A3

CITY OF VANCOUVER

ADMINISTRATIVE REPORT

CITY OF VANCOUVER

Report Date:	May 27, 2008
Author:	Brian Beck / Brian Crowe
Phone No.:	604.871.6752
RTS No.:	7193
VanRIMS No.:	11-4000-01
Meeting Date:	June 10, 2008

TO: Vancouver City Council

FROM: General Manager of Engineering Services

SUBJECT: Climate Change Adaptation

RECOMMENDATION

THAT Council receive this report for INFORMATION.

COUNCIL POLICY

On March 1, 2007 Council directed staff to examine potential impacts of climate change on City of Vancouver infrastructure and identify measures to minimize climate change impacts.

SUMMARY

The City has formed a new Climate Adaptation Working Group. The Working Group members established new collaborations with external stakeholders including the Pacific Climate Impact Consortium (PCIC), the BC Government, and Environment Canada. The City also joined the Canadian Alliance of Resilient City's (ARC) to share leading practices.

A framework for new adaptive planning was prepared. As a first step, The Working Group identified climate change variables of interest to the City, and PCIC provided the data contained in the preliminary Vancouver Climate Change Projections Table (Table 1). PCIC has performed several recent regional climate analyses. This is the first time PCIC has directly assisted with preparation of climate information to be used by a municipal adaptation working group. Timely access to this kind of data will help City staff's efforts to plan for the local

affects of climate change. At the same time, scientists are provided with a better idea of where focused research is required to help with local planning.

The table will be updated periodically by PCIC as well as other researchers and stakeholders on behalf of the City. The City will look to scientists to continue to improve the availability, and degree of certainty, around some of the data. For example, there are no local projections on wind extremes yet, and this is one of the key variables that a City needs to consider.

The City has already taken some early steps to address climate change in the areas of sewers (storm water and wastewater), parks, the water utility, and roadways. These areas represent the City's greatest investment in major infrastructure. Other impacts of climate change will need to be analyzed more carefully as part of the work in the coming year.

As a next step a screening-level City-wide vulnerability assessment will be completed in 2008 to help establish new focus areas for adaptation planning.

PURPOSE

This report provides a progress update on climate change adaptation work to-date and lists proposed next steps.

BACKGROUND

The City of Vancouver Corporate and Community Climate Change Action Plans were adopted in 2003 and 2005 respectively with a goal to significantly reduce greenhouse gas (GHG) emissions. Since then City and community leaders have worked to reduce local GHG emission levels. The City's progress to date on Greenhouse gas reduction is outlined in the 2007 Climate Protection Progress Report.

During the same period, leading scientists have recommended that, while the mitigation work is of utmost on-going importance, cities should also begin planning for the projected climate change that is expected to take place in the coming decades.

In March, 2007 Council directed staff to examine potential impacts of climate change on City infrastructure. Council also directed staff to integrate this work into regular City planning, and to report back through regular capital planning programs with recommendations for measures which could be taken to minimize climate change impacts.

This report outlines the steps taken by City staff to investigate methods, and arrive at recommendations on how planning processes need to evolve, to ensure that the City is resilient to climate change.

DISCUSSION

There is general agreement from scientists that climate change is now inevitable. Only the degree of change expected is in question, especially at the local level.

Local and regional governments around the world have expressed a strong desire to take action to prepare communities to deal with the impacts of climate change. In Sept 2007 the City joined the Canadian Alliance of Resilient Cities (ARC) in an effort to collaborate with other Canadian and international cities to accelerate understanding and action.

Climate Adaptation Working Group

The Climate Adaptation Working Group (The Working Group) was formed in 2007 in response to Council's recommendation to consider climate impacts as part of the infrastructure and capital planning process. The Working Group is initially comprised of City staff from Engineering Services, Parks, and the Sustainability Group.

As a first step, the Working Group has built a network of external contacts and resources from research institutes, the Provincial and Federal Government, and other North American cities. By working in a collaborative way with external scientific experts and stakeholders, City staff are able to adopt leading practices, and focus their efforts within their own fields of expertise.

The City has also created linkages with other adaptation pilot projects. For example, the Working Group is leveraging both Environment Canada (Richmond) and Engineers Canada (Public Infrastructure Engineering Vulnerability Committee - PIEVC) pilot studies and assessment protocols.

Initial scoping work and collaboration with external contacts has resulted in the following three key findings:

1) One of the main challenges that cities face is to find useful projections of future climate change that can be applied locally. Without this information, engineers and planners are left without the necessary inputs to develop their plans.

2) Local governments do not need to completely change existing infrastructure planning processes. Rather, existing processes need to incorporate climate change as one of many planning inputs, with flexibility to include new data as climate projections are updated.

3) Local governments should conduct an overall vulnerability assessment to determine which Infrastructure, facilities, and business planning areas are at greatest risk. It will then be possible to undertake risk assessments on a priority basis. The risk assessments will help staff to determine where existing or new funds can be most effectively spent to support climate change resiliency.

Adaptation Planning Framework

After researching a number of leading practices, including a King County, Washington guidebook[1], the Working Group recommended that the City adopt the following key steps for adaptive planning within the City:

- Gather Vancouver climate change projections
- Summarize early issues and opportunities
- Interview City staff leaders to broaden the scope of adaptation planning
- Complete a City-wide vulnerability assessment

[1] *Preparing For Climate Change, A Guidebook for Local, Regional, and State Governments*, Center for Science in Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington (in association with ICLEI)

- Complete selected risk assessments
- Complete selected cost /benefit studies
- Establish adaptation goals that are embedded in regular City infrastructure and capital planning processes

Vancouver Climate Change Projections
The Working Group collaborated with Environment Canada, the BC Government, Metro Vancouver, the Fraser Basin Council, and the Pacific Climate Impact Consortium (PCIC) to examine the various types of climate data.

This effort has resulted in a close working relationship with PCIC. One of PCIC's main roles is to help disseminate locally relevant, regional and global climate projections to communities to facilitate adaptation. They draw information from leading experts on climate change, such as the Canadian Centre for Climate Modeling and Analysis at the University of Victoria. PCIC also stays abreast of the latest analytical methods and helps communities to apply them.

The City worked with PCIC to build a top list of climate variables of interest that would useful for local adaptive planning. Much of the data thus far is gathered from the February 2008 Ouranos report: Climate Change in Canada: Climate Scenarios for the Public Infrastructure Vulnerability Assessment, Metro Vancouver Stormwater and Wastewater Infrastructure Case Study. PCIC also added results from a range of projections using the Regional Analysis Tool (www.PacificClimate.org/regionalanalysis), and from other studies. The result is summarized in the preliminary *Vancouver Climate Change Projections Table* (see Table 1 following page).

The Table represents the first such compilation of data by PCIC in direct collaboration with a municipality. The availability of this data is very timely and relevant for City Staff who require easier access to climate data to validate current projects, and to consider new initiatives. The projections are preliminary; therefore PCIC has provided valuable guidance interpreting the uncertainty of the data.

The Table includes projected changes for the following three 30 year periods to help show possible trends over the long term.

- 2011-2040 (2020s)
- 2041-2070 (2050s)
- 2071-2100 (2080s)

The most relevant data to the City is summarized in the 'Regional Climate Model' columns. Data from two runs shows some of the uncertainty in the data. At this time, only a limited number of Regional Climate Models are available. Scientists have access to many more Global Model runs to predict climate change on a global scale. Until more regional data is available, the Table also includes a range of this global data under the header 'Global Climate Model Range'. Scientists recommend the use of both types of models in order to take advantage of the strengths of each.

A more detailed interpretation of the Table is provided in Appendix 1. City staff will work with PCIC, and others, to update the Table over time so that new and/or missing data (e.g. wind) is available to City staff periodically. If climate change appears to be accelerating, this will be reflected in the updated data.

Table 1: Vancouver Climate Change Projections

Issued: May 27, 2008 - Data revised periodically by PCIC for City of Vancouver

			Regional Climate Model[1]						Global Climate Model Range[2]	
			2020s		2050s		2080s		2050s	
Climate Variable[3]	Units	Expected Change	run4	run5	run4	run5	run4	run5	10P	90P
Intense Rain Amount -1 Day Maximum[4]	% change	Increase	7	9	17	18	23	21	NA	NA
Intense Rain- Freq of Occurrence ≥5mm in 6 hrs	% change	Increase	16	25	31	36	43	48	NA	NA
Days of Consecutive Rainfall[5]	days change	Increase	2.5	2.5	4.3	2.4	6.8	3.6	NA	NA
Annual Precipitation	% change	Increase	4	13	12	16	15	20	-1	10
Winter Precipitation (Dec-Feb)	% change	Mixed	-2	11	9	28	8	25	-4	14
Spring Precipitation (Mar-May)	% change	Increase	13	26	18	13	32	19	0	20
Summer Precipitation (Jun-Aug)	% change	Mixed	14	1	4	-7	-5	-4	-26	-2
Fall Precipitation (Sept-Nov)	% change	Increase	2	11	12	14	19	23	-2	11
Annual Snowfall[5]	% change	Decrease	-36	-13	-45	-35	-64	-62	NA	NA
Winter Snowpack (Dec-Feb)	% change	Decrease	NA	NA	NA	NA	NA	NA	-27	1
Spring Snowpack (Mar-May)	% change	Large Decrease	NA	NA	NA	NA	NA	NA	-85	-30
Extreme Temperature - Warmest Day-time High	°C change	Increase	0.0	2.2	1.5	3.2	3.8	4.6	1	2.8
Extreme Temperature - Coolest Night-time Low	°C change	Increase	2.4	2.7	3.1	5.4	6.7	7.2	1.1	2.8
Growing Degree Days - GDDs	% change	Increase	**New Calculations Required (PCIC to provide)**							
Heating Degree Days - HDDs	% change	Decrease								
Sea Level	meters	Increase	**0.08-0.52 by 2100[6]**							
Storm Surge	meters	Increase	**New IOS Report Ready in 2008[7]**							
Wind (extremes, gusts)	-	Possible increase	**More research required.**							
Change in date of arrival of first winter rains	-	indicate possible delay of ~1 month.	**More research required.**							
Fraser River Flood Level	-	Not quantified.	**River Forecast Centre (RFC) Investigating**							

Notes:

1. 'Regional Climate Model' data is based on the Canadian Regional Climate Model CRCM4 run 4 & 5 set at 345m above sea level (Ouranos, December 2007 & February 2008).

2. 'Global Climate Model Range' data is based on 10th & 90th percentiles from 15 Global Climate Models (forced with emissions scenarios A2 & B1)

3. All results are presented as a difference from the 1961-1990 base period.

4. These values are also available for 10 mm and 20 mm cutoff. City interested to eventually get increase in 30min. to 1-hour maximum rainfall. This parameter affects sizing of sewer infrastructure (unlike the 1 day increase- which is important for Still Creek).

5. The effect of the 345 m above sea level RCM elevation influences this variable in particular. Compared to changes that would be expected at sea level, rain changes are overestimated and snow changes are underestimated.

6. Range of GPS and tide gauge based measured sea level rise and IPCC mean adjustment (0.3m). From Mazzotti, S., Jones, C., Thomson, R.E., 2008, Relative and Absolute Sea-Level Rise in Western Canada and North-western U.S. from a Combined Tide Gauge-GPS Analysis, J. Geophys. Res.-Oceans (submitted). Using IPCC extreme adjustment, based on rapid ice sheet melting, the projected increases are 0.60-1.36 meters by 2100.

7. New Data is expected tol come from report published by Institute of Ocean Sciences (IOS) in 2008. Report funded by BC Ministry of the Environment (MOE), DFO, and NRCAN.

Early Issues and Opportunities
The Working Group has focused, thus far, on the following adaptive planning areas that represent the City's greatest investment in major infrastructure:

- sewers (storm water and wastewater)
- parks and urban landscape
- the water utility
- roadways

The following sections summarize the climate variables of greatest interest to staff in these areas, and describe adaptation initiatives that are already underway.

- **Sewers**

Climate variable of greatest interest: Rain Intensity and Sea Level/Storm Surge.

In the late 1960's, the City of Vancouver informally initiated its Sewer Separation Program to replace single combined sewer main pipes with two separate sewers, one for sanitary sewer and one for stormwater. This program is now well established and requires the City to annually replace an average of 1% of its combined system. Early in this program, City Engineers concluded that the cost of upsizing of the new storm pipe was only a small portion of the overall sewer separation construction costs.

Well before any local projected climate change data was available to the City, Sewers Staff believed that the number and intensity of rainfall events was on the rise and therefore made appropriate changes to their design decision making. The result today is a stormwater design in separated areas that is capable of handling up to a 45% increase in rainfall intensity before flooding would occur. The projected increases in rainfall intensity for 2080 are only about half this number; however the available data is not directly comparable with traditional design information. Staff will continue to work with PCIC and other climate scientists to obtain projected changes in 1-hour rainfall intensity and "IDF" (intensity-duration-frequency) curves.

Sewers staff have implemented other stormwater initiatives that include bylaw changes that limit the impervious area for new construction, and completion of an Integrated Stormwater Management Plan (ISMP) for Still Creek. These changes result in less rainwater entering the City's system, effectively adding to the storm system's capacity.

A new budget category is now proposed for the 2009-2011 Capital Plan to continue with similar stormwater management and other climate change adaptation initiatives. This budget includes ISMP work for Musqueam Creek and other drainage basins, and design work to offset climate change impacts that may compound storm/tidal flooding challenges around the Kent Avenue and Manitoba Street area.

- **Parks and Urban Landscape**

Climate variable of greatest interest: Rainfall Intensity and Duration, Growing Degree days, Sea Level/Storm Surge, and Wind extremes.

To the extent that park storm water management relies on biofiltration systems and their associated ponds, extended periods of high water levels can be expected with increases to rainfall intensity and duration. Weir controls may have to be raised to increase storage capacity. Also, slope stabilization may be required in certain park areas.

Growing Degree Days is of interest to park staff, as a longer growing season can result in a longer mowing season unless expectations about the length of grass are adapted over time; however, this is an operational issue that is unlikely to affect capital planning.

Increases in sea level elevations in conjunction with higher winds may result in the seawall being under water from time to time. Raising the seawall is one response option, but another would be rebuilding seawalls in a fashion that facilitates occasional flooding without affecting the structural integrity. In other low lying areas, such as the beaches and parks around English Bay, high water levels in combination with storms may create occasional flooding and increased erosion, which could be mitigated in some areas by modestly increasing the height of shoreline protection works.

Possible increases in strong wind gusts would, and already have, affected forests and trees. Forest edges are particularly vulnerable as demonstrated in the 2006 storms.

A special tree pruning procedure called wind firming, has been implemented along Stanley Park trails and open areas to reduce the amount of "sail" in trees. Reducing the amount of sail also should be pursued more aggressively in other park woodlands and street tree management.

It is at present unclear as to how other combined effects in combination (i.e. temperature, wind, and rain) might affect local infestations of bugs/pests. As a first step, the City has implemented an integrated pest management system. The City will need to consider how this program is affected by projected changes, and whether significant changes to landscape designs will be required**.**

- **Water Utility**

Climate variable of greatest interest: Rain Intensity and Seasonal Timing, and Snowfall.

Climate change will have some impact on the City's water utility, but has more significant impacts on the Metro Vancouver water system. Changes to the amount of rain that is received, as well as having lengthier dry periods, will necessitate a review of the storage needs for the Metro Vancouver water system.

Expansion of storage is currently planned for mid-century and plans will need to be reviewed based on climate modelling and projected use. Current water conservation efforts including: sprinkling restrictions, education, and water loss prevention contribute toward delaying the expansion of storage and mitigating the demand changes from population growth and longer dry periods. Generally, water supply impacts are expected to be modest in the Pacific Northwest, where drought conditions are not projected to develop, compared with many regions where drought is already a problem and may worsen.

Water quality may be affected by temperature rise and changes in rainfall; however the completion of the new Seymour/Capilano water treatment plant will minimise turbidity and the re-growth of bio-films and bacteria, and the existing flushing program will continue to keep the water system clean.

Sea level rise may necessitate that some portions of the system be redesigned to deal with higher water tables and their potential corrosive effects on water mains.

- **Roadways**

Climate events of greatest interest: Rain Intensity, Wind, Extreme Temperature, Changes in Free-Thaw Frequency.

The City has a priority to design and maintain roadways to provide the best value to taxpayers. Recent intense weather events have placed an unusual burden on roadway operation, which likely foreshadow the effects of climate change.

It is necessary to make our roadway systems more resilient to climate change. A budget is now proposed to in the 2009-2011 Capital Plan to install traffic signal hangers to limit effects of windstorms, and also upgrades of traffic signals with UPS for power outages.

Curbed streets improve protection against stormwater flooding by containing water that cannot be removed by storm drains. In addition, stormwater is redirected back to the ground where possible through narrowing paved areas (i.e. centre strip paved lanes with pervious edges), construction of infiltration basins and bioswales, and use of permeable materials. Opportunities are mostly limited to rehabilitation programs because most areas of the City are completely built out and therefore very few new streets are being built.

Further work will be required to understand if roadways are capable of handling the volume of projected rainfall, changes in freeze-thaw cycles, and the effect of higher temperature on the asphalt pavement.

Broadening the Scope of Adaptation Planning

At this early stage, the Working Group participation is limited, with a focus on core infrastructure planning work (sewers, parks, water utility and roadways). However, as indicated above, an assessment of other business planning areas that may be affected in various degrees by climate change will be carried out. Those areas include land-use planning, housing and commercial buildings, energy supply, urban agriculture, human health, recreation, business and tourism, transportation, communications, police, fire and other emergency services.

For example, current estimates of local sea level rise and storm surge are manageable within existing flood construction levels for Vancouver's low-lying areas. Greater changes in sea level, such as those suggested in rapid ice-melting scenarios, could require modification of those elevations and consideration of other flood-protection measures or land-use regulations. These projections will be monitored closely. Regardless, various land-use planning strategies should be considered and evaluated for low-lying areas.

Adaptation will also include being prepared to respond to the immediate consequences of extreme weather events such as flooding, storm surges, and wind damage. Council's recent enhancement of our Emergency Management program is supportive of such adaptation planning.

The make-up of the Working Group will evolve over time to ensure that affected City business planning areas are involved.

Remaining 2008 Work program

Senior Staff Interviews
Review of leading practices suggests that completing interviews with City staff, from the possible City Adaptation planning areas, should be the next step to broaden our assessment of vulnerabilities, and prioritize new initiatives.

The objectives of the interviews will be to gather a list of projected consequences of climate change impacts on business planning areas, based on forecasted climate events. The interview questions from recent similar projects such as Environment Canada's Richmond scoping study and the King County Study can be used as a guide to form interview questions for the City.

It is expected that the interviews, conducted by Working Group members, will have the dual purpose of gathering data and raising awareness about possible local climate change impacts. The interviews will also ease the process of integrating climate change adaptive planning within the City's operations by showing City staff leaders that there are tools that can be used (eg Vancouver Climate Change Projection Table) to help with planning. Adaptive planning can then be incorporated into additional aspects of the City's long range planning processes.

City-wide Vulnerability Assessment & Risk Assessments
City staff will begin a city-wide vulnerability assessment supported by experts and higher levels of governments as required. Sensitive areas will be identified along with possible impacts, followed by an evaluation of ability to accommodate changes.

Systems that are sensitive to climate and less able to adapt will be considered to be vulnerable to climate change, and thus the highest priority for further work.

The vulnerability assessment should be followed by completion of risk assessments in the areas of highest sensitivity. These assessments should be based on the consequences, magnitude and probability of climate change impacts, as well as on an evaluation of risk tolerance and community values.

Considering New Opportunities
After completing the 2008 work plan the Working Group will re-evaluate priorities for 2009, and consider new initiatives such as additional risk assessments and cost-benefit studies. The intention is to have staff throughout the City incorporate this work into their regular capital planning.

FINANCIAL IMPLICATIONS

Financial implications have not been evaluated at this time. Financial implications, such as priorities for adaptation-based capital improvements, are anticipated after vulnerability and risk assessments are completed.

CONCLUSION

This progress report summarizes projected climate change data, and outlines steps taken in 2008 to incorporate climate change adaptation measures within the City's planning processes.

The City is already taking significant steps to be more resilient to climate change. At the same time there is still more work to be done.

The City now has timely access to emerging climate change projection data. That data, though not complete yet, is beginning to provide an indication of the degree of changes expected for our communities. The City will continue to work with leading research bodies (including PCIC, and others) to strengthen the data for the variables that are important to City engineers and planners. A screening-level City-wide vulnerability assessment will also be completed in 2008 to help establish new focus areas for adaptation planning.

* * * * *

Appendix 1- Overview Climate Change Projections Table

At this time, the majority of data for the Climate Change Projections Table (see Table 1) is gathered from the February 2008 Ouranos report: Climate Change in Canada: Climate Scenarios for the Public Infrastructure Vulnerability Assessment, Metro Vancouver Stormwater and Wastewater Infrastructure Case Study as well as the PCIC Regional Analysis Tool (www.PacificClimate.org/regionalanalysis).

It is important to note that climate models are numerical representations of the climate system based on the physical, chemical, and other properties of the climate, their interactions and feedback processes. Global Climate Models (GCMs) are used to project climate change into the future. Results from multiple GCMs are available. These provide plausible indications of expected climate changes on a global or continental scale. Due to their coarse resolution (~350km), GCM results are not representative of regional and local climate, especially in complex terrain.

Regional Climate Models (RCMs) are higher resolution models (~45km) embedded inside of GCMs. At this smaller scale, RCMs are able to resolve the effects of the land surface more accurately than GCMs, such as precipitation gradients created by mountains. At this time, data from two runs of the Canadian Regional Climate Model (CRCM4) were used. Additional projections from RCMs will be made available to PCIC from Ouranos Consortium and from the North American Regional Climate Change Assessment Program (NARCCAP), which has set out to systematically investigate the uncertainties in future climate chance projections at a regional level by running multiple RCMs with multiple GCMs over North America. Additional runs will help to develop confidence levels that will assist with local decision making.

Runs 4 and 5 from the CRCM4 are shown in the attached table. Run numbers refer to a run of the model that was made with the same emissions scenario[2], but with a very small change to the initial conditions of the model. The natural climate system is non-linear; small perturbations can yield different end results. Runs 4 and 5 are included to show how variable results can be for this area, even for the same model and emissions scenario. Comparison of these two runs does not provide an ability to explore the range of uncertainty arising from GCMs and from emissions scenarios (estimates of global greenhouse gas emissions). GCM results are available from many models and for different emissions scenarios. Therefore, one column of the table includes the low (10 percentile) and high (90 percentile) values from 15 GCMs, each run with the A2 and B1 emission scenarios (total of 30 model runs). The data in this column provides the full range in future projections.

RCM data represents dynamical downscaling, which is one way of getting greater resolution from the GCMs. Statistical downscaling techniques may also provide additional projections that will be relevant to the local area. Some statistical techniques provide an avenue for investigating extreme events in more detail. The City will consider applications for such techniques.

Some data that would be of interest to staff is either not yet available or is in the process of being prepared, as follows:

- Growing and Cooling Degree Days- results from most recent GCMs are not available in the ClimateBC tool. PCIC scientists will compute these values in coming months.

[2] Forced by version 3 of the Canadian GCM and emissions scenario A2

- Storm Surge- Additional data will come from new report to be published by the Institute of Ocean Sciences in Victoria – currently in review.
- Wind- need new model that is not available. Environment Canada has expressed interest in working with the City of Vancouver to run a special study that would gather forecasted data based on known historical trends.
- Intense Rain Amount- Projected frequency of occurrence of events with 5mm or more rain in the first 6 hours is available now. Staff will continue to work with PCIC and other climate scientists to obtain projected changes in for the first 1 hour, as well as "IDF" (intensity-duration-flow) curves.
- Change in Arrival of first rains- Not explicitly projected at this time - more research required. However, GCM results provide an indication that precipitation is expected to decrease for each of the months of June through September and increase by roughly 10% for October and November. This is an indication that the rainy season may be delayed towards October from September. http://www.pacificclimate.org/tools/select
- Fraser River Floods- BC River Forecast Center (RFC) is investigating.

The City will periodically update this summary of model results in partnership with PCIC, and others, as new information is made available from climate scientists.