# STAFF REPORT

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| **TO:** | Committee of the Whole | **MEETING:** | June 9, 2020 |
| **FROM:** | Jamai Schile<br>Senior Planner | **FILE:** | 5285-20 |
| **SUBJECT:** | Report on the Coastal Floodplain Mapping Project | | |

## RECOMMENDATIONS

1. That the Board direct the coastal flood hazard maps be communicated to the public.
2. That the Board direct the applicable land use bylaw amendments be reviewed and updated to incorporate the findings of the Coastal Floodplain Mapping Project.

## SUMMARY

In the Regional District of Nanaimo (RDN), flood management is addressed through a combination of policy and regulatory tools for land use, emergency planning, infrastructure design and sustainability. These actions reduce flood risk to people and property and protect the natural environment. In response to climate change impacts, the RDN recognizes the importance of better understanding coastal flood hazards, especially in the context of changing sea levels. To help the region become more resilient to future flood events a technical study of the coastal zone and a series of coastal flood hazards maps was completed. The next recommended step is to share the coastal flood hazard maps with the community and begin a public process to update the applicable land use bylaws.

## BACKGROUND

### *Regulatory Consideration*

Section 524 of the *Local Government Act* provides local government with the authority to designate land as floodplain and specify the flood level for the floodplain and setbacks from a watercourse, water body or dike of any landfill or structural support required to elevate a floor system or floor pad above the flood level.

Over the past two decades, riverine flood maps have been a key source of information in flood risk management in the RDN, used to regulate development within designated areas, in emergency response planning and in designing and locating infrastructure. In addition, flood maps increase public awareness of flood risks and socialize residents to share risk reduction responsibility.

Recognising that flood hazards pose a significant risk in the region, the RDN first adopted the Regional District of Nanaimo Floodplain Management Bylaw 1469, 2006, “Floodplain Bylaw”, in 1991. This bylaw designates three river/estuarine floodplains (Nanaimo River, Englishman River

and Little Qualicum River) that establishes a minimum Flood Construction Level (FCL) [1] and setback from the waterbody for the construction of buildings and structures within the designated floodplain area. For parcels subject to the Floodplain Bylaw, but not within one of the designated riverine floodplains, a property owner is required to submit a flood hazard assessment report, prepared by a qualified professional, to calculate the FCL and to certify that the land is safe for the intended use. A review of site-specific assessments confirmed variations in the interpretation of the methodology used to calculate FCLs, resulting in a range of FCLs in comparable geographical areas. Amending the Floodplain Bylaw to designate a coastal floodplain with FCL standards (similar to the existing riverine floodplain designations) would address this concern by providing a consistent approach and certainty for property owners and developers. For these reasons, it is recommended that the Floodplain Bylaw be updated by designating a coastal floodplain (based on the coastal hazard maps) and considered further through a public process.

### *Coordination with Member Municipalities*

As a Regional Growth Strategy implementation project, the member municipalities have been engaged at key stages of the Coastal Flood Mapping Project through periodic updates and events, including a technical workshop and at a recent meeting of regional planning directors. Through these activities, opportunities have been identified to develop key messages to support the implementation of the coastal flood maps, with the overarching objective of continuing to provide a coordinated approach to increasing flood resiliency.

### Sea Level Rise and Climate Adaptation Program

Initiated by the RDN, in 2016, the Sea Level Rise and Climate Adaptation Program[2] ("Adaptation Program") establishes a risk-based approach to flood management informed by the Sendai Framework. Recently adopted by both the Federal and Provincial government, the international Sendai Framework for Disaster Risk Reduction is the new global blueprint for building disaster resiliency. The approach is promoted through four priorities for action:

1. Understanding disaster risks
2. Strengthening disaster risk governance
3. Investing in disaster risk reduction for resilience
4. Enhancing disaster preparedness

This direction is relevant to the RDN as it works to increase resiliency to flooding by developing policies, plans and regulations and in seeking provincial and federal grant funding to support this important work.

By design, the Adaptation Program is composed of several phases to gather the required technical information, (such as the coastal flood hazard maps), to share the results through a public process and to inform the development of applicable policies, plans and strategies. This sequence of actions is scheduled to be advanced over several years due to the type of technical studies required, the geographical size of the region and the availability of funding, as shown in Table 1.

The successful completion of the coastal flood hazard maps is an essential step in this process that provides information that has never been available before. The purpose of the project was to

[1] Flood Construction Level is the required elevation of the underside of a wooden floor system or top of concrete slab for any habitable area.

[2] RDN webpage www.rdn.bc.ca/sea-level-rise-adaptation-program

conduct coastal modelling and mapping to better understand the coastal flood hazard, within the context of sea level rise. The study area included the marine coastal areas within the District of Lantzville, the City of Parksville, the Town of Qualicum Beach, Electoral Areas A, B, E, G and H, and the Snaw-Naw-As and Qualicum First Nation Indian Reserve Lands. The City of Nanaimo did not take part in the study as it is undertaking similar research through their Climate Resiliency Strategy.

The mapping project follows the approach set out in the Provincial Coastal Floodplain Mapping – Guidelines and Specifications (Kerr Wood Leidal, 2011) and various Provincial documents developed in BC to provide guidance on sea level rise (Ausenco Sandwell 2011a, 2011b, 2011c); the Engineers and Geoscientists of BC, Professional Practice Guidelines for Flood Mapping in BC (2017), and the Provincial Flood Hazard Area Land Use Management Guidelines (2018)[3].

The results is an atlas of maps that provide a visualization of the coastal flood hazard. The maps show the geographical location of land susceptible to flooding from the adjoining sea (the coastal floodplain) and the depth of flood waters in relation to the natural topography of the land. The atlas contains four types of flood hazard maps, which the professional engineers are required to produce for this type of study. Due to the extensive coastline of the RDN, a total of 152 map sheets have been produced. Each type of map can be used for a different application or used in conjunction with each other depending on the subject of the investigation. What follows is a summary of each type of map and possible uses:

1. **Coastal Storm Inundation Maps** – a storm surge is a localized increase in water levels on an open coast due to a change in atmospheric pressure and wind stress on the water surface that can result in storm flooding. Different combinations of storm conditions are assessed to determine the likelihood of particular events occurring in the future. The results of this analysis is then mapped to represent the total water depth and the extent of flooding landward from the sea. Flood inundation maps can be used for preparedness planning, to determine a suitable location for new infrastructure and facilities (i.e., water treatment plant, ferry terminal, hospital, etc) and ecological assessment (i.e., wetland identification).
2. **FCL Regulatory Map** – is a technical map that provides a visual account of the coastal floodplain area and the applicable topographical contours and FCLs within the floodplain. This type of map would be used by land use professionals, such as engineers in the preparation of a flood hazard assessment for a new development project.
3. **SLR Planning Area Map** – extend to cover the area between the floodplain limits (present day, 0.5 meter and 1.0 meters Relative Sea Level Rise[4]), which is the projected change in the natural boundary over time due to changing sea levels. This information can be used to monitor the rate of change over time, including when the coastal flood hazard maps should be updated to ensure that the maps remain representative of the storm flood conditions.
4. **FCL Reach Map** – is a simplified map that contains the coastal floodplain overlaid by colour coded polygons for each Reach. A Reach is a section of shoreline that is characterized by similar FCLs of the cross-transects and natural topography. The intent of this map is to assist in communications between planners and residents to easily identity which properties are within the coastal floodplain and what is the standard for FCL for that area and subject property. It can also be used to designate the coastal floodplain and FCL by adopting a land use bylaw. In the case of the RDN, by amending the Flood Management Bylaw (No. 1469), 2006.

[3] References list located in Attachment 2 of this report.

[4] Relative Sea Level Rise describes the rise of the sea level compared to vertical changes of the ground level (land uplift over time).

The project was carried out by certified professional engineers with experience in coastal analysis and flood risk management, and was completed within the approved budget of $235,700. The project budget was shared between the Province ($150,000) and the RDN ($85,700), resulting in the development of the first coastal flood hazard maps for the region.

Attachment 1 provides an overall summary of the project and Attachment 2 provides samples of each type of coastal flood hazard map. The full atlas has not been included in this package due to the volume of information.

***Next Steps***

Acknowledging the importance of involving the community early and often throughout the development of the Adaptation Program, it is recommended that the coastal flood mapping information be made publicly available on the RDN website for information.

Coinciding with the release, local professionals involved in land development will be notified and invited to participate in a meeting to share the mapping information. Professional practice guidelines for engineers and geoscientists require appropriate background information be reviewed when preparing flood assessments, which would include the coastal flood hazard maps.

## ALTERNATIVES

1. That the Board direct the coastal flood hazard maps be communicated and the applicable land use bylaw amendments incorporate the findings of the Coastal Floodplain Mapping Project.

2. That the Board provide alternative direction.

## FINANCIAL IMPLICATIONS

Proceeding with the recommendation would incur some costs associated with conducting a public process to update existing land use bylaws. A cost estimate for this work would likely not exceed $5,000, which is included in the Strategic and Community Development 2020 work plan and budget as per the 2020 - 2024 Financial Plan.

Beyond the recommendation presented in this report, proceeding with the implementation of the Adaptation Program has associated costs, in part accounted for in the 2020 – 2024 Financial Plan. Currently, $150,000/year has been allocated in the RDN Financial Plan. In addition to the RDN's contribution, provincial and federal grant funding is being actively pursued.

In 2018, the RDN was granted $150,000 by the Union of British Columbia Municipalities Community Emergency Preparedness Fund (CEPF) to support the development of the coastal flood hazard maps. With direction from the Board, a second CEPF funding application for $150,000 was submitted in February 2020. The announcement of funding approvals was expected in April, but has been delayed due to COVID-19. Were the RDN successful, the project to update the Englishman River floodplain map would proceed as planned in 2020. If unsuccessful, the project could be broken into two phases with the first being a river channel field study this summer, followed by the river hydraulic modelling and flood mapping in 2021. Table 1, provides an overview of the sequence of tasks and associated costs required to continue gathering the required information and engaging the community in reducing the risks of coastal and riverine flooding, influenced by a changing climate.

**Table 1: Overview of the SLR + Climate Adaptation Program**

| PHASES | KEY DELIVERABLES | BUDGET |
|---|---|---|
| **INCEPTION** | Backgrounder, Program Plan – complete 2016 | Staff time only |
| **RESEARCH** | Acquire LiDAR – completed 2017<br>Develop coastal flood hazard maps – complete 2018 - 2019<br>Update riverine floodplain maps (3) – pending 2020 - 2023<br>Combined coastal + riverine flood risk assessment – pending 2024 | $74,000 (actual)<br>$227,000 (actual)<br>$900,000 (estimated)<br>$175,000 (estimated) |
| **PLAN** | Adaptation Strategy - pending | $125,000(estimated) |
| **IMPLEMENT** | Various departmental implementation projects - pending | Varies depending on action taken |

## STRATEGIC PLAN IMPLICATIONS

Climate Change - Be leaders in climate change adaptation and mitigation, and become net zero by 2032.

The development of coastal floodplain maps aligns with the Board's strategic priority to be leaders in climate change adaptation by acquiring the required technical information to better understand coastal flood hazards within the context of sea level rise. The proposed next steps to communicate the maps will increase public awareness and provide a standardized approach to reducing the risk of current and future coastal flooding in the region.

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May 26, 2020

Reviewed by:

- K. Fowler, Manager, Long Range Planning, Energy & Sustainability
- G. Garbutt, General Manager, Strategic Community Development
- P. Carlyle, Chief Administrative Officer

Attachments:

1. RDN Coastal Floodplain Mapping Overview Report
2. Sample of RDN Coastal Flood Hazard Maps

# Regional District of Nanaimo

## Sea Level Rise Adaptation Program
## Coastal Floodplain Mapping
## Overview

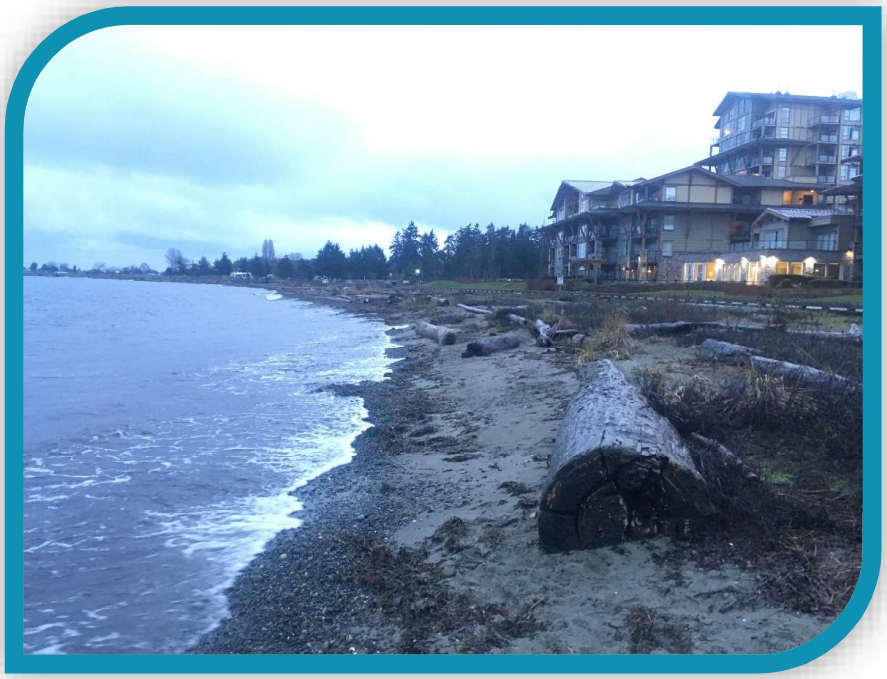

Photo: High tide in Parksville, December 26, 2018.


***18 December 2019***

ebbwater CONSULTING

CASCADIA COAST RESEARCH LTD.

### Disclaimer



This report provides a short overview of the work. Please refer to the full report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd. 2019: Regional District of Nanaimo Coastal Floodplain Mapping Final Report) and Phase II Addendum for full discussion of methods, results, and limitations.

## Introduction

The Regional District of Nanaimo (RDN)'s beautiful coastal landscape also means that it is exposed to flood hazards caused by coastal storms. These hazards are further increased by climate change and rising sea levels.

The RDN has recognized the importance of better understanding coastal flood hazards, especially in the context of changing sea levels, to support planning and emergency management. Flood hazard maps are a foundational tool to support this; a good understanding of where and how deep water might be in a flood event provides the basis for sound decisions on flood management.

To support the RDN in becoming more resilient to future flooding, Ebbwater Consulting Inc. and its partner Cascadia Coast Research Ltd. assessed coastal flood hazards from storms considering sea level rise in accordance with British Columbia Provincial guidelines.

Specifically, in this study, we asked:

1. Where and how deep might it flood during different coastal storm events? And how does this change with sea level rise?
2. What is a suitable elevation for new residential construction in coastal zones that incorporates allowances for sea level rise?

## Study Area

This study focused on the Regional District of Nanaimo on Vancouver Island from Deep Bay in the north to Cassidy in the south, including Gabriola Island (not including the City of Nanaimo). The flood mapping was conducted in two phases (Figure 1).

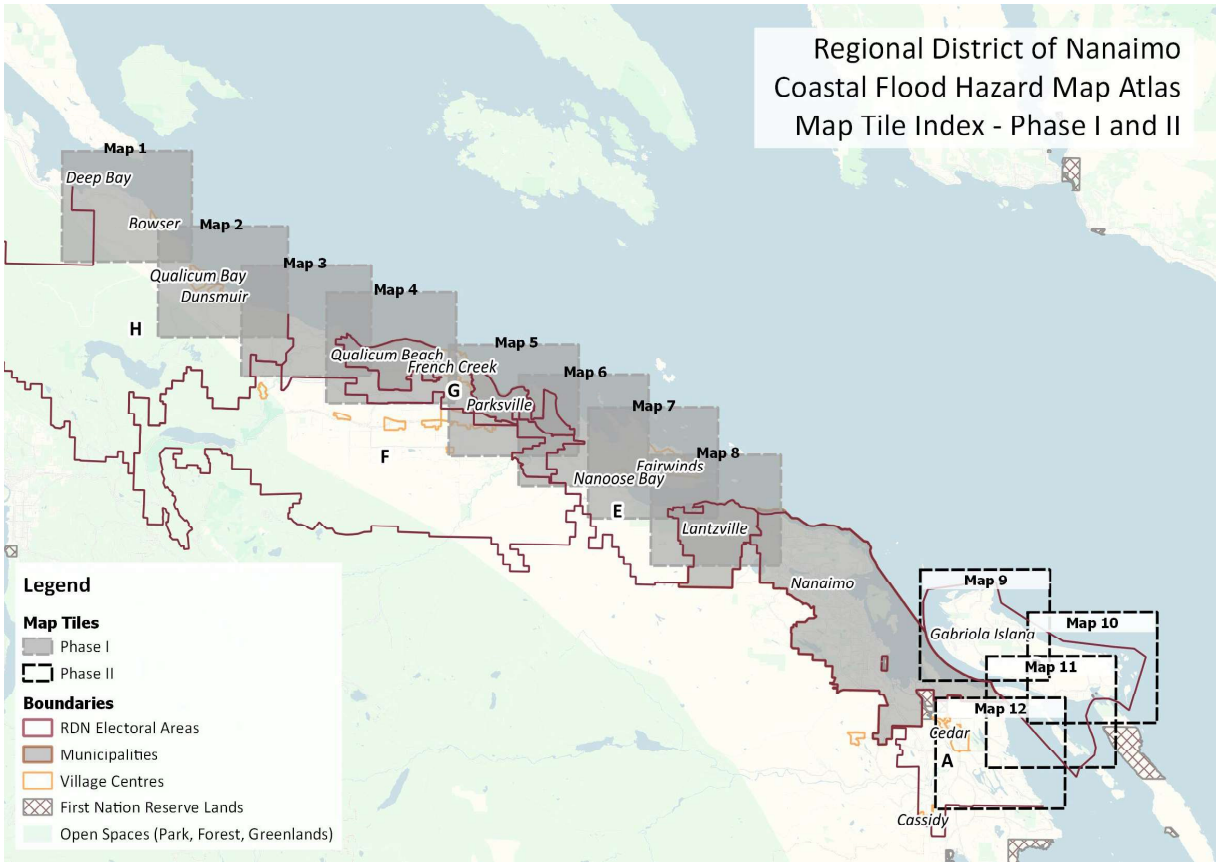


**Figure 1: Study area of the coastal floodplain mapping project (Phase I and II) in the RDN, showing flood map tiles.**

## What is a Coastal Flood Hazard?

Coastal storm-driven flood hazards arise when ocean water levels are higher than normal in the Strait of Georgia as a result of storm activities. Water levels in the ocean off the coast are a function of many components. Some of these are predictable (deterministic), such as tides. Other components are less predictable (probabilistic); these are factors that increase water levels as a result of storm events and include storm surge, wind set-up, and wave setup and effects (Figure 1). These processes have varying likelihoods of occurrence and require detailed analyses of specific events to quantify the resultant combined effect on total water levels.

## Coastal Storm Flood Hazard Method

Storm flooding was assessed using a "designated storm approach", where a series of different storm conditions are analyzed using records of local coastal weather patterns. We assessed different combinations of storm surge heights and wind and wave effects, and looked at the historic record to determine how frequently these conditions occurred. From this analysis, we estimated how likely particular events are to occur in future. This was done based on **Annual Exceedance Probabilities (AEPs).** The AEP describes the probability than an event will occur in any given year and is written as a percentage.

Another way to think about flood probability is through the use of **encounter probabilities**, which is the probability of encountering an event of a given size over a defined time period — for example, the length of an average mortgage (25 years) (Table 1).

Storms with different probabilities vary in magnitude and will have different impacts on the coastline. To understand the range of impacts (ranging from relatively small, relatively common storms to very large, much rarer storms), 5 different AEPs were determined (Table 1).

**Table 1: AEPs and corresponding encounter probabilities for the flood likelihoods assessed in this project.**

| Annual Exceedance Probability (AEP) | Encounter Probability of Occurrence | | | |
|---|---|---|---|---|
| | In 25 years | in 50 years | In 75 years | in 100 years |
| **6.67%** | 82% | 97% | 99% | 100% |
| **2%** | 40% | 64% | 78% | 87% |
| **1%** | 22% | 39% | 53% | 63% |
| **0.5%** | 12% | 22% | 31% | 39% |
| **0.2%** | 5% | 10% | 14% | 18% |

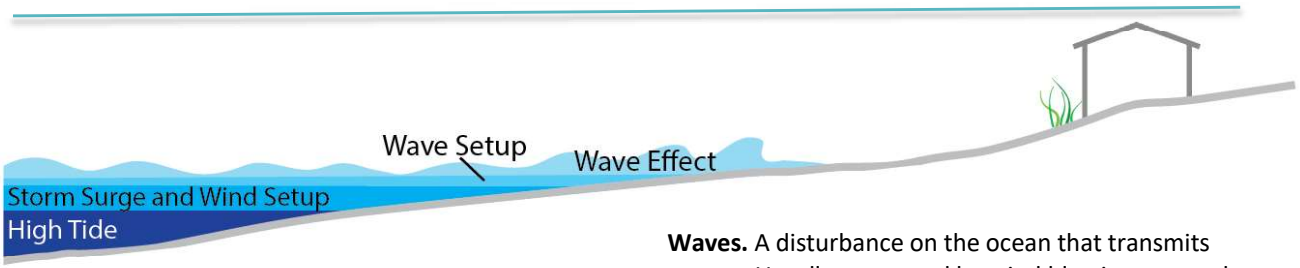


**Figure 2: Components of total water level.**

**Probabilistic (Unpredictable Components)**

**Storm Surge.** A rise above normal water level on the open coast due to a change in atmospheric pressure and wind stress on the water surface**.**

**Wind Set-up.** Increase in water level near the shore due to on-shore winds blowing over shallow water pushing it up.

**Waves.** A disturbance on the ocean that transmits energy. Usually generated by wind blowing across the ocean's surface. Waves breaking on the beach cause a static increase in water level (**wave set-up**) and dynamic variation in water level (**wave effects**).

**Deterministic (Predictable Components)**

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

## Changing Climate and Sea Levels

Around the world, sea levels are rising due to warming seas and the melting of ice caps and glaciers with climate change. Variations in local sea level rise occur due to differences in topography, gravitational forces, and ocean currents; the west coast of North America generally experiences lower than average global sea level rise rates.

In the RDN, sea level rise is partially offset by a rise in ground level (land uplift). In southwest BC, it occurs due to tectonic activity and the slow decompression of soils that were compressed by the weight of glaciers during the last ice age, and is also known as isostatic rebound (Figure 3). **Relative Sea Level Rise (RSLR)** describes the rise in sea level compared to vertical changes of the ground level.

RSLR is critical to understanding how the hazard will change over time. In this study, we looked at an RSLR of 0 m, 0.5 m, 1 m, and 2 m for each of the 5 AEP scenarios (20 scenarios in total). The effect of these scenarios on flooding vary along the coastline, as the local topography (i.e., the shape of the land surface) and bathymetry (i.e., the shape of the ocean ground) affects how water moves onshore.

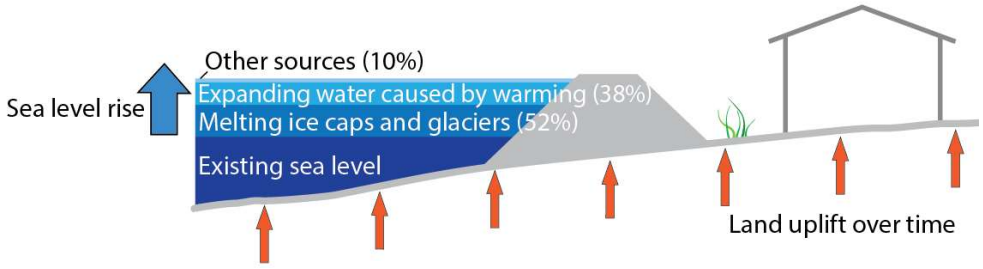


Figure 3: Drivers of RSLR including components of SLR and land uplift.

## Flood Maps

To better understand coastal flood hazards under sea level rise, flood maps are produced from hydraulic computer models and calculations to represent the extent of flooding under different scenarios. Flood inundation maps as well as simple and regulatory maps that include coastal Flood Construction Levels (FCLs) were developed.

### Flood Inundation Maps

Flood inundation maps are used to represent the total water depth and extents for storm events, as shown in the figures on the next page — the darker shades of blue represent deeper water. 12 map tiles were produced that show the RDN study area. Two example maps are provided for one map tile for the 0.5% AEP [1] and 0 m RSLR scenario (Figure 4) and the 0.5% AEP and 1 m RSLR scenario (Figure 5). The other flood maps can be accessed in the RDN Coastal Flood Hazard Map Atlas for Phase I and II. Water depths and extents increase with **sea level rise** and vary based on topography as the flood waters move inland. According to these examples, low lying areas are more subject to change, see the darker blues on the map with 1.0 m RSLR (Figure 5) in comparison to the first map (Figure 4) with 0 m RSLR.

[1] The 0.5% AEP flood event is the recommended Provincial standard. See Page 3 and Table 1 for AEP definition.

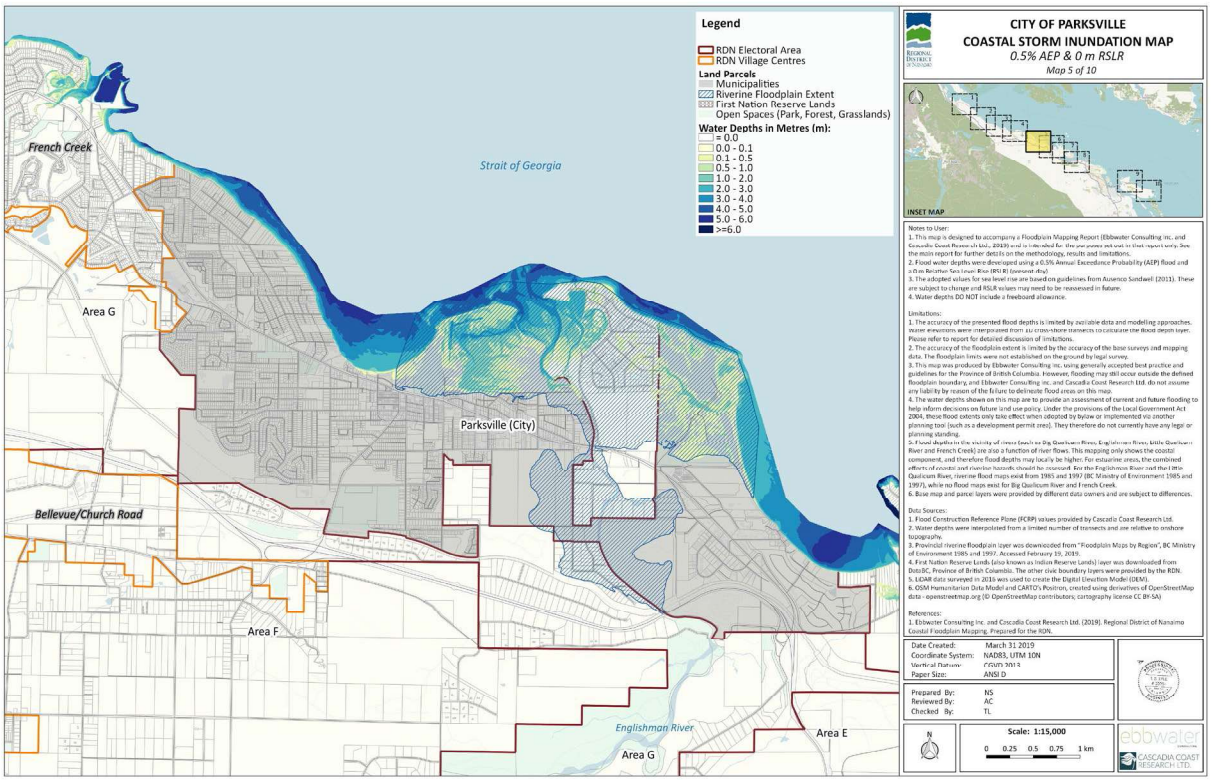


**Figure 4: Example 1 – Present-day: 0.5% AEP flood and 0 m RSLR.**

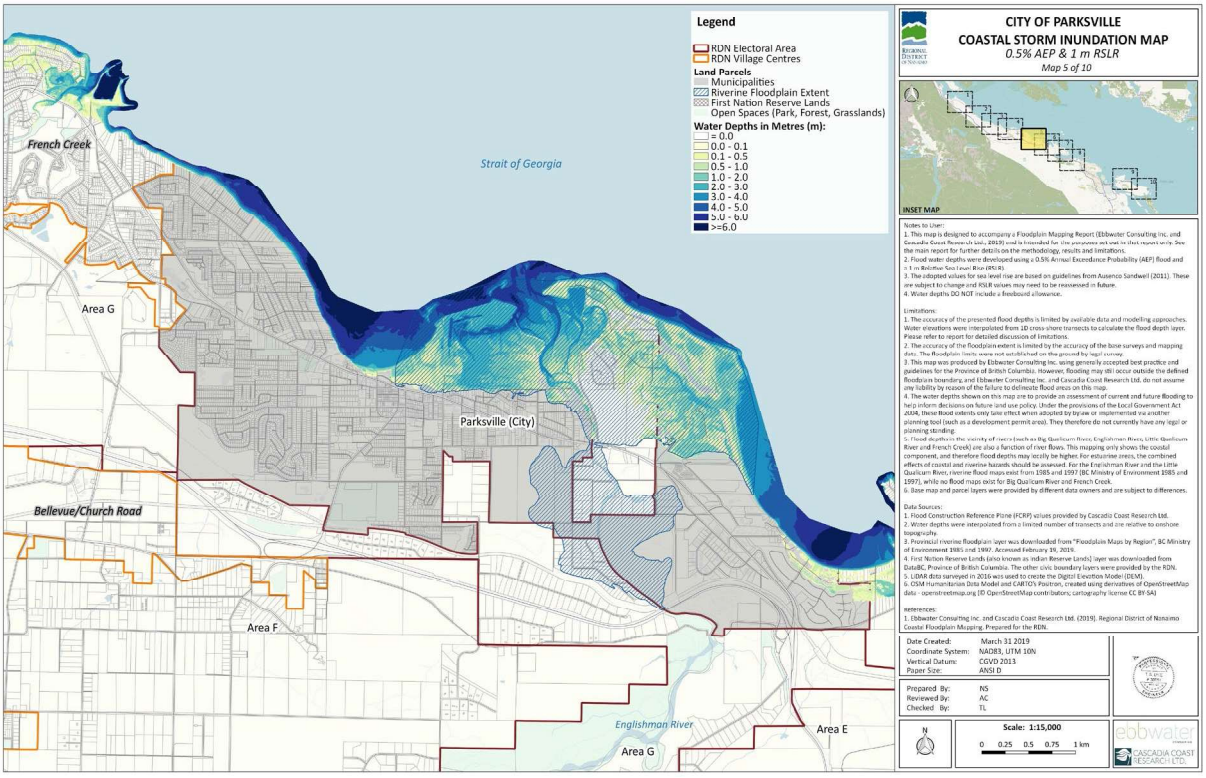


**Figure 5: Example 2 – With future sea level rise: 0.5% AEP and 1 m RSLR.**

# How does flood mapping affect me?

## Determining Flood Construction Levels

Flood maps are used in many ways to reduce the impacts of flooding on people, property and infrastructure. One key way is to identify affected areas and to define a **Flood Construction Level** (FCL). The FCL is the elevation of a floor system of a habitable building, which new buildings are required to achieve to minimize damages from flooding.

The Province provides guidelines[2] on how FCLs should be determined and how they can be used in local policy and regulations. The guidelines state that requirements for buildings and zoning should allow for sea level rise (SLR) to the year 2100. The FCL is defined as the total vertical water elevation above a geodetic datum (mean sea level)[3] at the shore (including tide, storm surge, wind and wave effects, and sea level rise), plus an uncertainty factor called freeboard (Figure 6). The FCL in the RDN is determined for the 0.5% AEP storm event, which is the provincial standard[1].

The FCL is extended from the shoreline horizontally landward, until the land surface elevation reaches the FCL. All land with an elevation below the FCL landward of the shoreline is considered within the FCL extent. It is important to note that the FCL always refers to an elevation above a geodetic datum; for this project, the Canadian Geodetic Vertical Datum (CGVD) 2013[4] was used.

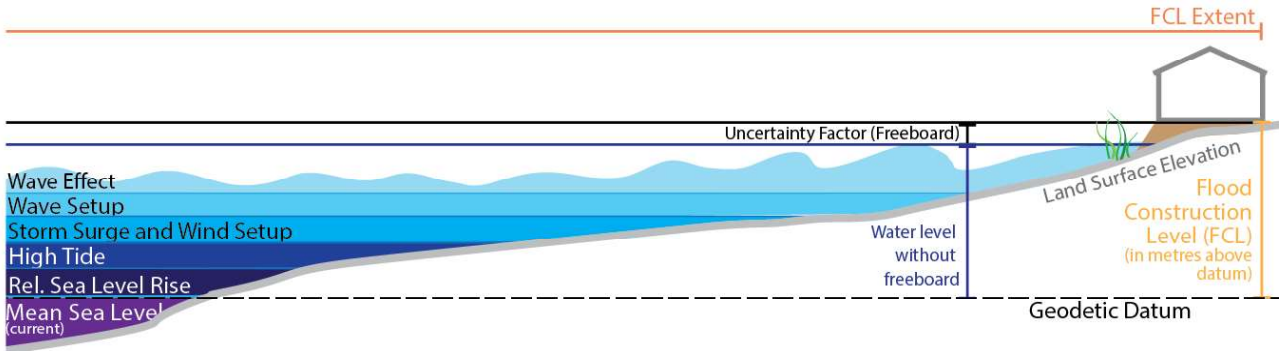


**Figure 6: The Flood Construction Level (FCL) is composed of relative sea level rise, high tide, storm surge, wind setup, wave setup, wave effects and an uncertainty factor (freeboard) and is reported in metres above geodetic datum (mean sea level).**

[2] Provincial guidelines: Ausenco Sandwell (2011). Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Guidelines for Management of Coastal Flood Hazard Land Use. Prepared for BC Ministry of Environment.
EGBC (2017). Flood Mapping in BC - EGBC Professional Practice Guidelines - V1.0. Association of Professional Engineers and Geoscientists of British Columbia.

[3] A geodetic datum is a reference point or surface that ties an abstract coordination system to Earth. It serves to provide a known location to begin surveys and to create maps.

[4] The Canadian Geodetic Vertical Datum (CGVD) of 2013 is defined by a reference surface that represents the coastal mean sea level for North America, and it replaces the former CGVD28 from 1928. Vertical elevation is reported relative to this datum.

The shoreline characteristics play a major role in how high the FCLs are. For instance, wave runup is typically much higher along steep rocky shores than on low-sloping sandy beaches (as can be observed in storms when waves crash high into steep rocky shores). While FCLs at steep shorelines are generally higher than on sandy beaches, the land surface elevations inland of steep cliffs are also typically higher than inland of sandy beaches. Thus, even though the FCL might seem high, it may in practice not require a much higher building construction above land surface elevation.

Shoreline orientation (i.e., if the coast is facing southeast or northeast, etc.) also plays an important role in terms of local wind and wave effects and may lead to differences in the FCLs.

## Flood Construction Levels in the RDN

With 1 m of RSLR, the FCLs in the RDN area range from 4.5 m to 6.8 m elevation. From Deep Bay to Parksville, the shoreline is characterized by low-sloping sandy beaches, and along this long stretch of coastline the estimated FCLs are 5.0 to 5.5 m. South of Parksville to Nanoose Bay, low-sloping sandy shores are interspersed with higher-sloped rocky shores. Through this area, the range of FCLs is larger, about 4.5 m to 6.4 m, with highest FCLs at the rocky shores. Outer Gabriola Island is characterized by steep rocky shores, coastal bluffs and a few sandy pocket beaches. Here, the FCLs range from 5.1 m to 6.8 m, with the largest values occurring at exposed coastal bluffs. The more protected southern coast of Gabriola Island has FCLs from 4.8 to 6.6 m. South of Nanaimo in Electoral Area A, FCLs range from 4.6 m to 5.7 m. See Figure 7 for an overview of the ranges of FCLs throughout the study area.

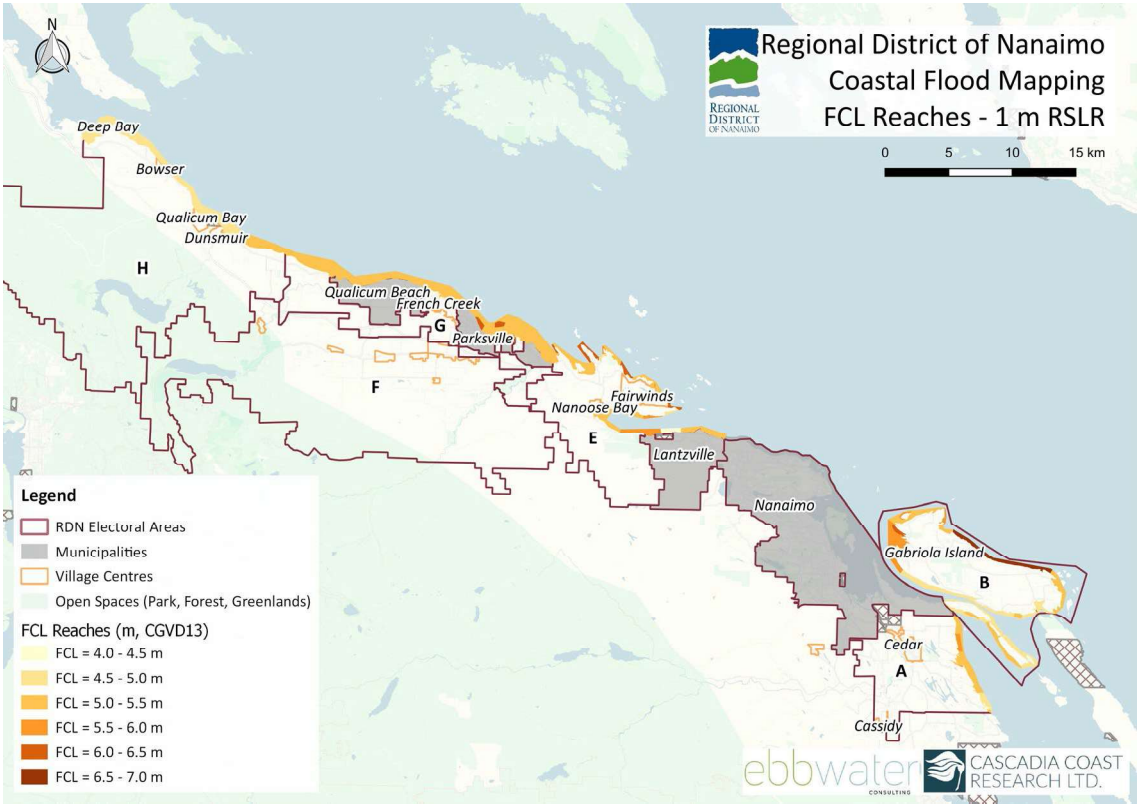


**Figure 7: FCL for the RDN for RSLR = 1 m and 0.5% AEP plus 0.6 m freeboard. FCLs are presented relative to CGVD2013[4].**

Zoomed-in FCL maps for the RDN are provided in the form of FCL reach maps, see an example in Figure 8 (the full set of FCL maps is provided in the RDN Coastal Flood Hazard Map Atlas for Phase I and Phase II). FCL reaches describe areas of similar shoreline characteristics that are all defined by the same FCL.

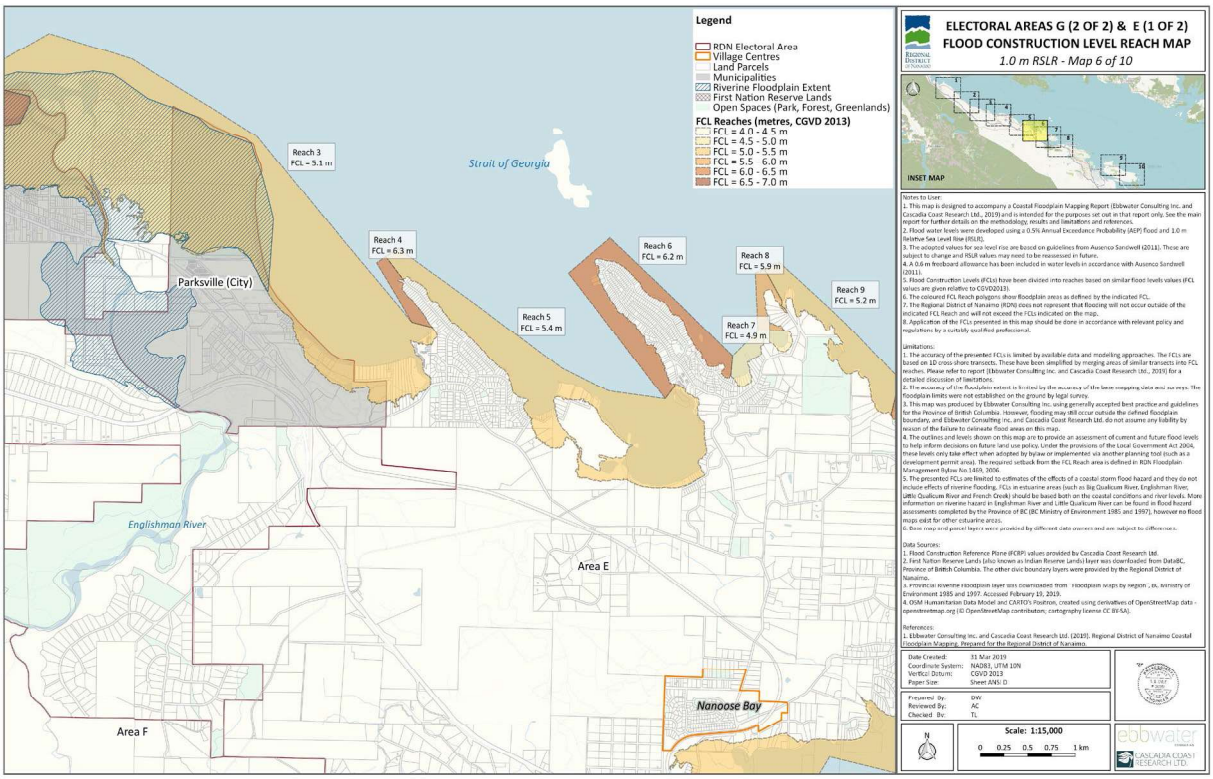


**Figure 8: Example 3: FCL reach map. FCLs are presented relative to CGVD2013.**

## Limitations

As with any study of this type, many uncertainties exist, and coastal modelling and flood mapping can only provide a simplified representation of a complex reality. This section summarizes some of the limitations and uncertainties from this study. Please refer to the final report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2019) for full discussion of limitations.

Storm hazard modelling was limited by the available historical data, and uncertainty is high especially for large storm events. As new information becomes available, especially on climate change impacts and the rate of sea level rise, the values used in this study should be reassessed.

The coastline of the RDN is varied with a steep shore and long beaches. While the modelling and mapping approach addressed these variations, the nature of the analysis also means that some of the details may not be represented in the results. Where assumptions had to be made, these were done in a conservative manner. For instance, for the definition of the FCL reaches, the highest (worst-case) water elevation within a reach was chosen.

## FCL Map Use

The FCL maps should be consulted in the application of the mapping information for a single dwelling unit. In cases of subdivision or rezoning, or higher levels of use (e.g., multi-residential, commercial, mixed used, industrial, institutional), contact the RDN.

## Contact Information

Regional District of Nanaimo
Strategic and Community Development Department
6300 Hammond Bay Road
Nanaimo BC V9T 6N2
Tel: 250-390-6510
Email: planning@rdn.bc.ca

Photo: High tide at Rathtrevor Beach Provincial Park, December 26, 2018.


REGIONAL DISTRICT OF NANAIMO

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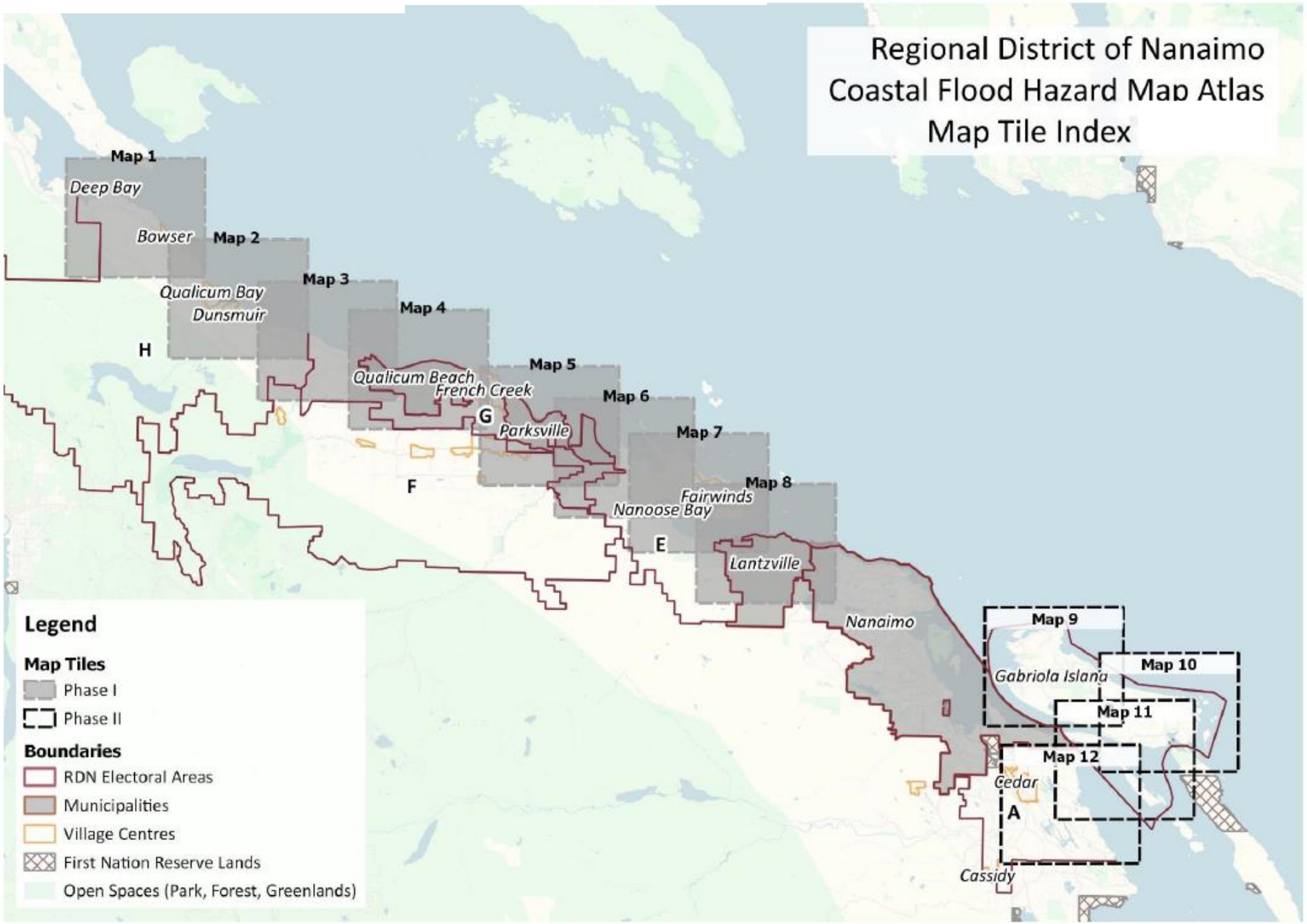
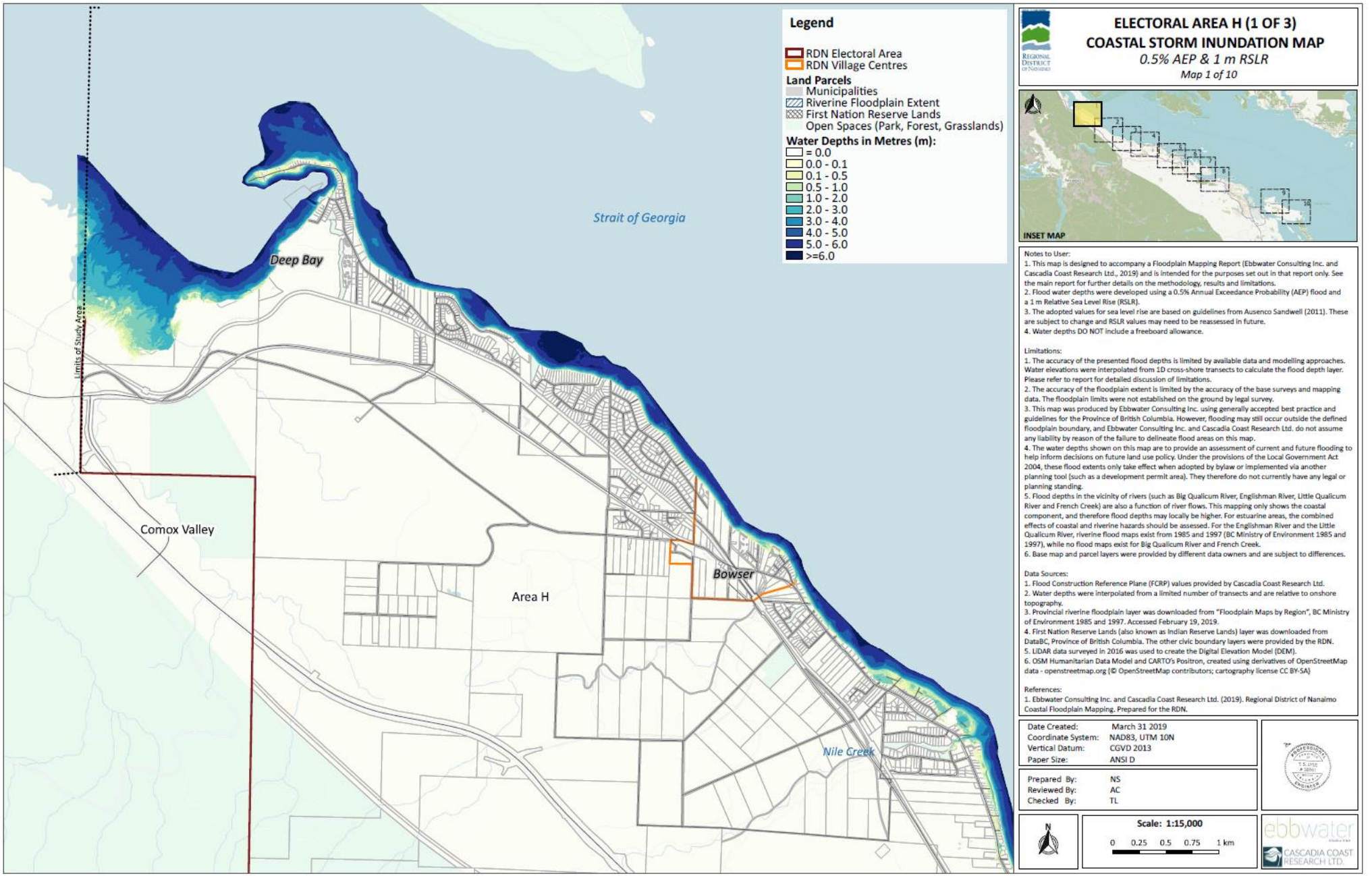
## Appendix 2: Sample of RDN Coastal Flood Hazard Maps

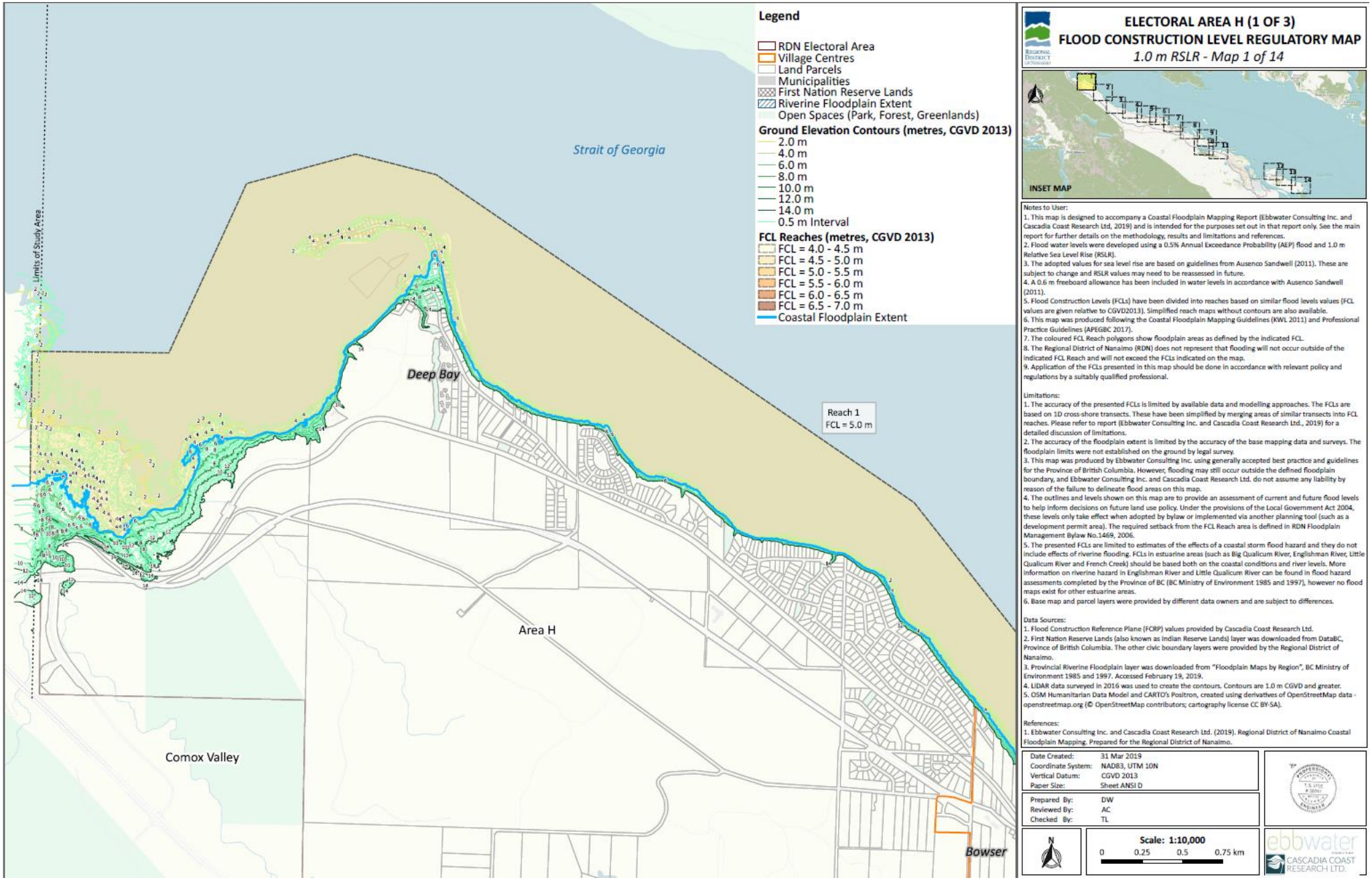
**Phase I & II Study Area Map Key**



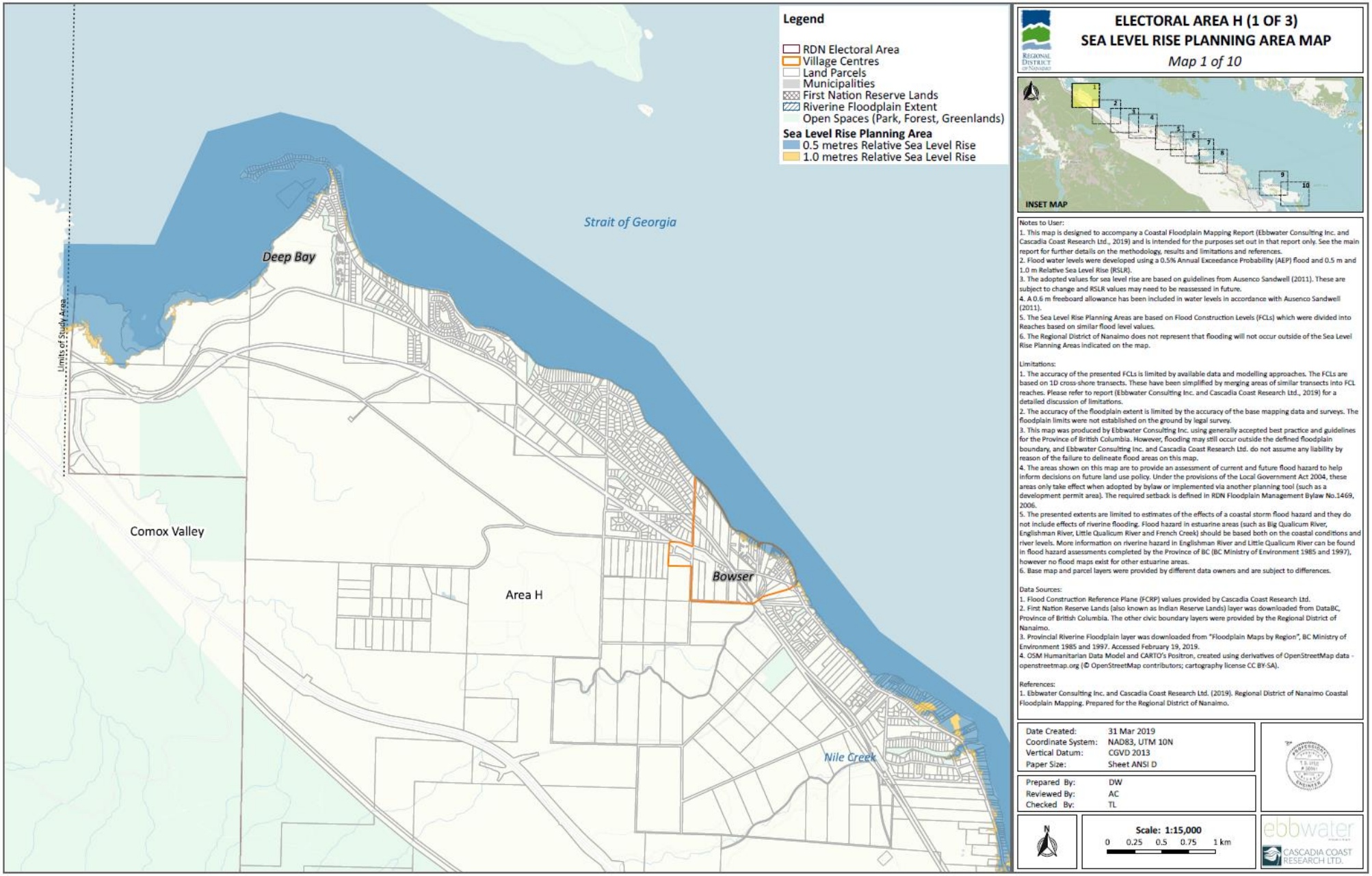
# Area H: Coastal Storm Inundation Map (0.5% AEP or 1:200 years)



# Area H: Flood Construction Level Regulatory Map

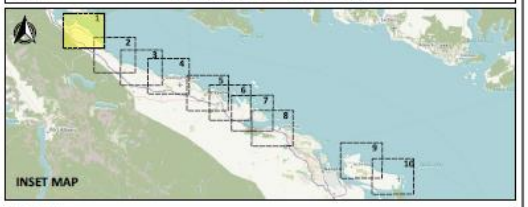


# Area H: Sea Level Rise Planning Area Map



# Area H: Flood Construction Level Reach Map


## ELECTORAL AREA H (1 OF 3)
## FLOOD CONSTRUCTION LEVEL REACH MAP
*1.0 m RSLR - Map 1 of 10*




Notes to User:
1. This map is designed to accompany a Coastal Floodplain Mapping Report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2019) and is intended for the purposes set out in that report only. See the main report for further details on the methodology, results and limitations and references.
2. Flood water levels were developed using a 0.5% Annual Exceedance Probability (AEP) flood and 1.0 m Relative Sea Level Rise (RSLR).
3. The adopted values for sea level rise are based on guidelines from Ausenco Sandwell (2011). These are subject to change and RSLR values may need to be reassessed in future.
4. A 0.6 m freeboard allowance has been included in water levels in accordance with Ausenco Sandwell (2011).
5. Flood Construction Levels (FCLs) have been divided into reaches based on similar flood levels values (FCL values are given relative to CGVD2013).
6. The coloured FCL Reach polygons show floodplain areas as defined by the indicated FCL.
7. The Regional District of Nanaimo (RDN) does not represent that flooding will not occur outside of the indicated FCL Reach and will not exceed the FCLs indicated on the map.
8. Application of the FCLs presented in this map should be done in accordance with relevant policy and regulations by a suitably qualified professional.

Limitations:
1. The accuracy of the presented FCLs is limited by available data and modelling approaches. The FCLs are based on 1D cross-shore transects. These have been simplified by merging areas of similar transects into FCL reaches. Please refer to report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2019) for a detailed discussion of limitations.
2. The accuracy of the floodplain extent is limited by the accuracy of the base mapping data and surveys. The floodplain limits were not established on the ground by legal survey.
3. This map was produced by Ebbwater Consulting Inc. using generally accepted best practice and guidelines for the Province of British Columbia. However, flooding may still occur outside the defined floodplain boundary, and Ebbwater Consulting Inc. and Cascadia Coast Research Ltd. do not assume any liability by reason of the failure to delineate flood areas on this map.
4. The outlines and levels shown on this map are to provide an assessment of current and future flood levels to help inform decisions on future land use policy. Under the provisions of the Local Government Act 2004, these levels only take effect when adopted by bylaw or implemented via another planning tool (such as a development permit area). The required setback from the FCL Reach area is defined in RDN Floodplain Management Bylaw No.1469, 2006.
5. The presented FCLs are limited to estimates of the effects of a coastal storm flood hazard and they do not include effects of riverine flooding. FCLs in estuarine areas (such as Big Qualicum River, Englishman River, Little Qualicum River and French Creek) should be based both on the coastal conditions and river levels. More information on riverine hazard in Englishman River and Little Qualicum River can be found in flood hazard assessments completed by the Province of BC (BC Ministry of Environment 1985 and 1997), however no flood maps exist for other estuarine areas.
6. Base map and parcel layers were provided by different data owners and are subject to differences.

Data Sources:
1. Flood Construction Reference Plane (FCRP) values provided by Cascadia Coast Research Ltd.
2. First Nation Reserve Lands (also known as Indian Reserve Lands) layer was downloaded from DataBC, Province of British Columbia. The other civic boundary layers were provided by the Regional District of Nanaimo.
3. Provincial Riverine Floodplain layer was downloaded from "Floodplain Maps by Region", BC Ministry of Environment 1985 and 1997. Accessed February 19, 2019.
4. OSM Humanitarian Data Model and CARTO's Positron, created using derivatives of OpenStreetMap data - openstreetmap.org (© OpenStreetMap contributors; cartography license CC BY-SA).

References:
1. Ebbwater Consulting Inc. and Cascadia Coast Research Ltd. (2019). Regional District of Nanaimo Coastal Floodplain Mapping. Prepared for the Regional District of Nanaimo.

| | |
|---|---|
| Date Created: | 31 Mar 2019 |
| Coordinate System: | NAD83, UTM 10N |
| Vertical Datum: | CGVD 2013 |
| Paper Size: | Sheet ANSI D |

| | |
|---|---|
| Prepared By: | DW |
| Reviewed By: | AC |
| Checked By: | TL |

N

**Scale: 1:15,000**

0 0.25 0.5 0.75 1 km

ebbwater
CASCADIA COAST RESEARCH LTD.

## Notes to Map User

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2. Flood water levels were developed using a 0.5% Annual Exceedance Probability (AEP) flood and 0.5 m and 1.0 m Relative Sea Level Rise (RSLR).
3. The adopted values for sea level rise are based on guidelines from Ausenco Sandwell (2011). These are subject to change and RSLR values may need to be reassessed in future.
4. A 0.6 m freeboard allowance has been included in water levels in accordance with Ausenco Sandwell (2011).
5. The Sea Level Rise Planning Areas are based on Flood Construction Levels (FCLs) which were divided into Reaches based on similar flood level values.
6. The Regional District of Nanaimo does not represent that flooding will not occur outside of the Sea Level Rise Planning Areas indicated on the map.

Limitations:

1. The accuracy of the presented FCLs is limited by available data and modelling approaches. The FCLs are based on 1D cross-shore transects. These have been simplified by merging areas of similar transects into FCL reaches. Please refer to report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2019) for a detailed discussion of limitations.
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4. OSM Humanitarian Data Model and CARTO's Positron, created using derivatives of OpenStreetMap data - openstreetmap.org (© OpenStreetMap contributors; cartography license CC BY-SA).

## REFERENCES


Ausenco Sandwell. 2011a. "Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Draft Policy Discussion Paper." Prepared for BC Ministry of Environment.

———. 2011b. "Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Guidelines for Management of Coastal Flood Hazard Land Use." Prepared for BC Ministry of Environment.

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APEGBC. 2017. "Flood Mapping in BC - APEGBC Professional Practice Guidelines - V1.0." Prepared For British Columbia Ministry of Forests, Lands and Natural Resource Operations.

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