Welcome to this Exhibit on Ucluelet Coastal Flood Mapping!

In September 2019, the District of Ucluelet embarked on a project to help the community become more resilient to flood hazards from coastal storms and tsunamis.

The District has recognized the importance of better understanding coastal flood hazards, especially in the context of changing sea levels, to support planning and emergency management decisions. Flood hazard maps are a foundation for understanding where and how deep water might occur, providing the basis to reduce community risk from flooding.

What are coastal flood hazards?

Coastal storm hazard arises when water levels are higher than normal as a result of surge, wind, wave, and tidal conditions.

Tsunami hazard occurs when a series of potentially large waves are created by displacement of mass in the ocean.

Sea-level rise, caused by expanding water and melting ice caps from climate change, slowly and steadily compounds coastal flood hazards.

Read more at ucluelet.ca/community/sustainability-climate-action/flood-mapping

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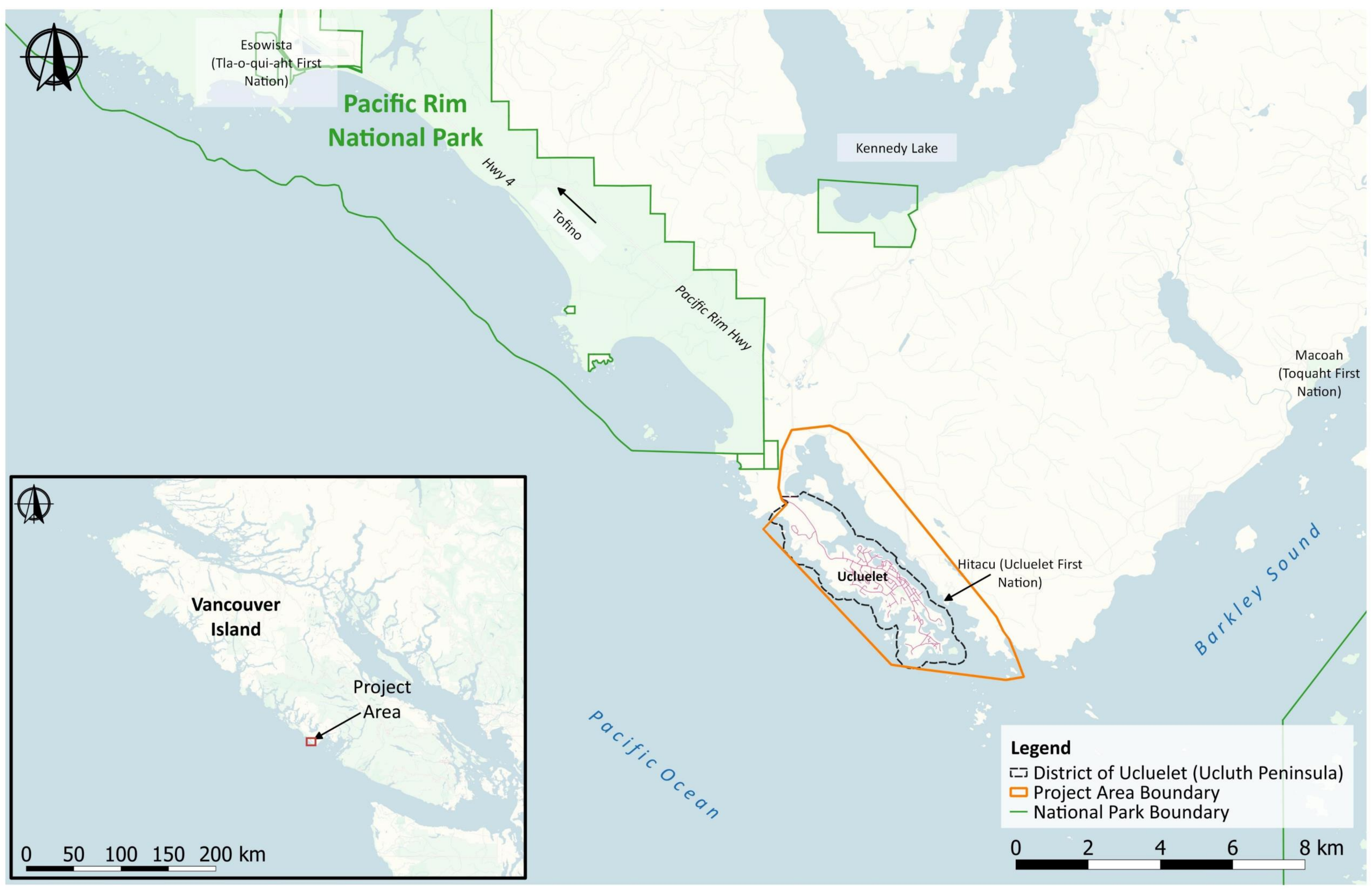
About this Project

Ucluelet's stunning coastal landscape also means that it is exposed to coastal flood hazards. The District wishes to better understand coastal storm and tsunami hazards on a regional scale, for better coordination and consistency of effort. Therefore, the study area, as shown in the figure below, goes beyond the District's boundaries.

Study Area and Project Team Photos from the Field



In this study, we asked:

1. Where and how deep might it flood during different storm events? And how does this change with sea-level rise?
2. How high should buildings be constructed to mitigate coastal storm flood damages?
3. Where and how deep might it flood during a tsunami (focusing on the Cascadia megathrust earthquake)? And how does this change with sea-level rise?
4. What are the different tsunami flood levels that the community can use for planning purposes?

Project Timeline

Nov/Dec 2019	Jan/Feb 2020	Mar 2020	Apr 2020	May 2020	Jun 2020
Confirm team, deliverables, responsibilities Project kick-off Data collection	Coastal storm model setup and calibration Tsunami model set-up and calibration; initial model runs and preliminary results	Site visit Preliminary tsunami results discussion Coastal storm modelling and preliminary results Coastal erosion data review	Modelling methods draft report Tsunami flood hazard mapping Coastal storm flood hazard mapping	Planning support mapping Hazard mapping refinements	Final reporting Public engagement materials Council presentation

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More on Coastal Storm Flood Hazard...

Components of Coastal Storm Floods

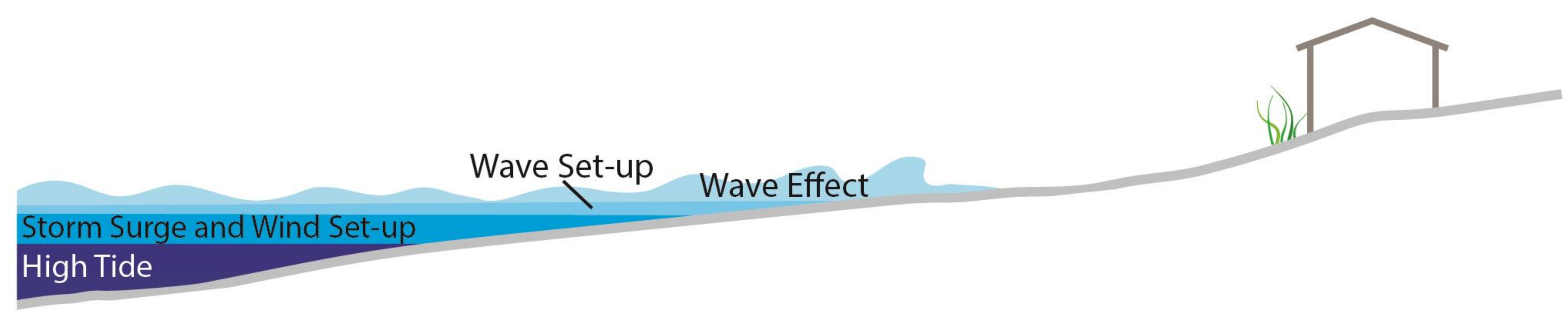
Deterministic (Predictable Components)

Tide	A periodic rise and fall of the ocean surface due principally to the gravitational interactions between the moon, sun and earth.

Probabalistic (Unpredictable Components)

Surge	A rise above normal water level on the open coast due to change in atmospheric pressure and wind stress on the water surface.
Waves	A disturbance on the ocean that transmits energy. Usually generated by wind blowing across the ocean's surface.
Set-Up	An increase in water level near the shore as a result of on-shore winds blowing over shallow water pushing it up and/or the increase in water level shoreward of breaking waves derived from the momentum of the waves

Total Water Level = Tide + Surge + Waves + Set-up



King Tide	A non-scientific term to describe the especially high tides seen when the moon is closest to the earth. They happen twice a year, but are typically more dramatic in the winter months (November through February)

Flooding induced by storms is assessed using a so-called "continuous simulation approach", where the total water level components are jointly analyzed over a historic period, using both observed water levels and numerical modelling. The frequency with which a specific storm size has occurred in the past is modelled. From that, estimates are made of how likely it is to occur in the future. This is done based on scenarios of **annual exceedance probabilities (AEPs)**. Combined with projections of **relative sea-level rise (RSLR),** a total of 20 coastal storm flood scenarios were modelled.

AEP The AEP describes the probability of an event occurring in any given year, written as a percentage. By comparing storms of different probabilities, we can see the impact of different sizes of storms on the coastline. To understand the range of impacts—from relatively small, common storms to very large, much rarer storms—five AEP floods were modelled. As shown in the table below, these are associated on a spectrum of frequent (small) to very rare (very large) floods. Modelling results from the 6.67% and 0.5% AEP floods were mapped.

AEP	Likelihood	Storm Size	Return Period (indicative)
6.67%	**Frequent**	**Small**	**15 year**
2%	Moderately frequent	Small-moderate	50 year
1%	Moderately infrequent	Moderate-large	100 year
0.5%	**Rare**	**Large**	**200 year**
0.2%	Very rare	Very Large	500 year

RSLR Relative sea-level rise (RSLR) describes the combined effect of rising sea levels from climate change and the slowly rising land surface in Ucluelet (due to rebounding after the last ice age). RSLR is critical to understanding how the hazard will change over time. RSLR of 0 m, 0.5 m, 1 m, and 2 m for each of the AEP floods was determined.

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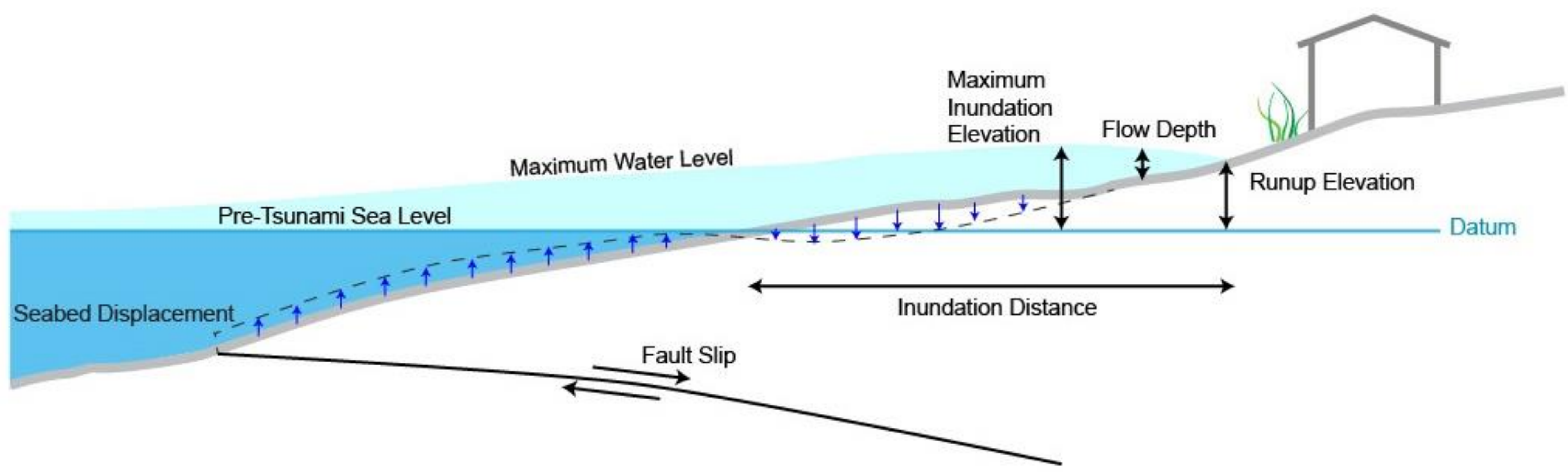
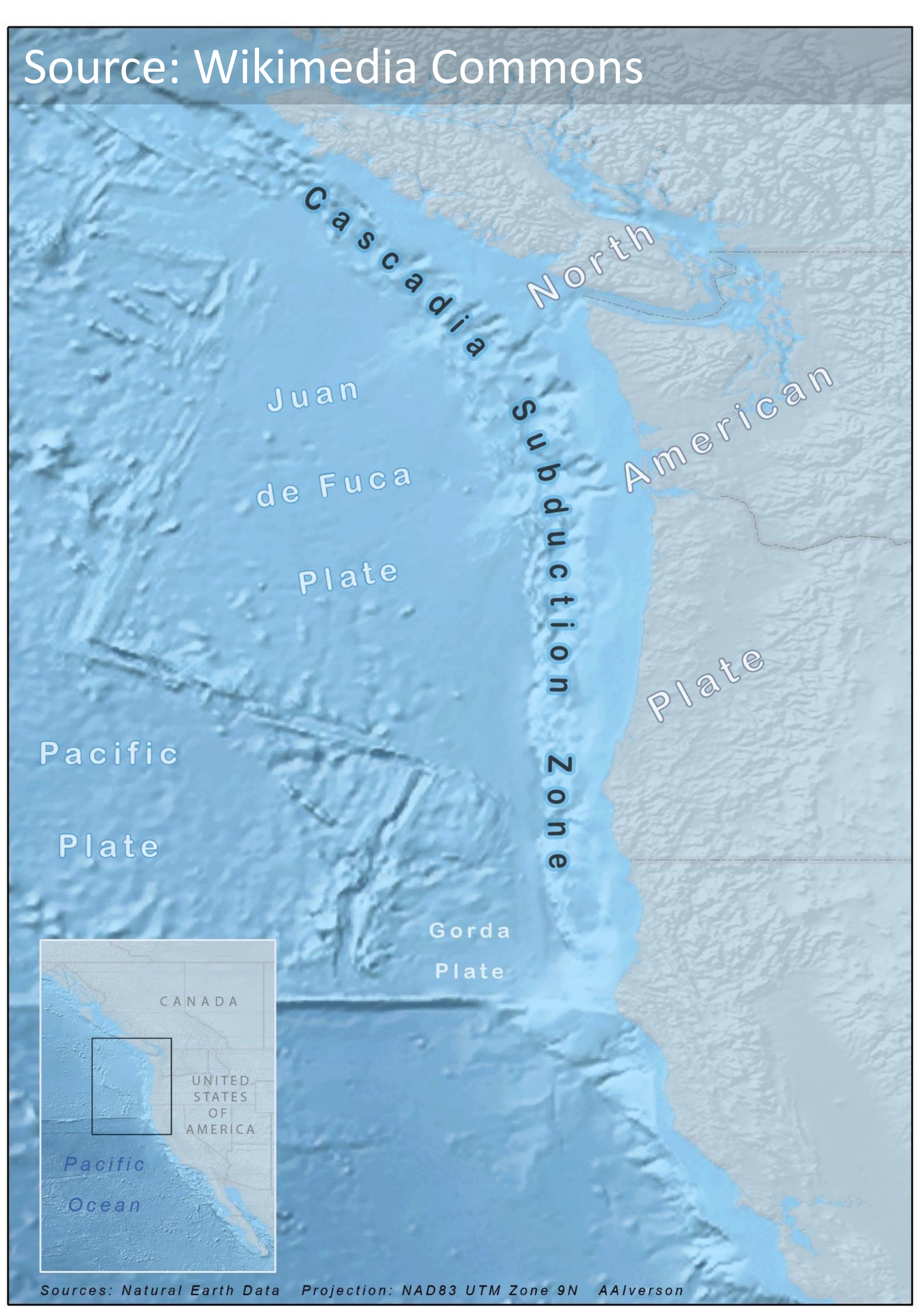
More on Tsunami Flood Hazard…

Components of a Tsunami Flood

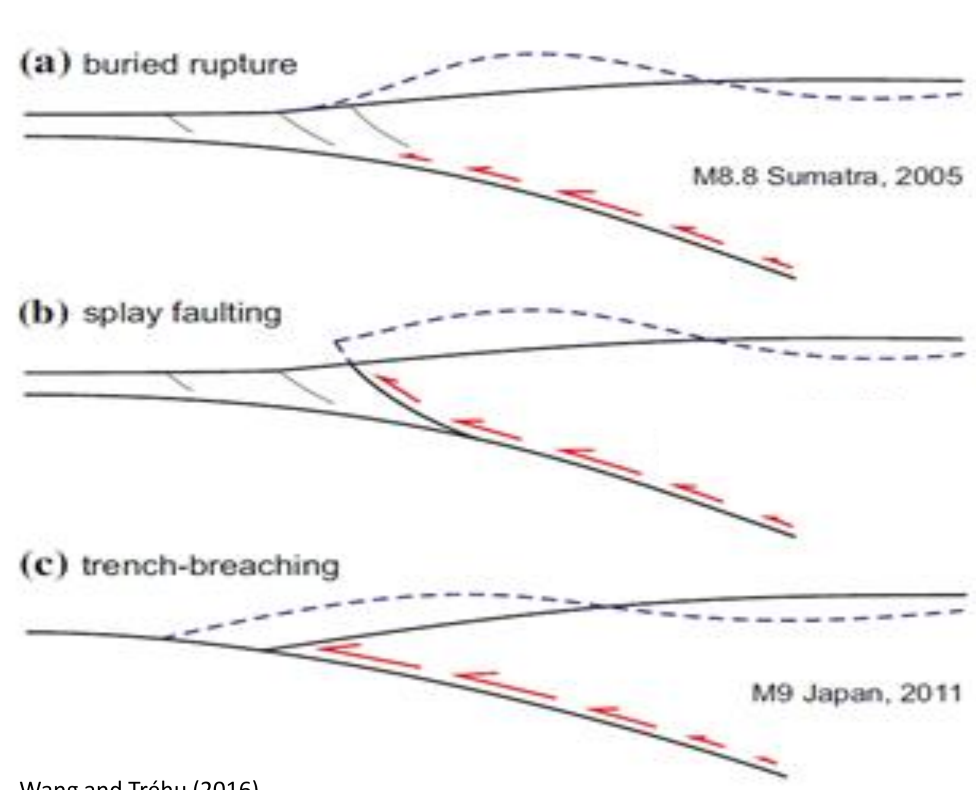
Total tsunami flood depth includes the tsunami wave amplitude (i.e., tsunami wave height in comparison to pre-tsunami water levels), a high tide (Higher High-Water Large Tide), relative sea-level rise if applicable, as well as land surface subsidence. During a **Cascadia Subduction Zone (CSZ)** earthquake, it is expected that the land surface in the DOU will subside by around 2 m as a direct result of the triggering earthquake, increasing the flood depth.



CSZ A tsunami caused by the Cascadia Subduction Zone (CSZ) earthquake is the most likely source to generate a worst-case tsunami. However, other more distant earthquake Sources, such as the Alaska earthquake of 1964, have also impacted the area. A CSZ tsunami would occur approximately 30 minutes after the earthquake is felt in Ucluelet. Three rupture types were investigated (see figure below) by modelling two variations of each (see table below). Considering relative sea-level rise, a total of 24 scenarios were modelled. Modelling results from the W2003 (buried rupture) and G2018-S-A (splay faulting A rupture) were mapped.



Rupture Model	Model Abbreviation
Buried	**W2003**
Buried	G2018-B
Splay faulting A	**G2018-S-A**
Splay faulting B	G2018-S-B
Trench-breaching 50% peak slip	G2018-T-50
Trench-breaching 100% peak slip	G2018-T-100



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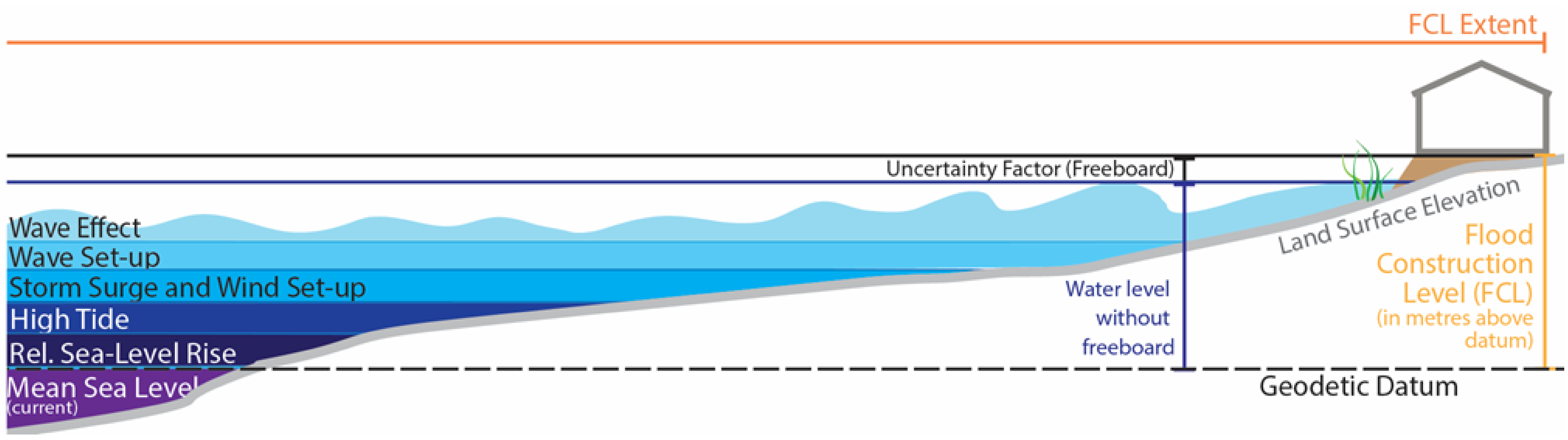
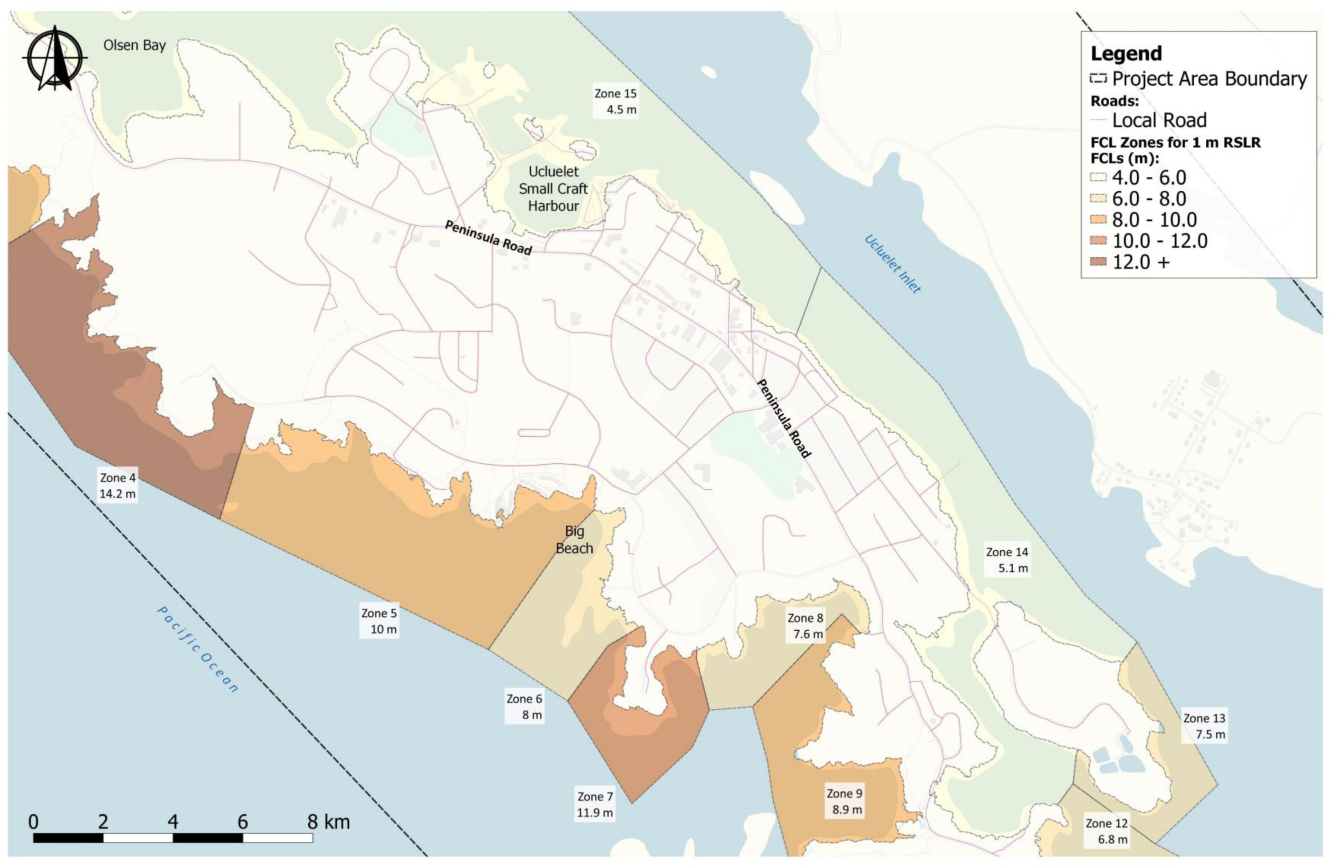
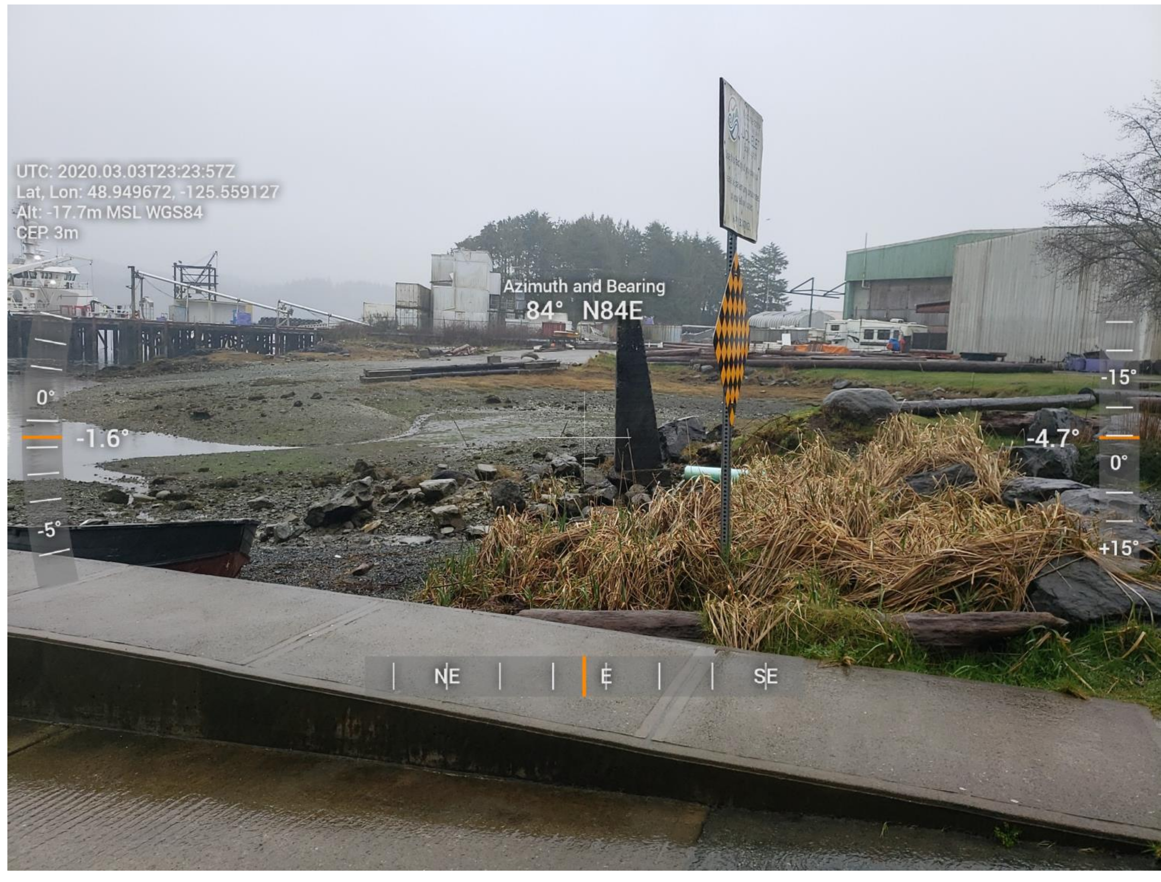
How Do the Flood Maps Affect Me?

FCL Flood maps are used in many ways to support mitigation of flood damages in the short and long term. One of the key ways these maps can be used is to define flood construction levels (FCLs). FCLs are used to determine the “safe” level that the ground floor of a habitable building should be constructed at to minimize damages from flooding.

The Province of British Columbia provides guidelines on how FCLs should be determined and how they can be used in local policy and regulations. The FCL is defined as the total water level (including tide, storm surge, wind and wave effects, as well as sea-level rise), plus an uncertainty factor called freeboard.







Tsunami flood depth and extent maps were also used as the basis to produce planning support maps for the DOU. However, in contrast to FCLs used for coastal storm flooding, guidelines development is in its infancy for tsunami flood hazard. Safety factors (equivalent to freeboard used to determine FCLs) are a critical component. To establish the tsunami flood planning levels, results for two rupture models were used, both with a 50% safety factor and without. With more information, these maps can help planners define the community’s “risk tolerance” in siting infrastructure and implementing emergency response plans.

Project Limitations

As with any study of this type, many uncertainties exist, and modelling and mapping can only provide a simplified representation of a complex reality. Please refer to the final report (Ebbwater Consulting Inc. and Cascadia Coast Research, 2020) for a full discussion of limitations.

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Next Steps for Ucluelet

The Coastal Flood Mapping study provides a scientific foundation for making informed decisions. Where we go from here will depend on community discussion and decisions by its elected Council. The results of the flood mapping study inform emergency preparedness planning and the location of future municipal infrastructure. Where and how we build as a community should be adjusted over time to reduce the risk of flood damage.

Next Steps include:

- ✓ Create a web page to make the results of this study, the methodology and mapping all available to the public;
- ✓ Share the project results with the Yuułuʔiłʔatḥ Government, ‘Tukwaaʔath Nation, Alberni Clayoquot Regional District, Parks Canada and the District of Tofino for their information;
- ❑ Update emergency preparedness plans based on the results of this study;
- ❑ Review municipal infrastructure and our plans for long-term management of District assets - are we resilient to flooding or do we need to make changes over time? Adjustments to things like sewer pump stations can reduce the impact of how a flood event would affect the community;
- ❑ Review development regulations on existing properties so that, over time, buildings will meet the Flood Construction Levels identified in this study; and,
- ❑ Consider new policy to avoid areas of flood risk in future developments.

View the Methodology, Reports, Maps and more at
ucluelet.ca/community/sustainability-climate-action/flood-mapping

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