

The Future Isn't What it Used to Be: Assessing Climate Change Impacts on Flood Risk in British Columbia

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Climate change will alter the hydro-climate regimes of this province and will therefore change our exposure to floods. This is true both on the coast where communities are exposed to sea level rise and storm surges, as well as in the interior where river hydrology is the key factor. Of course, exposure to flooding is also very much dependent on how we choose to develop in flood prone areas. A recent study published by the OECD ranked the Vancouver region 15th among the world's largest port cities for assets exposed to damage due to climate change and extreme events over the coming century.

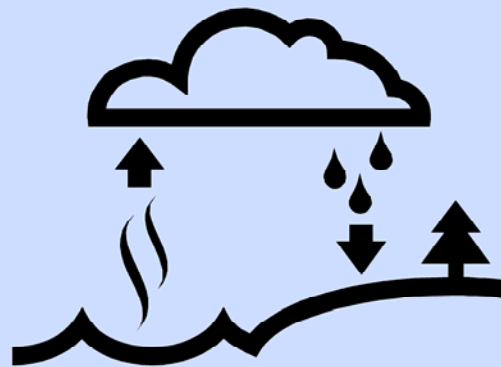
Ranking port cities exposure to climate extremes.

http://are.berkeley.edu/courses/EEP151/fall2008/wordpress/wp-content/uploads/2008/09/hellegateetal_oecd.pdf



The challenge for those of us who make provincial policy about flood management, and for you who actually manage floods on the ground is that the future isn't what it used to be. We can no longer rely on past flood statistics to guide design of future flood protection. The world's hydro-climate regime is now dynamic and will continue to shift far into the future. This dynamic shift will result in changes in the statistical means of hydrological phenomena, and will more importantly, result in shifts in the extremes.

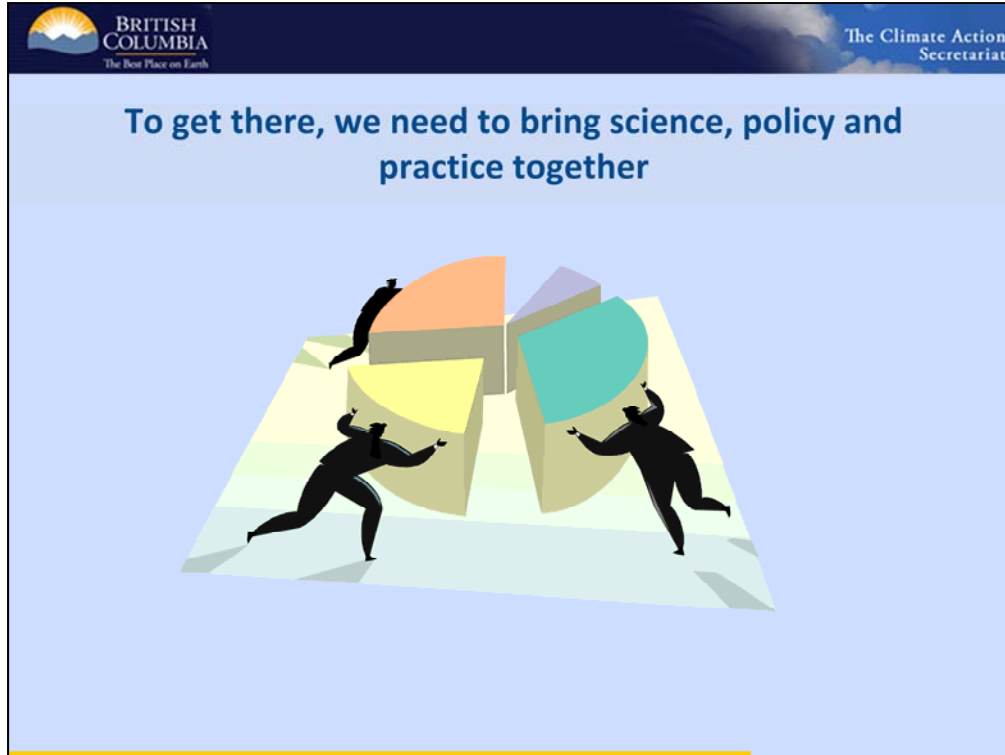
As flood management professionals, how do you take climate change into account when design and build for the future?



What does this mean for the way we plan for, build for and manage floods? You have a professional commitment to producing quality work using best professional practices. Therefore, these new realities about flooding need to be integrated into professional practice and into the policy context in which you work so that whatever you design and build today will be effective throughout its lifetime.



You therefore need some new tools and you need the right policy context and guidance in order to use them.

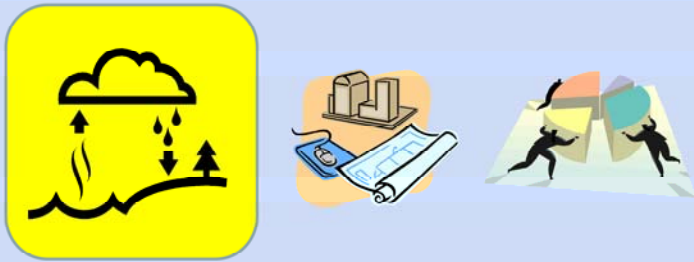


How do we build these new tools and create the right policy context? I propose that we need to go through a process of assessment where we bring together the climate science, the policy and the on-the-ground practice to determine how climate change will impact flood risk in the province, determine what tools and policies are needed and set about making the necessary changes.

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Climate Change will alter flood prediction science and flood statistics



The image contains three icons. The first is a yellow rounded square with a black outline, depicting a cloud with an upward arrow, a downward arrow, and a tree. The second is a blue and white icon showing a bar chart, a smartphone, and a rolled-up document. The third is a colorful 3D pie chart with two figures running towards it.

In the next few slides I will present some of the climate change science that is relevant to flood risk in BC, including both coastal flooding and river flooding. Note that the climate models don't actually tell us anything about flooding per se, but tell us about some of the climate variables that influence flooding.

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BC can expect about 1m of sea level rise by 2100

http://www.env.gov.bc.ca/cas/adaptation/sea_level.html

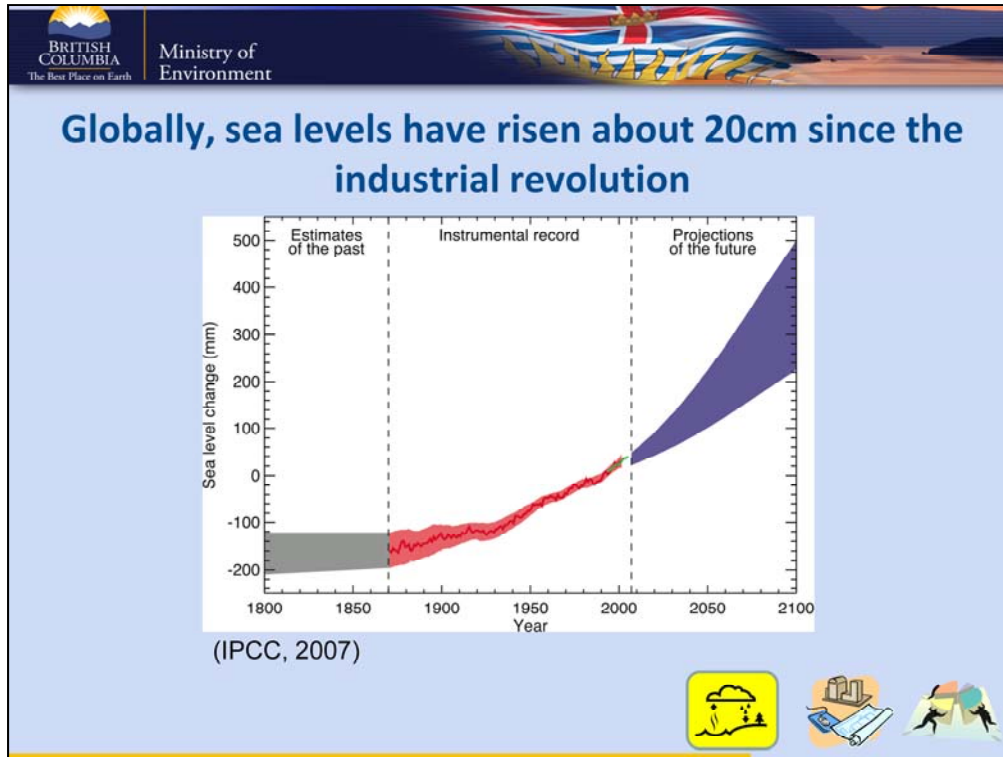


ecstaticist



The BC Sea Level Rise Report, published in 2008, calculated sea level rise scenarios for coastal BC based on IPCC global SLR scenarios and local factors such as vertical land movement. The report gives us local sea level rise scenarios for tide gauge locations along the coast. Generally speaking, the coast of BC will see about 1m of sea level rise by the year 2100.

Further information on sea level rise in BC, including links to the BC Sea Level Rise reports go to http://www.env.gov.bc.ca/cas/adaptation/sea_level.html.



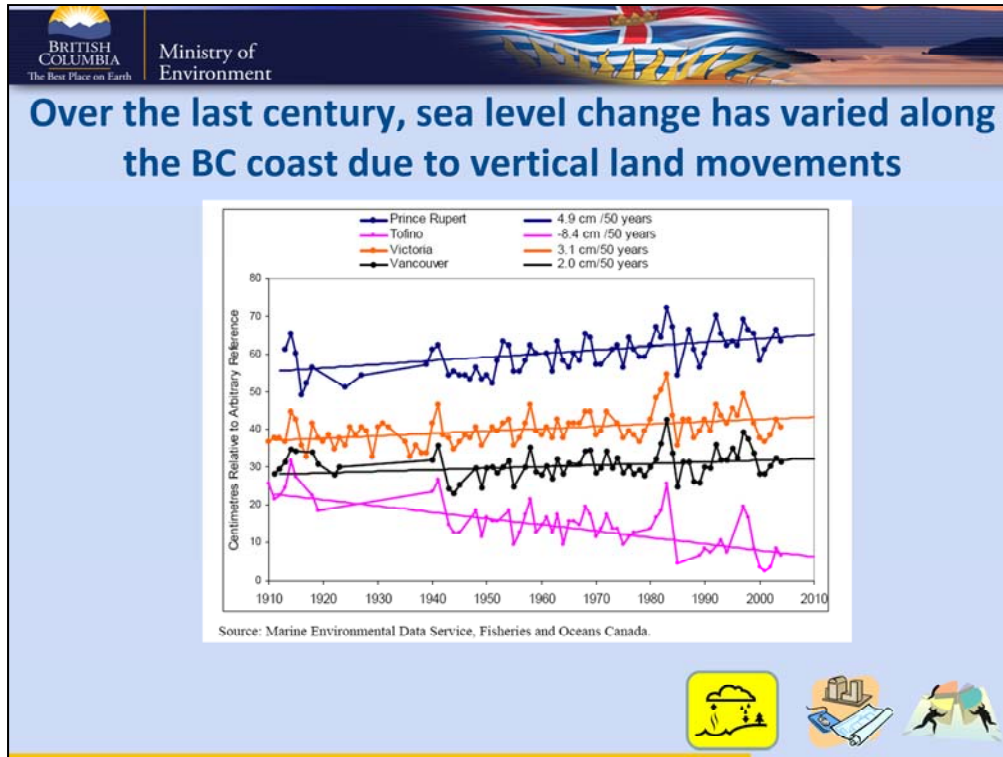
This graph was published in the 4th Assessment Report of the Intergovernmental Panel on Climate Change. The report was released in 2007 and summarized the state of knowledge on climate change at that time. This graph shows both historical sea levels and projected future sea level rise at the global scale.

Before 1870, global measurements of sea level are not available. The grey shading shows the range of estimated long-term rate of sea level change prior to tide gauge measurements.

The red line is a reconstruction of global mean sea level from 1870 to the present day, from tide gauge data. The small green line shows global mean sea level observed from satellite altimetry.

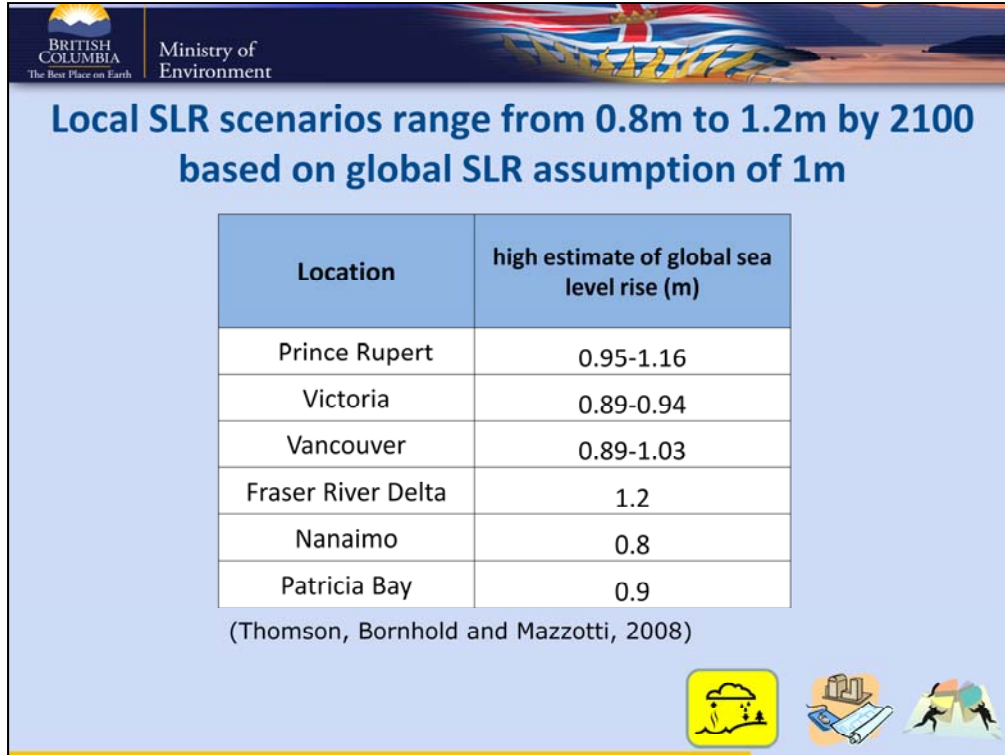
In 2007, the Intergovernmental Panel on Climate Change (IPCC) estimated the most *probable* global sea level rise by 2100 will be between 0.2 and 0.6m. This is now considered a very conservative range because the studies that contributed to the IPCC report published in 2007 did not include complete estimates of inputs from all the world's glaciers and ice sheets. A study released today (May 3, 2011) by the Arctic Monitoring and Assessment Programme estimates global sea level rise will be between 0.9 and 1.6m above 1990 levels by 2100 (see <http://amap.no/swipa/>).

Future sea-level rise will consist of both a continued response to past greenhouse gas emissions (due to the long lag times in the deep ocean's heating response to climate warming) and to future emissions. Over many centuries or millennia, sea level could rise by several metres.



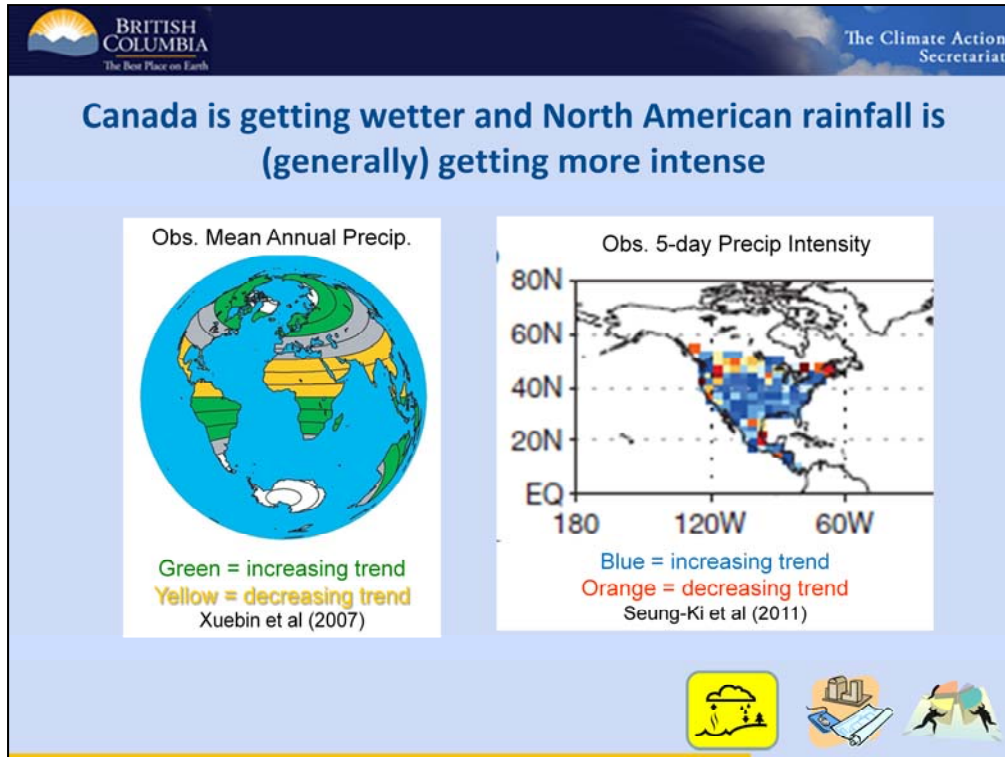
This graph shows sea level trends for four locations along the BC coast from the early 1900s to the present day. Local differences in sea level trends occur along our coast because of land height changes (rebound and subsidence). Local sea levels have been rising in some locations, such as Prince Rupert, Victoria and Vancouver, and falling in others such as Tofino, primarily due to tectonic process and rebound from the last ice age. – rebound along the west coast of Vancouver Island and subsidence in the large river deltas.

Variability is also due to inter-annual changes from tides ($\pm 5\text{m}$), large-scale ocean circulation (ENSO) ($\pm 30\text{cm}$), atmospheric pressure ($\pm 30\text{cm}$), winds or storm surges ($\pm 1\text{m}$), season variations in ocean temp. and salinity from freshwater inputs ($\pm 10\text{cm}$) that manifest differently along the coast. (BC Coastal Environment, 2006)



This table shows a sample of findings from the 2008 BC Sea Level Rise report (Thomson, Bornhold and Mazzotti, 2008). The report provides projections of SLR for all tide gauge stations along BC’s coast. The differences in projections between locations reflects the contributions of local vertical land movement and other factors affecting local sea level. Note that Nanaimo, where land is moving upward, has a lower range of SLR. The Fraser Delta, where land is subsiding, shows a higher range. Despite vertical land movement, all locations along BC’s coast will see some degree of SLR by the end of the century.

Note: The projections published in the BC Sea Level Rise report were based on the IPCC 4th Assessment’s published range of global sea level rise by 2100 (0.2 to 0.6m) and an additional “extreme high” scenario of 1m global rise. The projections in this table are based on the 1m global sea level rise scenario, which is now at the low end of the most recently published global sea level rise range (0.9 to 1.6m)

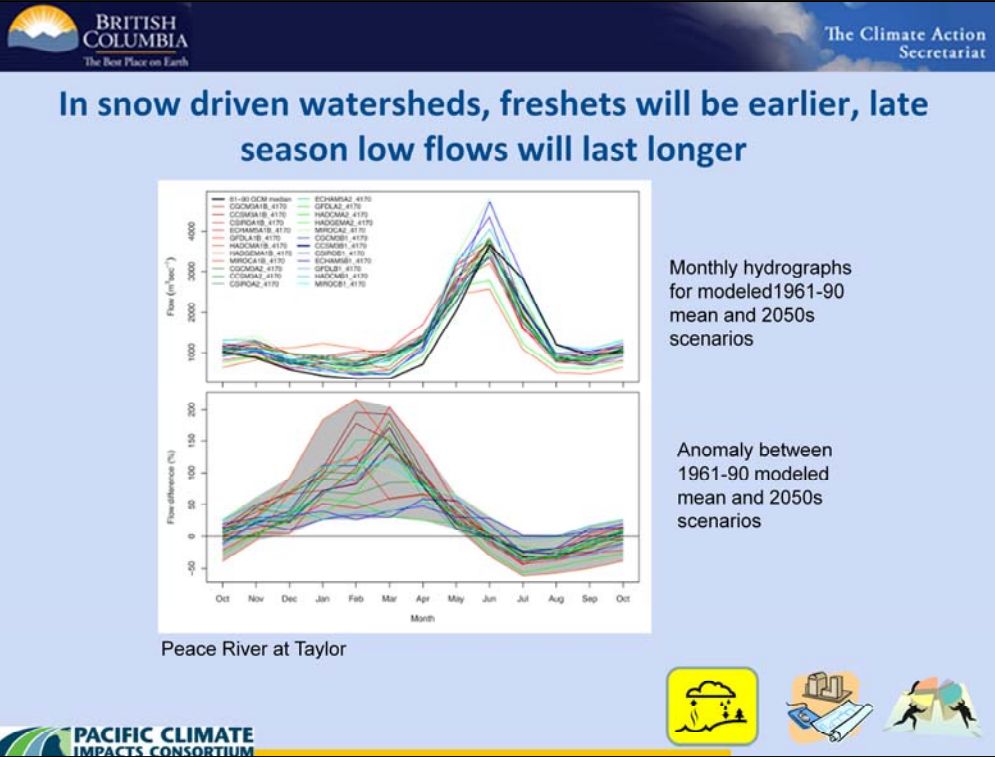


Xuebin et al (2007) documented the human-induced observed global redistribution of mean annual precipitation over the past century. Green areas of the global map (left) indicate areas of increasing mean annual precipitation. Yellow areas indicate a decreasing trend (gray areas indicate no agreement in trends).

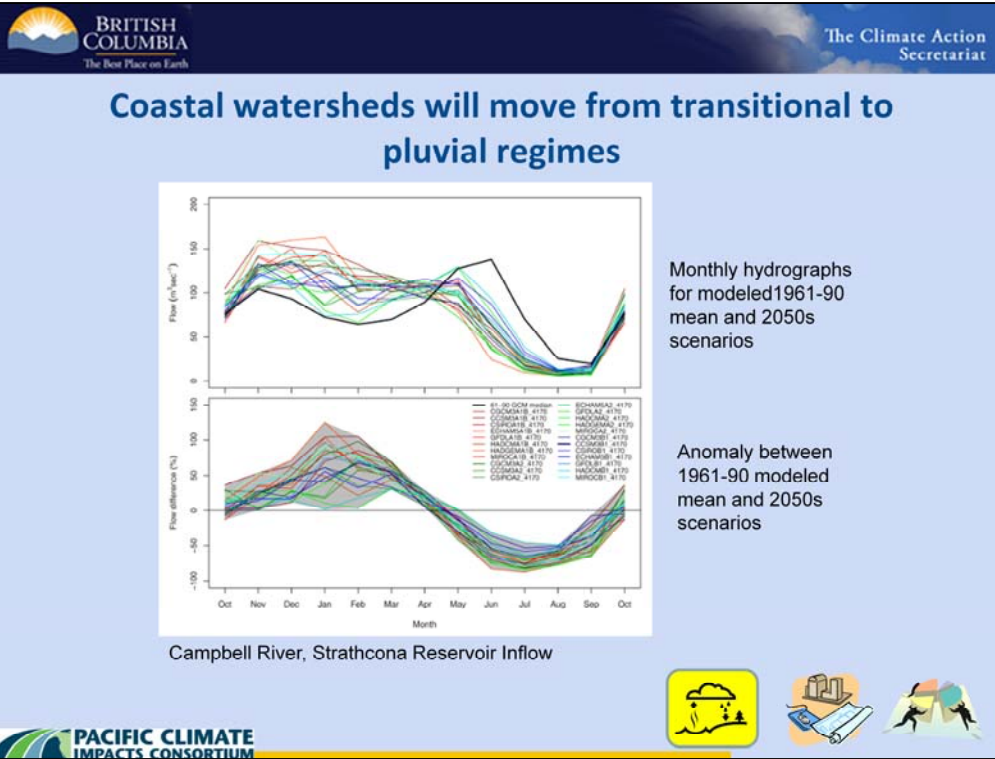
Sueng-Ki et al (2011) showed that human-induced increases in greenhouse gases have contributed to the observed intensification of heavy precipitation events found over approximately two-thirds of data-covered parts of Northern Hemisphere land areas (right). Blue dots indicate an increasing trend in 5-day observed precipitation intensity. Orange and yellow dots indicate a decreasing trend. British Columbia appears to have both increasing and decreasing trends.

Xuebin, Z., Zwiers, F. W., Hegerl, G. C., Lambert, F., Gillett, N. P., Solomon, S., & ... Nozawa, T. (2007). Detection of human influence on twentieth-century precipitation trends. *Nature*, 448(7152), 461-465. doi:10.1038/nature06025

Seung-Ki, M., Xuebin, Z., Zwiers, F. W., & Hegerl, G. C. (2011). Human contribution to more-intense precipitation extremes. *Nature*, 470(7334), 378-381. doi:10.1038/nature09763




Lower elevation snow-driven regimes may become transitional regimes in future. Full reports can be accessed at <http://www.pacificclimate.org/project/hydrologic-modelling-peace-campbell-and-columbia-river-basins>.



Transitional regimes found on BC's coast may become pluvial, with most water flowing through autumn to spring.
<http://www.pacificclimate.org/project/hydrologic-modelling-peace-campbell-and-columbia-river-basins>

How do we figure out what all this means for flooding in BC?



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The Climate Action Secretariat has a mandate to organize climate change assessments



PREPARING FOR CLIMATE CHANGE
British Columbia's Adaptation Strategy


February 2010

 Ministry of Environment

Science and Tools

Government Adaptation

Sectoral Assessments



British Columbia's Climate Change Adaptation Strategy allows government to prepare for climate change impacts. The three complimentary components of the strategy are


1. continued development of science and tools to support adaptation decision-making in BC;
2. 2. Mainstreaming adaptation to climate change into government business and operations; and
3. 3. to conduct assessments of climate change implications for various sectors and implement priority adaptation options.

A copy of the adaptation strategy can be found at env.gov.bc.ca/cas/adaptation/strategy.htm.


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A sea level rise “sectoral” assessment is currently underway



- Flooding
- Land Use
- Erosion
- Habitat
- Freshwater Resources



The Climate Action Secretariat is currently coordinating an assessment of sea level rise and its implications for government business. Through a cross-government consultation, we have identified five areas of government interest and jurisdiction that we will focus on in the assessment: coastal flooding, land use planning, erosion, habitat/environmental protection and freshwater resources.

The assessment will answer the question, *“How will sea level rise affect government business and how should government adapt its policies and operations to respond?”* The assessment will focus on the provincial government’s role as an adaptor and as a facilitator of adaptation by local governments, the private sector, NGOs and individuals.

Working groups will be established for each of the five areas of government interest identified above, with Climate Action Secretariat (CAS) staff acting as secretariat. The groups will be comprised of experts, identified through the Pacific Institute for Climate Solutions (PICS), ministry staff and representatives of relevant stakeholder organizations.

Each working group will hold a consultation workshop involving government and non-government stakeholders to identify knowledge gaps, discuss adaptation needs and formulate recommendations for government. An assessment report will be delivered in spring 2012.

NEW technical guidelines for sea dikes and coastal development under consideration

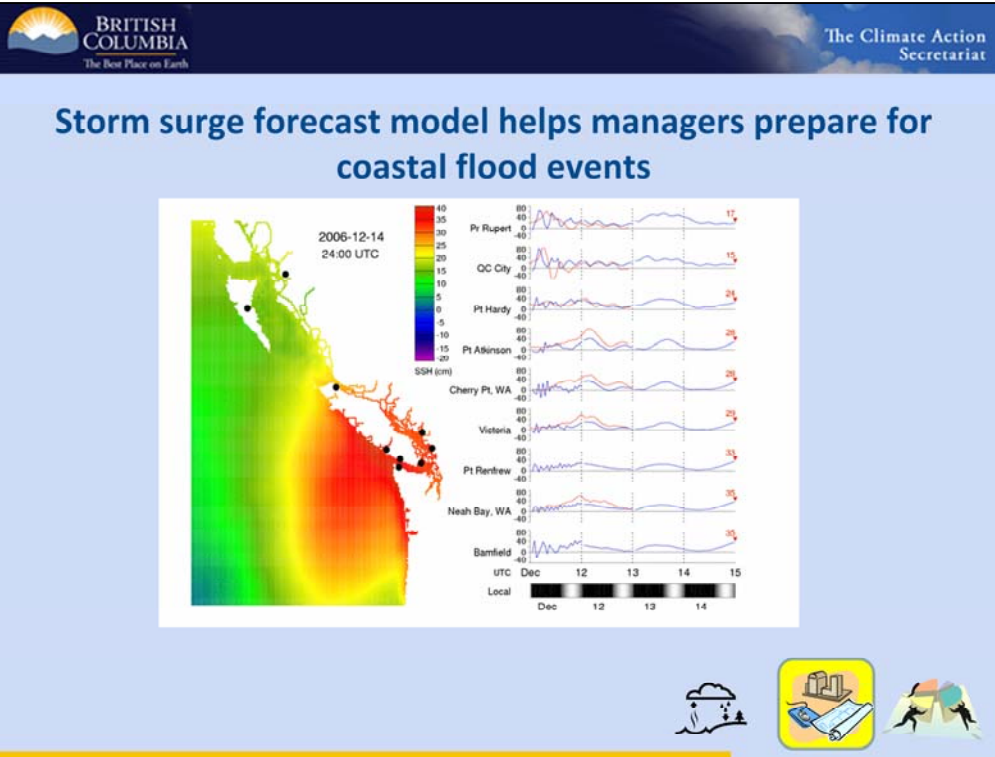


Several products and recommendations have already been developed that will contribute to the **Flooding** portion of the sea level rise assessment. These include new technical guidelines for sea dike design and coastal flood hazard land use management guidelines (flood construction levels and setbacks from the natural boundary). These documents were prepared as projects under the Regional Adaptation Collaborative and were jointly funded by Natural Resources Canada and the Flood Safety Section of the Ministry of Forests, Lands and Natural Resource Operations. The reports are set to be released for public review in the next few days and will be available on the MFLNO website. These reports are “advice to government” and are not yet considered government policy. A series of consultation workshops will be held to collect feedback from stakeholders on report recommendations.

Flood plain mapping guidelines for sea level rise also coming soon



New guidelines for mapping coastal flood plains to include sea level rise projections are also under development. This project is also part of the Regional Adaptation Collaborative and is led by the Flood Safety Section of the MFLNO.



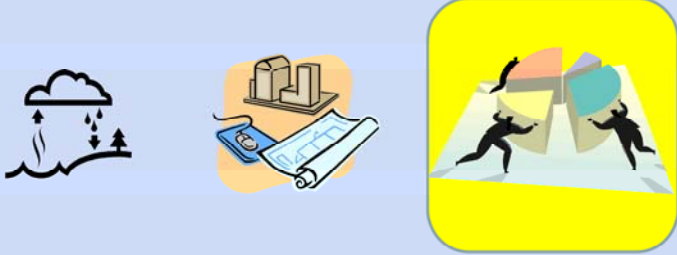
For several years, the Ministry of Environment has partnered with Fisheries and Oceans Canada to develop a storm surge forecasting model for British Columbia. The model is intended to provide early warnings of extreme storm surge events to coastal flood managers. The model is based on weather forecasts and indicates the difference between predicted astronomical tide levels and weather-induced water levels. The model is currently in a transition phase from a research project to an operational tool. We are continuing to work with Fisheries and Oceans Canada to get this product to “go live”.

The model runs during the winter storm season when BC’s coast experiences its largest astronomical tides and biggest storm surges. Access to the model is currently available at the following link: http://www.pac.dfo-mpo.gc.ca/sci/juandefuca/storm_surge/storm_surge.htm

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What pieces and people do we need to do an assessment of climate change and flooding?




The image contains three icons: 1. A black and white line drawing of a cloud with rain falling over a landscape with a tree and a river. 2. An orange circular icon showing a blue smartphone, a rolled-up blueprint, and a small 3D model of buildings. 3. A yellow rounded square icon showing two black silhouettes of people working together to assemble a 3D puzzle.

What about the rest of the province? How can we establish an assessment process for river flooding in BC?


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A flooding “sectoral” assessment to answer questions: What? So what? Now what?



The photograph shows a residential area that has been flooded. In the foreground, a person wearing a red life jacket and waders is standing in the water next to a small white boat. Another person is visible in the background, also in the water. The water is murky and reflects the surrounding buildings and trees. The background shows several houses and a large pile of wood or debris.



The icons represent different aspects of flooding: a house with water, a building with a roof, and a person running.

Clearly, climate change will dramatically alter hydrology in British Columbia and therefore flood risk for BC's communities. An assessment process could help to answer the questions:

- What will climate change mean for flood risk in BC?
- What will these changes mean for flood hazard management?
- What do we need to do to adapt to these changes?



We are very lucky in BC to have world-class expertise available to us on climate change science and modeling. The Pacific Climate Impacts Consortium, based at Uvic, is BC's premiere resource for climate scenarios and information to inform adaptation. Dr. Francis Zwiers, the CEO of PCIC is one of Canada's leading climate modelers and is also an IPCC author.

PCIC has a well-established hydrological modeling program and has recently complete several studies on hydrological change under climate change scenarios for BC Hydro (as seen earlier in this presentation). PCIC would be our source of hydrological scenarios for a flood hazard assessment. Unlike the BC Hydro work, the assessment would require scenarios of future extreme flows. We will need to engage PCIC early in the assessment process to determine what types of scenarios are possible to generate based on climate model output.

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BC Government roles in flood management and recovery include technical guidance, infrastructure funding, planning support, etc.

Ministry of **Community, Sport and Cultural Development**

Ministry of **Forests, Lands and Natural Resource Operations**

Ministry of **Environment**

Ministry of **Public Safety and Solicitor General**



British Columbia has at least four ministries involved in some aspect of flood hazard planning, management and recovery. To proceed with an assessment we would be seeking participation and support from all of these ministries.

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Professionals and local governments also need to be involved, but who?

Environment Canada / Environnement Canada

UNION OF BRITISH COLUMBIA MUNICIPALITIES

CWRA ACRH
Canadian Water Resources Association / Association Canadienne des Ressources Hydrauliques

Professional Engineers and Geoscientists of BC

Fraser Basin Council

cebc
Consulting Engineers of British Columbia

COLUMBIA BASIN TRUST
a legacy for the people

PIBC PLANNING INSTITUTE OF BRITISH COLUMBIA
FORWARD THINKING SHAPING COMMUNITIES

Fisheries and Oceans Canada / Pêches et Océans Canada

To carry out an effective assessment, the team would also need to include professionals, like yourselves, local governments and others. Who should be involved? Who could contribute resources?



As a first step in establishing a climate change flood hazard assessment for BC, I propose we establish a steering committee comprised of government staff, flood engineering professionals, planners, local government staff and experts. The Climate Action Secretariat would act as secretariat to the committee and establish an online “collaboration space” for stakeholders involved in the assessment. The committee would work over the next several months to develop a terms of reference for the assessment and then seek the necessary funding (from government and non-government sources) to complete the work.



If you have feedback on the idea of a flood hazard assessment for BC, or anything else you have seen in today's presentation, please do not hesitate to contact me.