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PPS/PS 2013-07

REPORT TO THE PLANNING, TRANSPORTATION AND PROTECTIVE SERVICES COMMITTEE MEETING OF JUNE 26, 2013

SUBJECT **UPDATES TO THE CAPITAL REGIONAL DISTRICT MODELLING OF POTENTIAL TSUNAMI INUNDATION LIMITS AND RUN-UP**

ISSUE

Requested follow-up to the May 24, 2013 Planning, Transportation and Protective Services Committee (PTPSC) meeting regarding clarifications within the Executive Summary of the report and the legal implications of the Capital Regional District (CRD) Board endorsing the report for use by local emergency programs.

BACKGROUND

At the May 24, 2013 PTPSC meeting, staff was requested to incorporate revisions to the Executive Summary of the report "Capital Regional District Modelling of Potential Tsunami Inundation Limits and Run-up" to clarify the intended use of the report, as per Committee discussions. Committee also requested legal advice regarding whether the report needed to be endorsed or simply received in order for staff to use it for emergency planning purposes and whether endorsement conferred any additional liability on the CRD.

ALTERNATIVES

1. That the CRD Modelling of Potential Tsunami Inundation Limits and Run-up report be received and provided for use by local emergency programs as a guideline in planning for tsunami risk and response procedures.
2. That the "CRD Modelling of Potential Tsunami Inundation Limits and Run-up" report be referred to staff for further analysis and report back.

LEGAL IMPLICATIONS

CRD staff sought and obtained legal advice regarding whether endorsement of the tsunami report was needed in order for staff to use it for emergency planning purposes. The advice recommends that Committee and Board need only receive the report for this purpose as representing best available information to the CRD regarding tsunami hazard.

This advice supports the use of the tabled motion from the May 24, 2013 PTPSC meeting, that the report be received for use by the local emergency programs as a guideline in planning for tsunami risk and response procedures.

This is also consistent with the *Local Authority Emergency Management Regulation* which states that a local authority's emergency plan must reflect "*the commitment of the local authority to provide policy guidance and direction to the emergency management organization*".

AMENDMENTS TO THE EXECUTIVE SUMMARY

CRD staff requested the consultant to amend the Executive Summary to reflect Committee comments from the May 24, 2013 meeting, as follows:

1. Impact of sea level rise (or other climate change effects) not explicitly accounted for in the report in relation to its use for infrastructure design;
2. Use of High High Water Mean Tide (HHWMT) in relation to potential higher water from storm surges or higher than average tides and the impact on the results; and

3. The relationship between this model and the risk of tsunami from a "Delta Slump" or other secondary event, triggered by the Cascadia Subduction Zone event.

The amended Executive Summary is attached (Appendix 1).

CONCLUSION

The Executive Summary has been updated to address Committee concerns raised at the last meeting. The legal opinion received supports the tabled motion presented at the May 24, 2013 meeting of the PTPSC.

RECOMMENDATION

That the Planning, Transportation and Protective Services Committee recommends to the Capital Regional District Board that:

1. the CRD Modelling of Potential Tsunami Inundation Limits and Run-up report be received and provided for use by local emergency programs as a guideline in planning for tsunami risk and response procedures.

ORIGINAL SIGNED

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Appendix 1: Executive Summary, CRD Modelling of Potential Tsunami Inundation Limits and Run-up (updated - June 12, 2013)

Executive Summary

This report, “Modelling of Potential Tsunami Inundation Limits and Run-Up” summarizes the work performed and the results of modelling the tsunami impacts along the entire coastline within the Capital Regional District (CRD) that would result from a possible, predicted Cascadia Subduction Zone (CSZ) earthquake occurring off the west coast of Vancouver Island. Cascadia Subduction Zone earthquakes have occurred, on average, every 500 years and the most recent 1-in-500-year earthquake for this zone is thought to have occurred in the year 1700.

The report was developed to inform the CRD, in relation to Emergency Management, the types of risk and impacts they should consider when developing preparedness and response plans, including evacuation routes based on tsunami risk from this type of event. This study shows predicted tsunami effects resulting from the CSZ earthquake off the west coast of Vancouver Island and does not include potential effects of secondary events, such as landslides or slumps that may occur within the general geographical area surrounding Greater Victoria. The likelihoods of these possible secondary events are unknown and they would need to be the subjects of separate studies of the specific areas taking into account local geotechnical and geological information.

The US National Seismic Hazard Maps shows 12 possible combinations of earthquake magnitudes and rupture configuration scenarios that would each represent a 1-in-500-year earthquake. Amongst these, the combination having the highest joint probability, which comprises a magnitude Mw 9.0 and global analog (GA) rupture scenario, was selected as the event to be analyzed.

The model used to analyze the tsunami wave generation and their impacts when reaching land was NEOWAVE. It is a model developed by researchers at the University of Hawaii and University of Alaska led by Dr. Kwok Fai Cheung, who was the lead modeller for this project. In 2009, NEOWAVE competed and won against seven other tsunami numerical models and it has been validated against data obtained from a number of recent tsunami events, including the 2011 Tohoku tsunami in Japan. It is the official model for tsunami inundation mapping in Hawaii, American Samoa, the US Gulf of Mexico coastal states and Puerto Rico.

In order to perform the tsunami modelling, a complete and seamless digital elevation model (DEM) containing both topographic (land) and bathymetric (sea-floor) information was first required. To accurately model the propagation of the tsunami through the Strait of Juan de Fuca the area to be covered included shoreline areas of the entire CRD and, within the USA, the Olympic Peninsula, San Juan Islands and portions of Puget Sound. This whole process required the compilation of data from multiple original sources (sometimes overlapping), having varying accuracies and reliabilities that needed to be resolved. Some of the challenges encountered and overcome included differences in both coordinates and elevations used in Canada and USA; use of differing elevation datums within the various sources; overlapping data providing differing elevations; and shoreline discontinuities, all of which could have had a significant impact on the modelling results.

The NEOWAVE model was applied to the DEM in a series of nested grids, with increasing accuracy applied to smaller grid areas as follows:

- The complete CRD was modelled at a 90-m grid size
- Esquimalt Harbour, including the area from Albert Head to Clover Point was further modelled at an 18-m grid size; and
- Victoria Harbour including Inner Harbour, Upper Harbour and Selkirk Waterway was then further modelled at a 9-m grid size.

The models were run using the Higher High Water Mean Tide (HHWMT) at Victoria as the base water level, which is approximately 0.732 m above Mean Water Level (MWL). Modelling results are presented in a series of colour-scaled figures or maps showing:

- Maximum water level – this includes, and is not additive to, the HHWMT (i.e. this is not the wave height, which is smaller)
- Maximum Drawdown of Water - this value is relative to the base water level (HHWMT)
- Maximum water flow speed – similar to the water current
- Tsunami Arrival Time – time to first positive wave
- Time to Maximum Water Level – time that water reaches its maximum (impacted by resonating wave effects)

The use of HHWMT (or its US equivalent) as the initial water level is supported by the National Tsunami Hazard Mitigation Program (NTHMP) as a standard. However, the HHWMT is an average of Higher High Tides and there may be tide levels that are higher than this value. As well the use of the current HHWMT does not include allowances for potential sea level rise due to climate change. It is expected that revision of the initial water beyond HHWMT would increase the Maximum Water Level results by a similar amount; and this has been verified within a range of 2 metres variation.

Table ES-1 provides a summary of the values referenced above for several selected locations within the CRD. The values in the tables have been inferred from Figures 5.1 through 5.5 – the reader is encouraged to refer to the figures for these and any other specific values.

Table ES1 – Summary of Tsunami Model Results at Selected Locations

Location	Maximum Water Level (m)	Maximum Drawdown of Water (m)	Maximum Water Flow Speed (m/s)	Tsunami Arrival Time (min)	Time to Maximum Water Level (min)
Port San Juan (entrance near Port Renfrew)	3.5	-1.0	0.7	35	50
Sooke Harbour (entrance)	2.5	-0.2	0.6	60	75
Esquimalt Harbour (entrance)	2.7	-1.2	2.0	77	96
Victoria Harbour (entrance)	2.5	-1.05	1.0	76	95
Cadboro Bay	2.0	-0.2	0.8	90	160
Sidney	2.0	-0.2	0.6	110	150

As can be seen from the figures in the report, for much of Greater Victoria, the maximum water level is predicted to be less than 3.5 m and the maximum flow speed is predicted to be in the order of 1 m/s, excluding areas with narrows or waterway constrictions. To provide a comparative reference, the 2011 Tohoku tsunami resulted in a maximum water level of 40 m (recorded at a cliff on the Iwate coast) and a maximum water flow speed of approximately 12 m/s (inferred from video images taken in Myagi).

Based upon the modelling results, a Tsunami Hazard Line has been prepared for all coastline areas within the CRD. The Tsunami Hazard Line has been developed based upon the model-predicted

Maximum Water Level, with consideration for earthquake-induced land subsidence and a Factor for Public Safety, as follows:

- Maximum water level, plus
- Land subsidence (since lowering of the ground surface effectively adds to the water level), plus
- An allowance of 50% added to the total of maximum water level and subsidence.

The 50% allowance has been included as a Factor for Public Safety to account for a) uncertainty related to the magnitude of the earthquake event that occurs; b) possible variations in the initial tide condition; and c) variability of the available topographic information.

The resulting Tsunami Hazard Line has been created as a layer to be added to CRD's GIS mapping.

To further benefit from the model developed and its results, a series of potential next steps has been suggested. These include:

- Using the results and Tsunami Hazard Line for other emergency considerations, including:

- Evacuation planning
- Emergency response planning
- Infrastructure assessment
- Transportation planning

It should be noted that any infrastructure assessment, for example, should include risk parameters suitable to the infrastructure project and use this report as a baseline of current levels with adjustments made to address all risk factors as required.

This report, its data and interpretations made are intended for emergency management personnel and purposes only and the CRD and AECOM are not responsible for interpretations by others for any other purpose.