means but also weather extremes that were scientifically consistent with anticipated weather patterns changes and local geography. The Weather Research and Forecasting Model enabled the full incorporation of the Great Lakes and other natural features (such as the Niagara Escarpment) to forecast climate change driven local weather that Toronto could experience in the 2040's.

What did we do? What approach did we follow?

The SENES Study adopted a combined climate and weather model capable of operating at a very fine resolution (1 km x 1 km). Such scaling is imperative to address such events as heavy summer thunderstorms. This allows different climate and weather projections to be established for even small areas within Toronto rather than only large regional areas such as southern Ontario or even larger jurisdictions. For example, this allows the spatial differences to be seen between Toronto and more distant places, such as North Bay and Ottawa that other models would not provide.

Combined output from standard Global Climate Models and Regional Climate Models was used to verify the performance of the City's climate-weather model. The City's results for the ten-year period 2040-2049 were judged to be within the range of expected results derived from the standard approach output, which gives added confidence to the results.

How much did the study cost?

The two volume SENES Study was produced at a cost of $250,000. Investment in studies of this nature are becoming increasingly pressing for municipal governments. Over the last decade a number of catastrophic extreme weather events across Canada have demonstrated the substantial economic and social impacts of extreme weather.

In mitigating costs associated with extreme weather events, governments are increasingly looking to build emergency and disaster resilience into infrastructure development and operations. For example, a 2012 report by the National Roundtable on the Environment and the Economy completed a cost benefit analysis of implementing proactive adaptation actions versus dealing with the consequences of extreme weather after they occur.

What new information did the study provide for Toronto?

The SENES Study predicts that climate change will continue to create different weather patterns across Toronto in the future. Some changes can be regarded as being positive, for example a longer growing season and fewer City resources required for winter snow clearance. However, other changes can be regarded as being negative. For example, there will be fewer storms but they will be more violent and produce greater amounts of rainfall, which may mean more City resources required for infrastructure (sewers and culverts) sizing upgrades.

How will the weather patterns change in the future?

The major predicted changes comparing 2000-2009 monitored data with modelled results for 2040-2049 can be summarized as follows:

- Less snow and more rain in the winter
- 26 fewer snow days per year, 9 less in December
- Slightly more precipitation (snow plus rainfall) overall
- Marked rainfall increases in July (80%) and August (50%)
- Extreme rainstorm events will be fewer in number but more extreme

- Average annual temperatures increase by 4.4^{o}C
- The projected average winter temperature increases by 5.7^{o}C.
- The projected average summer temperature increases by 3.8^{o}C.
- The extreme daily minimum temperature "becomes less cold" by 13^{o}C.
- The extreme daily maximum temperature "becomes warmer" by 7.6^{o}C.

- Wind speeds will be unchanged on average
- Maximum wind speeds will be reduced

CONCLUSION

The Benefits of the Future Weather Predictions

The SENES Study provides outcomes to inform present and future infrastructure design and construction (e.g., water pipe sizing and heat resistance of road surface materials) and policy development and planning (heat wave responses and pest infestations).

The innovative modelling method developed by the Toronto Environment Office and SENES – combining weather and climate models to generate future local climate and weather conditions – was completely new and innovative when this project was initiated.

The method combined output from a Global Climate Model as input to a Regional Climate Model, and the output from the Regional Climate Model as the input to the Weather Research and Forecasting Model. This method of model integration provided very fine resolution output data that was Toronto specific for the period 2040 to 2049. The basic method has subsequently been independently adopted by the National Centre for Atmospheric Research in the United States of America, as well as by the Ontario Ministry of the Environment working in partnership with the University of Toronto.

By improving the level of certainty regarding the magnitude and frequency of anticipated climate change and the changes in extreme weather events, the City is better guided in making decisions regarding capital works investments, adjustments to operational procedures over time and risk assessment. The risk of over-building and over-paying, as well as the risk of inadequate sizing and subsequent costly repairs can be better managed.

A software application known as the Risk Assessment Tool has been developed by the Toronto Environment Office to assess and manage various types of risks in City operations, including the risks due to extreme weather associated with climate change as identified by the SENES Study. Risk assessment and management is undertaken to help drive cost savings and reduce service disruption.

The Certainty of the Future Weather Predictions

The weather of the future will almost undoubtedly continue to change rapidly and at an accelerating rate into the future. This can be addressed by the City adopting a watching brief of: (i) the changing state of climate change science and predictions; (ii) the ongoing

changes in weather extremes and means for Toronto and environs; and (iii) by assessing the significance, value and needs of timely adaptation and financing its costs.

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ATTACHMENT

Appendix A. Table 1: Record Weather Events in Toronto by Year in Period 2000-2009

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Table 1: Record Weather Events in Toronto by Year in Period 2000-2009

Year	Record Events
2000	Wettest summer in 53 years
2001	Driest growing season in 34 years; First ever "heat alert";
2002	Warmest summer in 63 years; 5th coldest Spring ever
2003	Rare mid-Spring ice storm; Pearson Airport used a month's supply of glycol de-icer in 24-hours
2004	Year of the wettest summer;
2005	Warmest January 17 since 1840; January 22nd blizzard with whiteouts; August 19 storm washed out part of Finch Avenue
2006	23 tornadoes across Ontario (14 normal); Record one-day power demand of 27,005 MW due to summer heat (ON)
2007	Protracted January thaw; 2nd least snow cover ever in Toronto (½ the normal amount); 2-to-3 times the normal number of hot days in the summer; record latest-in-season string of +30°C days around Thanksgiving
2008	Toronto's 3rd snowiest winter ever; Record for highest summer rainfall
2009	3rd rainiest February in 70 years; One of the wettest summers on record; Unusually mild and storm-free and snow free November in Toronto; First snow-free November at Pearson Airport since 1937
Also	
2000,2005,2012	Three 1 in 100 year storms in Toronto in less than 12 years
2012	Toronto's earliest ever official heat wave (June 19-21)