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# Nanaimo Sea Level Rise Management Plan

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## EXECUTIVE SUMMARY

The City of Nanaimo is preparing a Sea Level Rise Management Plan to better understand and respond to coastal flooding, erosion, and long-term climate-driven sea level impacts along more than 30 km of shoreline. The project builds on the 2018 Sea Level Rise Study and focuses on four vulnerable coastal areas: Departure Bay, Downtown Nanaimo, Protection Island, and Duke Point. The work is being completed in coordination with Snuneymuxw First Nation, the Regional District of Nanaimo's Our Changing Coast project, and the broader community. The project is organized into two phases. Phase 1 includes development of the coastal flood adaptation strategies and Phase 2 focuses on coastal erosion monitoring and communications. Together, these components provide a technical and community-informed foundation for future planning, regulation, infrastructure renewal, and shoreline adaptation.

Engagement began with Listening Conversations to identify how best to reach First Nations, equity-seeking groups, vulnerable populations, and other interest holders. Two public rounds followed: Round 1 introduced sea level rise, adaptation concepts, and community values; Round 2 shared technical results, hazard exposure information, and potential adaptation objectives and strategies for each study area. Community feedback strongly supported proactive planning before flood impacts worsen. Participants prioritized protecting homes, infrastructure, shoreline access, recreation, and ecosystems. Common objectives included avoiding new development in the highest-risk areas where possible, protecting critical infrastructure, adapting or relocating less-critical assets, improving foreshore habitat, and maintaining public waterfront access.

The coastal flood hazard assessment evaluated flooding and wave hazards across four relative sea level rise scenarios of 0.0 m, 0.5 m, 1.0 m, and 2.0 m and five annual exceedance probability events, ranging from 6.7% AEP to 0.2% AEP. The assessment used a joint probability analysis of extreme water levels and winds, and numerical wave modelling. Regulatory floodplain maps were prepared using the 0.5% AEP design event with 1.0 m of relative sea level rise, wave effects, and 0.6 m of freeboard. The maps identify flood construction levels, design flood inundation extents, and wave effect zones.

The risk assessment used modelled results to evaluate buildings, roads, and City infrastructure. Building risk was quantified using expected annual damage, roads with a semi-quantitative framework, and utilities with an impact-based approach. Risk increases under all modelled sea level rise scenarios, with the greatest escalation at 2.0 m RSLR. Present-day flood risk is relatively low, though some Departure Bay and Protection Island assets are exposed during larger storms. Damages increase across all areas at 0.5 m RSLR, rise substantially at 1.0 m—particularly as Duke Point industrial buildings are affected—and increase sharply at 2.0 m, especially in Duke Point and Downtown Nanaimo. Road risk grows from approximately 1.2 km of road at risk under current conditions to approximately 7.3 km under the 2.0 m scenario, with most of that length categorized as high risk. These results indicate that transportation disruption, utility exposure, and infrastructure renewal planning are central considerations for adaptation.

The project identifies a range of adaptation approaches for each area, including avoiding new exposure, retreating from high-risk areas, protecting critical assets, and accommodating flooding through raising or redesign. The preferred mix of approaches varies by shoreline type, current land use, exposure timing, infrastructure importance, and community values. Nature-based and hybrid solutions are emphasized where feasible, including shoreline naturalization, beach nourishment, habitat features integrated into hard protection, and designs that maintain or improve public access. Because relative sea level rise projections remain uncertain, it is recommended that an adaptive management pathway approach be developed for the planning and selection of appropriate adaptation options within foreseeable future planning horizons. This approach identifies near-term actions, monitors changing conditions, and defines trigger points for shifting to alternative strategies as hazards increase or as information improves.

The report recommends that the City reduce future exposure by relocating City infrastructure from affected sea level rise areas as assets reach end of life, limiting infrastructure in vulnerable areas, and implementing a relative sea level rise development permit area. That permit area should restrict increasing density in exposed areas and require buildings and infrastructure to meet flood construction levels.

Short-term priorities include developing an adaptive strategy for the Randle and Battersea Road area and preparing a phased naturalization and adaptation plan for Maffeo Sutton Park. Medium-term priorities include preparing an adaptive management strategy for Departure Bay Beach, planning for long-term raising and renewal of the Harbourfront Walkway, raising Front Street near the Boat Basin to reduce inland flooding, and raising low sections of Highway 19 serving Duke Point when upgrades are required.

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## ABBREVIATIONS

| Acronym / Abbreviation | Definition                               |
|------------------------|------------------------------------------|
| AEP                    | annual exceedance probability            |
| ARI                    | average Recurrence Interval              |
| CGVD2013               | Canadian Geodetic Vertical Datum of 2013 |
| DEM                    | Digital Elevation Model                  |
| EAD                    | expected annual damage                   |
| FCL                    | flood construction level                 |
| FFE                    | finished floor elevation                 |
| GIS                    | geographic information system            |
| NHC                    | Northwest Hydraulic Consultants Ltd.     |
| R <sub>2</sub> %       | Two percent exceedance wave run-up level |
| RSLR                   | relative sea level rise                  |
| SLR                    | sea level rise                           |

## SYMBOLS AND UNITS OF MEASURE

| Symbol / Unit of Measure | Definition              |
|--------------------------|-------------------------|
| %                        | percent                 |
| m                        | metre                   |
| m <sup>3</sup> /s        | cubic metres per second |
| km <sup>2</sup>          | square kilometres       |

## GLOSSARY

| Term                            | Definition                                                                                                                                                                                                                                                                                                                  |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Expected Annual Damage          | the estimated average cost of flood damages that a property or area could experience in any given year, accounting for the likelihood of both minor and catastrophic floods.                                                                                                                                                |
| Design Flood Level              | is the calculated or observed maximum water surface elevation, at a particular location or near a shoreline of interest, during the design event; it is used to determine the FCL; in does not include wave effects.                                                                                                        |
| Design Flood Inundation Extent  | where the design flood level meets the height of land. This is the area expected to be flooded. It includes freeboard but not wave effects.                                                                                                                                                                                 |
| Flood Construction Level        | the design flood level plus an allowance for freeboard, used to establish the minimum elevation required for habitable and commercial structures to achieve an acceptable level of flood risk; typically defined as the elevation of the underside of a wooden floor system or the top of a concrete slab (MFLNRORD, 2018). |
| Flood Construction Level Extent | where the flood construction level meets the height of land.                                                                                                                                                                                                                                                                |
| Relative sea level rise         | The change in water levels locally, it includes other factors like local subsidence or uplift.                                                                                                                                                                                                                              |
| Sea level rise                  | the change in water levels on a global scale.                                                                                                                                                                                                                                                                               |
| Wave Effect Zone                | the area where waves are expected to have an impact. This area includes wave run-up in the flood construction level.                                                                                                                                                                                                        |
| Wave Run-up                     | the vertical extent of wave uprush above the still water level, typically represented by a statistical measure (e.g., $R_2\%$ ) and used to characterize wave effects along the shoreline                                                                                                                                   |

# 1 INTRODUCTION

The City of Nanaimo has over 30 km of diverse coastline along mid-Vancouver Island, some of which will become vulnerable to sea level rise as the climate changes. Much of this coastal area has been developed into residential communities, commercial hubs, and corridors for essential services like transportation and utilities. Where undeveloped, the coastline has diverse ecosystems, prized scenic landscapes, and natural areas used frequently by local residents and visitors from afar. Planning is needed to develop robust shoreline adaptation strategies to protect valued infrastructure and ecosystems and to align both the City's and community's priorities and values. This project – Nanaimo's Sea Level Rise (SLR) <sup>1</sup> Management Plan – is just one component in a long-term plan to increase Nanaimo's resilience to climate change. The primary objective of the project is to help the City of Nanaimo understand and respond to climate-driven sea level impacts. The project builds upon the previous work to expand the City's understanding of sea level rise and storm surge impacts in order to help the City identify and evaluate plausible adaptation solutions. **Our Coastal City**, as this project has been called in the information provided to the communities, is about starting conversations, planning ahead, and taking action to prepare Nanaimo.

## 1.1 Background

In 2018, Nanaimo completed a Sea Level Rise Study which identified key coastal areas—downtown, Departure Bay, Duke Point, and Protection Island—that face increasing vulnerability to flooding and erosion. There are more than 270 buildings, ranging from single- and multiple-family residential, to commercial and industrial facilities, that fall within the projected RSLR inundation zone, highlighting the significant potential for long-term impacts and need for proactive mitigation and adaption measures.

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<sup>1</sup> While the project is called Nanaimo SLR Management plan, the report will use the term relative sea level rise (RSLR) when referring to site or region specific sea level change to be explicit. Relative sea level change is the change in ocean level relative to the land. It includes the effects of global-sea level rise vertical land motion. SLR is generally specific to the global rise in sea level resulting from climatic effects.



### Sea Level Rise Study (2018)

The Sea Level Rise Study was conducted to better understand potential coastal flooding vulnerabilities along the City's shorelines. It identified several low-lying areas along the coastline which are likely to be impacted by sea level rise.

### Climate Change Resilience Strategy (2020)

The Climate Change Resilience Strategy built on the Sea Level Rise Study to identify a wider range of climate related vulnerabilities within the City and suggest best practice actions to address or avoid climate related risks.

### Our Coastal City (CURRENT)

We are exploring practical short- and long-term actions to reduce risk in key areas. The team is also conducting further modeling to refine likely impacts of sea level rise, as well as conduct an economic risk assessment of its impact in the City.

### Implementation, Monitoring & Further Work (FUTURE)

Climate change impacts cannot be solved in a single plan or project. The City's work will be ongoing and adaptive, requiring collaboration across communities, governments, and interest holders. By building a strong knowledge base and decision-making structures now, we lay the foundation for long-term success in addressing sea level rise and coastal change.

The project was conducted in cooperation with the Regional District of Nanaimo, particularly the Our Changing Coast Project, and the Snuneymuxw First Nation, ensuring a consistent, collaborative, and regionally integrated approach.

## 1.2 Scope

The RSLR Management Plan was divided into 2 phases which are outlined in this document. Phase 1 includes the coastal flood hazard assessment, floodplain mapping, risk assessment, and adaptation strategies for the key coastal areas identified at risk and Phase 2 is the erosion monitoring plan for the identified vulnerable areas as well as a communication strategy. The areas identified for Phase 1 (Departure Bay, Downtown, Protection Island and Duke Point) are different from those identified for Phase 2 (North Shore, Departure Bay, Cilare, Protection Island). The study is summarized in the following sections and additional technical information, maps and supporting material are contained in the appendices.

### Phase 1:

1. Engagement Summary
2. Coastal Flood Hazard Assessment

3. Erosion Monitoring
4. Regulatory Floodplain Mapping
5. Hazard Exposure
6. Risk Assessment
7. Coastal Flood Adaption Options
8. Adaptation Strategies for Nanaimo
9. Adaptive Management Pathways Example
10. Recommendations

#### **Appendices:**

- Engagement Summaries
- Coastal Flood Hazard Assessment and Floodplain Mapping details
- Floodplain Maps
- Risk Results

#### **Phase 2:**

- Erosion Monitoring Plan
- Communications Strategy

The Erosion Monitoring Plan is attached as an appendix in this report. Materials developed for the Communication strategy are not reported in this document.

### **1.3 Applicable Guidelines**

The following guidelines and regulations are relevant to this study:

- BC Floodplain Mapping Guidelines - Draft (Water Land Resource Stewardship (WLRs), 2025)
- Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC (EGBC, 2018)
- Flood Hazard Area Land Use Management Guidelines (Government of BC, 2018)
- Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Draft Policy Discussion Paper (BC Ministry of Environment, 2011a)
- Coastal Floodplain Mapping – Guidelines and Specifications (BC Ministry of Environment, 2011b)

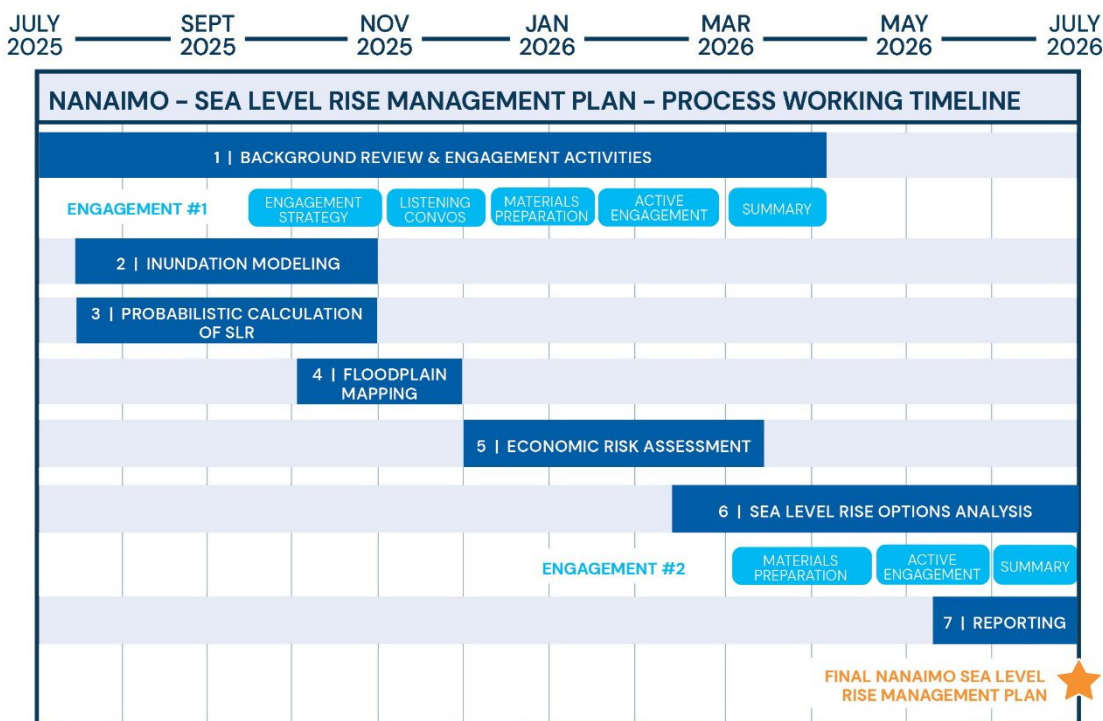


- Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Guidelines for Management of Coastal Flood Hazard Land Use (BC Ministry of Environment, 2011c)
- Hazard Risk Vulnerability Analysis (HRVA) Toolkit - Emergency Management BC
- Coastal Flood Risk Assessment Guidelines for Building and Infrastructure Design: Supporting Flood Resilience on Canada's Coasts - National Research Council Canada

## 2 ENGAGEMENT

NHC collaborated closely with Lanarc in this project to bring the results of the coastal flood hazard assessment and floodplain mapping to the public. Engagement has been conducted over the course of the Nanaimo Sea Level Rise Management Plan project to help recognize values and concerns for consideration in identifying and evaluating coastal adaptation objectives and priorities. Sea level rise can be a sensitive topic to engage on. The topic includes complex technical information, participants may come to a process with widely different beliefs that can challenge constructive dialog, and the lengthy timelines and transformative adaptation options can be difficult to envision. Throughout the engagement process, the team has worked to develop clear, consistent, and easy-to-understand messages and materials to support difficult conversations about the future. By having these conversations now, the City can plan ahead for new or end-of-life redevelopment to more prepared for future coastal flood hazards and align with the community's values.

Five principles were created to outline the approach to communications and engagement in order to maintain a clear trajectory, even as the process adapted to emerging needs and diverse contexts. The principals are: equitable engagement; adaptable materials; engage in reconciliation; begin with values; and engage early and often. The project's engagement began in the fall of 2025, and the initial Listening Conversations were held in December. Round 1 occurred through February and March of 2026. Round 2 followed from April to June of 2026. The diagram below illustrates the process for the project.



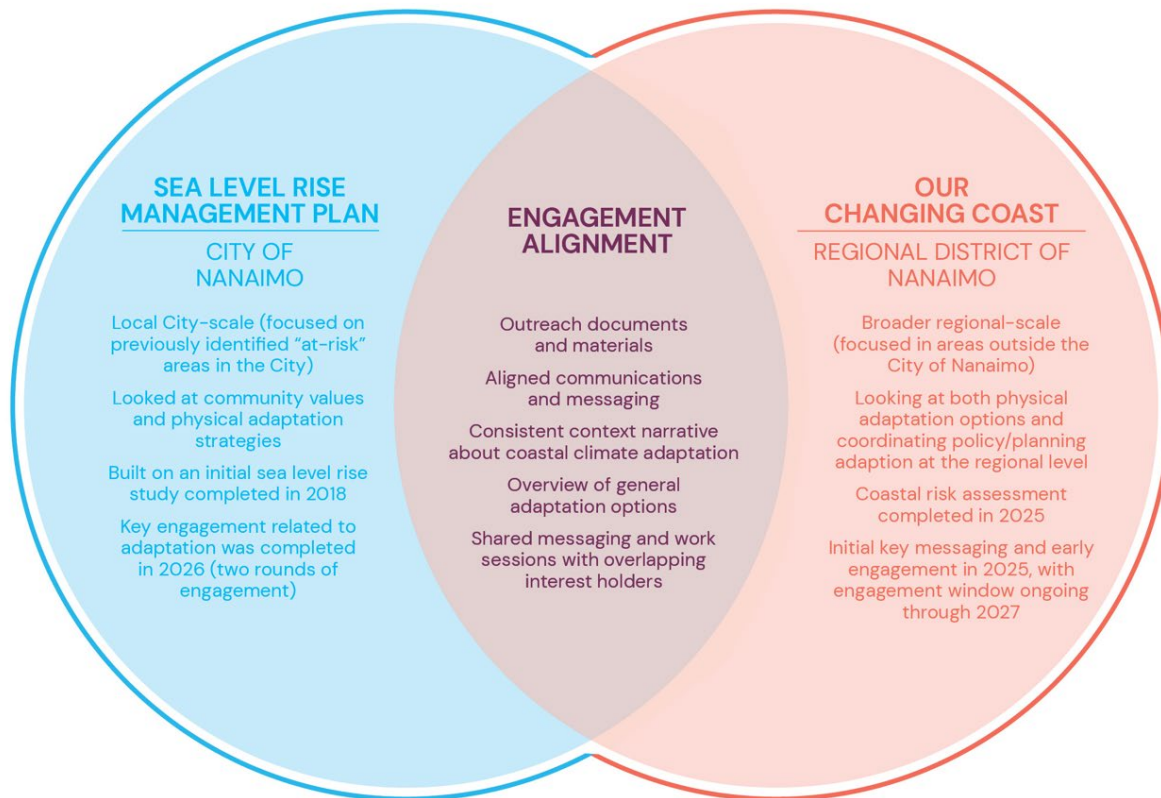
**Figure 2.1 Project timeline diagram (figure provided by Lanarc)**

The *Nanaimo SLR Management Plan* sought to involve a wide range of audiences to ensure that diverse voices and feedback guided the work. The following broad groups were consulted as part of the project:

- Snuneymuxw First Nation as a partner, through workshops and regional collaboration meetings)
- Neighbouring municipalities- primarily completed through RDN's - *Our Changing coast*
- Interested technical parties
- Provincial and federal government agencies, ministries, and Crown corporations
- City of Nanaimo senior leadership and staff
- Property owners in affected areas, neighbourhood associations, and other local residents
- Local community organizations, equity-seeking populations, and business groups
- The broader public

The City and project team partnered with Snuneymuxw First Nation and aligned with the Regional District of Nanaimo's *Our Changing Coast* sea level rise study. Together, the projects educated the public on sea level rise and adaptation options. The shared materials, data and learnings, and coordinated joint engagement activities. Under the shared *Our Coastal City*

branding, the partnership also broadened regional collaboration through workshops involving more than 15 local governments, First Nations, government agencies, conservation groups, and other interest holders.



**Figure 2.2** Diagram showing shared processes with the RDN's 'Our Changing Coast' project

## 2.1 Pre-Engagement: Listening Conversations

The first conversations for the *Nanaimo SLR Management Plan* project were a series of 'Listening Conversations.' Planned as a pre-engagement stage, these were a series of focused calls with select interest holders representing First Nations, vulnerable populations, and/or other equity-seeking groups. The purpose of the meetings was to hear how communications and engagement could be designed to better connect with people in their community. The outcomes of these meetings were then used to structure the main stages of the project's engagement process.

## 2.2 Round 1: Community Values

The first round of outreach and engagement was conducted to assess community awareness of sea level rise and listen to values related to sea level rise adaptation. It sought to share information on coastal climate change and introduce the concept of adaptation options at a high level (Section 8). Key goals for this round were to raise awareness of the issues and to give the team an understanding of the public values that should shape specific adaptation objectives (summarized on the hazard exposure maps in Section 6) and options that are were later developed in Section 9.

Round 1 engagement included the following outreach and activities:

- Creation of project webpages where updates and activities were posted.
- News releases, articles, and social media posts advertising the process and opportunities for input in Round 1.
- Direct communications with interest holders and involved community members to share information about the process.
- Creation of diverse educational materials introducing the project and important concepts.
- A series of focus group meetings and workshops with key interest holders and partner First Nations to connect directly on the project and provide time and space for feedback and conversations.
- Posting of an online survey to collect broader public feedback.
- A Round 1 engagement summary communicating the findings.

### Participation Highlights



**Figure 2.3 Participation highlights from Round 1 engagement.**

Further detail on Round 1 outreach and engagement activities can be found in the 'Round 1 Engagement Summary (April 2026),' attached in Appendix A.

## 2.3 Round 2: Objectives & Strategies

The second round of outreach and engagement shared the results from Round 1 with the public, and conveyed the findings of the coastal flood hazard assessment (Section 3), floodplain mapping (Section 5), and hazard exposure (Section 6). It also shared the values, perceptions, and aspirations that interest holders and the public highlighted in the initial conversations and survey. During Round 2, the project also outlined viable adaptation strategies and objectives that were identified for each of the areas at risk (Section 6 and 9). These were high-level views of both the risks and objectives for each area, and some potential ways to address them in the future. With technical interest holders, the strategies were presented at a granular level — discussing nuances like raised seawalls, retreat, and naturalization. With the general public, high-level risks and objectives were presented in a way that allowed them to identify what was important for each area, and the general things that might be done to preserve what is valued. Key outcomes from Round 2 were a collection of both overall and area-specific feedback on preferred objectives to pursue and risks to address. These allowed the project team to refine the final recommendations (Section 11) for each area.

Round 2 engagement included the following outreach and activities:

- Updates to the project webpages.
- Further news releases, articles, and social media posts promoting the process and opportunities for input in Round 2.
- A second round of direct communications with interest holders and involved community members.
- Workshops with City of Nanaimo staff and technical interest holders to provide updates about the project and collect input on priority strategies and objectives for each of the areas.
- Open house meeting with the public to provide updates about the project and collect input on for each of the areas.
- Presentations to City senior leadership.
- A follow-up online survey available to the general public.
- A Round 2 engagement summary communicating the findings.

### Participation Highlights



**Figure 2.4 Participation highlights from Round 2 engagement**

Further detail on Round 2 outreach and engagement activities can be found in the 'Round 2 Engagement Summary (July 2026),' attached in Appendix A.

## 2.4 Engagement Learnings & Results

The outreach and engagement were valuable to the project and led to a number of important findings that guided the work. Pre-engagement helped to craft the approach to expand the project's audience. During Round 1, useful feedback was provided on community values and the priorities and concerns that were top of mind when responding to sea level rise. Round 2 gave more detailed feedback on which strategies and objectives were most likely to meet the community's needs, as well as a host of area-specific comments that would guide more detailed place-based strategies. The key findings are summarized below:

### Listening Conversations:

- Reaching isolated populations is most effective when you rely on an already established network and its regular pre-established events.
- Discuss RSLR related issues in the context of items that are already top of mind, such as housing or emergency preparedness.
- Include time in meetings for informal conversations rather than relying on a strict agenda.

- Barriers to participation will include items like transportation or conflicts with other commitments; meet people where they are at and at a time of their choosing.
- Provide educational materials in a range of formats (both digital and physical), and tailor the complexity of the findings to the audience.

### Round 1:

- There is a high level of awareness and knowledge regarding sea level rise in the community.

- The community wants to see proactive planning to reduce the impacts of RSLR on future generations.
- Residents want solutions that protect homes and infrastructure, and preserve shorelines and natural areas.
- Future solutions should maintain safe public access to the shoreline and waterfront public spaces.
- The vast majority of residents want to prioritize solutions that mimic the natural coast.

- Priorities and concerns were generally consistent between those who own/live on waterfront property and those who don't.
  - Where critical elements are at risk, respondents supported protecting them as needed.
  - For less-critical elements, accommodate future flooding by adapting them or relocating them away from areas at risk.
  - Many comments made clear that do nothing was not an option. They wanted proactive planning to avoid reactionary long-term costs.
  - Popular objectives across the study areas included maintaining public waterfront access, supporting collaborative solutions, improving foreshore habitat, and preserving access to transportation uses.
- Round 2:**
- Respondents wanted to see the City avoid future development in areas most at risk when possible.

A full set of results from the Round 1 and Round 2 engagement — including area-specific feedback — can be found in the 'Round 1 Engagement Summary (April 2026)' and 'Round 2 Engagement Summary (July 2026),' attached in Appendix A.

## 2.5 Engagement Summary

Overall, engagement confirmed that residents of Nanaimo are concerned about sea level rise and want to see proactive action and planning to reduce the long-term costs and risks the community is likely to see over the next century. Across technical interest holders, equity groups, local residents, and the general public, there was strong support for adaptations that not only address the risks of sea level rise, but also concurrently improve the City's shorelines in a way that prioritizes nature-based solutions and provides access to much-loved community destinations. The engagement findings provide a clear foundation for identifying priority objectives and strategies for each area at risk, and help to illuminate where further information is needed.

## 3 COASTAL FLOOD HAZARD ASSESSMENT

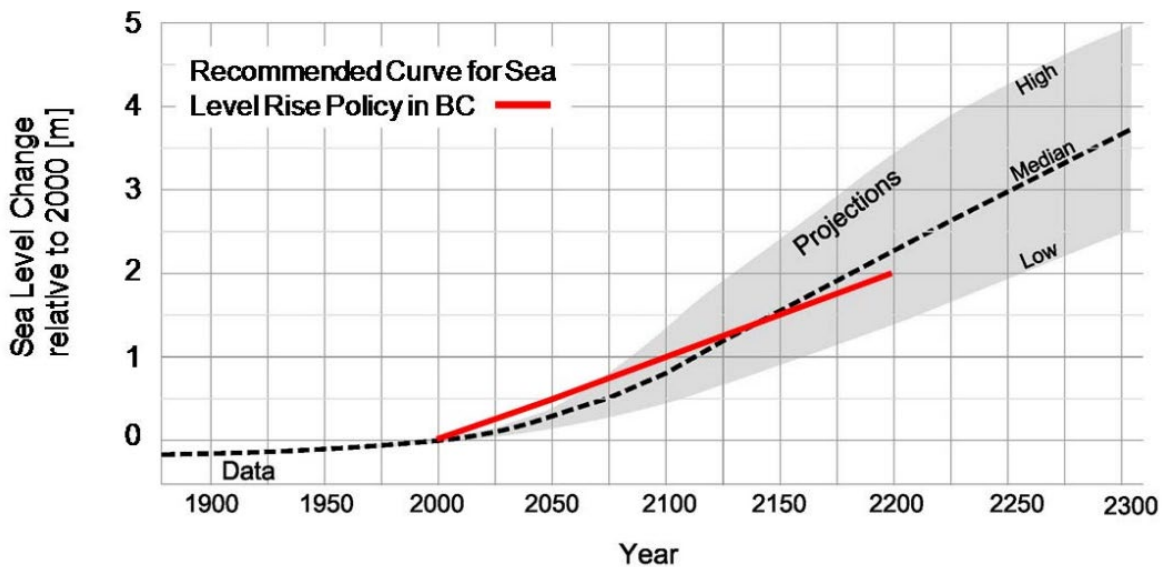
The coastal flood hazard assessment evaluates coastal flood and wave hazard along the Nanaimo shoreline across a range of relative sea level rise (RSLR) scenarios. The assessment was completed using best-available data and a statistical analysis of the joint probability of extreme waves and water levels.

Wave effects within the coastal flood zone were estimated using a combination of empirical methods and numerical models. A detailed description of the coastal analysis is provided in **Appendix B – Coastal Analysis**. Unless otherwise stated, all elevations in this study are referenced to CGVD2013 (Canadian Geodetic Vertical Datum of 2013).



### 3.1 Regional Climate Change Projections

Global climate change is expected to result in increased sea levels resulting from melting of global ice and increased ocean volume due to rising water temperature. The BC Provincial Sea Dike Guidelines (BC Ministry of Environment, 2011) recommend considering a rate of sea level rise of 10 mm/year, which yields an increase of 0.5 m to the year 2050, or a 25-year time horizon relative to present day, and 1 m to the year 2100, relative to the year 2000 or a 75-year time horizon relative to present day (Figure 3.1). In the near term, the BC Guidelines overestimate the expected SLR, as the rate is not constant but rather is expected to increase over time.



**Figure 3.1 Sea Level Rise projections from year 2000 using 10 mm/year (BC Ministry of Environment, 2011).**

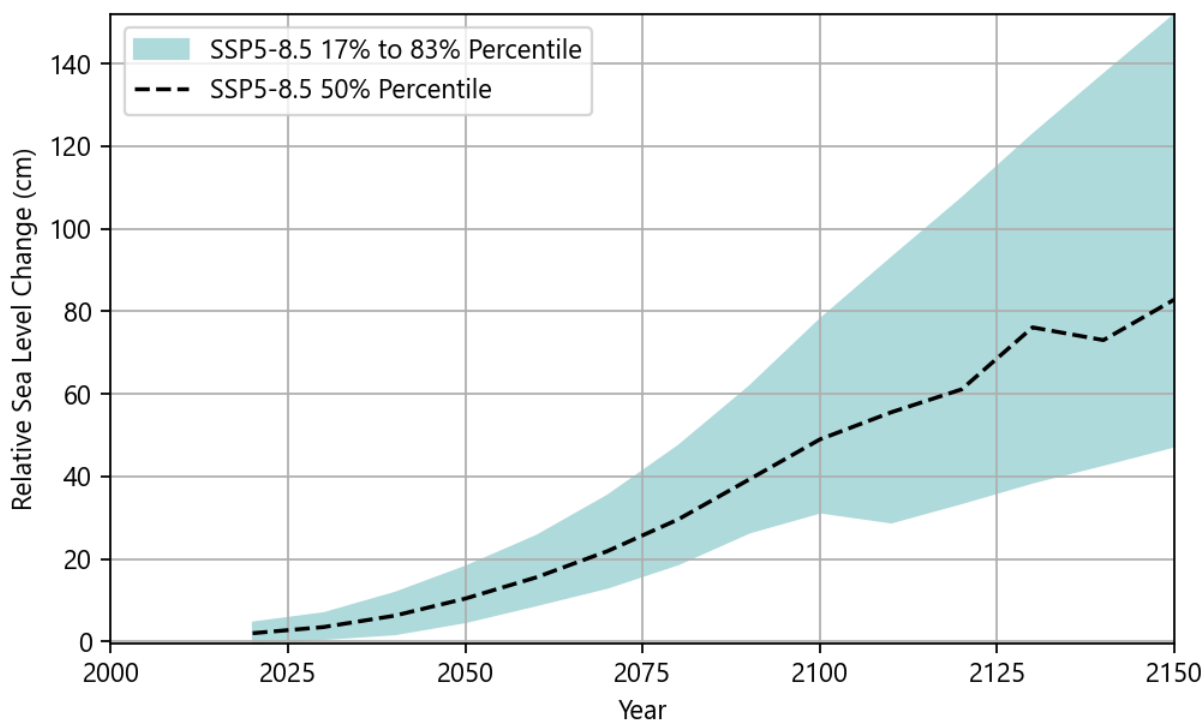
Additional information became available since the BC Provincial Sea Dike Guidelines were developed including the CMIP-6<sup>2</sup> dataset based on the International Panel for Climate Change (IPCC) Assessment Report 6 (AR6) (IPCC WGI, 2021) which have been applied by NRCan to provide more refined estimates of relative sea level rise (RSLR)<sup>3</sup> on Canada's maritime coasts. The range of regional RSLR projections (17<sup>th</sup> to 83<sup>rd</sup> percentile) for the shared socio-economic

<sup>2</sup> CMIP-6 is the Coupled Model Intercomparison Project Phase 6 or the global collaboration of climate modelling institutions, who develop an ensemble of climate models and statistics for climate change projections every five to seven years. This work forms the basis of the IPCC Assessment Reports (AR).

<sup>3</sup> RSLR refers to the change in water levels locally and includes other factors like local subsidence or uplift. SLR refers to the change on a global scale.



pathway<sup>4</sup> (SSP) SSP5-8.5 is shown by the blue band in Figure 3.2. The RSLR 50<sup>th</sup> percentile of the SSP5-8.5 climate model projections is shown by the black-dashed line.



**Figure 3.2 Relative sea level rise (RSLR) projection developed from 2021 for Nanaimo based on SSP5-8.5 CMIP-6 (ECCC, CRIM, Ouranos, PCIC, PCC, and HabitatSeven, 2025; James et al., 2021).**

The RSLR values shown in Figure 3.2 include changes in ground elevation due to uplift or subsidence, which influence the RSLR experienced at the site location. The total vertical land movement in Nanaimo is estimated at +0.02 cm/year, based on the national-scale crustal velocity model published by National Resources Canada (NRCan; Robin et al., 2020). This implies that the ground elevation is increasing, producing a lower RSLR than global SLR rates and lower than the value recommended in the BC guidelines (Figure 3.1).

Due to the inherent uncertainty of climate change, climate models predict a wide variation of RSLR predictions with uncertainty increasing with time as shown by widening of the blue band over time in Figure 3.2. Table 3.1 compares the year by which 0.5 m, 1.0 m, and 2.0 m RSLR is expected to occur in Nanaimo for three shared SSP's including:

- SSP5-8.5 High ice sheet loss B 83<sup>rd</sup> percentile

<sup>4</sup> Scenarios used for climate modelling presented in the IPCC AR6 report including scenarios from sustainability to fossil-fuel development.

- the soonest or most pessimistic scenario representative of *fossil-fueled development* with collapse of the Antarctic Ice Sheet
- SSP5-8.5 83<sup>rd</sup> percentile
  - the scenario commonly used for engineering design and planning
- SSP1-2.6 17<sup>th</sup> percentile
  - the latest or most optimistic scenario representative of *sustainability*

**Table 3.1 Year by which RSLR is expected to occur based on CMIP-6 projections for Nanaimo based on RSLR projections for Departure Bay**

| Scenario                                                                              | 0.5 m                 | 1.0 m                 | 2.0 m                 |
|---------------------------------------------------------------------------------------|-----------------------|-----------------------|-----------------------|
| Year by which SSP5-8.5 High ice sheet loss B RSLR occurs (soonest)                    | 2062<br>(36 years)    | 2085<br>(59 years)    | >2100<br>(> 75 years) |
| Year by which SSP5-8.5 (83 <sup>rd</sup> percentile) RSLR occurs (engineering design) | 2083<br>(57 years)    | >2100<br>(> 75 years) | >2100<br>(> 75 years) |
| Year by which SSP1-2.6 (17 <sup>th</sup> percentile) RSLR occurs (latest)             | >2100<br>(> 75 years) | >2100<br>(> 75 years) | >2100<br>(> 75 years) |

The risk assessment summarized in this report was completed somewhat independently of timeframe or scenarios due to the deep uncertainty surrounding socio-economic pathways and climate change projections. By assessing risk in terms of 0.5 m, 1.0 m, and 2.0 m RSLR, this allows for flexibility and potential modification of the strategies in terms of timing if significant changes to the science, socio-economic pathways, or technological developments occur in the future.

## 3.2 Joint Probability Analysis

This project adopts a probabilistic framework to estimate the annual exceedance probability (AEP) of jointly occurring extreme water levels and winds. A joint probability analysis (JPA) was conducted on regional water levels and winds to define events for modelling. This approach considers the likely contributions of tides, surge, and wind-generated waves on flooding while avoiding over-estimating the combined likelihood of occurrence.

Selected scenarios consider multiple RSLR cases and various water level-wind return periods developed from the JPA. The scenarios are summarized as:

- RSLR scenarios: 0.0 m, 0.5 m, 1.0 m, 2.0 m
- AEPs (5): 6.7% (1-in-15 year), 2.0% (1-in-50 year), 1.0% (1-in-100 year), 0.5% (1-in-200 year), 0.2% (1-in-500 year)

For each AEP, five wind directions were considered: NW, N, NE, E, SE.

### 3.3 Numerical Modelling

Four regions of interest were selected for modelling: Departure Bay, Downtown Nanaimo, Duke Point, and Protection Island. All regions were modelled using a regional-scale phase-averaging numerical wave model (SWAN, Simulating WAVes Nearshore). This model was driven by a regional wind field to estimate significant wave height and peak period offshore of each region of interest.

Results from the regional-scale wave model were used to estimate the wave runup elevation for each region of interest. For each region, the wind direction that produces the high wave runup elevation for a given AEP was selected as the governing storm event and used for further investigation. In this study, easterly events were consistently found to generate the greatest vertical runup elevation.

The nearshore wave conditions were investigated in further detail in each region of interest. Empirical formulae for runup were used at Protection Island to determine vertical runup and inundation extents. A more detailed wave model was configured for Departure Bay, Downtown Nanaimo, and Duke Point to determine runup, inundation, and overland wave heights.

#### 3.3.1 Protection Island

At Protection Island, nearshore wave conditions were analyzed empirically. Run-up was estimated along cross-shore transects along the shoreline. The local slope, water, beach material, and other site-specific features were determined at each transect to compute R2%, defined as the elevation on the beach face that is exceeded by the highest 2% of incident waves. Two empirical methods were used:

- EurOtop (EurOtop, 2018), suited to natural and engineered shorelines
- Stockdon et al. (2006), suited to natural, dissipative beach conditions

Computed values of R2% were added to still water levels to determine total water level. Total water level was projected inland to determine the landward extent of wave influence. A maximum inland setback of 30 m from still water inundation was applied where the total water level would otherwise project further inland. This approach provides a conservative and consistent spatial representation of wave hazard, while remaining practical for planning applications.

#### 3.3.2 Other Domains

At Departure Bay, Downtown Nanaimo, and Duke Point, nearshore waves were simulated with a 2-dimensional, non-hydrostatic wave model (XBeach) forced by SWAN model outputs over a 4-

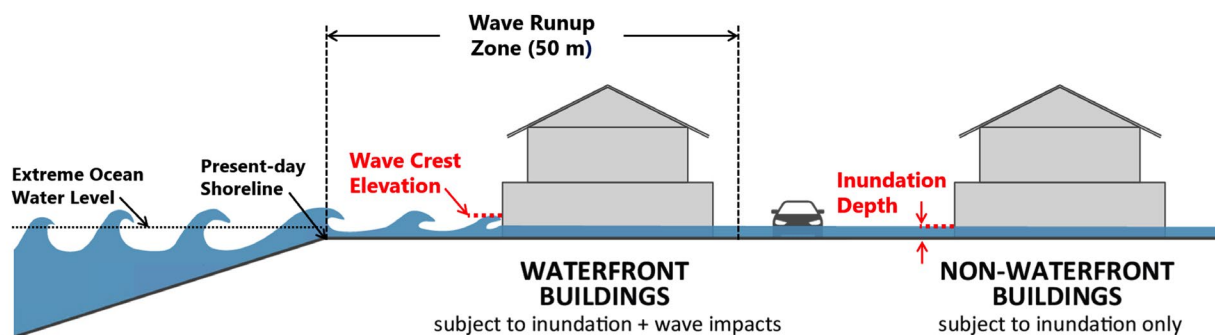
hour storm event. The XBeach model was used to determine the inundation extents of each event. The wave runup, expressed as  $R_{2\%}$ , was computed for every 50 m along the shoreline using the wave runup timeseries output from the model. Significant wave heights used to estimate overland wave propagation for the floodplain maps and risk assessment were derived from the variance of XBeach water-level fluctuations across the model domain.

### 3.4 Application to Risk Assessment

Coastal flood hazard quantified in the risk assessment of this study is characterized by:

- Relative wave crest elevations for waterfront assets
  - Representative of the wave climate coinciding with an extreme ocean water level
- Flood inundation depths for non-waterfront assets
  - Representative of the extreme ocean water level (including the effects of tides, storm surge, and RSLR) outside of the wave effects zone

Wave crest elevations and inundation depths (defined in Figure 3.3) at the location of assets were calculated for each of the 20 coastal flood hazard scenarios. The scenario, for a given AEP, with the maximum wave crest elevation (waterfront assets) or inundation depth (non-waterfront assets) is used for determining damages (described in Section 4) for a given AEP.



**Figure 3.3 Definition of wave crest elevation in the wave runup zone and flood inundation depth.**

## 4 EROSION MONITORING

In addition to the coastal areas vulnerable to RSLs, for Phase 2 of this project, the City identified several other locations that were experiencing erosion including the North shore, Departure Bay, Cilare and Protection Island. A baseline erosion hazard assessment to develop a coastal erosion

monitoring program was conducted (summarized in Appendix E). The main objectives for the baseline erosion assessment are to establish a baseline shoreline position and initial erosion rates along the identified shorelines, and provide recommendations for a long-term monitoring plan. This study consists of a field assessment and topographic survey, a review of background studies and surveys, an analysis to calculate erosion rates, and a characterization of the morphology and shoreline conditions to identify coastal processes and erosion drivers. The baseline shoreline position is based on a topographic survey conducted for this project in 2026 and the initial erosion rates are calculated using the GeoBC lidar from 2019 and the topographic survey from 2026.

*{Results to follow}*

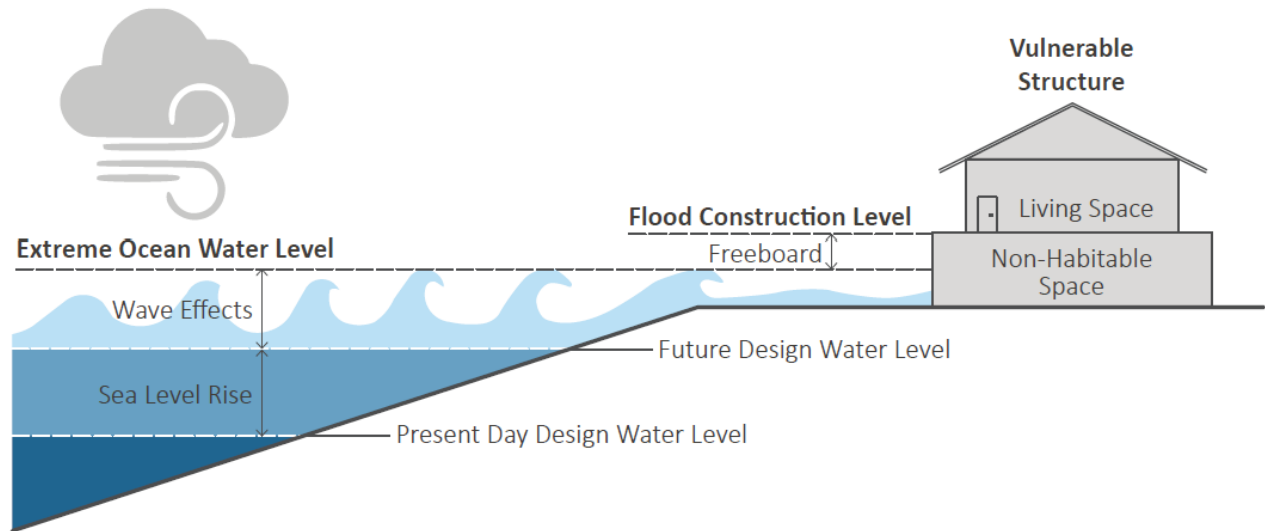
## 5 REGULATORY FLOODPLAIN MAPPING

The coastal flood hazard assessment results were used to develop regulatory floodplain maps for the City of Nanaimo. Floodplain maps support land use planning by identifying areas expected to flood and by providing flood construction levels (FCLs) for those areas. FCLs establish the minimum elevation for habitable, commercial, and industrial buildings, as well as other infrastructure, to reduce flood risk.

In BC, a regulatory floodplain map delineates the area that can be expected to flood, on average, once every 200 years under future climate conditions. This means there is a 0.5% chance of the storm event happening in any given year. The 0.5% AEP event (200-year) flood plus RSLR is selected based on Provincial guidance (EGBC, 2017; WLRS, 2025) and is used to set the FCL.

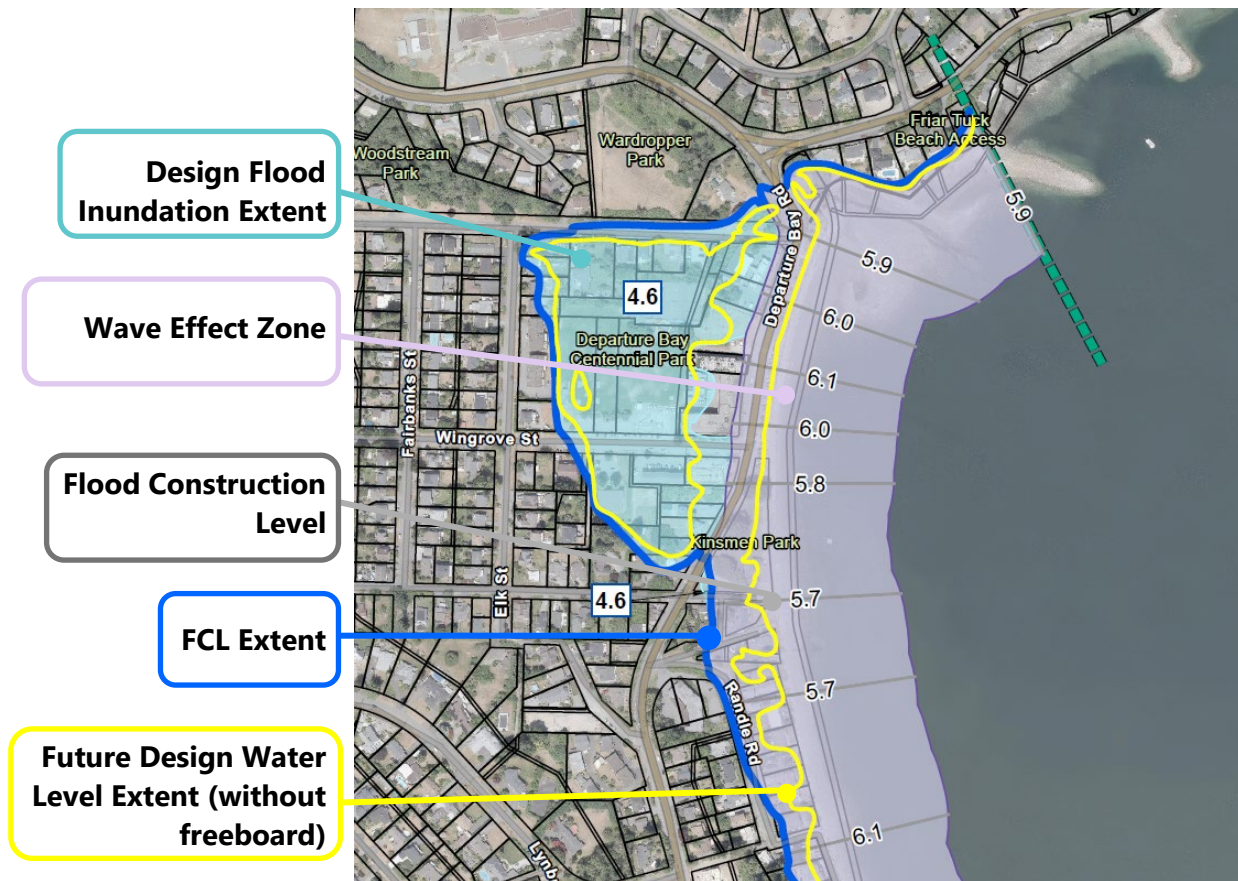
The floodplain maps produced for Nanaimo show the FCL and extent based on the 0.5% AEP event including 1 m of RSLR, the wave effects (in the form of the  $R_{2\%}$  wave runup) associated with the 0.5% AEP event and 0.6 m of freeboard (see Appendix C). The freeboard allowance accounts for uncertainty and localized variation in water level, including shoreline conditions and data accuracy.

FCL's define the minimum elevation required for a development to protect habitable living space from flood damage; it is equal to the sum of the design flood level plus wave run-up (wave effect zone only) and freeboard. Figure 5.1 shows the components of the flood construction level in profile.



**Figure 5.1 Components of the FCL shown on the floodplain maps.**

The wave effect zone (shown in purple, Figure 5.2) is the area where incoming waves impose additional hazards of higher water levels from wave set-up, breaking, and run-up as well as erosion and impact from the incoming waves and wave-transported debris. For this assessment, this zone extends landward to where the wave run-up reaches high ground, with a maximum distance of 30 m from where the still water level intersects with the foreshore. The wave run-up is the primary component of local variations in water level. The Design Flood Inundation Extent (light blue) includes areas of inundation landward of the wave effect zone (i.e., beyond the 30 m maximum).



**Figure 5.2 Example clip of Departure Bay Floodplain Map**

The flood maps are displayed at a 1:5000 scale; there are 4 map sheets for the floodplain that cover the study area. Designated flood maps are located in Appendix C. Additional layers for all the storm events (AEPs (5): 6.7% (1-in-15 year), 2.0% (1-in-50 year), 1.0% (1-in-100 year), 0.5% (1-in-200 year), 0.2% (1-in-500 year)) for all levels of RSLR scenarios (0.0 m, 0.5 m, 1.0 m, 2.0 m) have been generated and provided digitally.

## 6 HAZARD EXPOSURE

Using the results of the coastal flood hazard assessment, the 1% AEP (100-year) storm event over all the RSLRs scenarios was also mapped in addition to the regulatory maps to better define the expected hazard exposure for the different areas of Nanaimo through time. A description of the hazard as well as the objectives and values for Nanaimo's shorelines collected from the initial engagement were summarized on the maps. The vulnerable shorelines were broken into different reaches based on shoreline type. The hazard for all the different reaches across the four mapped areas is summarized in Figure 6.1 through Figure 6.4. The timeline for



the coastal flood hazard to impact the community is listed for each shoreline ranging from short term (0 m to 0.5 m of RSLR) to long term (1m+ of RSLR).

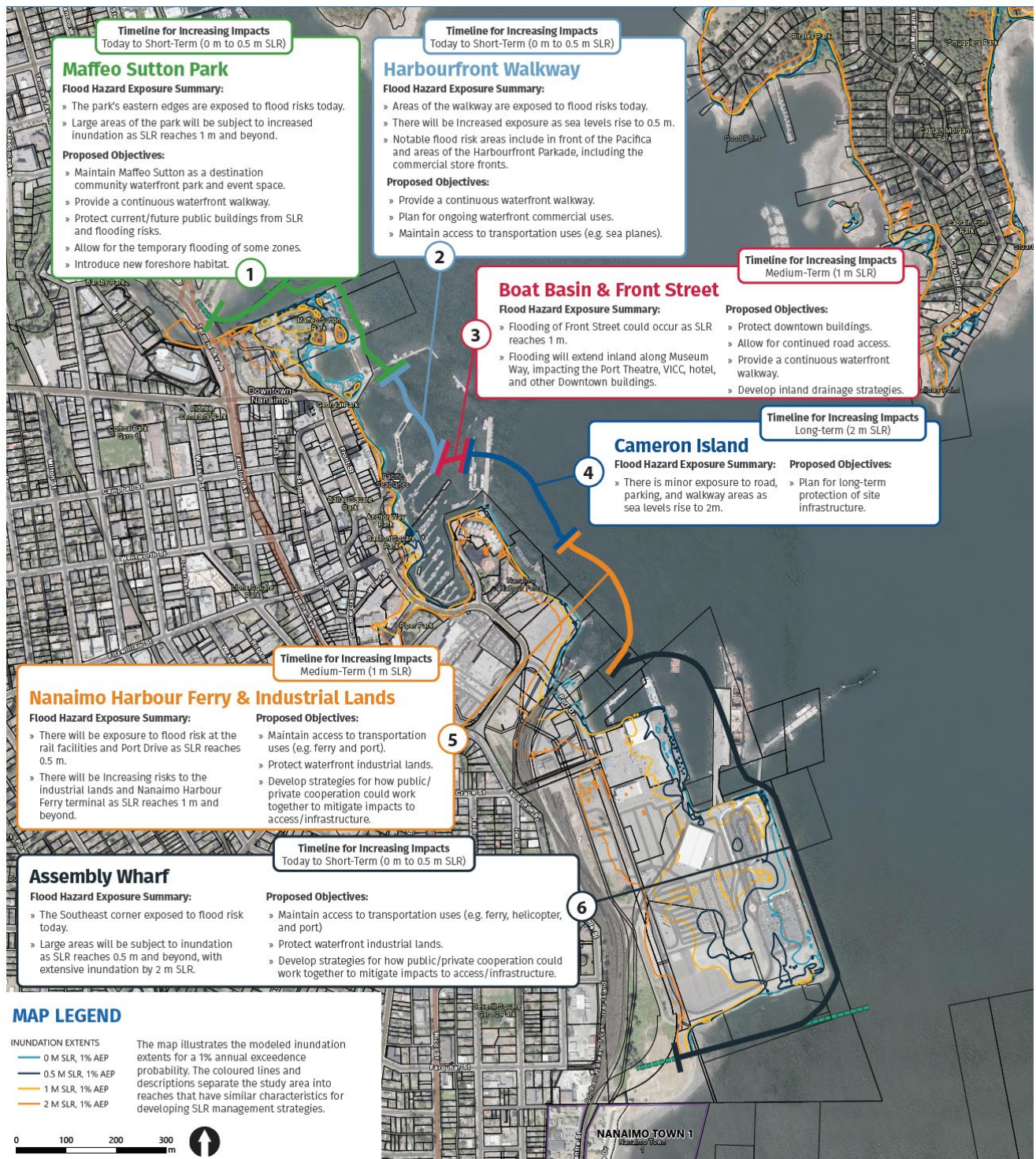
Areas of note that are impacted in the shorter term include:

- Randle and Battersea Roads in Departure Bay,
- Maffeo Sutton Park, the waterfront walkway, and Assembly Wharf in the downtown
- South Island and Gallows Point and sections of East Island on Protection Island and
- The sawmill site & Duke Point highway and the undeveloped industrial lands on Duke point.

These areas will need adaptation options sooner than other sections of Nanaimo where there is more time to consider a suitable plan.

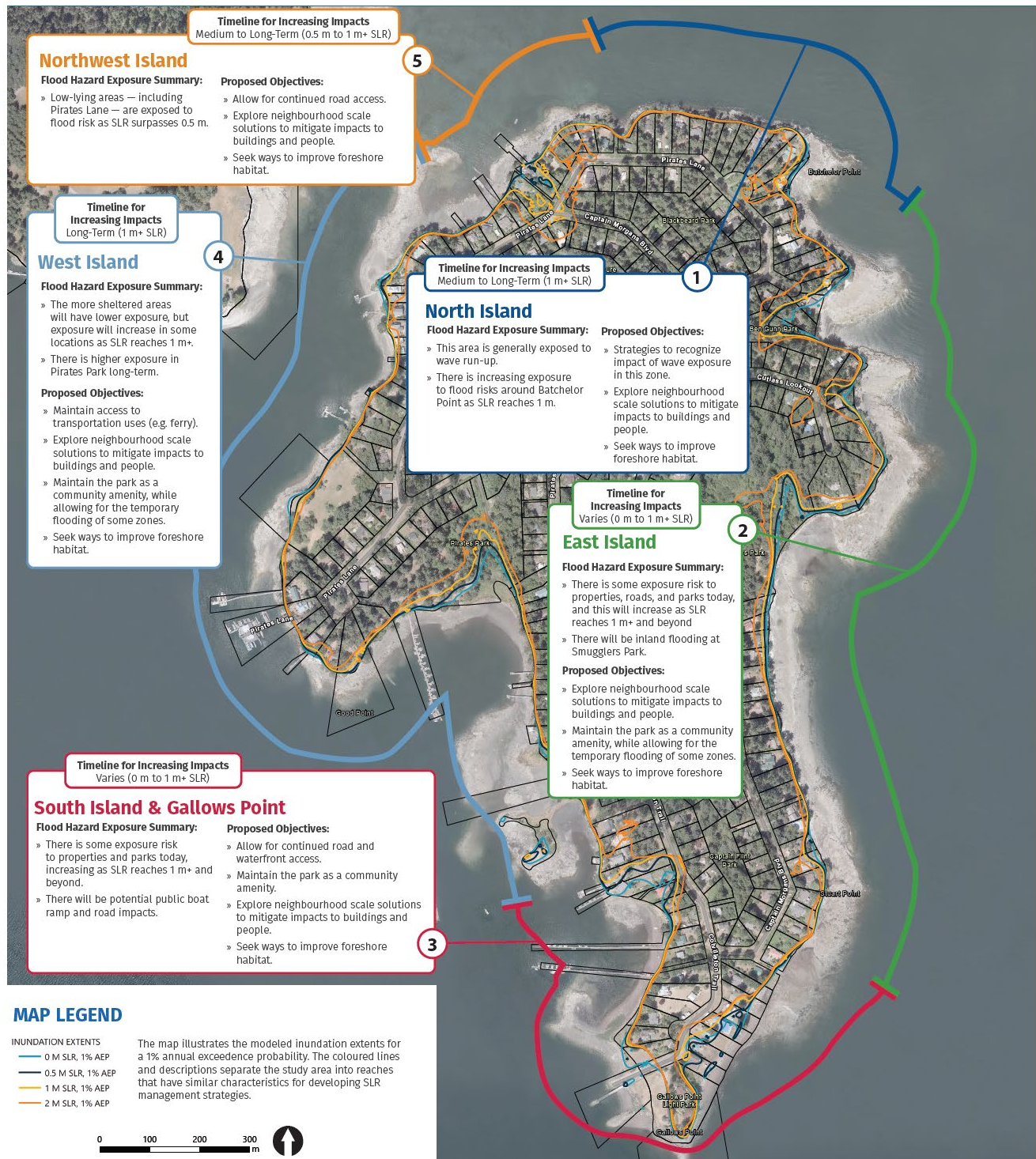






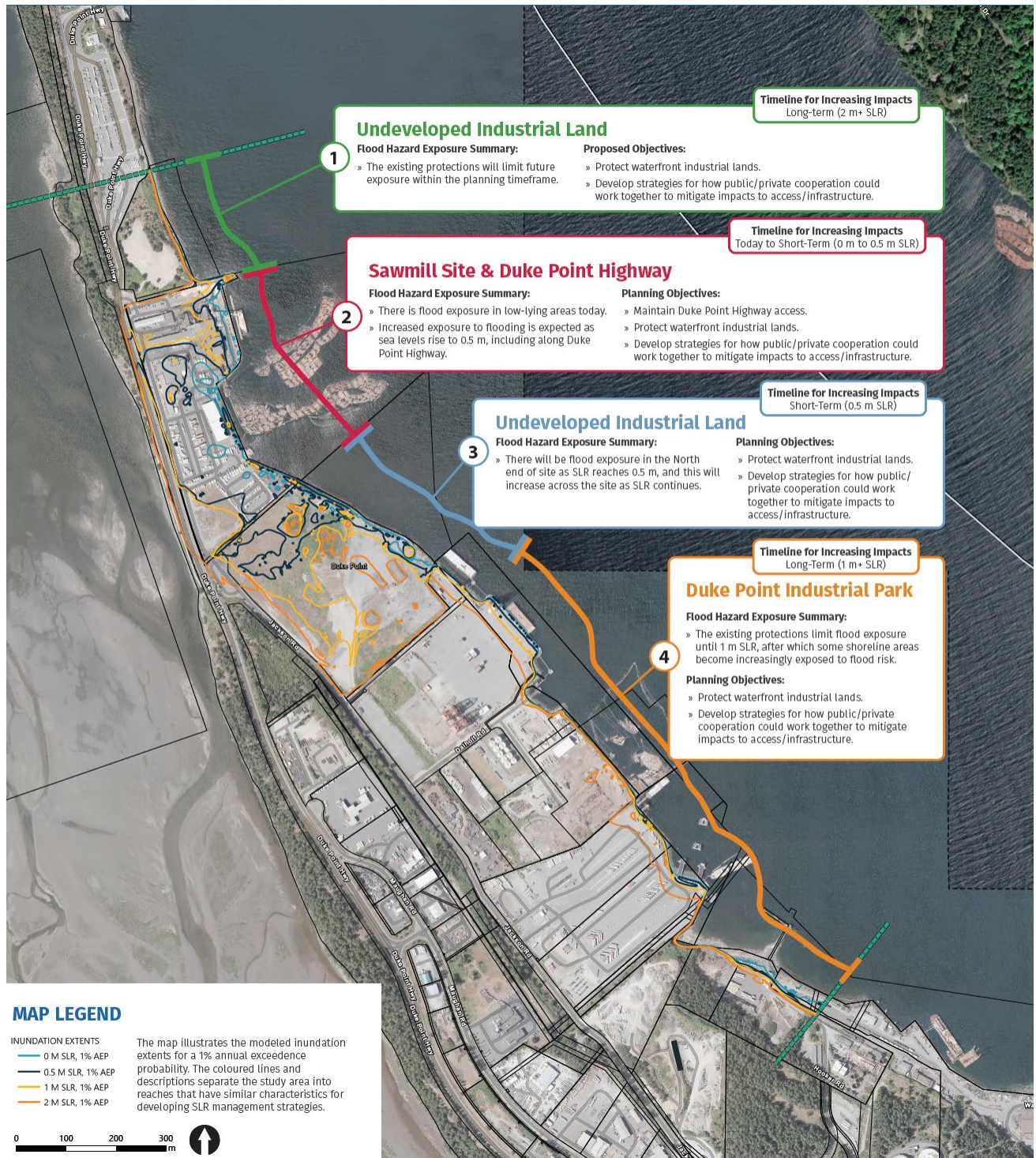
**Figure 6.2 Summary of flood hazard for Downtown**





**Figure 6.3 Summary of flood hazard for Protection Island**





**Figure 6.4 Summary of flood hazard for Duke Point**

## 7 RISK ASSESSMENT

A risk assessment was conducted for the flooded sections of Nanaimo based on the coastal flood hazard assessment (Section 3.4). Flood risk is the potential for adverse impacts where assets, people or values may be affected by flooding and the outcome is uncertain. Risk is often represented as a probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Flood risk can be expressed as a combination of the exposure and the vulnerability of the asset to flooding. As such, flooding only presents a risk if we have assets of value that are (or may in the future be) exposed to the flooding hazard and are vulnerable to it. This study evaluated the flood risk for three main assets: buildings, roads, and critical water, sewer and sanitary infrastructure (summarized in Appendix D). This section describes the results of the technical analyses undertaken to assess the flood risk used to guide the adaptation strategies.

### 7.1 Buildings – Quantitative Risk Assessment

The building risk assessment followed NRCan and EGBC guidance and evaluated both still water inundation and wave-effect exposure across the modelled coastal flood hazard scenarios (See Figure 3.2). A GIS-based asset dataset was developed from City of Nanaimo building footprints, quality checked against aerial imagery, refined to 167 buildings, and categorized into generalized building types for assigning vulnerability curves. Building elevations were derived from the 2019 LidarBC DEM, with finished floor elevations and basement assumptions applied based on building type and local knowledge. Stillwater damages were estimated in CanFlood using regional vulnerability functions adjusted to 2025 Nanaimo values, while wave-effect damages were assessed separately using coastal vulnerability curves where applicable. For each asset, damage from still water and wave effects were compared, and the greater value was retained; industrial and commercial buildings were assessed for still water risk only where wave-effect curves were not available.

Results are shown as expected annual damage (EAD), the average annual cost of flooding. EAD spreads monetary damages from all hazard probabilities and magnitudes evenly over time; actual damages vary by year, with some years high and others minimal.

#### 7.1.1 Results

The EAD for each sea level rise scenario across each study area is shown in Figure 7.1. The impacts on individual buildings for each study area, and under each RSLR scenario is shown in Appendix D Section 1.

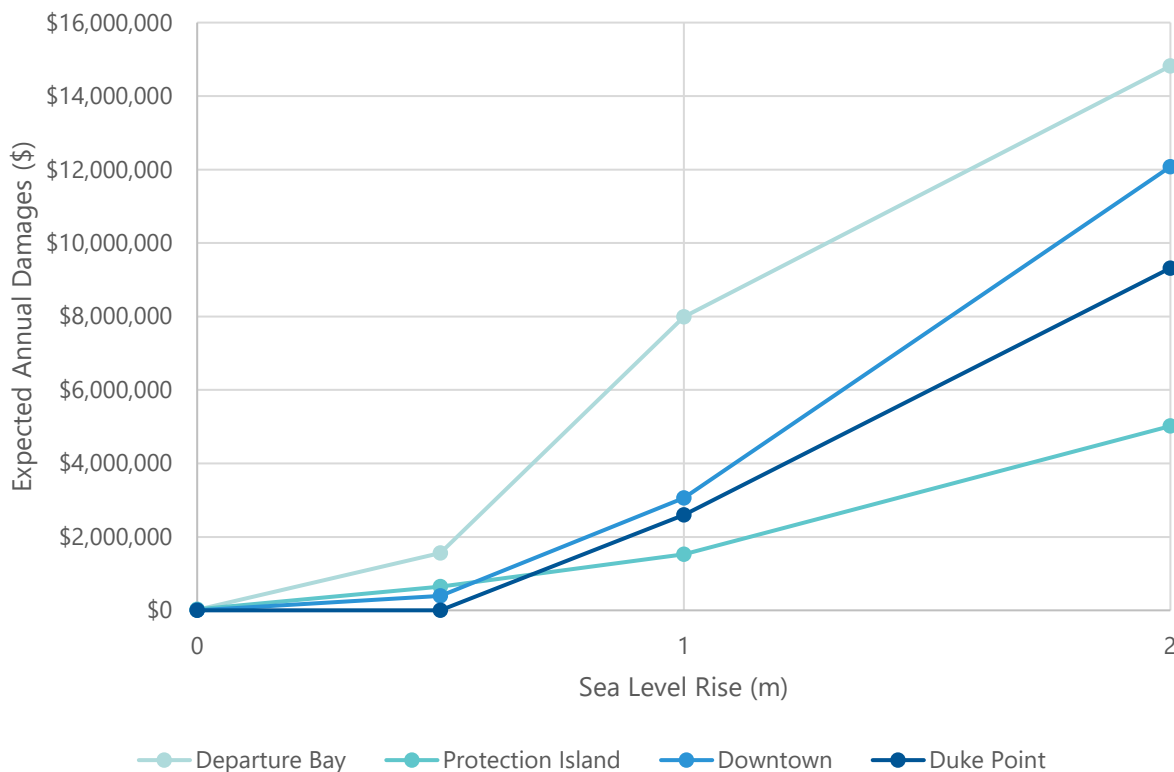
For the present day (RSLR of 0 m), there are no buildings at risk in the Downtown and Duke Point study areas. Some buildings in Departure Bay start to get inundated at the 2% AEP scenario, whereas some buildings on Protection Island become inundated at the 6.7% AEP scenario. The EADs for all study areas remain low for this RSLR scenario.

For the 0.5 m RSLR scenario, buildings in Duke Point become inundated at the 0.5% AEP scenario (although the damages remain minor), and buildings in all other study areas become inundated at the 6.7% AEP scenario. There is an increase in EAD across all study areas, with the most pronounced increase being in Departure Bay, due to the significant increase in inundation extents that occur at this RSLR scenario.

For the 1 m RSLR scenario, there is a significant increase in EADs across all study areas, being most pronounced for the Duke Point study area, as significant damages start to occur to large industrial buildings. All study areas see buildings being inundated during 6.7% AEP storms.

For the 2 m RSLR scenario, there is again a significant increase of 272% in EADs across all study areas. This is due to greater flooding extents and wave heights across all study areas; however the increase is greatest in the Duke Point and Downtown study areas and is largely driven by increasing damages to large commercial, industrial, and institutional buildings.

It should be noted that the risk to buildings is based on the assumptions noted in Appendix D. Of particular note is the effect of building generalizations. For example, the single-family dwelling damages for Departure Bay are partially driven by basement damages. The results of a future study could be refined by a detailed analysis of all buildings within a study area, to determine the presence of a basement and the FFE.

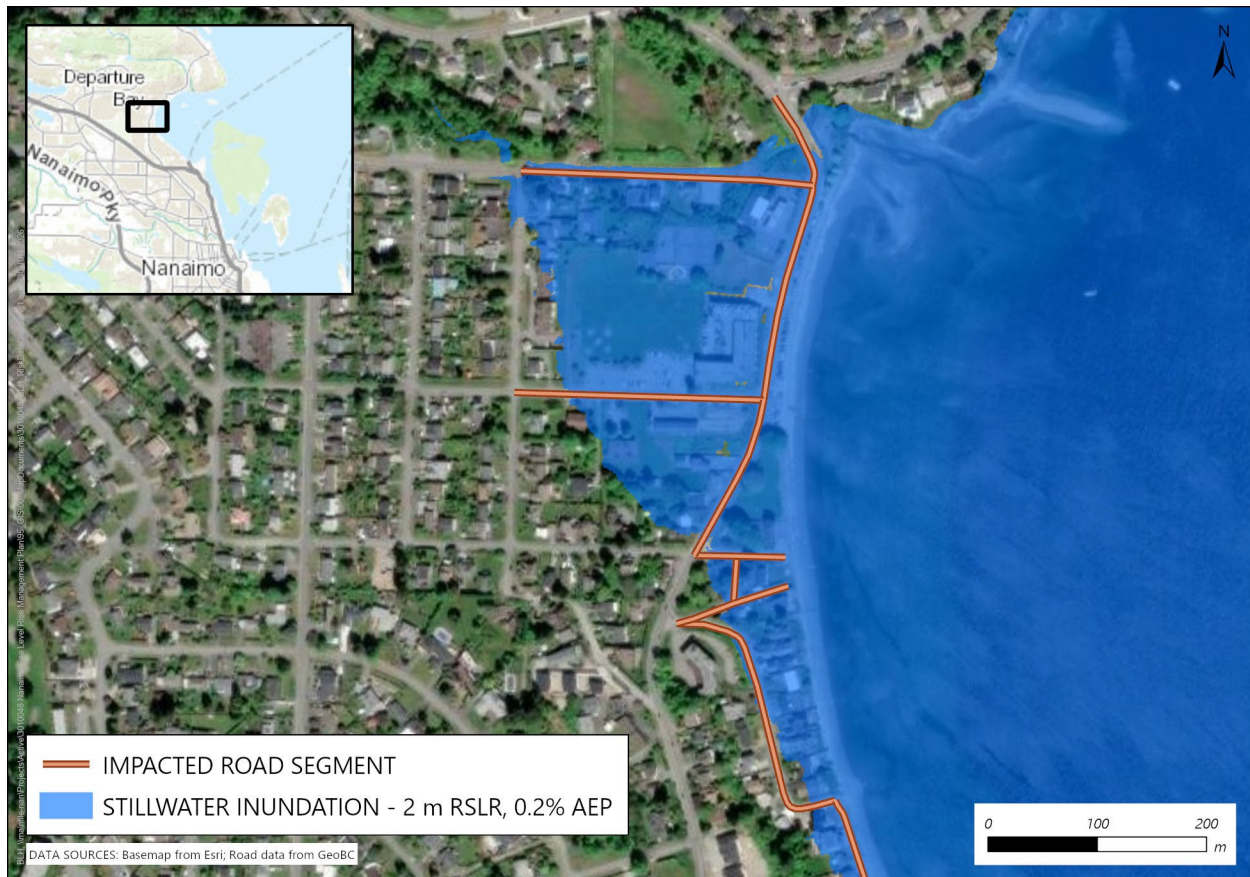


**Figure 7.1 Building EAD by RSLR Scenario**



## 7.2 Municipal Infrastructure - Impact and Semi-Quantitative Risk Assessment

Roads and water-related utility infrastructure were assessed using different methods to reflect the available data and risk characterization needs. Roads were evaluated using a semi-quantitative risk approach based on flood depth, nearshore wave height, asset location, and event likelihood. Road exposure was assessed by segment using GeoBC's Digital Road Atlas, with an entire segment considered inundated if any portion intersected the inundation or wave-effect zone, consistent with EurOtop guidance (Figure 7.2). Consequence ratings were assigned using defined depth and wave-height thresholds, then combined with likelihood ratings to determine an overall qualitative risk rating ranging from low to high. Water-related utility infrastructure was assessed separately using an impact-based approach rather than the road risk-rating matrix.



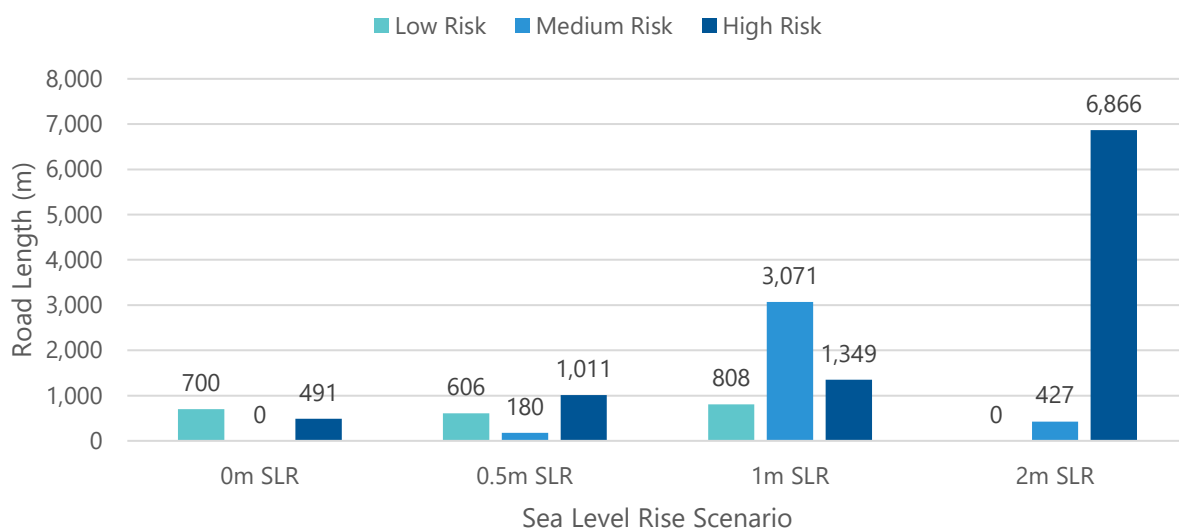
**Figure 7.2 Impacted road segments in Departure Bay beach area at 2m RSLR, 0.2% AEP**

Water, sanitary, and stormwater infrastructure were assessed using a binary impact analysis because the available datasets included a wide range of infrastructure types. Infrastructure points were classified as impacted where either significant wave height or still water depth exceeded 0.6 m. This threshold was assumed to represent the depth at which above-ground infrastructure, such as pump stations, may be damaged. The method is consistent with other regional and national flood studies; however, the assessment should be refined through further study because unclassified features influence some results, all infrastructure types were assigned the same impact threshold, and wave impacts may differ from standing-water impacts.

## 7.2.1 Result

### Roads

The risk to roads in all study areas will increase with RSLR, with a trend towards the high-risk category. Under current sea level conditions, there are 1.2 km of road at risk throughout all study areas, with 490 m being at high risk. The length of road at risk increases to 1.8 km (with 1.0 km at high risk) with 0.5 m of RSLR, 5.2 km (with 1.3 km at high risk) with 1 m of RSLR, and 7.3 km (with 6.9 km at high risk) with 2 m of RSLR. Under the 2m RSLR scenario, the study area with the most roads at high risk is Duke Point with 2.4 km, followed by Departure Bay with 1.9 km. It should be noted that roads were assessed on a segment-by-segment basis (i.e. if a given point on a road is high risk, the whole road segment was considered high risk). This increase in risk to roads with RSLR has the potential to significantly disrupt transportation around the City of Nanaimo, cut off major routes during large storm events (such as Departure Bay Road and Front Street), and increase damages to roads. An overview of the risk to roads for all study areas can be seen in Figure 7.3. Further information on the number of roads at risk for each study area can be seen in Appendix D, Section 2



**Figure 7.3 Total Length of Road at Risk by RSLR Scenario**

## Water-Related Utility Infrastructure

The number of impacted water, stormwater, and sanitary infrastructure points increase both with RSLR and with AEP, when amalgamating results across all study areas. Detailed information on the number of impacted points in each of these categories can be found in Appendix B.

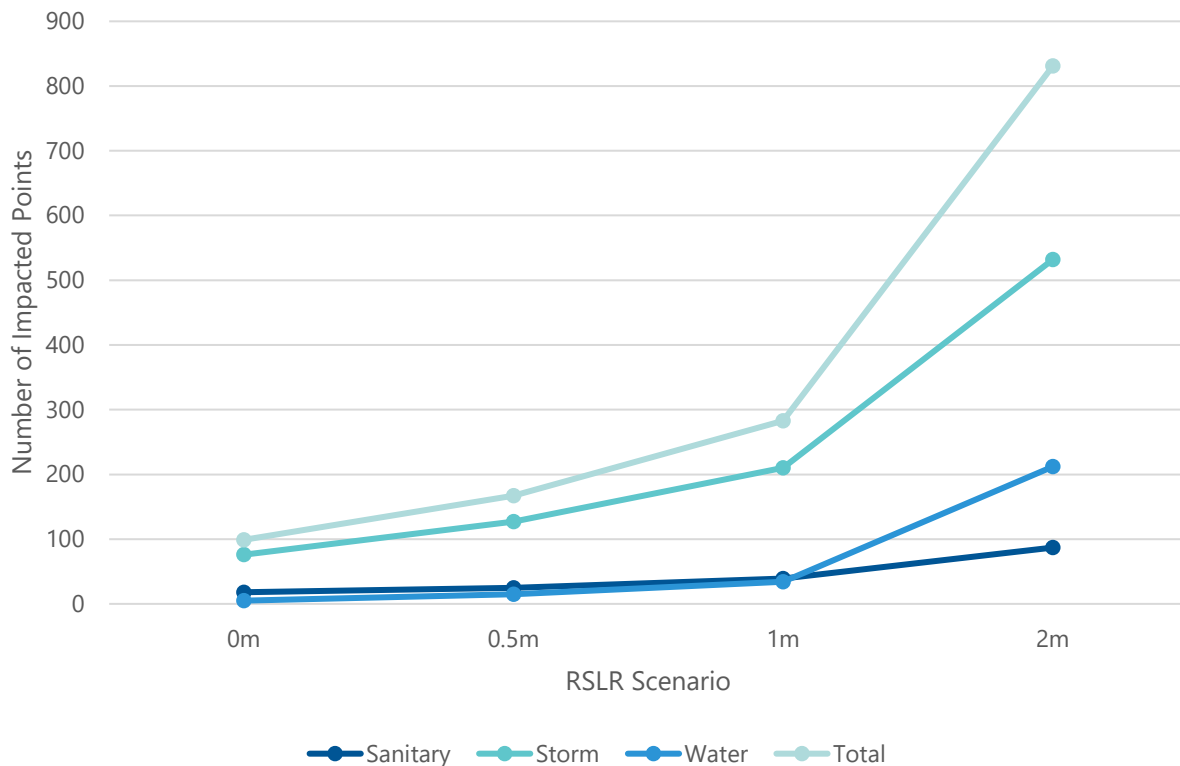
Figure 7.4 shows that the impacts of a 0.2% AEP storm on all assessed water-related utility infrastructure increase with increasing RSLR. The increase is gradual from 0 m RSLR until 1 m RSLR, however there is a significant increase (739%) in the amount of impacted infrastructure at 2 m RSLR.

The increase in impacted features is not consistent across all study areas. At Duke Point, the number of all impacted features increases across all categories with increasing AEP at 2 m RSLR but remains mostly static at all other RSLR scenarios. This is due to significant inundation not occurring at Duke Point until 1 m RSLR is reached, and becoming more severe at 2 m RSLR.

For Downtown, although there is an increase in impacted water and stormwater features with increasing RSLR and AEP, this does not occur with sanitary features. There is consistent damage across all AEPs at 0 m and 0.5 m RSLR, but this increases at 1 m RSLR, with a significant increase at 2 m RSLR. For all of the feature types, there is a significant increase in the number of impacted features once 2 m RSLR is reached.

For Protection Island, there are no sanitary features impacted until a 0.5% AEP storm, at 1 m RSLR. This number increases significantly once 2 m RSLR is reached. A similar pattern can be seen for water infrastructure, where impacts begin to occur with a 0.2% AEP storm, at 0.5 m RSLR, increase slightly for all scenarios at 1 m RSLR, and increase significantly for all scenarios at 2 m RSLR. Storm water infrastructure is impacted at all AEPs for all RSLR scenarios, and there is a significant increase in impacted infrastructure at 2 m RSLR.

For Departure Bay, , there are impacts to both sanitary and stormwater infrastructure for all RSLR scenarios, which rise gradually with increasing storm severity, with significantly higher impacts for 2 m RSLR. For water infrastructure, there are no impacts until a 2% AEP storm at 0.5 m RSLR, however the impacts remain relatively low until 2 m RSLR.



**Figure 7.4 Combined Infrastructure - Impacted Water-Related Utility Infrastructure by RSLR Scenario Across All Study Areas (0.2% AEP)**

### 7.3 Summary of Risk Assessment Findings

In summary, the risk assessment shows that the impacts and risk from the still water inundation and wave effects of coastal flooding will increase at every modelled RSLR scenario, with the most significant increases occurring at 2 m RSLR. These findings are consistent for all modelled consequence variables, in all study areas. These findings provide the basis for identifying and evaluating adaptation options in Section 9.

## 8 COASTAL FLOOD ADAPTATION OPTIONS

### 8.1 Protentional Adaptation Options

Sea level rise management plans must consider existing infrastructure, relative threats, timelines for increasing hazards, and community usage of the region. Adaptation options can take a variety of approaches, typically broadly classed by how an option adapts to the changing sea

level: *do nothing, avoid, retreat, and protect and accommodate*. These options are described in the figure below (Figure 8.1).

### Do Nothing



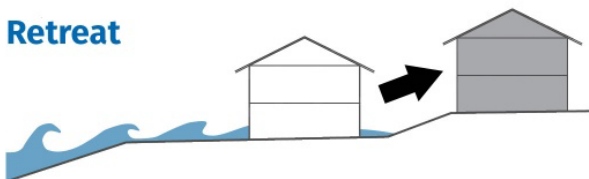
This means not planning, preparing or developing any strategies to deal with the impacts of sea level rise. **Doing nothing will most likely result in a delayed and much a more costly response** to sea level rise in the future.

### Avoid



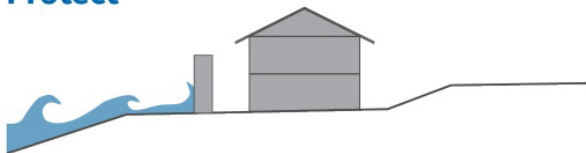
In areas that presently have little or no development, **avoiding future development through “no-build” areas is often the most effective approach to mitigating coastal hazards**. In areas with extensive existing human development, this approach may be more difficult.

### Retreat



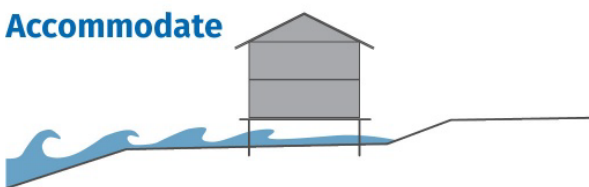
Retreat involves strategic, and often phased, **relocation of people and assets outside of high hazard areas**. It may also benefit the natural environment by providing space to adapt to the effects of climate change and sea level rise. Retreat can be implemented with assistance over long timescales to avoid negative outcomes.

### Protect

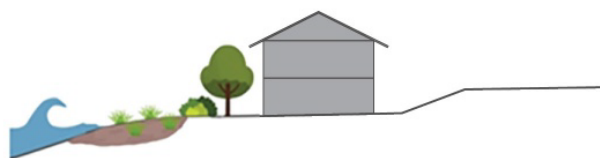


Protecting involves constructing barriers against flood waters. This can include **“hard” measures like dykes and seawalls or “soft” measures like green shores**. “Hard” measures often have negative impacts on ecosystems.

### Accommodate



**Accommodation involves adapting existing land uses** through measures like elevating living areas and improving building design to help a structure withstand flooding.



“Soft” measures work with natural systems to find ways to protect against flooding while expanding the ecological integrity of a shoreline. These often involved the creation of new habitat and ecosystems.

**Figure 8.1 Description of different coastal adaptation options.**



For each region in this study (Departure Bay, Downtown, Protection Island and Duke Point), the locations of concern along each shoreline were identified and the mapping results were assessed to determine potential adaptation options for sea level rise management.

Adaption measures provided in this report span a broad spectrum from green (nature-based) to grey ('traditional' or 'hard') including hybrid approaches. Also, within any given option there are opportunities to soften or provide soft features within them. The 'soft' or green measures themselves also occur on a spectrum that ranges from full naturalization (e.g., no human influence or 're-wilding') to green protection (e.g., Green Shores) to green features (e.g., habitat enhanced pocket beaches or wetlands built along armoured shorelines or with the incorporation of hard control structures). For example, when a seawall or revetment is recommended, micro tide pools or micro-habitat features can be built in to provide additional ecological benefits.

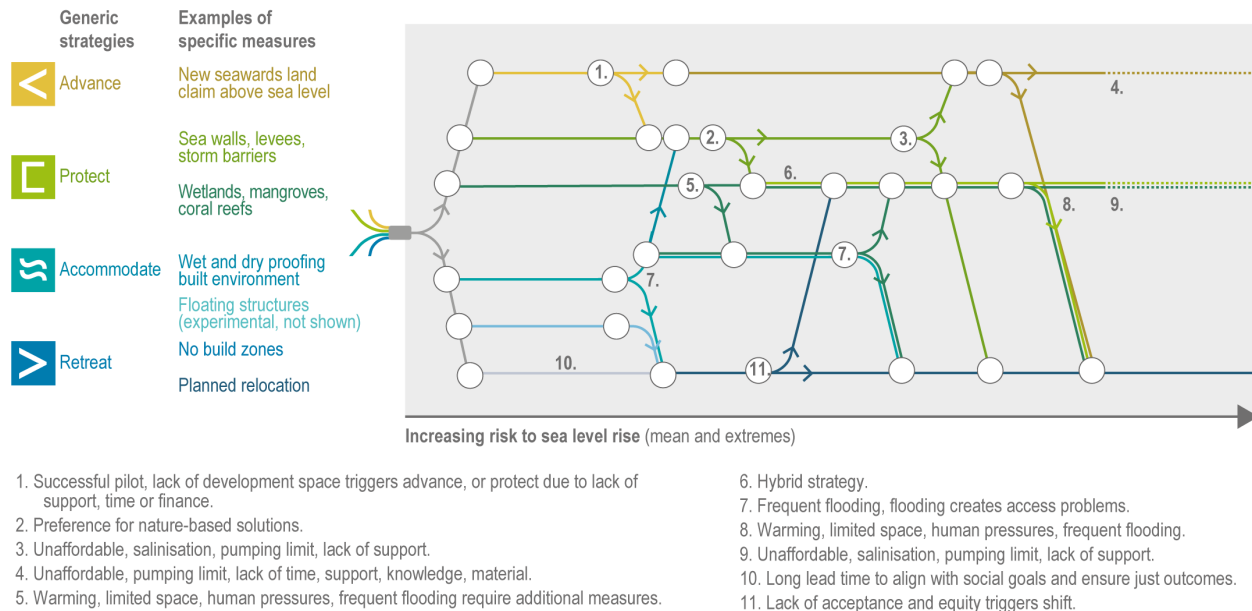
## 8.2 Potential Adaptation Management Option Pathways

To accommodate the large range of possible future conditions with RSLR, and the inherent deep uncertainty associated with RSLR projections, an adaptive management approach, such as the Dynamic Adaptive Policy Pathways (DAPP) approach (Haasnoot et al., 2013), is recommended for developing detailed site specific mitigation strategies. An example of an adaptive management pathway for a generic coastal city subject to RSLR was created for the IPCC AR6 report and is shown in Figure 8.2. The DAPP methodology can be applied rigorously to produce a complex series of pathways and quantitative assessment of alternative actions built upon combination and sequencing of individual mitigation strategies (i.e., avoid, retreat, advance, protect and accommodate). The main components of the adaptive management process can be broken down as follows:

- An overview of the region, constraints to the present and future development, and the objectives of the plan.
- A description of the uncertainties that will play a role in deciding future actions and outcomes. Future uncertainties include climate change, coastal erosion, technological change, and socio-economic pathways. Present uncertainties include data availability, our ability to predict coastal erosion, and impacts resulting from our actions.
- An analysis of the present and potential future problems including vulnerabilities and opportunities. This step also includes defining the most critical drivers (external factors that impact the region) and a set of future scenarios (this report).
- Identification of possible actions that can be taken to meet the plan's objectives. A description of possible actions can include the mitigation options discussed in Section 9; Adaptation Strategies for the City of Nanaimo.
- Evaluate the actions for each future scenario, identify when the actions will no longer meet the plan's objectives (*tipping points* shown by the white circles in Figure 8.2.) and evaluate other pathways that will need to be followed (next phase).

- Design the adaptive plan including short-term actions and longer-term options, strategies, and monitoring programs that are needed to update or re-assess the plan.

The following sections in this report provide high-level potential adaptation strategies that could potentially be applied to areas within Nanaimo. However, at this stage the strategies are not rigorously developed pathways. DAPP is a potential tool that could be used in combination with a community engagement program to develop the Coastal Climate Adaptation Strategy.



**Figure 8.2 Example of adaptive management pathways for a generic coastal city subject to RSLR (Glavovic et al., 2022).**

## 9 ADAPTATION STRATEGIES FOR CITY OF NANAIMO

Adaptation or mitigation strategies for the different areas of Nanaimo were developed using the coastal flood hazard exposure, risk assessment and engagement feedback. The strategies follow the high-level concepts of avoid, retreat, protect or accommodate, but are more tailored for the specific shorelines. Many options were considered for each of the reaches in each of the vulnerable sections of Nanaimo, but the list was refined based on the feasibility for different shore types and community's values.

The strategies discussed in this report are a starting point for both short- and long-term planning. A more thorough review for several locations will be required with feedback from the community to determine a preferred option for a specific shoreline reach. For areas with short- or medium-term solutions, adaptive management pathways, as described in the previous section, should be considered. The options developed for each region are summarized below

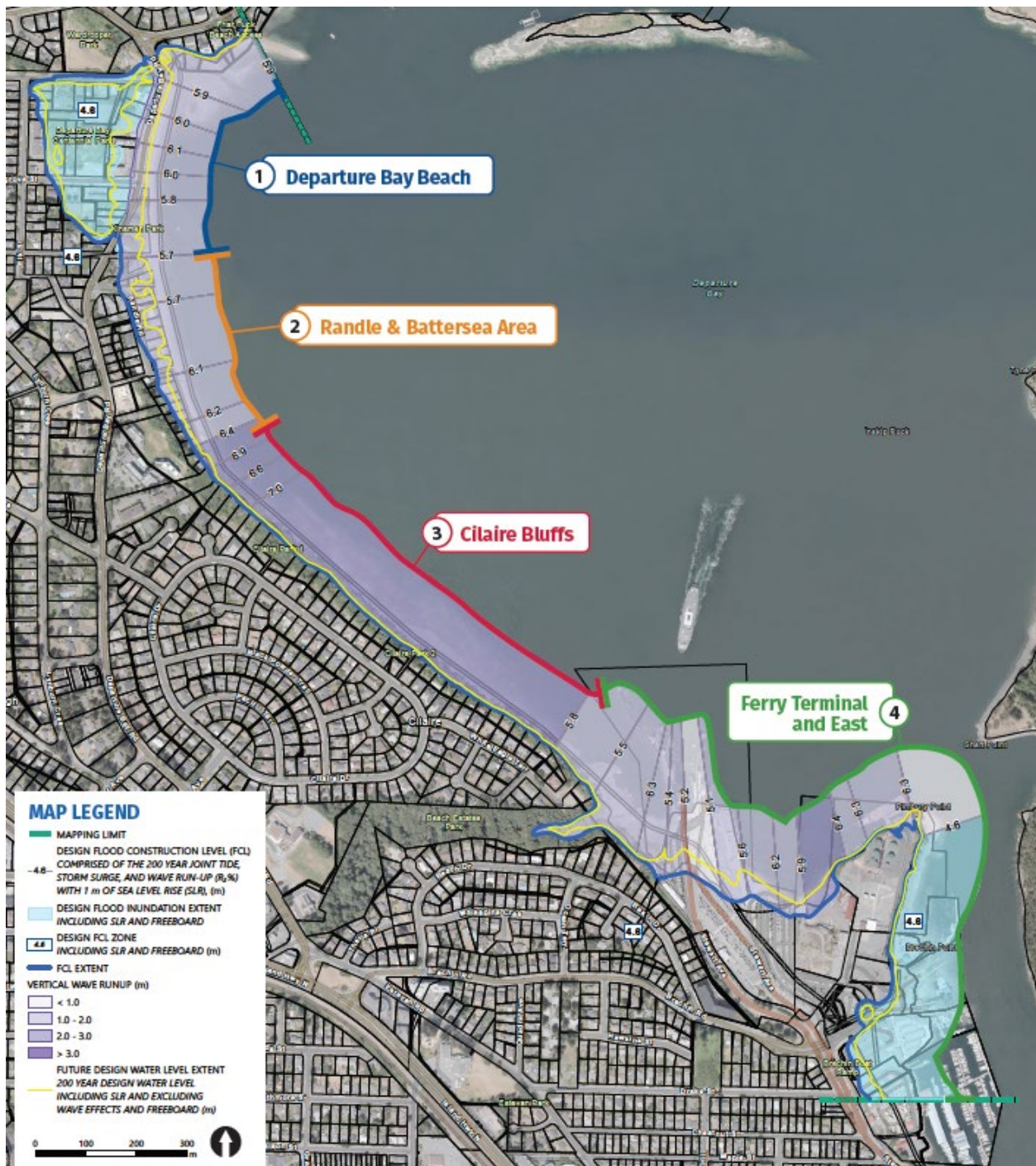
for Departure Bay (Table 9.1), Downtown Nanaimo (Table 9.2), Protection Island (Table 9.3), and Duke Point (Table 9.4).

Adaptation recommendations are provided for present day or near-term implementation (0 m-0.5 m RSLR), medium-term measures (0.5 m to 1.0 m), long-term measures (1.0 m + RSLR), and very long-term (2.0 m + RSLR) for each area. The approximate range of RSLR is based on current climate change projections. The timeframe for adaptation recommendations is based on when assets are expected to be at risk based on RSLR projections for Nanaimo:

- If assets are presently at risk, then adaptation options are recommended for the near-term
- If assets are at risk for the 0.5 m RSLR scenario, then adaptation options are recommended in the medium-term (5 to 25 years)
- If assets are at risk for the 1 m RSLR scenario, then adaptation options are recommended in the long-term (25 to 75 years).
- If assets are at risk for the 2 m RSLR scenario, then adaptation options are recommended in the very long-term (> 75 years).

The economic risk shown for each adaptation option is based on the 200-year storm event with 1.0 m of RSLR (the design event used in the floodplain maps).

## 9.1 Departure Bay



**Figure 9.1** Departure Bay shoreline reaches divided for adaptation measures



Table 9.1 Departure Bay Adaptation Strategies

| Strategy                                                                                                                                                                                                                      | Strengths                                                                                                                                                                                                     | Challenges                                                                                                                                                                          | Opportunities                                                                                                                                                                                                                | Threats                                                                                                                                                                                                                                                         | Trigger Threshold                                                                                                                                                                                                                             | Risk                                                                                                                           | Cost Estimate |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|---------------|
| 1. Departure Bay Beach                                                                                                                                                                                                        |                                                                                                                                                                                                               |                                                                                                                                                                                     |                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                               |                                                                                                                                |               |
| <div>Strategy A:<br/>Raise Seawall</div> <div> Seawall, Departure Bay Road, and infrastructure raised, new builds to meet FCLs</div>         | <ul style="list-style-type: none"><li>Protect existing buildings, cultural sites, and people</li><li>Requires limited space</li></ul>                                                                         | <ul style="list-style-type: none"><li>View impacts</li><li>Wave effect impacts are increased</li><li>Limits future adaptations</li></ul>                                            | <ul style="list-style-type: none"><li>Allows for continued development in low areas</li><li>Maintains access through area and quicker emergency response</li><li>Can build in green features or additional habitat</li></ul> | <ul style="list-style-type: none"><li>Densification of the area will result in increased flood risk</li><li>Seawall height is limited, increased density because of an upgraded seawall may limit or make other options in the future more difficult.</li></ul> | Medium Term (0.5 m – 1.0 m RSLR) - road overtopping becomes issue in medium term                                                                                                                                                              | <ul style="list-style-type: none"><li>Building EAD: \$2,687,829</li><li>Number of impacted infrastructure points: 34</li></ul> | \$\$\$ High   |
| <div>Strategy B:<br/>Phased Retreat</div> <div> Long-term process of retreating existing buildings and relocating Departure Bay Road</div>   | <ul style="list-style-type: none"><li>Removes people / infrastructure from flood zone</li><li>Potential for recreation</li><li>Long-term road connections outside flood zone</li></ul>                        | <ul style="list-style-type: none"><li>Removal of existing economic benefits</li><li>Potential cultural site impacts</li><li>Public acceptance challenges</li></ul>                  | <ul style="list-style-type: none"><li>Current seawall still has some life, an assessment could provide a timeline until replacement required</li><li>Beach nourishment could be used to enhance the beach</li></ul>          | <ul style="list-style-type: none"><li>Relocated commercial properties may struggle to re-establish</li><li>Beach and park will require ongoing maintenance</li></ul>                                                                                            | Short Term (0 m - 0.5 m RSLR) – Planning process will need to begin, starting with avoidance, before flooding creates accessibility concerns.<br><br>Medium Term (0.5 m – 1.0 m RSLR) – phased retreat as needed leading into a full retreat. | <ul style="list-style-type: none"><li>Total length of impacted roads: 939 m</li></ul>                                          | \$\$\$ High   |
| 2. Randle and Battersea Area                                                                                                                                                                                                  |                                                                                                                                                                                                               |                                                                                                                                                                                     |                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                               |                                                                                                                                |               |
| <div>Strategy A:<br/>Raise Buildings &amp; Roads</div> <div> New builds to meet FCLs, roads raised: Battersea, Randle, Loat, Seaview</div> | <ul style="list-style-type: none"><li>Retains existing residential properties</li><li>Cost of on-parcel improvements by property owners</li></ul>                                                             | <ul style="list-style-type: none"><li>Raised roads will require erosion protection from frequent inundation</li><li>Areas not raised will be subject to periodic flooding</li></ul> | <ul style="list-style-type: none"><li>Variety of future adaptation options available. Can protect or retreat in future.</li></ul>                                                                                            | <ul style="list-style-type: none"><li>May be only a short term solution.</li><li>Road becomes inundated.</li><li>Properties may be at risk for erosion</li></ul>                                                                                                | Short Term (0 m - 0.5 m RSLR) – Currently impacted by large storm events                                                                                                                                                                      | <ul style="list-style-type: none"><li>Building EAD: \$539,756</li><li>Number of impacted infrastructure points: 28</li></ul>   | \$\$ Moderate |
| <div>Strategy B:<br/>Phased Retreat</div> <div> Long-term process of retreating existing buildings and infrastructure</div>                | <ul style="list-style-type: none"><li>Removes people/ infrastructure from flood zone</li><li>Ecosystem benefits</li><li>Potential recreation opportunities</li><li>Major road outside of flood zone</li></ul> | <ul style="list-style-type: none"><li>Removal of existing economic benefits</li><li>Potential cultural site impacts</li><li>Public acceptance challenges</li></ul>                  | <ul style="list-style-type: none"><li>Allows room for RSLR adaptation and recreation area expansion</li></ul>                                                                                                                | <ul style="list-style-type: none"><li>If used for recreational purposes, will likely require some ongoing maintenance</li></ul>                                                                                                                                 | Short Term (0 m - 0.5 m RSLR) – Currently impacted by large storm events                                                                                                                                                                      | <ul style="list-style-type: none"><li>Total length of impacted roads: 662 m</li></ul>                                          | \$\$\$ High   |





| Strategy                                                                                                                                                                                         | Strengths                                                                                                                               | Challenges                                                                                                                                                                                                      | Opportunities                                                                                                                                                       | Threats                                                                                                                                                                                                   | Trigger Threshold                                                        | Risk | Cost Estimate |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------|---------------|
| <b>Strategy C:<br/>Seawall Extension</b><br> Seawall extended to protect roads/properties, expand public access | <ul style="list-style-type: none"><li>Supports recreational access</li><li>Protects roads, cultural sites, and infrastructure</li></ul> | <ul style="list-style-type: none"><li>Life span is limited</li><li>May require beach nourishment or offshore energy dissipation</li><li>Requires land acquisition</li><li>Impact to foreshore habitat</li></ul> | <ul style="list-style-type: none"><li>Beach enhancement could increase recreational use</li><li>Can incorporate green features and add additional habitat</li></ul> | <ul style="list-style-type: none"><li>May require upgrades to accommodate future RSLR</li><li>Beach nourishment can be cost prohibitive</li><li>Will eventually require wave energy dissipation</li></ul> | Short Term (0 m - 0.5 m RSLR) – Currently impacted by large storm events |      | \$\$\$ High   |

3. Cilaire Bluffs

|                                                                                                                                                                                                                      |                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                           |                                  |                                                                                                                        |                     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------|---------------------|
| <b>Strategy A:<br/>Status Quo, Monitor Erosion</b><br> No change in short term, monitor/mitigate potential future erosion of bluffs | <ul style="list-style-type: none"><li>Not currently vulnerable to floods</li><li>No costs</li><li>Erosion supplies sediment to beach</li></ul> | <ul style="list-style-type: none"><li>Bluffs vulnerable to erosion which could worsen with coastal flooding and RSLR</li></ul>                                                                                                                                                                                                             | <ul style="list-style-type: none"><li>Variety of options are available in the future if erosion increases</li></ul>                                                                                                                                  | <ul style="list-style-type: none"><li>Erosion of Cilare bluffs may worsen with time and require retreat from above or some action to stabilize the cliff base</li></ul>                                   | Medium Term (0.5 m – 1.0 m RSLR) | <ul style="list-style-type: none"><li>Building EAD: \$0</li><li>Number of impacted infrastructure points: 12</li></ul> | \$ Low - monitoring |
| <b>Strategy B:<br/>Seawall Extension</b><br> Seawall extended to help protect Cilaire bluffs, expand public access                 | <ul style="list-style-type: none"><li>Supports recreational access</li><li>Can protect bluffs from ongoing toe erosion</li></ul>               | <ul style="list-style-type: none"><li>Life span is limited</li><li>Removes bluff function as coastal sediment supply</li><li>May require beach nourishment or offshore energy dissipation</li><li>Loss of beach as RSLR continues.</li><li>Doesn't reduce erosion occurring at top of bluffs</li><li>Impact to foreshore habitat</li></ul> | <ul style="list-style-type: none"><li>Beach enhancement could increase recreational use</li><li>Can help long term stability of bluffs by protecting against toe erosion</li><li>Can incorporate green features and add additional habitat</li></ul> | <ul style="list-style-type: none"><li>May require upgrades to accommodate future RSLR</li><li>Beach nourishment can be cost prohibitive</li><li>Will eventually require wave energy dissipation</li></ul> | Medium Term (0.5 m – 1.0 m RSLR) | <ul style="list-style-type: none"><li>Total length of impacted roads: 25 m</li></ul>                                   | \$\$ Moderate       |

4. Ferry Terminal and East

|                                                                                                                                                                                                                                  |                                                                                                                    |                                                                                                                                                     |                                                                                                                                                         |                                                                                                                 |                                  |                                                                                                                                                                              |             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| <b>Strategy A:<br/>Raise Buildings &amp; Roads</b><br> New builds in low areas raised to meet FCLs, roads and infrastructure raised over time | <ul style="list-style-type: none"><li>Low additional cost, each building raised as required when rebuilt</li></ul> | <ul style="list-style-type: none"><li>May not feasible to raise specific buildings or roads depending on space and building requirements,</li></ul> | <ul style="list-style-type: none"><li>Can be phased slowly over time</li><li>Supports future flexibility for additional raising or retreating</li></ul> | <ul style="list-style-type: none"><li>Some facilities may require future relocation as RSLR continues</li></ul> | Medium Term (0.5 m – 1.0 m RSLR) | <ul style="list-style-type: none"><li>Building EAD: \$2,823,456</li><li>Number of impacted infrastructure points: 39</li><li>Total length of impacted roads: 321 m</li></ul> | \$\$\$ High |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|

**OPTIONS COLOUR LEGEND**

 = primarily public lands adaptations     = primarily private property adaptations     = mix of private and public adaptations

## 9.2 Downtown

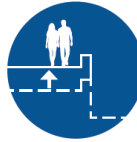


**Figure 9.2** Downtown shoreline reaches divided for adaptation measures





Table 9.2 Downtown Adaptation Strategies

| Strategy                                                                                                                                                                                                                                                    | Strengths                                                                                                                                       | Challenges                                                                                                                                    | Opportunities                                                                                                                                                                                                                        | Threats                                                                                                                                                                      | Trigger Threshold                                                                                                                                                                  | Risk                                                                                                              | High Level Cost |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-----------------|
| 1. Maffeo Sutton Park                                                                                                                                                                                                                                       |                                                                                                                                                 |                                                                                                                                               |                                                                                                                                                                                                                                      |                                                                                                                                                                              |                                                                                                                                                                                    |                                                                                                                   |                 |
| <div>Strategy A:<br/>Naturalization</div> <div><div>Hardened shore protection removed, shorelines re-naturalized, permanent infrastructure relocated or raised</div></div> | <ul style="list-style-type: none"><li>More natural beach areas</li><li>Reduction of wave impacts</li><li>Ecological benefits</li></ul>          | <ul style="list-style-type: none"><li>No additional protection for City infrastructure</li><li>Maintenance required</li></ul>                 | <ul style="list-style-type: none"><li>Maintains recreational space</li><li>Could increase ecological benefits</li><li>Flexible to future adaptation</li></ul>                                                                        | <ul style="list-style-type: none"><li>Requires maintenance with rising sea levels.</li><li>May require sediment control and periodic re-nourishment of beach areas</li></ul> | Short Term (0 m - 0.5 m RSLR) - Flooding concerns presently, process will need to begin before flooding creates accessibility concerns in medium term.                             | Building EAD: \$0<br>Number of impacted infrastructure points: 55<br>Total length of impacted roads: 295 m        | \$\$ Moderate   |
| 2. Waterfront Walkway                                                                                                                                                                                                                                       |                                                                                                                                                 |                                                                                                                                               |                                                                                                                                                                                                                                      |                                                                                                                                                                              |                                                                                                                                                                                    |                                                                                                                   |                 |
| <div>Strategy A:<br/>Raise Shoreline Protection/Walkway</div> <div><div>Raise walkway, low-lying buildings, retain existing parking garage</div></div>                    | <ul style="list-style-type: none"><li>Maintains continuous walkway</li><li>Supports potential for ongoing commercial activity</li></ul>         | <ul style="list-style-type: none"><li>May require rebuilding of existing commercial units</li></ul>                                           | <ul style="list-style-type: none"><li>May allow for better adapted commercial spaces and more public walkway space that could be used for other purposes</li><li>Can incorporate green features and add additional habitat</li></ul> | <ul style="list-style-type: none"><li>Lifespan of protection will continue to be an issue as RSLR continues</li><li>Long-term replacement may not be feasible</li></ul>      | Short Term (0 m - 0.5 m RSLR) – some sections of the walkway (closer to Maffeo Sutton) will become vulnerable.<br>Medium Term (0.5 m – 1.0 m) – rest of the walkway toward harbour | Building EAD: \$178,728<br>Number of impacted infrastructure points: 6<br>Total length of impacted roads: 4 m     | \$\$\$ High     |
| 3. Boat Basin                                                                                                                                                                                                                                               |                                                                                                                                                 |                                                                                                                                               |                                                                                                                                                                                                                                      |                                                                                                                                                                              |                                                                                                                                                                                    |                                                                                                                   |                 |
| <div>Strategy A:<br/>Raise Front Street</div> <div><div>Raise front Street from Promenade Drive to Coast Bastion Hotel</div></div>                                       | <ul style="list-style-type: none"><li>Stops inland flooding of Museum Way and adjacent buildings</li><li>Maintains continuous walkway</li></ul> | <ul style="list-style-type: none"><li>Potential view impacts</li><li>Changes to natural drainage patterns (low point in Museum way)</li></ul> | <ul style="list-style-type: none"><li>Raising can be phased</li></ul>                                                                                                                                                                | <ul style="list-style-type: none"><li>Potential for groundwater issues as RSLR continues</li></ul>                                                                           | Medium Term (0.5 m – 1.0 m)                                                                                                                                                        | Building EAD: \$1,302,813<br>Number of impacted infrastructure points: 9<br>Total length of impacted roads: 643 m | \$\$ Moderate   |
| 4. Camerson Island                                                                                                                                                                                                                                          |                                                                                                                                                 |                                                                                                                                               |                                                                                                                                                                                                                                      |                                                                                                                                                                              |                                                                                                                                                                                    |                                                                                                                   |                 |
| Limited exposure within the planning period                                                                                                                                                                                                                 |                                                                                                                                                 |                                                                                                                                               |                                                                                                                                                                                                                                      |                                                                                                                                                                              | Very Long Term (2+ m RSLR)                                                                                                                                                         | Building EAD: \$0<br>Number of impacted infrastructure points: 1<br>Total length of impacted roads: 169 m         | No costs        |



| Strategy | Strengths | Challenges | Opportunities | Threats | Trigger Threshold | Risk | High Level Cost |
|----------|-----------|------------|---------------|---------|-------------------|------|-----------------|
|----------|-----------|------------|---------------|---------|-------------------|------|-----------------|

5. Nanaimo Harbour Ferry and Industrial Lands

|                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                     |                                                                                                                                                                                    |                                                                                                                                           |                                  |                                                                                                                                                                      |             |
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| <p>Strategy A:<br/>Phased Retreat</p>  <p>Long-term process of retreating existing industrial uses through buy-outs or development area limits</p> | <ul style="list-style-type: none"><li>Removes people / infrastructure from the flood zone</li><li>Nothing currently built on the industrial lands, blank slate to develop with RSLR incorporated in design</li><li>Potential for environmental and recreational benefits</li></ul> | <ul style="list-style-type: none"><li>Loss of industrial land</li></ul>                                                                                                                                                                             | <ul style="list-style-type: none"><li>Long-term ecological benefits</li></ul>                                                                                                      | <ul style="list-style-type: none"><li>Loss of economic benefits from industrial business requiring water access</li></ul>                 | Medium Term (0.5 m – 1.0 m RSLR) | <ul style="list-style-type: none"><li>Building EAD: \$0</li><li>Number of impacted infrastructure points: 22</li><li>Total length of impacted roads: 148 m</li></ul> | \$\$\$ High |
| <p>Strategy B:<br/>Property-level Seawalls/Revetments</p>  <p>Property level hard protection to protect industrial uses</p>                        | <ul style="list-style-type: none"><li>Protects land from flooding and erosion at properties</li></ul>                                                                                                                                                                              | <ul style="list-style-type: none"><li>May not align with specific waterfront industrial needs</li><li>Low lying areas may still see flooding</li><li>Potential drainage issues</li><li>Additional costs with nothing to currently protect</li></ul> | <ul style="list-style-type: none"><li>Can be phased as RSLR continues</li><li>Can be added as required</li><li>Can incorporate green features and add additional habitat</li></ul> | <ul style="list-style-type: none"><li>Low lying areas still vulnerable/inundated with RSLR</li><li>Drainage can become an issue</li></ul> | Medium Term (0.5 m – 1.0 m RSLR) |                                                                                                                                                                      | \$\$\$ High |

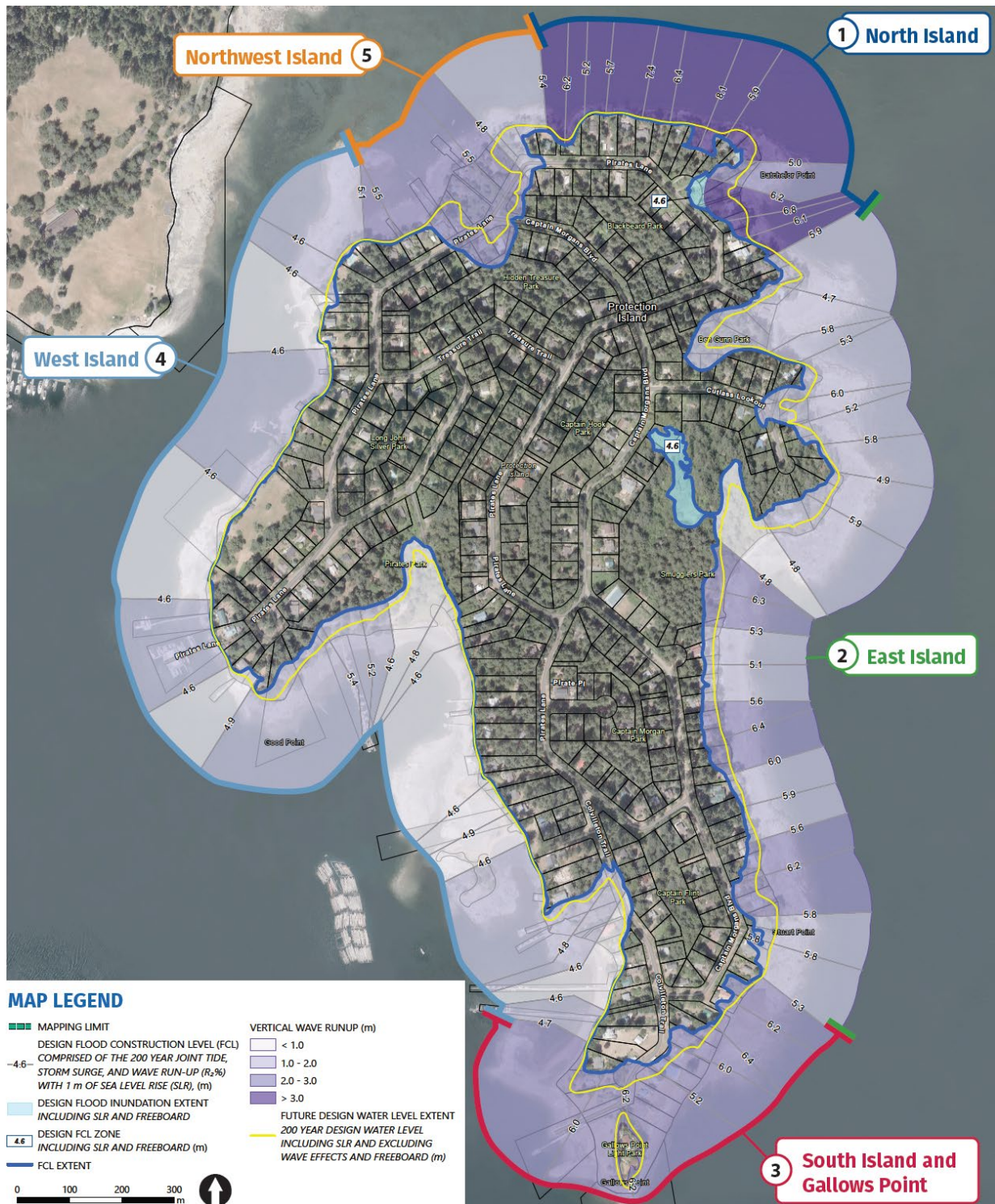
6. Assembly Wharf

|                                                                                                                                                                                                                              |                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                   |                                                                                                                                                                                     |                                                                                                                                                                      |                                  |                                                                                                                              |             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------------|-------------|
| <p>Strategy A:<br/>Phased Retreat</p>  <p>Long-term process of removing or relocating infrastructure out of the floodplain</p>            | <ul style="list-style-type: none"><li>Removes people / infrastructure from the flood zone</li><li>Potential for additional recreation benefits</li><li>Ecological benefits</li></ul>                                                       | <ul style="list-style-type: none"><li>Loss of waterfront industrial properties</li><li>Public acceptance challenges</li><li>Mass repurposing of the area</li></ul>                                                                                | <ul style="list-style-type: none"><li>Long-term ecological benefits</li><li>Mass repurposing of the area using naturalization can provide more recreation and other uses.</li></ul> | <ul style="list-style-type: none"><li>Loss of economic benefits from industrial business requiring water access</li></ul>                                            | Medium Term (0.5 m – 1.0 m RSLR) | <ul style="list-style-type: none"><li>Building EAD: \$834,441</li><li>Number of impacted infrastructure points: 21</li></ul> | \$\$\$ High |
| <p>Strategy B:<br/>Property-level Seawalls/Revetments</p>  <p>Single or multi-property hard protection to protect existing properties</p> | <ul style="list-style-type: none"><li>Is aligned with existing uses from flooding and erosion</li><li>Can be phased with protection added / changed as land uses in area evolve</li><li>Lower maintenance than natural solutions</li></ul> | <ul style="list-style-type: none"><li>Low-lying areas may still see flooding and may require further adaptation</li><li>Some facilities may require future relocation as RSLR continues</li><li>No improvement to the foreshore habitat</li></ul> | <ul style="list-style-type: none"><li>Can be phased as RSLR continues</li><li>Can be added as required</li><li>Can incorporate green features and add additional habitat</li></ul>  | <ul style="list-style-type: none"><li>Low lying areas still vulnerable/inundated with RSLR</li><li>Drainage can become an issue</li></ul>                            | Medium Term (0.5 m – 1.0 m RSLR) | <ul style="list-style-type: none"><li>Total length of impacted roads: 144 m</li></ul>                                        | \$\$\$ High |
| <p>Strategy C:<br/>Raise Critical Infrastructure</p>  <p>Raise access roads and buildings/docks within floodplain</p>                     | <ul style="list-style-type: none"><li>Maintains access to industrial and transportation uses</li><li>Allows individual property owners to address issues over time as required to suit their needs</li></ul>                               | <ul style="list-style-type: none"><li>Selective raising leave other industrial infrastructure at risk.</li></ul>                                                                                                                                  | <ul style="list-style-type: none"><li>Can be phased slowly over time</li><li>Supports future flexibility for additional raising or retreating</li></ul>                             | <ul style="list-style-type: none"><li>Low lying area may become unusable with RSLR</li><li>Some facilities may require future relocation as RSLR continues</li></ul> | Medium Term (0.5 m – 1.0 m RSLR) |                                                                                                                              | \$\$ High   |

OPTIONS COLOUR LEGEND

 = primarily public lands adaptations     = primarily private property adaptations     = mix of private and public adaptations

### 9.3 Protection Island



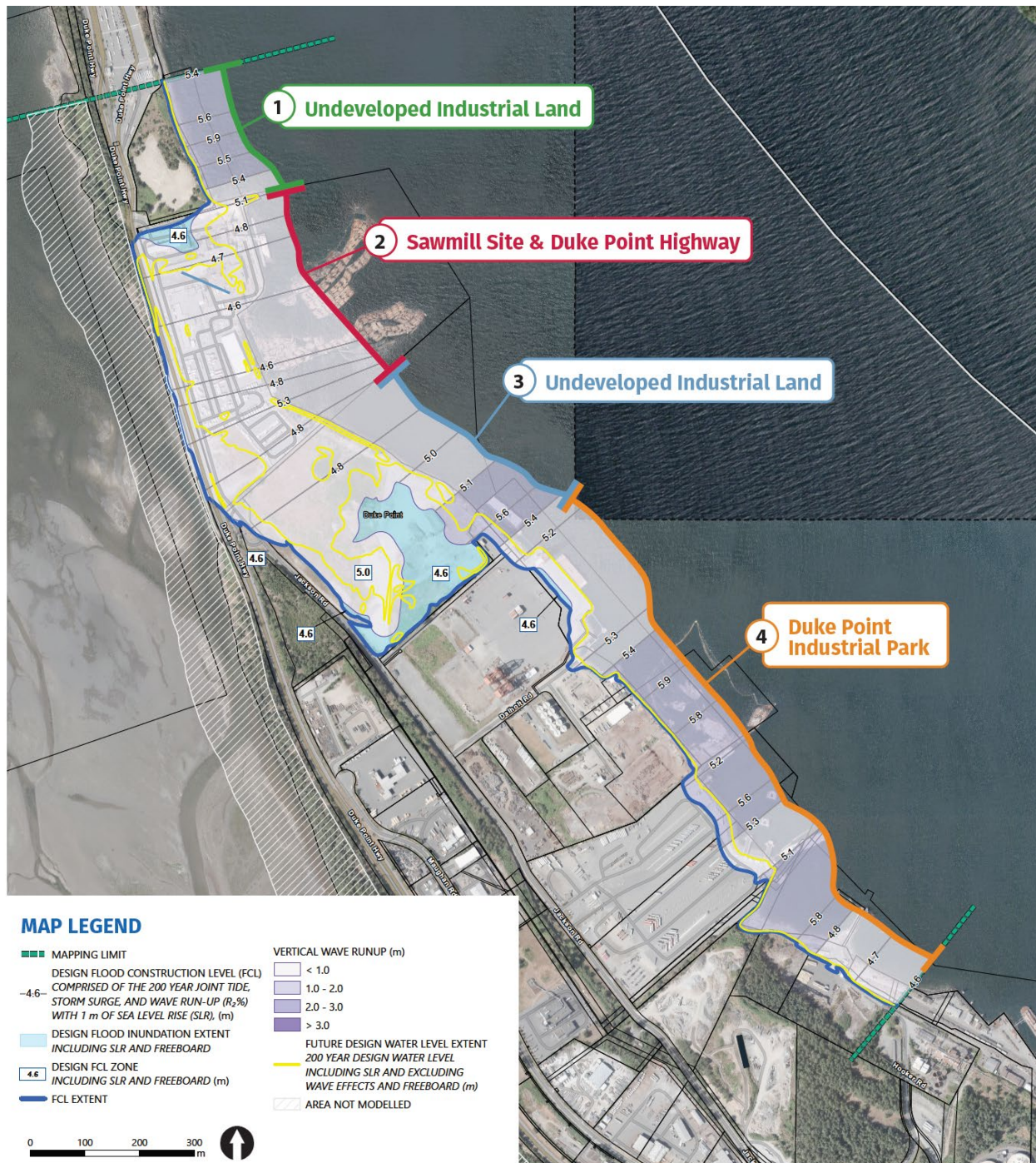
**Figure 9.3 Protection Island shoreline reaches divided for adaptation measures**



Table 9.3 Protection Island Adaptation Strategies

| Strategy                                                                                                                                                                                                                                                                                                                                                                                                             | Strengths                                                                                                                                                             | Challenges                                                                                                                                                                                              | Opportunities                                                                                                                                                                           | Threats                                                                                                                                                                                       | Trigger Threshold                | Risk                                                                                                                                                                                 | High Level Cost             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| 1-5 In Problem Locations Across All Areas                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                       |                                                                                                                                                                                                         |                                                                                                                                                                                         |                                                                                                                                                                                               |                                  |                                                                                                                                                                                      |                             |
| <div>Strategy A:<br/>Property-level Naturalization</div> <div>Single or multi-property nature-based solutions to reduce wave energy</div>                                                                                                                                                                                           | <ul style="list-style-type: none"><li>• Potential to reduce wave energy</li><li>• Lengthens use of property</li><li>• Ecological benefits</li></ul>                   | <ul style="list-style-type: none"><li>• Requires maintenance</li><li>• Buildings may be required to set back as RSLR continues</li></ul>                                                                | <ul style="list-style-type: none"><li>• Increased ecological benefits</li><li>• Flexibility for future adaptation options</li></ul>                                                     | <ul style="list-style-type: none"><li>• Shore lifespan</li><li>• Ongoing adaptation required as RSLR continues</li></ul>                                                                      | Short Term (0 m - 0.5 m RSLR) -  | <ul style="list-style-type: none"><li>• Building EAD: \$1,158,031</li><li>• Number of impacted infrastructure points: 12</li><li>• Total length of impacted roads: 1,751 m</li></ul> | \$\$\$ High                 |
| <div>Strategy B:<br/>Property-level Seawalls/Revetments</div> <div>Single or multi-property hard protection to reduce waves and protect buildings</div>                                                                                                                                                                             | <ul style="list-style-type: none"><li>• Reduces flooding and erosion at properties</li><li>• Lower maintenance than natural solutions</li></ul>                       | <ul style="list-style-type: none"><li>• Edge tie-ins issues, potential impacts to neighbours</li><li>• Loss of beach / foreshore in front of structures</li><li>• Impact to foreshore habitat</li></ul> | <ul style="list-style-type: none"><li>• Can prevent erosion and loss of land area</li><li>• Lower maintenance than natural solutions</li><li>• Can incorporate green features</li></ul> | <ul style="list-style-type: none"><li>• Ongoing adaptation needed as RSLR continues</li><li>• Can increase erosion for adjacent shorelines</li><li>• Can degrade quality of beaches</li></ul> | Medium Term (0.5 m – 1.0 m RSLR) |                                                                                                                                                                                      | \$\$\$ High for individuals |
| <div>Strategy C:<br/>Phased Retreat</div> <div>Long-term process of retreating existing buildings through buy-outs or development area limits</div>                                                                                                                                                                               | <ul style="list-style-type: none"><li>• Removes people / infrastructure from the flood zone</li><li>• Potential for environmental and recreational benefits</li></ul> | <ul style="list-style-type: none"><li>• Loss of residential properties</li><li>• Offers no protection to public infrastructure</li><li>• Public acceptance challenges</li><li>• </li></ul>              | <ul style="list-style-type: none"><li>• Long-term ecological benefits</li><li>• Increased recreational areas</li></ul>                                                                  | <ul style="list-style-type: none"><li>• Erosion can occur</li><li>• May require additional infrastructure in future</li><li>• Water access may be impacted</li></ul>                          | Medium Term (0.5 m – 1.0 m RSLR) |                                                                                                                                                                                      | \$\$\$ High                 |
| <div>Strategy D:<br/>Raise Buildings &amp; Roads</div> <div>New builds in low areas raised to meet FCLs, roads and infrastructure raised over time</div>                                                                                                                                                                          | <ul style="list-style-type: none"><li>• Allows residents to stay on existing properties</li><li>• Can be phased slowly, as houses are rebuilt</li></ul>               | <ul style="list-style-type: none"><li>• City infrastructure may also need protection</li><li>• Does not offer long-term solution, some properties will be inundated as RSLR continues</li></ul>         | <ul style="list-style-type: none"><li>• Can be phased slowly over time</li><li>• Supports future flexibility for additional raising or retreating</li></ul>                             | <ul style="list-style-type: none"><li>• Low lying area may become unusable with RSLR</li><li>• Some properties may require future relocation as RSLR continues</li></ul>                      | Medium Term (0.5 m – 1.0 m RSLR) |                                                                                                                                                                                      | \$\$ Moderate               |
| OPTIONS COLOUR LEGEND                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                       |                                                                                                                                                                                                         |                                                                                                                                                                                         |                                                                                                                                                                                               |                                  |                                                                                                                                                                                      |                             |
| <div> = primarily public lands adaptations</div> <div> = primarily private property adaptations</div> <div> = mix of private and public adaptations</div> |                                                                                                                                                                       |                                                                                                                                                                                                         |                                                                                                                                                                                         |                                                                                                                                                                                               |                                  |                                                                                                                                                                                      |                             |

## 9.4 Duke Point



**Figure 9.4 Duke Point shoreline reaches divided for adaptation measures**



Table 9.4 Duke Point Adaptation Strategies

| Strategy                                                                                                                                                                                                                                   | Strengths                                                                                                                                                                                          | Challenges                                                                                                                                                                                                                                                                                                        | Opportunities                                                                                                                                                                                                                        | Threats                                                                                                                                                              | Trigger Threshold                | Risk                                                                                                                                                                           | High Level Cost |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1-4 In Problem Locations Across All Areas                                                                                                                                                                                                  |                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                      |                                                                                                                                                                      |                                  |                                                                                                                                                                                |                 |
| <div>Strategy A:<br/>Phased Retreat</div> <div>Long-term process of retreating existing industrial uses through buy-outs or development area limits</div> | <ul style="list-style-type: none"><li>Removes people / infrastructure from the flood zone</li><li>Potential for environmental and recreational benefits</li></ul>                                  | <ul style="list-style-type: none"><li>Loss of waterfront industrial lands and shrinks overall industrial land use inventory</li></ul>                                                                                                                                                                             | <ul style="list-style-type: none"><li>Long-term ecological benefits</li></ul>                                                                                                                                                        | <ul style="list-style-type: none"><li>Loss of economic benefits from industrial business requiring water access</li></ul>                                            | Medium Term (0.5 m – 1.0 m RSLR) | <ul style="list-style-type: none"><li>Building EAD: \$1,969,490</li><li>Number of impacted infrastructure points: 15</li><li>Total length of impacted roads: 2,444 m</li></ul> | \$\$\$ High     |
| <div>Strategy B:<br/>Property-level Seawalls/Revetments</div> <div>Property level hard protection to protect industrial uses</div>                        | <ul style="list-style-type: none"><li>Protects land from flooding and erosion at properties</li><li>Phased implementation with structures added as needed</li></ul>                                | <ul style="list-style-type: none"><li>May not align with specific waterfront industrial needs</li><li>Low lying areas may still see flooding</li><li>Potential drainage issues</li><li>Some facilities may require future relocation as RSLR continues.</li><li>No improvement to the foreshore habitat</li></ul> | <ul style="list-style-type: none"><li>Can be phased as RSLR continues</li><li>Can be added as required</li><li>Can incorporate green features and add additional habitat</li></ul>                                                   | <ul style="list-style-type: none"><li>Low lying areas still vulnerable/inundated with RSLR</li><li>Drainage can become an issue</li></ul>                            | Medium Term (0.5 m – 1.0 m RSLR) |                                                                                                                                                                                | \$\$\$ High     |
| <div>Strategy C:<br/>Raise Critical Infrastructure</div> <div>Raise Duke Point Highway and access roads within the floodplain</div>                     | <ul style="list-style-type: none"><li>Maintain access to Duke Point ferry Terminal</li><li>Allows individual property owners to address issues over time as required to suit their needs</li></ul> | <ul style="list-style-type: none"><li>Selective raising leaves other industrial infrastructure at risk</li></ul>                                                                                                                                                                                                  | <ul style="list-style-type: none"><li>Can be phased slowly over time</li><li>Supports future flexibility for additional raising or retreating</li><li>Possible cost sharing with Ministry of Transportation and BC Ferries</li></ul> | <ul style="list-style-type: none"><li>Low lying area may become unusable with RSLR</li><li>Some facilities may require future relocation as RSLR continues</li></ul> | Medium Term (0.5 m – 1.0 m RSLR) |                                                                                                                                                                                | \$\$\$ High     |

OPTIONS COLOUR LEGEND

 = primarily public lands adaptations     = primarily private property adaptations     = mix of private and public adaptations



## **10 ADAPTIVE MANAGEMENT PATHWAYS EXAMPLE**

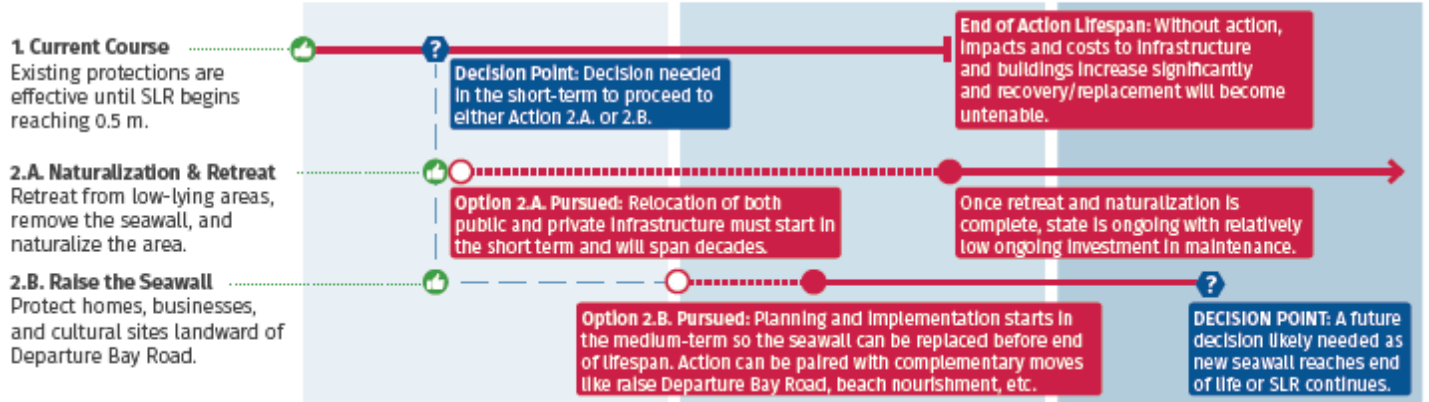
An example of an adaptive management pathway for Departure Bay seawall and the Randle and Battersea Road area is outlined below (Figure 10.1). The purpose of the adaptive management pathway example is to show that any option may have a limited timeframe in which it may be the appropriate solution after which a trigger point is reached and alternatives may need to be considered to better adapt to the communities needs or in response to shoreline changes. For example, a sea wall could be rebuilt in the future in Departure Bay in the medium term. But there could come a point where it's no longer financially feasible to rebuild a sea wall to heights required to withstand the rising sea levels. Therefore, the plan can change to move to another solution that is more technically feasible such as setting back from the shoreline.



## Planning Horizons (approx.)

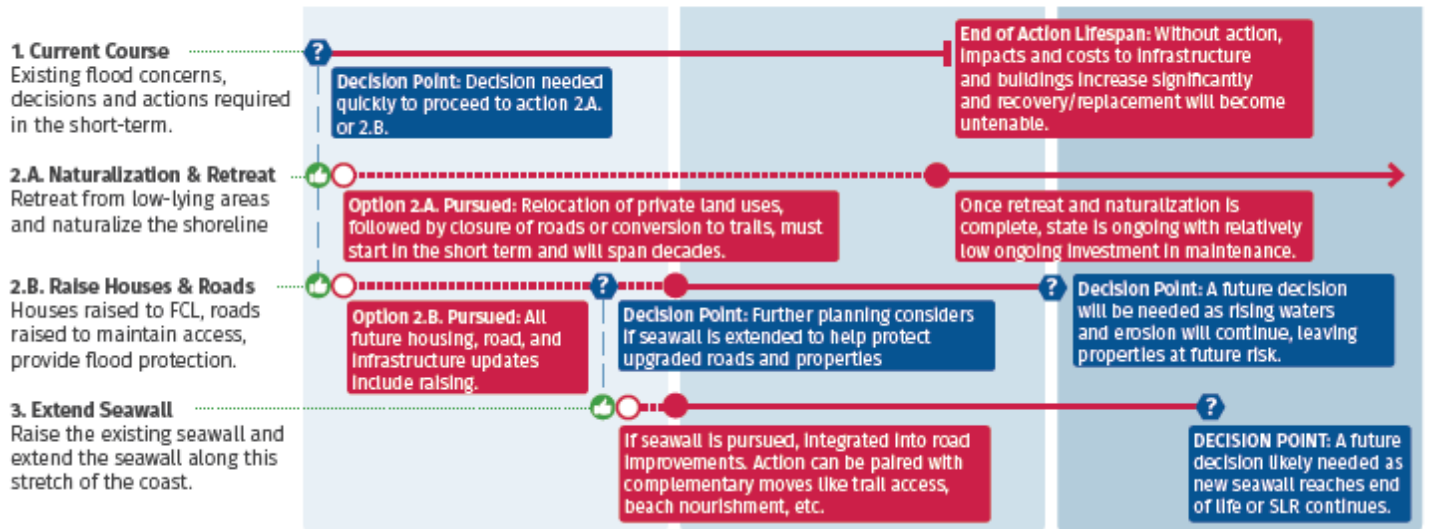
### Departure Bay Seawall

**Objectives:** Waterfront access, foreshore habitat, waterfront walkways, road access, continued residential and commercial uses.



### Randle Road & Battersea Road Area

**Objectives:** Walking/cycling connectivity, foreshore habitat, and public/private cooperation.



**Figure 10.1** Example of adaptive management pathways for Departure Bay seawall and Randle and Battersea Road Area

## 11 RECOMMENDATIONS

As the City moves forward with Our Coastal City and looks to implement changes with respect to RSLR, the following recommendations should be considered.

1. Move all City infrastructure within the affected RSLR area that comes to end of life from this point forward. This may involve laying out plans early for large infrastructure such as pump stations, water, stormwater, and sewer mains. Many stormwater infrastructure points are impacted in our current climate in a large storm with the exposure increasing significantly with RSLR. Both sanitary and sewer infrastructure only have a few impacted sites, but they become more exposed after 1.0 m of RSLR.
2. Limit or prevent development or expansion of new infrastructure within the affected RSLR area.
3. Implement a RSLR development permit zone. The RSLR development permit zone should:
  - a. Restrict rezoning for increased density within the RSLR area.
  - b. Require all buildings and infrastructure within the development permit zone to be raised to the FCL.
  - c. Restrict new development or expansion within the area (within existing zoning). For example, empty parcels, or any single /multiple lot looking to rebuild with increased density (single house to duplex, quadplex or apartment complex) would not be permitted. Rebuilding single family homes to FCL would be allowed. Overall purpose is to reduce the exposure to the hazard and reduce the potential for adverse consequences that would need to be borne by the municipality.
4. Conduct feasibility assessments for all short- and medium-term options listed below. Feasibility studies should be completed as the first step in developing an implementation plan for each strategy. These studies should confirm whether each proposed adaptation strategy can be built or undertaken, and should include:
  - community engagement to confirm support and identify concerns;
  - preliminary cost estimates;
  - confirmation of project extents;
  - review of technical, environmental, regulatory, and property constraints; and
  - identification of appropriate phasing, where required.

The results of the feasibility studies should be used to refine the preferred options, outline an adaptive management pathway, confirm implementation requirements, and support future decision-making.

### Short Term (0 to 5 Years)

Consider adopting strategies in the short term to reduce flood risk. Sites are listed in order of most exposed:

- a. **Randle and Battersea Road Area.** This area is currently vulnerable to the design (0.5% AEP + 1.0 m RSL) storm event with approximately \$540,000 EAD and will continue to become more exposed with time. It is recommended that a strategy with an adaptive management plan and public consultation be developed for this location. An example of a possible plan was provided in Section 9.
- b. **Maffeo Sutton Park.** The park is currently vulnerable to the design storm event with no buildings exposed however there are some infrastructure and roads impacted, and there would be impacts to recreational use of the park which is its primary purpose. The park will continue to become more exposed with time, particularly the Lagoon. It is recommended that a new plan for the park be developed in a configuration that accommodates the future sea level with a focus on naturalizing the shorelines where possible. This plan can be phased and different sections of the park addressed over time as money becomes available.
- c. **Waterfront (Harbourfront) Walkway.** Portions of the walkway are vulnerable to the design storm event. It is recommended to start planning for a long-term raising of the walkway to accommodate 1.0 m of RSLR as sections of the structures come to end of life, particularly the end closer to Maffeo Sutton Park and Georgia Park. This could be completed within the Maffeo Sutton Park option.

### Medium Term (5 to 25 years)

Consider adopting strategies in the medium term to reduce flood risk.

- a. **Departure Bay Beach.** The area will become vulnerable to the storm events with increasing SLR with approximately \$2.69M in EAD for buildings, almost 1km of road and many infrastructure points exposed. It is recommended that a long-term strategy with an adaptive management plan and public consultation be developed for this location. An example of a possible plan was provided in Section 9.
- b. **Waterfront (Harbourfront) Walkway.** The walkway is vulnerable to the design storm event with approximately \$180,000 in EAD for buildings. It is recommended to start planning for a long-term raising of the walkway to accommodate 1.0 m of RSLR as sections of the structures come to end of life. A plan should be developed to look at the phasing of end of life of the commercial spaces and parking garage and the sequencing of rebuilding/raising of these properties to provide continuous access to the walkway.
- c. **Boat Basin and Front Street.** The section of Front Street directly behind the boat basin is low and will become exposed to SLR in the medium term with \$1.3M EAD exposed. It is recommended to raise Front Street to provide protection to Museum Way.
- d. **Raise Hwy 19.** The highway to Duke Point becomes overtopped in the medium-term during storm events. While this does not have a direct EAD cost associated with it, it has

roads and infrastructure exposed, and it is a major transportation hub. This is one of the main access points to and from the island and there would be economic consequences if it was disrupted. It is recommended to raise the low points of the highway in the medium term when upgrading is required.

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# **APPENDIX A**

## **ENGAGEMENT SUMMARY 1 AND 2**

# OUR COASTAL CITY

## Round 1 Engagement Summary

April 2026



## Acknowledgments

The City of Nanaimo is located on the Traditional Territory of the Snuneymuxw First Nation. This project is led by the City of Nanaimo as part of the *Sea Level Rise Management Plan (SLRMP)* initiative. Technical work is being led by Northwest Hydraulics Consultants Ltd. (NHC) with engagement and planning support from Lanarc 2015 Consultants Ltd. (Lanarc). We would like to extend our gratitude to all parties and people who have provided time, knowledge and information to assist in this work.

### PREPARED FOR:



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### PREPARED BY:



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### IN COLLABORATION WITH:



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Canada



# What We Heard ...

181

Survey  
Respondents

5

Focus Group  
Meetings

+640

Get Involved  
Page Visitors



ROUND 1  
COMMUNITY  
VALUES



## SUMMARY HIGHLIGHTS:

**Most respondents (94%)** have at least a basic knowledge of sea level rise (SLR).

**30% of respondents** live on or own property that they think is at risk of being impacted by sea level rise.



### COMMUNITY PRIORITIES FOR ADAPTING TO SLR

- » Preserve shorelines and natural areas
- » Plan with consideration for future generations
- » Protect homes and infrastructure
- » Maintain safe public access to the shoreline

**(93%) of respondents** prioritize solutions that mimic the natural coast



### ACCESS TO THE COAST

Top ways respondents access the coast are:

- Visiting public spaces (parks, beaches, etc.)
- Enjoying scenic views (from home or public locations)

### AREAS WITH NOTABLE IMPACTS



- Departure Bay
- Protection Island
- Downtown
- Duke Point

### RESPONDENT CONCERNS



- » Loss of beaches, shoreline habitat, and public access
- » Too much short term focus and not enough planning for the future
- » Public cost and taxes to fund adaptation projects

### HOME OWNER FEEDBACK



#### HOMEOWNER CONCERNS ABOUT SLR

- » Loss of the shoreline and beaches
- » Impacts to homes and property
- » Too much short term focus and not enough planning for the future

#### HOMEOWNER PRIORITIES FOR ADAPTING TO SLR

- » Preserve the shoreline
- » Protect homes and property
- » Include long term planning for future generations









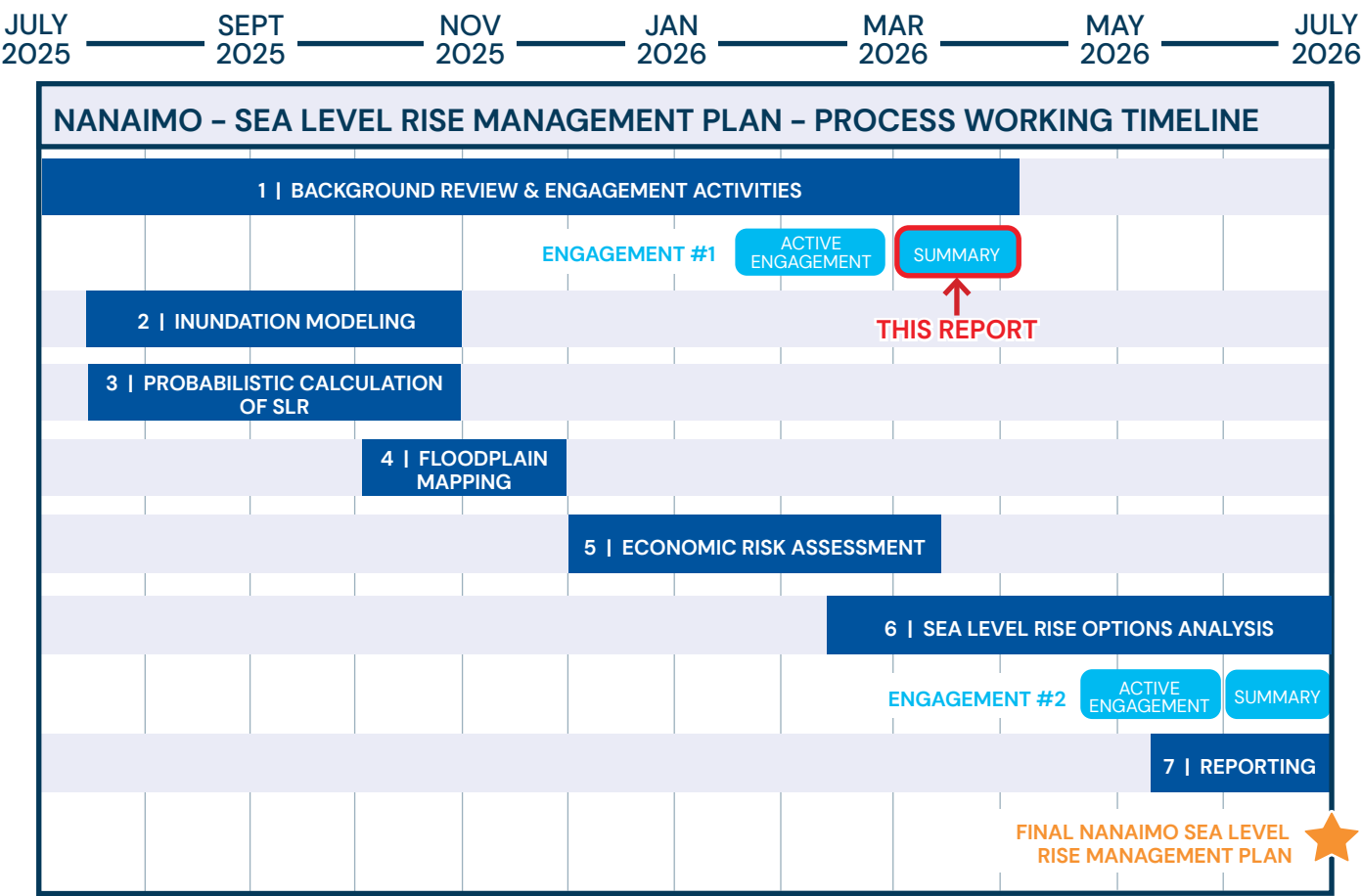
# What's inside?

**Lots of information! Feel free to skip around to what interests you most.**

|                                        |    |
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# Process Diagram

The diagram below illustrates the process for the **Our Changing City** project, the City of Nanaimo's sea level rise management plan.



## SECTION 1

# Engagement Overview

## 1.1 Process Overview

The City of Nanaimo, working with Snuneymuxw First Nation, is developing a Sea Level Rise (SLR) Management Plan to guide coastal adaptation solutions for areas of Nanaimo at risk of coastal flooding. This project builds upon the Sea Level Rise Study completed in 2018, which identified the study areas that are the focus of this project.

The process diagram on the adjacent page show the overall timeline and process for the project.

- In Round 1 engagement information was gathered about community awareness of sea level rise and values related to assets and approach to sea level rise adaptation.
- Coming up in Round 2 engagement, sea level rise adaptation options will be brought to the community for consideration and prioritization.
- This document summarizes what we heard in Round 1.

**THANK YOU FOR YOUR INPUT!**



## 1.2 Outreach



Outreach helps us reach and gather input from a diversity of people

The following outreach tools were used to inform community members about engagement opportunities:

- **City of Nanaimo Website:** A project page was launched on the City's website. The project page can be found at: [nanaimo.ca/your-government/projects/sea-level-rise-management-plan](https://nanaimo.ca/your-government/projects/sea-level-rise-management-plan)
- **Get Involved Project Page:** A project page was launched on the City's engagement platform to share information about the process and opportunities for involvement. The project page can be found at: [getinvolvednanaimo.ca/sea-level-rise](https://getinvolvednanaimo.ca/sea-level-rise)
- **News Release:** The City published a news release to advertise the process and opportunities for input in Round 1.
- **News Article:** An article was published by the Nanaimo News Bulletin, Chek News, Nanaimo News Now, and My Coast Now advertising the process and opportunities for input in Round 1.
- **Direct Email:** The City distributed an email with the survey link to Get Involved subscribers, identified interest holders, key neighbourhood associations, and a local school.
- **Social Media Posts:** Posts were shared to the City of Nanaimo's Facebook, Instagram, and X accounts providing a link to the online survey.
- **Word of Mouth:** Interest holders and community members shared information about the process with their neighbours and friends.

## 1.3 Who We Engaged

In Round 1 the City and project engaged with interest holders, under represented populations, and the general public.

Key interest holders included the Snuneymuxw First Nation, City of Nanaimo working group, technical interest holders, Port of Nanaimo representative, and neighbourhood groups. Interest holders provided input on detailed shoreline analysis and mapping work and their organizations interests and values relating to sea level rise.

Under represented populations and the general public provided input on their knowledge, values, and priorities related to sea level rise. The public process aimed to gather input from a diverse and representative sample of the community.

To gather input from youth the survey was shared with a local school who circulated it within a classroom and the school's 'EcoClub'.

## 1.4 Engagement Activities

The following engagement activities were hosted in Round 1.



### Values Survey

|                 |                                                                                                                                                                                                                                                                                   |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DATES</b>    | February 16th - March 13th, 2026                                                                                                                                                                                                                                                  |
| <b>LOCATION</b> | Online at: <a href="http://www.getinvolvednanaimo.ca/sea-level-rise/sea-level-rise-values-survey">www.getinvolvednanaimo.ca/sea-level-rise/sea-level-rise-values-survey</a>                                                                                                       |
| <b>DETAILS</b>  | The values survey was available online through the City's engagement page and through outreach materials. The focus of the values survey was to gather information on the community's general awareness and knowledge of sea level rise and identify what assets are valued most. |



### Focus Group Meeting #1 - CoN Working Group

|                 |                                                                                                                                                                                              |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DATES</b>    | February 12th, 2026                                                                                                                                                                          |
| <b>LOCATION</b> | Virtual through Microsoft Teams                                                                                                                                                              |
| <b>DETAILS</b>  | The project team met with the internal City of Nanaimo staff working group to provide information about the process and review detailed shoreline analysis and mapping for future scenarios. |



### Focus Group Meeting #2 - Technical Interest Holders

|                 |                                                                                                                                                                        |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DATES</b>    | February 13th, 2026                                                                                                                                                    |
| <b>LOCATION</b> | Virtual through Microsoft Teams                                                                                                                                        |
| <b>DETAILS</b>  | The project team met with technical interest holders to provide information about the process and review detailed shoreline analysis and mapping for future scenarios. |

## Participation Highlights

**181**

Survey Responses

**5**

Focus Group Meetings

**+640**

Get Involved Page Visitors



### Focus Group Meeting #3 - Nanaimo Family Life Association

**DATES** February 19th, 2026

**LOCATION** Navy League of Canada - Nanaimo Branch  
750, Fifth Street, Nanaimo, BC

**DETAILS** The project team met with a group of older adults to provide information about the process and gather input on their knowledge and values related to sea level rise impacts.



### Focus Group Meeting #4 - Neighbourhood Groups

**DATES** February 24th, 2026

**LOCATION** Vancouver Island Conference Centre,  
101 Gordon Street, Nanaimo BC

**DETAILS** The project team met with neighbourhood groups, elected officials, and representatives from the Port of Nanaimo. The meeting aimed to provide information about the process, share detailed technical analysis and mapping materials, and discuss community values with participants.



### Focus Group Meeting #5 -Snuneymuxw First Nation

**DATES** February 27th, 2026

**LOCATION** Snuneymuxw First Nation Offices

**DETAILS** The project team met with the Snuneymuxw First Nation marine division to provide information about the process, share detailed technical analysis and mapping materials, gather input on areas of significance or concern, and learn about community values related to sea level rise.

## SECTION 2

# What We Learned

The following pages summarize the feedback that was received from the Values Survey.

This information is summarized as follows:

- About You (Demographics)
- Your Knowledge & Experiences
- What Are Your Values?
- Communications



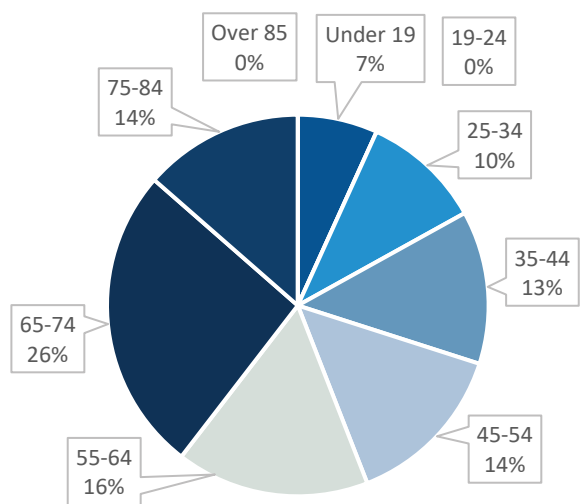
# 2.1 About You (Demographics)

The following demographics questions have been brought to the front of this summary to first show who we heard from before diving into what was learned from the survey respondents.

*Note: demographics questions were asked in the latter half of the online and hard copy surveys.*

## Age of Respondents

Q. What age are respondents?

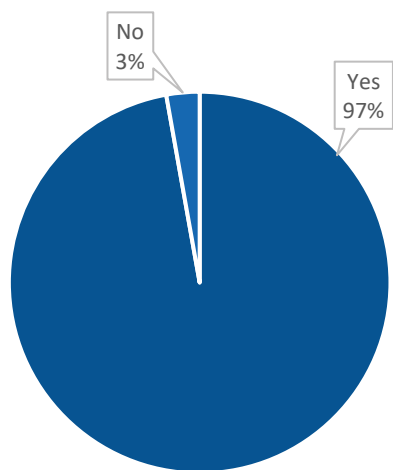


### KEY FINDINGS:

- There is limited representation of the younger demographic (under 35) among survey respondents.
- More than half of respondents are the age of 55 and up.

## Geographic Representation

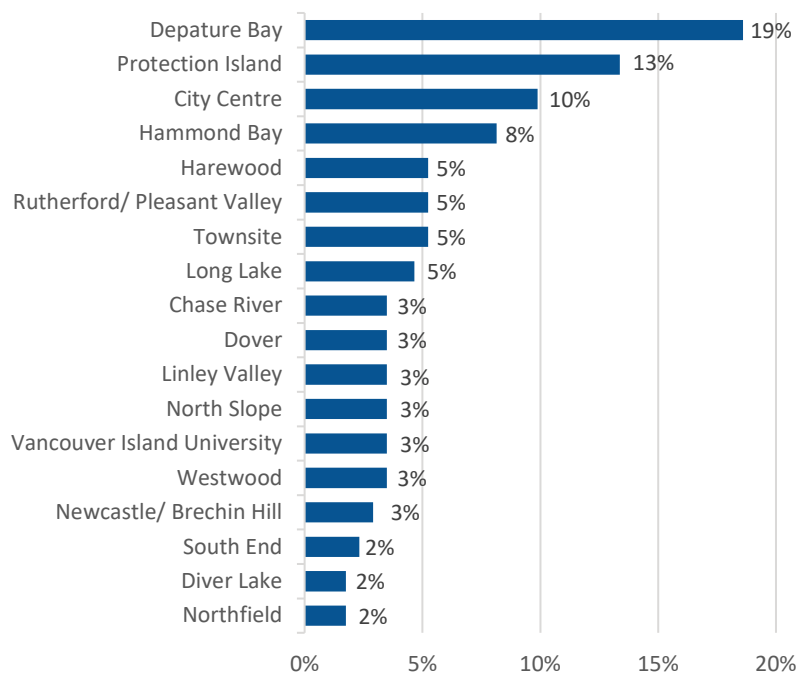
Q. Are you a resident of Nanaimo?



### KEY FINDINGS:

- The majority of respondents live in the City of Nanaimo (97%).

### Q. What neighbourhood do you live in?

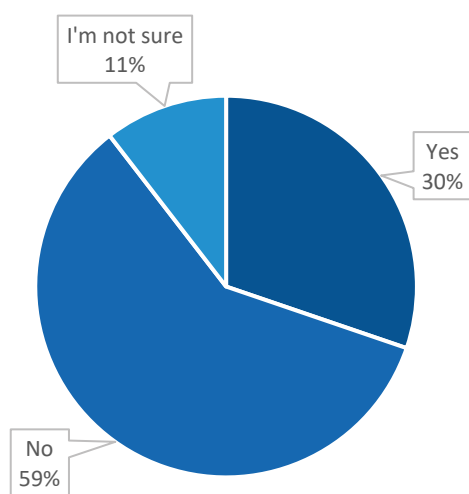


#### KEY FINDINGS:

- (50%) of respondents live in areas that either have or are predicted to experience impacts of sea level rise.
- All neighbourhoods in Nanaimo are represented to some extent through resident survey input.

## Perception of Future Risk / Impact

Q. Do you live on or own property that you think may be at risk from coastal flooding, coastal erosion, sea level rise, or other coastal hazards?



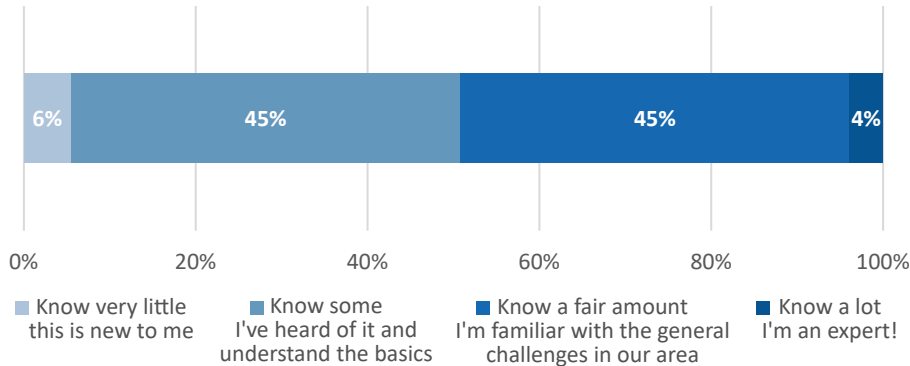
#### KEY FINDINGS:

- (30%) of respondents expect to be impacted by coastal flooding, erosion, sea level rise and/or other coastal hazards.

## 2.2 Your Knowledge & Experiences

### Knowledge & Understanding of Sea Level Rise

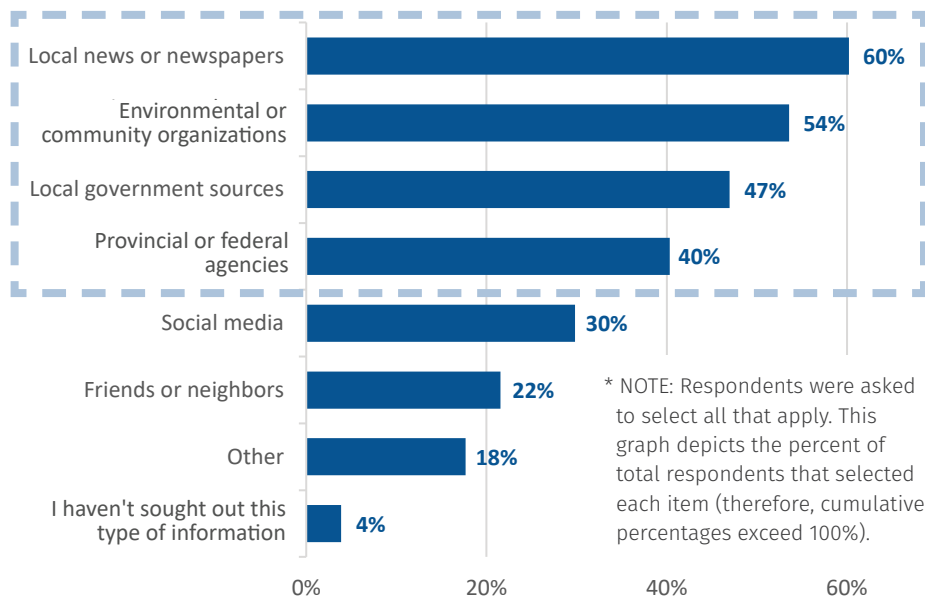
Q1: How would you describe your current understanding of sea level rise?



#### KEY FINDINGS:

- Most respondents (94%) are aware of sea level rise and have at least a basic understanding of what it is.

Q2: Where do you currently get most of your information about coastal issues (flooding, erosion, or climate impacts)?



#### KEY FINDINGS:

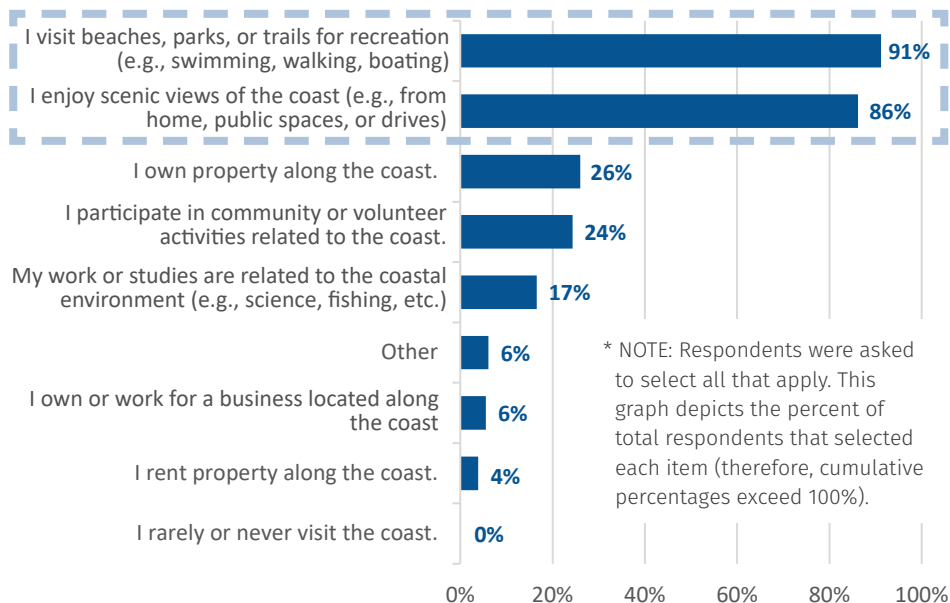
- Top sources for respondents to acquire information about coastal issues are **local news or newspapers**, **environmental or community organizations**, **local government sources**, and **provincial or federal agencies**.

#### OTHER RESPONSES:

- Respondents who selected other specified first hand observation, books, personal research, academic literature, academic schooling, books, online resources, videos / documentaries, and news broadcasting.

## Coastal Interaction

### Q3: In what ways do you currently interact with the coast?



#### KEY FINDINGS:

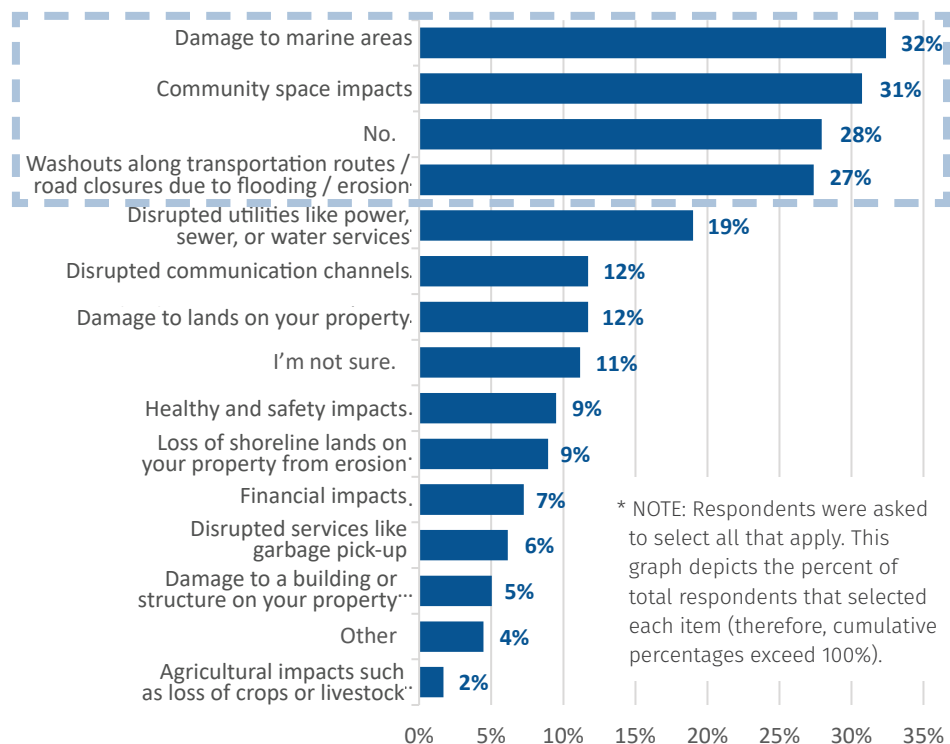
- The top ways respondents currently interact with the coast are **visiting beaches, parks, or trails for recreation**, and **enjoying scenic views**.
- (26%) of respondents own property on the coast.

#### OTHER RESPONSES:

- Respondents who selected other specified, live(d) by the ocean, boating (e.g., kayak, motor), and fishing.

## Coastal Hazard Impacts

### Q4: How have you been impacted by coastal hazards (e.g., flooding, erosion)?



#### KEY FINDINGS:

- Respondents have been most impacted by damage to **marine areas, community space impacts**, and **washouts along transportation routes / road closures due to flooding / erosion**.
- (28%) of respondents said they have not been impacted.

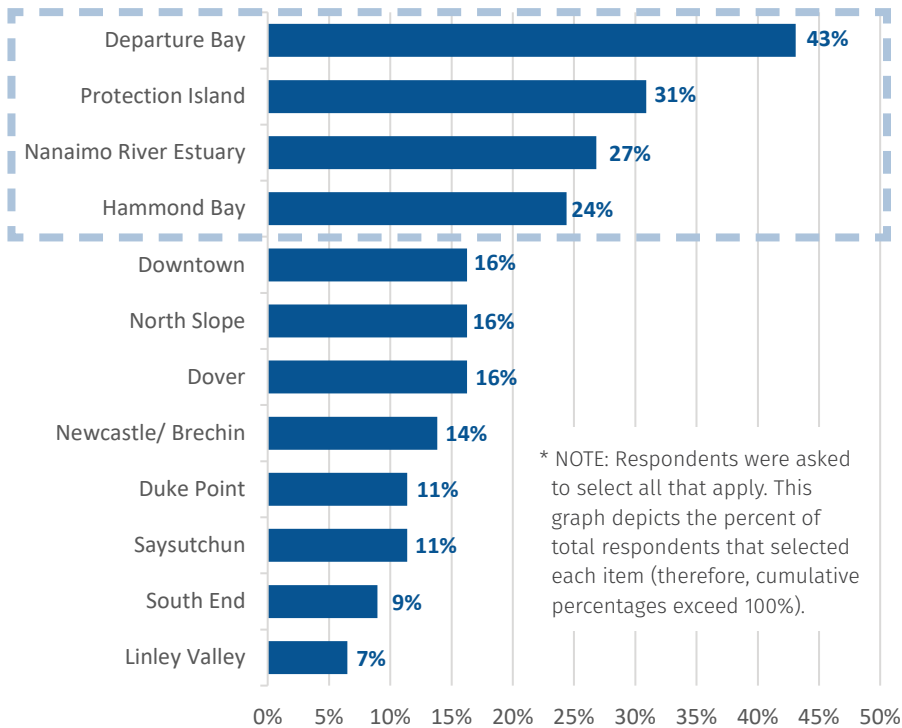
#### OTHER RESPONSES:

- Respondents who selected other specified work related impacts and other considerations.



## Coastal Hazard Impact Locations

Q5: In what areas of the City (if any) have impacts been most noticeable?



### KEY FINDINGS:

- Respondents most noted impacts in **Departure Bay, Protection Island, Nanaimo River Estuary, and Hammond Bay.**

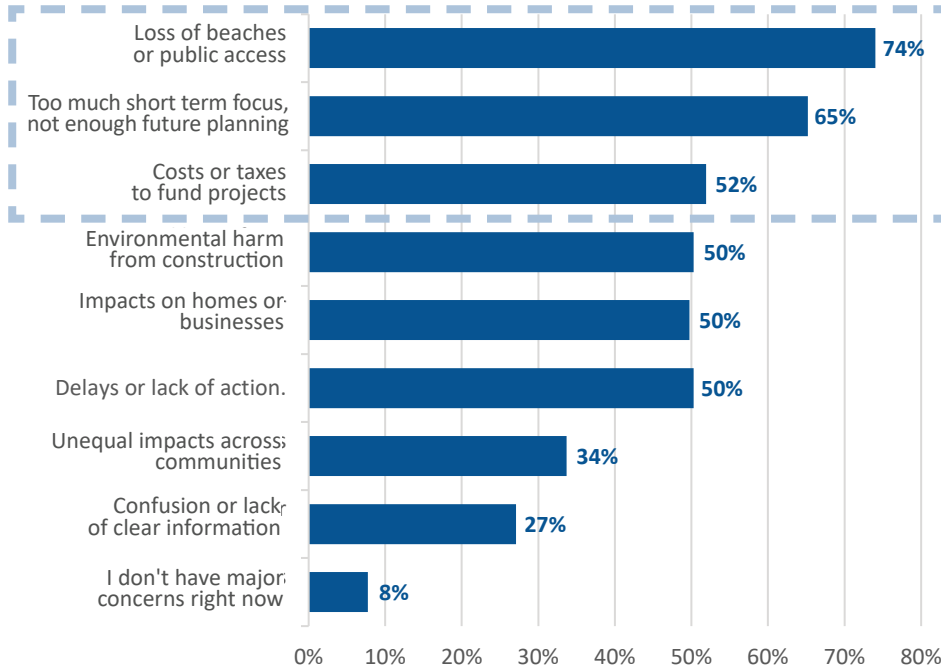
*An example nature-based adaptation at Beach Creek Estuary, Qualicum Beach, BC.*



## 2.3 What Are Your Values?

### Coastal Management Concerns

Q6. What are your concerns related to managing sea level rise?



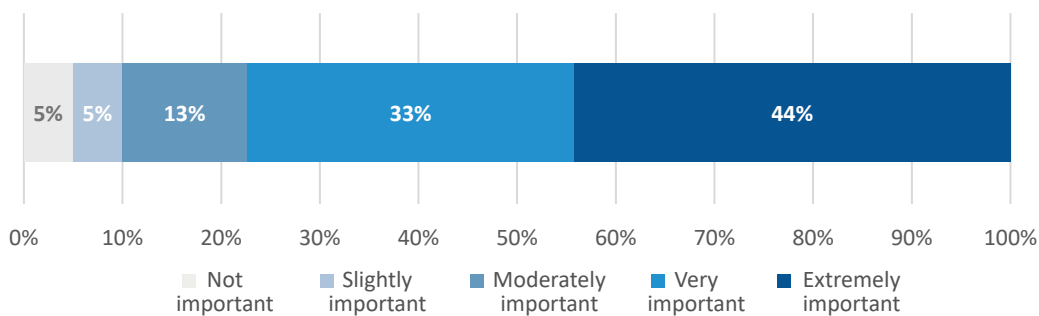
#### KEY FINDINGS:

- Top concerns identified by respondents are **loss of beaches or public access**, **too much short term focus, not enough future planning**, and **costs or taxes to fund projects**.

\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).

### Planning Priorities

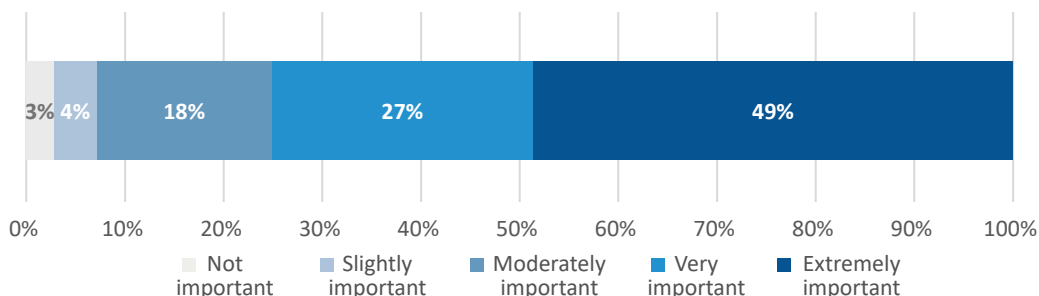
Q7. How important is it to you that planning considers impacts on future generations (beyond 30-50 years)?



#### KEY FINDINGS:

- (90%) of respondents think planning for future generations is important.

Q8. How important is it to you that planning prioritizes nature-based solutions?



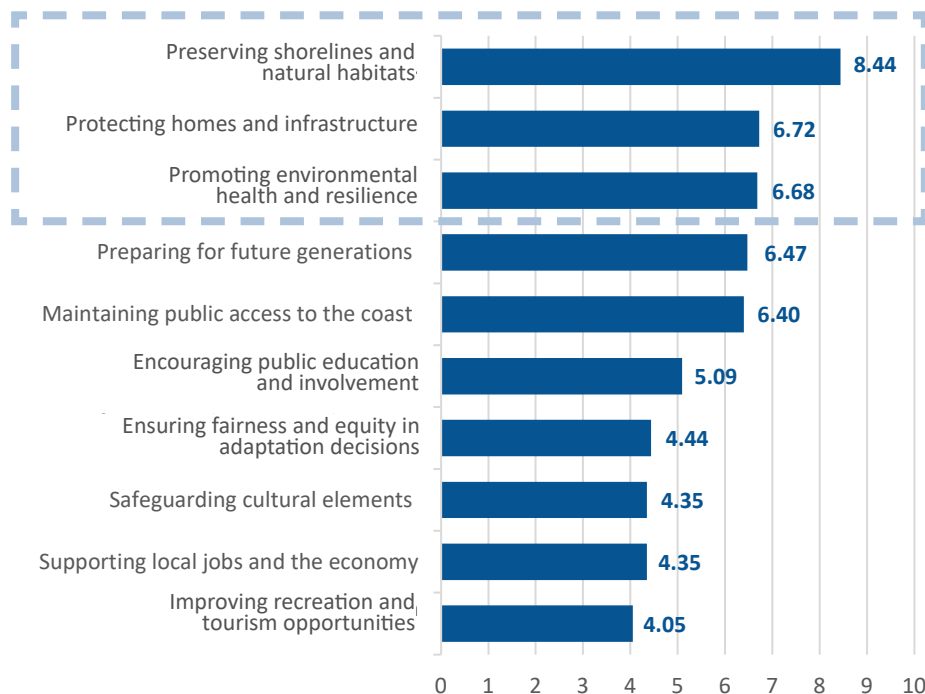
#### KEY FINDINGS:

- (93%) of respondents think it's important to prioritize nature-based solutions.

\* NOTE: Due to rounding cumulative percentage is slightly less than 100%.

## Values

**Q9. Please rank the following coastal values in order of most to least importance.**



### KEY FINDINGS:

- Top 3 values identified by respondents are preserving **shorelines and natural habitats**, **protecting homes and infrastructure**, and **promoting environmental health and resilience**.

\* NOTE: Values were ranked on a scale of 1-10. Each selection was attributed a score corresponding with the selected position. Scores were averaged based on the number of responses.

**Q10. Are there any values missing from the list?**

### OTHER VALUES SPECIFIED BY RESPONDENTS:

- Some respondents shared specific revisions to the to listed values
- Monitor and adapt to a changing environment
- Educated planning, decision making, and sustainable construction practices
- Public education about climate change
- Wildlife protection and management
- Concerns of fiscal responsibility
- Reservations regarding governance efficacy

## Comments

### Q11. Do you have any other comments you would like to share?

The themes below capture feedback gathered.

#### Planning for the Future

- Many respondents shared encouragement for the process and expressed the importance of early planning.
- Respondents identified the importance of regional and provincial partnerships to develop a collaborative approach to coastal adaptation.
- Some respondents emphasized the importance of planning for future generations.
- Some respondents identified creeks, rivers, and watersheds as other waterbodies important to include in coastal planning.

#### Adaption Tools, Projects, and Priorities

- Many respondents expressed a desire to prioritize protection of shoreline habitat.
- Many respondents identified a desire to prioritize retreat of buildings from flood plains.
- Some respondents want to prioritize safe public access to the waterfront.
- Some respondents indicated interest in converting coastal land to public park.
- Respondents expressed the urgency of taking action now to protect the environment and critical infrastructure at risk.
- Respondents shared their priorities for coastal adaptation tools and impact mitigation in general and for specific locations.

#### Fiscal Management

- Respondents shared that homeowners should be responsible for the cost of their own coastal adaptation needs, choices for how to act, and be provided with information about options they could pursue.
- Respondents shared concerns about the implication of projects on tax payers.



*This is a great initiative and hope the project expands to all areas throughout the city not just the four identified areas.*



*I would focus more on our water shed infrastructure to withstand higher amounts of precipitation.*



*Let's stop building in flood plains and then being surprised when there is a flood. The earth is dynamic so our approach needs to be dynamic. We can't expect coastlines to remain unchanged when weather changes. Let's build systems that grow and adapt.*



*I think it's very important that governments identify at-risk areas and start investing now to mitigate the affects of rising sea levels*



*Will there be new obligations for real estate sales of waterfront properties? Will costs of infrastructure protection/ replacement in a specific neighbourhood be shared over the whole City or paid for only by the affected neighbourhood?*





## Public Engagement

- Some respondents expressed the need for more public education and engagement opportunities (e.g., with Protection Island residents).

## Governance

- Some respondents shared reservations about governance objectives.



*I'd love more straightforward information about how rising sea levels may impact the downtown core, since this is where I live. Maybe more resources, maps, etc to better understand if my home / community is at risk over the next 50 years.*

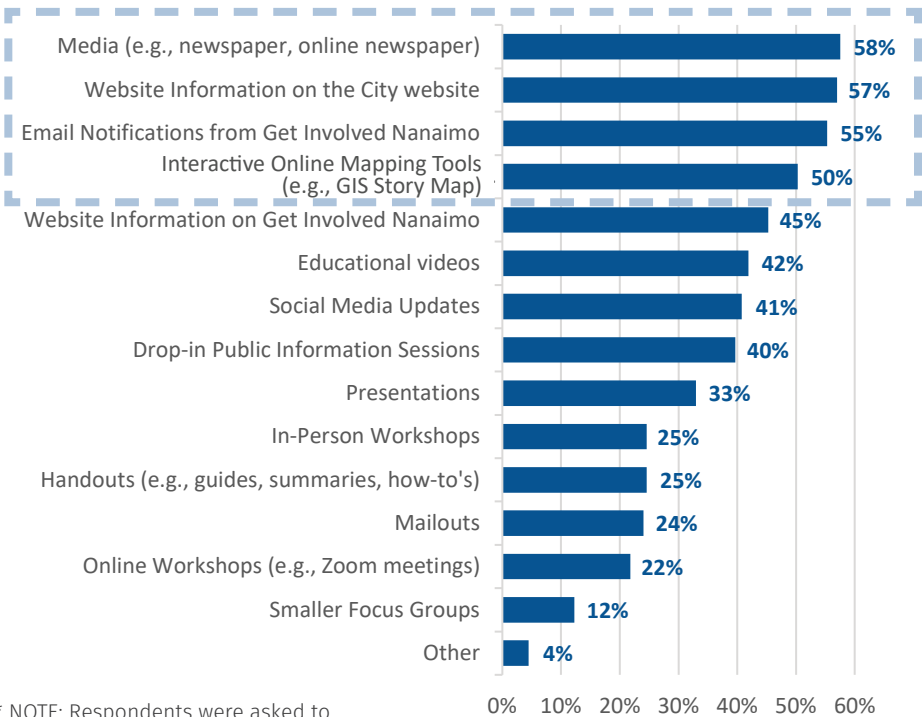


Neck Point Park, Nanaimo

# 2.4 Communications

## Future Communications

**Q12. What types of communications materials would you find most useful for sharing information and engaging on coastal risks in the City in the future?**



\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).

### KEY FINDINGS:

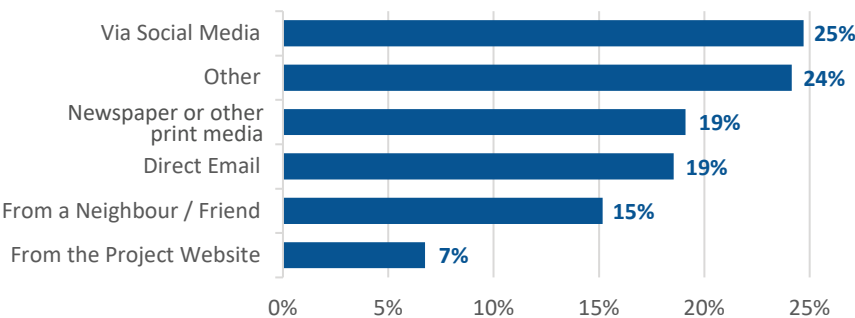
- Preferred communication materials across respondents include media, website information on the City website, Email notifications from Get Involved Nanaimo, and interactive online mapping tools.

### OTHER COMMUNICATION METHODS SHARED:

- A variety of other communication methods (e.g., information inserts with publicly distributed notices, pop-up presentations, training groups)
- Fiscal concerns

## Round 1 Outreach

**Q13. How did you learn about the survey.**



\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).

### KEY FINDINGS:

- Respondents learned about the survey through a variety of avenues.
- Top ways respondents learned about the survey include **social media**, **"other"**, **newspaper or other print method**, and **direct email**.



## SECTION 3

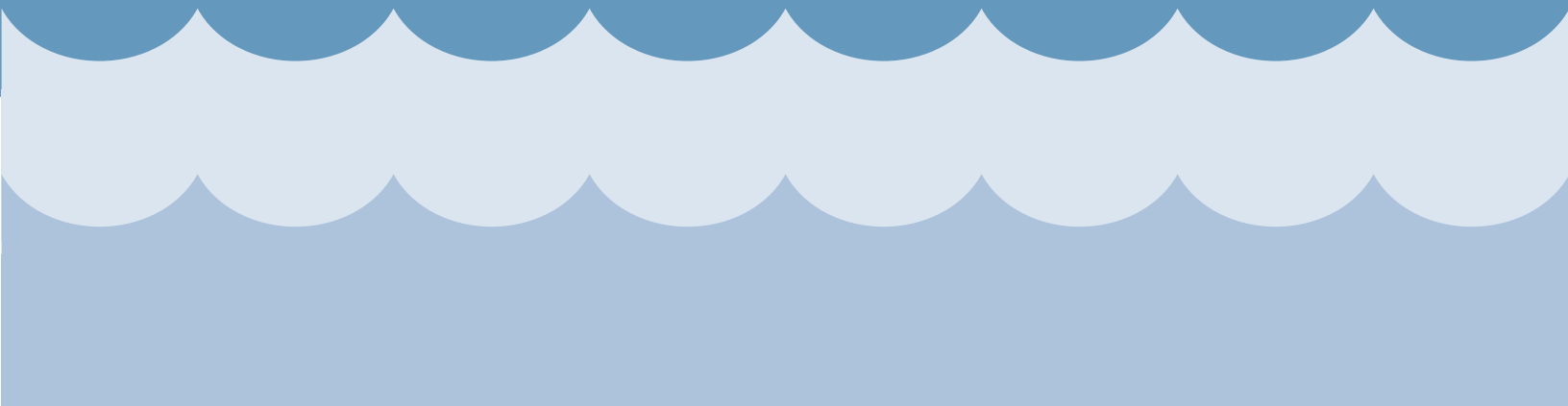
# Next Steps

The feedback heard in Round 1 Engagement will inform coastal adaptation options development.

Next steps in the public process include:

- Update about what we learned during Round 1 Engagement process (this summary).
- Round 2 Engagement (coastal adaption options review) proposed in Spring / Summer 2026.
- Continued updates posted to the Project webpage:  
[www.nanaimo.ca/your-government/projects/sea-level-rise-management-plan](http://www.nanaimo.ca/your-government/projects/sea-level-rise-management-plan)

**Thank you for your participation in this process!**

A decorative graphic at the bottom of the page consisting of a series of overlapping, rounded, wave-like shapes in shades of blue and white, creating a scalloped or wavy border effect.

# APPENDIX A

# VERBATIM COMMENTS

The following pages list the verbatim comment responses for:

- A.1 "Other" Survey Selections
- A.2 Comments

*Please note: Some comments have been removed that do not align with standards for respectful community conversation.*

*Thank you for your understanding.*

# APPENDIX A

## Verbatim Comments

### A.1 "Other" Selections (from questions within the Online Survey)

The following verbatim comments were specified by respondents who selected "Other" for the indicated survey question.

#### Q2: Where do you currently get most of your information about coastal issues (such as flooding, erosion, or climate impacts)?

- ▶ Books
- ▶ Discussion and written reports by concerned scientists.
- ▶ Educational youtube videos
- ▶ First hand observation - boat the a section of coast 5 days a week
- ▶ Have done research on it.
- ▶ I live on Protection Island. I observe my surroundings
- ▶ I live on the waterfront - 56 years
- ▶ I live on water front property with a cabin from 1933 on piles on the seashore so watch water levels closely.
- ▶ I live within 15 m of the ocean. I have been familiar with the site since 1960
- ▶ I lived on the beach for several years in Ladysmith
- ▶ Looking things up on my own out of interest
- ▶ Many generations living in the area
- ▶ My own formal science education
- ▶ My science teacher
- ▶ Newspapers, TV news
- ▶ Observational experience
- ▶ online sources
- ▶ professional articles, journals, international agencies
- ▶ Reading books on the subject
- ▶ Research
- ▶ Research institutions, for example the University of Victoria
- ▶ School
- ▶ Science
- ▶ self-study, university courses, etc.
- ▶ specifically read about the matter and its impact to Vanc Is- Nanaimo coastal areas
- ▶ Steven Earle's (PhD) "Brief History of the Earth's Climate," (2021)
- ▶ Studies and papers on the subject
- ▶ University
- ▶ websites
- ▶ Work
- ▶ National news, documentaries

#### Q3: In what ways do you currently interact with the coast?

- ▶ Fishing
- ▶ I kayaked on the coast for years.
- ▶ I live on Protection Island
- ▶ I often use Hullo and BC Ferries.
- ▶ Live on the ocean front
- ▶ I own property within 200m of the ocean
- ▶ I've lost homes to natural disasters: flood (also fire, earthquake). I live high up now.
- ▶ landscape design of coastal properties
- ▶ Many generations of living here
- ▶ My boat is kept in Nanaimo and interacts with the coast.,)

## APPENDIX A

# Verbatim Comments

**Q4: Below is a list of impacts that could result from coastal hazards like flooding and erosion. Have you ever been affected by any of these?**

- ▶ As a first responder to local, annual flooding event
- ▶ I have observed no abnormal impacts as a result of a rising sea
- ▶ Interruptions to daily commutes
- ▶ Only during winter storms or wind storms
- ▶ Strong consideration when purchasing property
- ▶ This all a pile of crap. Of course there is going to be change.! It is nature. It has always change. When you pay engineers to give you an opinion, they will always give you what you want to hear and what makes them the most money. Come on, open your eyes!
- ▶ This is a scam.

**Q10: Are there any values missing from the previous list?**

- ▶ ....seriously? Yes, a lot.
- ▶ Accept that historical evidence needs to be considered
- ▶ Accountability; ensuring mechanisms to enforce decisions that are in the best interest of the overall community
- ▶ Adapting to changes in the environment
- ▶ Because climate impacts are uncertain, adaptive planning should emphasize flexible policies and monitoring. Key aspects: Monitoring shoreline change and environmental conditions Adjusting policies and designs over time Using pilot projects and innovative
- ▶ Biodiversity / food sources (preserving natural areas is very general, but might include these)
- ▶ Clarify that environment health includes preservation of drinking water quality/ supply and protection of sewerage systems
- ▶ Cost issues often become an issue for governments acting on projects
- ▶ Costs
- ▶ I have no clue
- ▶ Incompetent government need to be checked before they waste money.
- ▶ Might want to plan for more sea level rise then your research indicates. New research is coming out that we underestimated the potential increase and rate at which it will rise.
- ▶ Recognizing the impact sea level rise will have on archaeology sites, traditional village sites, and other areas that are important to First Nations
- ▶ no
- ▶ No, not that I can think of right now. To whoever is reading this. Have a nice day! :)
- ▶ Not acting out of fear, mainly based on inaccurate modeling and predictions from international agencies.
- ▶ Promoting Sustainability and awareness on Risk Assessment
- ▶ protecting taxpayers from paying for property improvements for an elite few who live on the waterfront
- ▶ Proven current science models
- ▶ Reducing fossil fuel emissions asap
- ▶ Solutions with cost based implications, are choosing solutions with the financial impacts in mind
- ▶ Some formula to provide government support/ financial compensation where properties cannot be protected that includes a cutoff date for property owners to make a decision to comply with planning decisions or lose their eligibility for compensation .
- ▶ Stop spending my money I don't have.
- ▶ There is way too much misinformation on climate change. The science has been replaced with hysteria and activism.
- ▶ They're all important!!!!



# APPENDIX A

## Verbatim Comments

### (CONTINUED) Q10: Are there any values missing from the previous list?

- ▶ unsure
- ▶ Using construction materials that do not end up adding more pollution by leaching into ocean.
- ▶ values listed are important but their integration across the list will have the most impact
- ▶ Wildlife maintenance & protection.
- ▶ wildlife, shellfish
- ▶ You have a job that you want to protect, so promoting this manner of thinking benefits you. You will not want to discuss this in an honest manner because you want to protect your job. This is another government industry, an excuse to justify your job!

### Q12: What types of communication materials would you find most useful for sharing information and engaging on coastal risks in the City in the future?

- ▶ Don't waste time and money on this, focus on crime and homelessness instead
- ▶ Information inserts with bill/tax/misc notices.
- ▶ It is not going to matter. Eventually we have to realize we are on one planet with finite resources. On a local level we can do little. We need all levels of government and our citizens to face the truth.
- ▶ Keeping the cost under control
- ▶ Presentations at the sites where anyone can walk up and listen or take pamphlet
- ▶ say nothing
- ▶ Training and mentoring groups with action plans/ ideas

### Q13: How did you find out about this survey?

- ▶ Check news article on web.
- ▶ CHEK news
- ▶ CHEK News website
- ▶ Comment on social media
- ▶ Departure Bay Neighbourhood Association
- ▶ Direct email, via Departure Bay Neighbourhood Association?
- ▶ Email from Departure bay neighbourhood association
- ▶ From a community organisation
- ▶ from the city directly
- ▶ Google Alert "Protection Island"
- ▶ Harbour City Scoop
- ▶ Local online news
- ▶ I attended the Our Coastal City: Neighbourhood Association & Residents Meeting.
- ▶ LinkedIn
- ▶ My earth science teacher
- ▶ my nanaimo this week - e news
- ▶ My Nanaimo This Week direct email
- ▶ My science teacher
- ▶ My teacher.
- ▶ Nanaimo Family Life Association
- ▶ neighbourhood association
- ▶ Neighbourhood Association involvement
- ▶ news outlet website
- ▶ Notice from Protection Island Neighbourhood Association via ProIsle
- ▶ Online news site
- ▶ Protection Island email information.
- ▶ Rocky Point Neighbourhood Association
- ▶ School
- ▶ Speakers
- ▶ Through eco club at my school
- ▶ Through work
- ▶ Twitter/X
- ▶ Update from City of Nanaimo News -- I subscribe to this for updates
- ▶ Your city personnel visiting Nanaimo Family Life Association to speak.
- ▶ NFLA
- ▶ TAPS Nanaimo Family Life Association
- ▶ At a "TAPS" meeting

# APPENDIX A

## Verbatim Comments

### A.2 Comments (Q11 long form answer in the survey)

- ▶ Action is not optional. We are well into of an environmental crisis and species collapse.
- ▶ Coastal flooding can affect our creeks and rivers as well, so it's good if those areas are included in planning.
- ▶ Creating a walking, riding seawall from Departure Bay to Downtown, and beyond is worth keeping in mind through this process
- ▶ Firesmart ran to ensure communities could decrease fire risks - City could work with province +other sectors to introduce OceanH20Smart communities program to help individuals prepare homes/biz for water rise/protection
- ▶ Glad to see this happening
- ▶ Government inefficient when attempting to change the natural order of the environment
- ▶ Green Shores approach!!
- ▶ I agree that its important in built-up areas to protect shoreline in a local scale, but leave it at that.
- ▶ I am a volunteer with BC Marine Trails and we work to ensure continued respectful, safe public access to coastal recreation and sites. I am pleased to see this survey and recognize its importance for 27K km of BC coastline
- ▶ I applaud your effort to think forward on this subject. Areas of concern in Nanaimo have spent a lot of money making improvements to the area with little forethought for the impacts of sea levels. I'm glad it's being considered going forward.
- ▶ I believe a map of properties that will be affected by sea level rise up to 3 meters needs to be created and those properties need to require a plan for mitigation or obsolescence and it be title and not have tax payers foot the bill
- ▶ I hope sea level rise will happen slowly enough to enable buildings to retreat over time, rather than building sea walls
- ▶ I don't want regulations that interfere with property owners rights to make decisions about how they use their property and what risks they are willing to take as long as it doesn't impact public use of the foreshore.
- ▶ I live on Protection Island, as Lots become unfeasible to build on due to sea level rise, salt water intrusion, and higher ground water table, , declare these lots sterile and return them to parkland.
- ▶ I live on Protection Island. It would be great if someone would come and talk with our community to inform us about the problem, to listen to our ideas, and to engage us in the solutions
- ▶ I think it's very important that governments identify at-risk areas and start investing now to mitigate the affects of rising sea levels
- ▶ I think more fishing opportunities should be available.
- ▶ I would definitely want this plan to address the grassroots problems and focus on real-time risks. Thank you
- ▶ I would focus more on our water shed infrastructure to withstand higher amounts of precipitation.
- ▶ I'd love more straightforward information about how rising sea levels may impact the downtown core, since this is where I live. Maybe more resources, maps, etc to better understand if my home / community is at risk over the next 50 years.
- ▶ Insurance rates go up due to cities allowing construction in flood zones. Building permits should require both a setback which accounts for 100years of erosion, and an elevation requirement to ensure against flooding.
- ▶ International agencies and organizations have been predicting catastrophic sea level rise for over five decades, none of their predictions have thus far come true. Hundreds of years of historical record show sea level essentially unchanged to date.
- ▶ Keep Nanaimo Green!

## APPENDIX A

# Verbatim Comments

- ▶ Let's stop building in flood plains and then being surprised when there is a flood. The earth is dynamic so our approach needs to be dynamic. We can't expect coastlines to remain unchanged when weather changes. Let's build systems that grow and adapt.
- ▶ Long term homeowners on the waterfront have much knowledge gained by experience
- ▶ Mitigating impacts to critical infrastructure, and identifying/ mitigating potential harmful leaching into the coastal environment are probably some of the highest priorities for the overall public good
- ▶ More communication with the public is needed
- ▶ No
- ▶ No, well not that I can think of. To whoever is reading this, Have a nice day! :), If you already read this, have a REALLY good day!!! :)
- ▶ not at this time
- ▶ Nuh uh
- ▶ Please do not allow variances for builds near the shoreline and instead create more parks on and around the shoreline. If a disaster strikes, it will be much cheaper to clean up the park than an insurance claim on a demolished house.
- ▶ Please do not diminish access to beaches and stream for animals like otter by building concrete structures that are not absolutely necessary to prevent erosion. Thanks for being pro-active on this.
- ▶ Please reconsider an expansion of the Harbourfront Walkway to Departure Bay. It may be a waste of money due to the likelihood of erosion from storms.
- ▶ Please think about the future of the people who can't make decisions because of their age
- ▶ protect the shorelines, not possible with plants etc.... must be stronger measures
- ▶ Should Nanaimo and the RDN have a moratorium on new builds and replacement buildings in areas that will flood or suffer damage from storm surges in the next 50 years?
- ▶ So many. After this survey is done in 5 ish years, is there going to be the least likely survey as well? Congrats on scamming Nanaimo though.
- ▶ Suggest drawing from international examples, such as Australia Q Coast 2100 and local work such as the RDN Coastal Climate Adaptation Program. Focus should be broader/regional emphasis collaboration between all levels of government.
- ▶ Thank you for creating this survey
- ▶ Thank you so much for having foresight and planning ahead!!!!
- ▶ The world is changing as it always has. Short term views and thinking without objectively looking at history has us where we are today. Protect the environment. People next, honesty.
- ▶ This is a great initiative and hope the project expands to all areas throughout the city not just the four identified areas.
- ▶ We've modified our shorelines ... where is the natural shoreline?
- ▶ Where has our democracy gone?
- ▶ Who will bear the financial cost of rising sea levels? The science is clear. The increase in carbon dioxide in our atmosphere due to the burning of fossil fuels is a major contributing factor. Fossil fuel companies need to pay their fair share.
- ▶ Why is Newcastle not included as a high risk area?
- ▶ Will there be new obligations for real estate sales of waterfront properties? Will costs of infrastructure protection/replacement in a specific neighbourhood be shared over the whole City or paid for only by the affected neighbourhood?





*Departure Bay, Nanaimo*





For project updates and ongoing information about the project please visit:  
[www.nanaimo.ca/your-government/projects/sea-level-rise-management-plan](http://www.nanaimo.ca/your-government/projects/sea-level-rise-management-plan)



# OUR COASTAL CITY

## Round 2 Engagement Summary

July 2026



## Acknowledgments

The City of Nanaimo is located on the Traditional Territory of the Snuneymuxw First Nation. This project is led by the City of Nanaimo as part of the *Sea Level Rise Management Plan (SLRMP)* initiative. Technical work is being led by Northwest Hydraulics Consultants Ltd. (NHC) with engagement and planning support from Lanarc 2015 Consultants Ltd. (Lanarc). We would like to extend our gratitude to all parties and people who have provided time, knowledge and information to assist in this work.

### PREPARED FOR:



#### **City of Nanaimo**

455 Wallace Street  
Nanaimo, British Columbia V9R 5J6  
Canada

### PREPARED BY:



#### **Lanarc 2015 Consultants Ltd.**

405-256 Wallace Street  
Nanaimo, British Columbia V9R 5B3  
Canada

### IN COLLABORATION WITH:



#### **Northwest Hydraulics Consultants Ltd.**

30 Gostick Place  
North Vancouver, British Columbia V7M 3G3  
Canada

# What We Heard ...

132

Online Survey  
Respondents

5

In-Person  
Events

+780

Get Involved  
Page Visitors



ROUND 2  
**STRATEGIES  
EVALUATION**

## ➤ SUMMARY HIGHLIGHTS:



### TOP ADAPTATION STRATEGIES REQUESTED TO BE PRIORITIZED

1. Start by **avoiding** future development in areas most at risk when possible.
2. Where critical elements are at risk, **protect** through either 'soft' or 'hard' measures.
3. For other elements, **accommodate** future flooding by adapting uses or construction.



Many comments expressed the feedback that **"do nothing" was not an option.** They wanted proactive planning to avoid reactionary long-term costs.

**24% of respondents** live on or own property that is at risk of being impacted by sea level rise.



### TOP AREAS OF CONCERN

- » Downtown
- » Departure Bay

Some comments expressed **apprehension over potential costs** of future solutions.



### POPULAR OBJECTIVES ACROSS THE STUDY AREAS

- » Maintain public waterfront access
- » Improve foreshore habitat
- » Support collaborative solutions
- » Preserve access to transportation uses

**Feedback identified** many future **projects** and upgrades that need to be coordinated with SLR.



There was continued **popular support** for nature-based solutions.

A few comments **showed skepticism** over climate change.

## What We Heard

# Departure Bay

Departure Bay is a dynamic part of the City, with important residential, commercial, and transportation uses. **How the City responds to sea level rise here is of high interest to the public**, and may present interesting opportunities.



### TOP RATED OBJECTIVES

WHEN ADAPTING THE AREA TO SLR

1. Maintain public waterfront access.
2. Seek ways to improve foreshore habitat.
3. Develop strategies to mitigate the impacts of erosion.



### SLR RELATED RISKS

OF MOST CONCERN IN THE AREA

1. Seawall no longer able hold back flooding in its current configuration.
2. Ferry access and terminal exposed to flood risks.
3. Risk to residential properties and neighbourhood streets from flooding today.

### OTHER SUGGESTIONS FOR THIS AREA



- » Expand ways the public can interact with the waterfront
- » Preserve as much natural environment as possible
- » Limit runoff and pollution sources into the bay
- » Maintain road access and commercial uses
- » Explore adapt/retreat

### PARALLEL PROJECTS

NOTED FOR FUTURE



- » Departure Bay force main and pump station upgrade
- » Various sanitary and storm upgrades
- » New multi-family housing developments
- » Kin Hut lease expiry
- » Conceptual waterfront walkway extension

### Many respondents

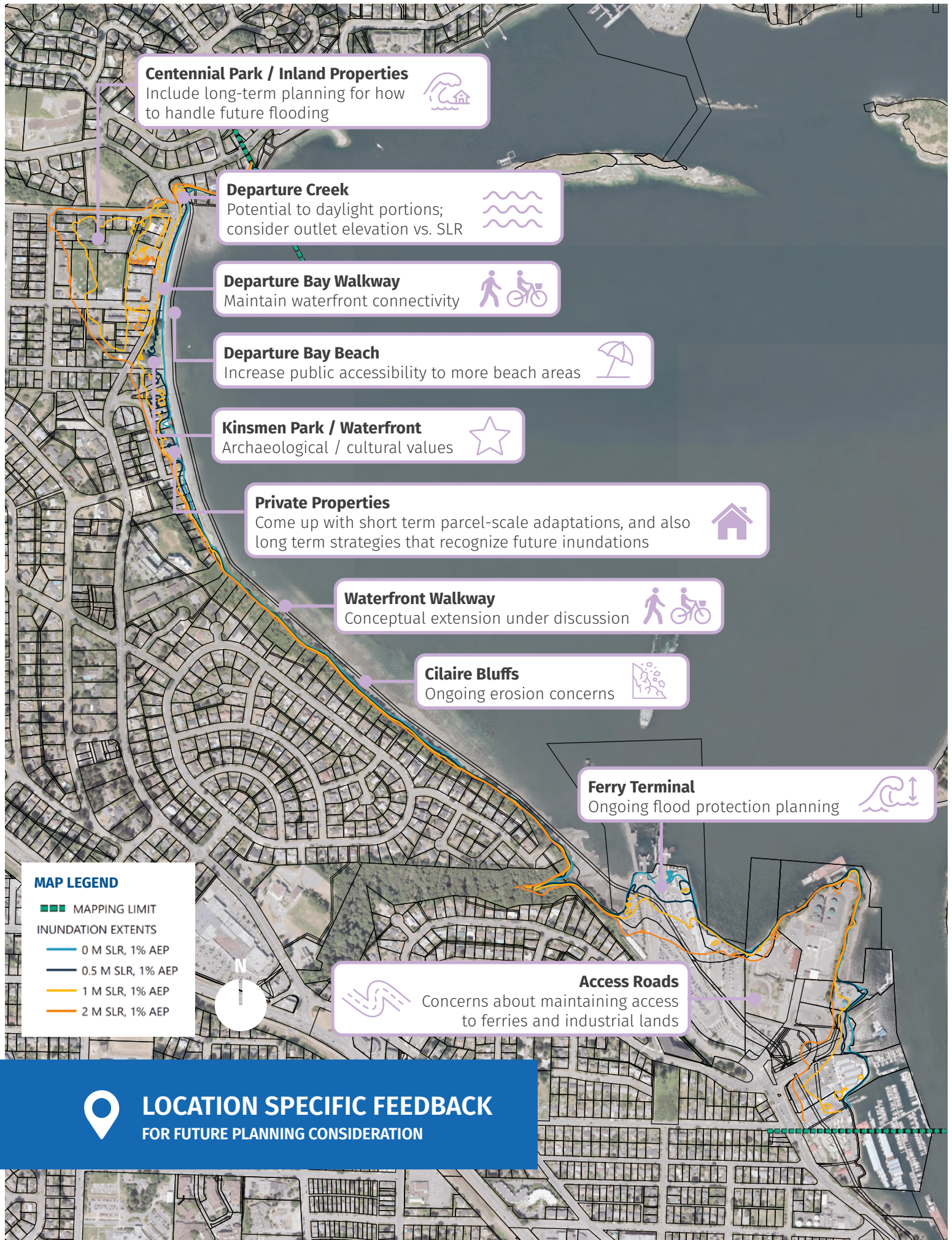
requested natural solutions be used vs. 'hard' measures.



Feedback recognized that uncertainty will cause adaptation plans to change over time, and asked for a **hybrid / pragmatic blend of solutions** to be considered.

Many respondents noted that **Departure Bay Beach** currently feels too small for its present popularity. They requested that future plans for the area mitigate the impacts of flooding while **expanding ways for the public to access the beach and interact with the water.**





**Centennial Park / Inland Properties**

Include long-term planning for how to handle future flooding



**Departure Creek**

Potential to daylight portions; consider outlet elevation vs. SLR



**Departure Bay Walkway**

Maintain waterfront connectivity



**Departure Bay Beach**

Increase public accessibility to more beach areas



**Kinsmen Park / Waterfront**

Archaeological / cultural values



**Private Properties**

Come up with short term parcel-scale adaptations, and also long term strategies that recognize future inundations



**Waterfront Walkway**

Conceptual extension under discussion



**Cilaire Bluffs**

Ongoing erosion concerns



**Ferry Terminal**

Ongoing flood protection planning



**MAP LEGEND**

- MAPPING LIMIT
- INUNDATION EXTENTS
- 0 M SLR, 1% AEP
  - 0.5 M SLR, 1% AEP
  - 1 M SLR, 1% AEP
  - 2 M SLR, 1% AEP



**Access Roads**

Concerns about maintaining access to ferries and industrial lands



**LOCATION SPECIFIC FEEDBACK**  
FOR FUTURE PLANNING CONSIDERATION

## What We Heard

# Downtown

The feedback for Downtown recognized the **urban nature of this portion of the City, and the many important uses along its coastline**. Maintaining these elements when dealing with sea level rise was a consistent theme in comments.



### TOP RATED OBJECTIVES

WHEN ADAPTING THE AREA TO SLR

1. Maintain public waterfront access.
2. Provide continuous waterfront walk- and cycle- ways.
3. Maintain waterfront park and event spaces.



### SLR RELATED RISKS

OF MOST CONCERN IN THE AREA

1. Flooding risks to the waterfront walkways.
2. Flooding along Front Street, impacting downtown buildings.
3. Impacts and access challenges for transportation options in the area (e.g. ferry, helicopter, port).

### OTHER SUGGESTIONS FOR THIS AREA



- » Plan waterfront parks to allow for temporary flooding while protecting critical park infrastructure
- » Maintain waterfront commercial uses as a key urban design feature
- » Raising Front Street could be a key move to prevent flooding of Downtown

### PARALLEL PROJECTS

NOTED FOR FUTURE



- » Lift station upgrades
- » Various sanitary and storm upgrades
- » Redevelopment activities to properties throughout the downtown core
- » Port lands developments and industrial activities

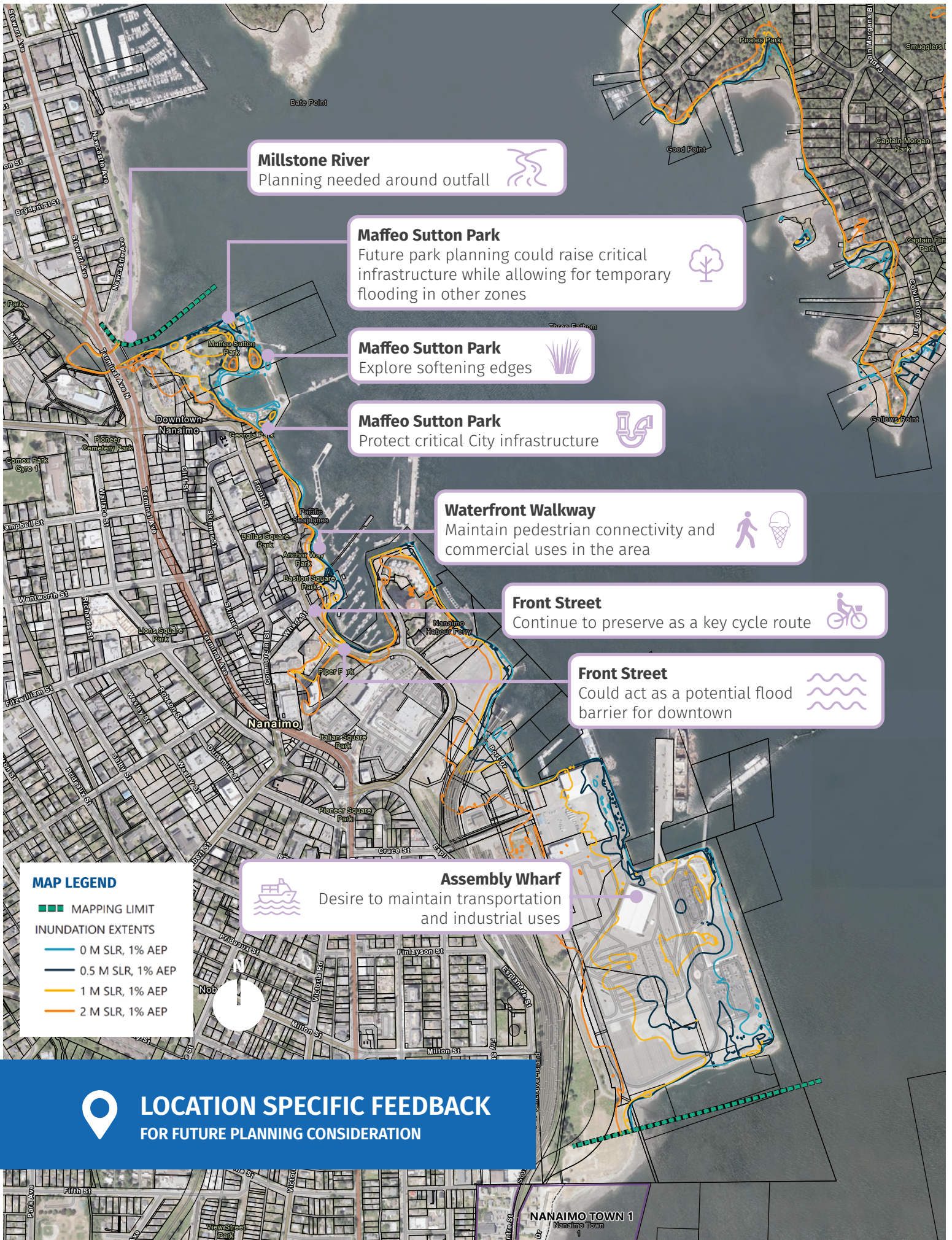
Where possible, respondents wanted to see **shoreline softening** and green measures.

Feedback for the Assembly Wharf area included questions about how you could a) **maintain access** and b) **protect the uses on the property.** The large, private lots could pursue property level solutions to protect a portion — or the entirety — of the parcels.

The waterfront parks in the area — including Maffeo Sutton — were consistently noted as **important for events and culture** in the City.









## What We Heard

# Protection Island

Responses for Protection Island emphasized **mitigating impacts to private property, access routes, roads, and transportation**. There was also a strong level of support for nature-based solutions to improve foreshore habitat.



### TOP RATED OBJECTIVES

WHEN ADAPTING THE AREA TO SLR

1. Mitigate impacts to private property.
2. Develop strategies for how public/private cooperation could work together to mitigate impacts to homes, access, and infrastructure.
3. Maintain transportation access.



### SLR RELATED RISKS

OF MOST CONCERN IN THE AREA

1. Flooding and damages to residential properties.
2. Impacts from wave exposure.
3. Loss of foreshore habitat in some zones.

### OTHER SUGGESTIONS FOR THIS AREA



- » Neighbourhood scale solutions can coordinate responses to SLR and avoid pushing effects to nearby properties
- » Strong support for nature-based solutions where appropriate (e.g. where waves and debris won't damage shorelines)

### PARALLEL PROJECTS

NOTED FOR FUTURE



- » Various sanitary and storm upgrades anticipated in future
- » Septic upgrades / replacements
- » Drainage upgrades
- » Ongoing maintenance/ upkeep to ferry terminal

### Emergency planning

and access routes were raised as important to consider.



Where solutions would be a set of actions taken by private-property owners, there were **questions about the role the City could take.** Coordinator? Educator?

When rebuilding, residents asked if this project (or other area-wide studies) could be **used to streamline permitting and reduce design costs** by avoiding site-specific studies when the City has already established the relevant technical findings.



### Exposed Shorelines

Where locations are exposed to higher wind and waves, hybrid solutions will be needed to adequately protect shore stability



### Low-Lying Roads

Want to plan to avoid flooding and maintain access and emergency egress routes

### Waterfront Parks

Work with future flooding while still allowing for public waterfront access



### Waterfront Residential

Encourage cooperative action where possible

### Protection Island Ferry

Maintain long-term island access and ferry operations



### MAP LEGEND

■■■■ MAPPING LIMIT

INUNDATION EXTENTS

— 0 M SLR, 1% AEP

— 0.5 M SLR, 1% AEP

— 1 M SLR, 1% AEP

— 2 M SLR, 1% AEP



### Mud Bay

Preserve use of the dock



### Gallows Point

Protect community resources like the boat ramp and pier



**LOCATION SPECIFIC FEEDBACK**  
FOR FUTURE PLANNING CONSIDERATION



## What We Heard

# Duke Point

Discussions regarding sea level rise impacts on Duke Point were largely centred around **how to maintain access to the ferry terminal**. Conversations also noted the importance of the area for the City's supply of industrial lands.



### TOP RATED OBJECTIVES

WHEN ADAPTING THE AREA TO SLR

1. Maintain access to transportation uses (e.g. ferry connection).
2. Seek ways to improve foreshore habitat.
3. Allow for continued road operations.



### SLR RELATED RISKS

OF MOST CONCERN IN THE AREA

1. Impacts to transportation access (e.g. ferry connection).
2. Impact to waterfront industrial uses.
3. Flooding of Duke Point Highway.

### OTHER SUGGESTIONS

FOR THIS AREA



- » Raising Duke Point Highway
- » City can play a coordinating role, or help to raise awareness, about the long-term planning required for the area
- » Work with private property owners to help coordinate solutions across the area

### PARALLEL PROJECTS

NOTED FOR FUTURE



- » Culvert upgrades currently ongoing under highway
- » Ongoing maintenance/upkeep to ferry terminal
- » Regular roadway maintenance
- » Various parcel scale upgrades and new site access routes

The importance of **maintaining the City's industrial lands** inventory was noted.

**Solutions in the area will require coordination and partnership:** elements like Storm and Water are City owned; sanitary infrastructure is owned by the RDN; Duke Point Highway is under the jurisdiction of the MoTT; the Duke Point Ferry Terminal is operated by BC Ferries.



It was anticipated that during future flooding events, **floating debris from the industrial parcels** has the potential to damage surrounding uses.



### Duke Point Ferry Terminal

Need to maintain access to the ferry terminal during future storm events



### Industrial Parcels

Consider the impacts of floating equipment, logs, debris, etc. during storm events



### Duke Point Highway

Future road upgrades will need to account for low road elevation in this area



### Nanaimo River Estuary

Future studies will be required to understand flooding / wave action from Western exposure



### Industrial Parcels

Importance for container and freight operations on Vancouver Island



### Maughan Road

Sanitary infrastructure is RDN owned



#### MAP LEGEND

■■■■ MAPPING LIMIT

INUNDATION EXTENTS

— 0 M SLR, 1% AEP

— 0.5 M SLR, 1% AEP

— 1 M SLR, 1% AEP

— 2 M SLR, 1% AEP



## LOCATION SPECIFIC FEEDBACK

FOR FUTURE PLANNING CONSIDERATION

### Duke Point Pollution Control Centre

Critical infrastructure treating wastewater from connections in the Duke Point service area











# What's inside?

**Lots of information! Feel free to skip around to what interests you most.**

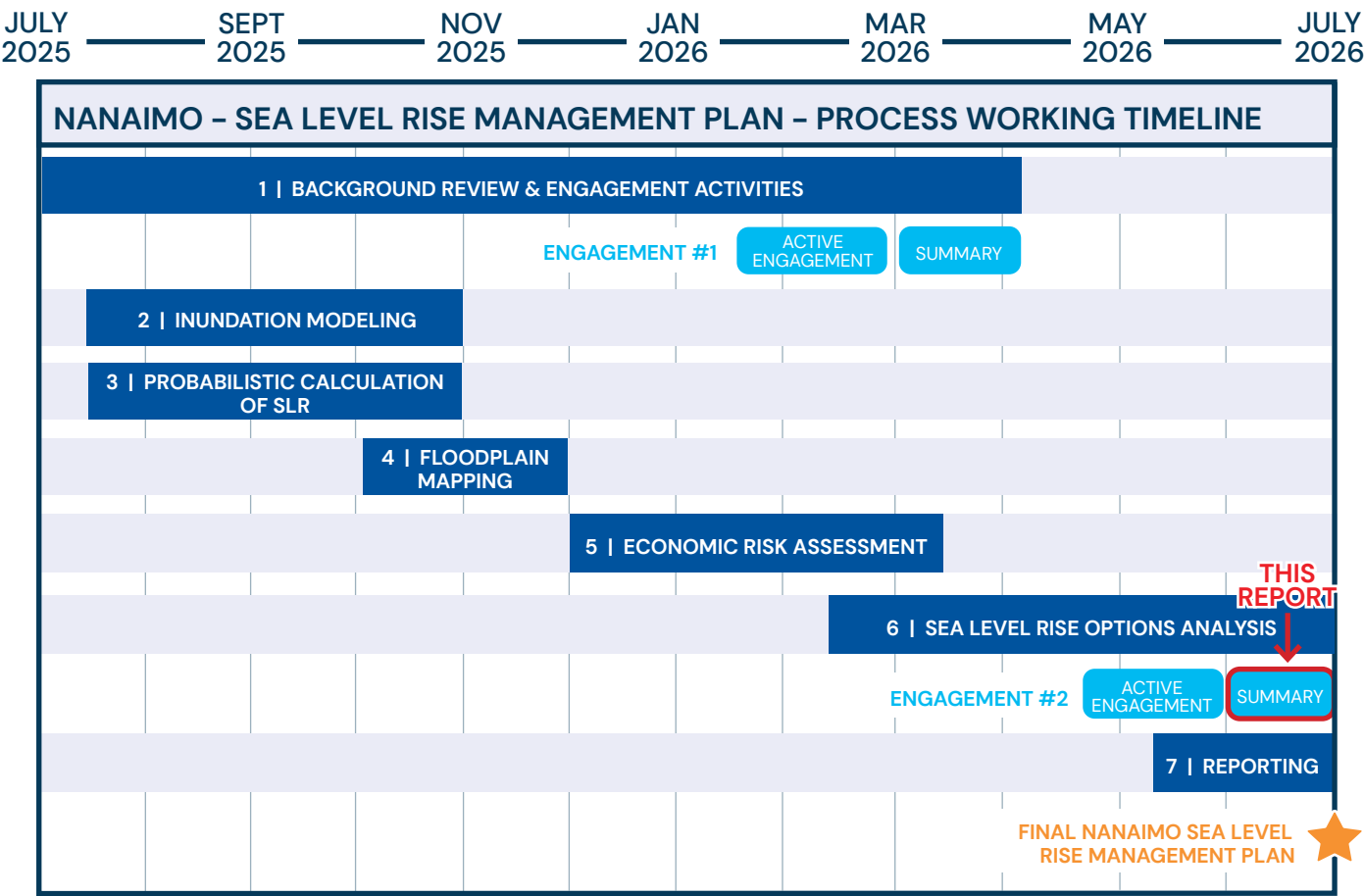
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# Process Diagram

The diagram below illustrates the process for the **Our Changing City** project, the City of Nanaimo's sea level rise management plan.



## SECTION 1

# Engagement Overview

## 1.1 Process Overview

The City of Nanaimo, working with Snuneymuxw First Nation, is developing a Sea Level Rise (SLR) Management Plan to guide coastal adaptation solutions for areas of Nanaimo at risk of coastal flooding. This project builds upon a Sea Level Rise Study completed in 2018, which identified areas of high vulnerability in the City.

Technical studies as part of this project have been completed to help us understand what sea level rise related risks we will be facing in the future.

The process diagram on the adjacent page shows the overall timeline and process for the project.

- In Round 1 engagement, information was gathered about community awareness of sea level rise and values related to assets and approach to coastal adaptation.
- In Round 2 engagement, initial objectives and coastal adaptation strategies were presented to the community for each focus area (Departure Bay, Downtown, Protection Island, and Duke Point). Feedback was collected about priorities for each area and what we might do to preserve what we value.
- This document summarizes what we heard in Round 2.

**THANK YOU FOR YOUR INPUT!**

## 1.2 Outreach

Outreach helps us talk to and gather ideas from a diversity of people in the community

The following outreach tools were used to inform community members about engagement opportunities:

- **City of Nanaimo Website:** A project page was updated on the City's website. The project page can be found at: [nanaimo.ca/your-government/projects/sea-level-rise-management-plan](https://nanaimo.ca/your-government/projects/sea-level-rise-management-plan)
- **Get Involved Project Page:** A project page was updated on the City's engagement platform to share information about the process and opportunities for involvement. The project page can be found at: [getinvolvednanaimo.ca/sea-level-rise](https://getinvolvednanaimo.ca/sea-level-rise)
- **News Release:** The City published a news release to advertise the process and opportunities for input in Round 2.
- **News Article:** An article was published by the Nanaimo News Bulletin, Chek News, Nanaimo News Now, and My Coast Now advertising the process and opportunities for input in Round 2.
- **Radio Advertisement:** A news feature and interview was broadcast by CHLY 101.7FM about the project. This segment was also posted as an article online.
- **Direct Email:** The City distributed an email with the survey link to Get Involved subscribers, identified interest holders, and key neighbourhood associations.
- **Social Media Posts:** Posts were shared to the City of Nanaimo's Facebook, Instagram, and X accounts providing a link to the online survey.
- **Word of Mouth:** Interest holders and community members shared information about the process with their neighbours and friends.
- **Community Event:** City Staff had a presence in a local park event to help promote the project and survey.
- **Senior Leadership Presentation:** The team presented the project to the City of Nanaimo's senior leadership group.
- **Delegation Presentation:** City staff presented the project to a delegation of local government elected officials, senior staff from the Philippines, and the Climate Risk Institute.

## 1.3 Who We Engaged

In Round 2 the City and project team engaged with interest holders and the general public.

Key interest holders included a representative from Snuneymuxw First Nation, City of Nanaimo working group members and senior staff, and technical interest holders. Interest holders provided input on adaption strategies developed from technical studies. Participants shared their organization's objectives for each area related to coastal adaptation.

The general public provided input on the objectives and perceived risks for the four study areas. The public process aimed to gather input from a diverse and representative sample of the community.

## 1.4 Engagement Activities

The following engagement activities were hosted in Round 2.



### Options Survey

**DATES** May 15th - June 11th, 2026

**LOCATION** Online at: <https://www.getinvolvednanaimo.ca/sea-level-rise/sea-level-rise-options-survey>

**DETAILS** The options survey was available online through the City's engagement page and through outreach materials. The focus of the options survey was to gather feedback on the adaption objectives and what matters most to the community in the four focus areas, Departure Bay, Downtown, Protection Island, and Duke Point.



### Workshop #1 - CoN Working Group

**DATES** April 27th, 2026

**LOCATION** In-person at Main Boardroom, City of Nanaimo Service and Resource Centre

**DETAILS** The project team met with the internal City of Nanaimo staff working group to discuss adaptation strategies developed from technical studies and priorities for the four study areas.

## Participation Highlights

**132**

Survey Responses

**4**

Workshops

**1**

Park Event

**788**

Get Involved Page Visitors





### Workshop #2 - Joint RDN Event

**DATES** May 12th, 2026

**LOCATION** Nanoose Library Centre, Nanoose Bay

**DETAILS** The project team hosted City of Nanaimo project material at a public open-house hosted by the Regional District of Nanaimo for their parallel 'Our Changing Coast' project.



### Workshop #3 - Technical Interest Holders

**DATES** May 14th, 2026

**LOCATION** In-person at Main Boardroom, City of Nanaimo Service and Resource Centre and virtually through Microsoft Teams

**DETAILS** The project team met with technical interest holders to discuss adaptation strategies developed from technical studies and priorities for the four study areas.



### Workshop #4 - Community Meeting

**DATES** May 21st, 2026

**LOCATION** Dodd Narrows Room A, Vancouver Island Conference Centre

**DETAILS** The project team met with interested residents to provide information about the project and collect input on priority objectives for each of the four study areas.



### Park Event #1 - World Oceans Day

**DATES** June 5th, 2026

**LOCATION** Maffeo Sutton Park

**DETAILS** City Staff took part in an Oceans Day event at Maffeo Sutton Park to help promote the project and survey, and discuss it with the public.

## SECTION 2

# What We Learned

The following pages summarize the feedback that was received from the Options Survey.

This information is summarized as follows:

- About You (Demographics)
- Areas of Focus
- Approaches to Adaptation
- Risks and Objectives

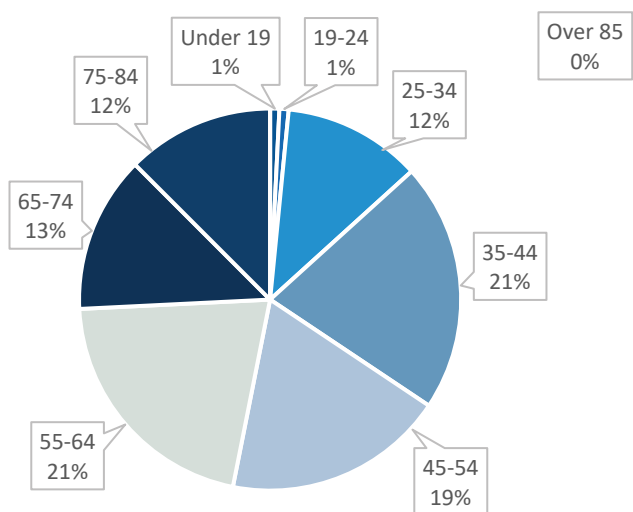
# 2.1 About You (Demographics)

The following demographics questions have been brought to the front of this summary to first show who we heard from before diving into what was learned from the survey respondents.

*Note: demographics questions were asked in the latter half of the online and hard copy surveys.*

## Age of Respondents

Q. What age are respondents?

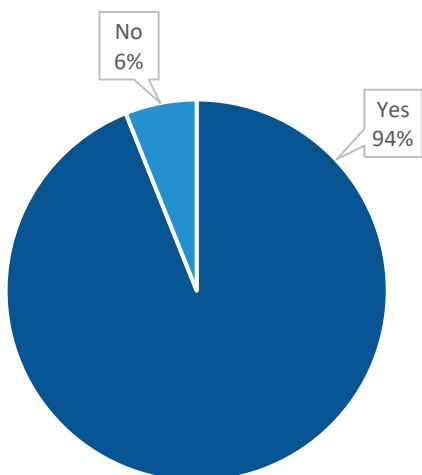


### KEY FINDINGS:

- There is limited representation of the younger demographic (under 35) among survey respondents.
- There were no respondents over the age of 85.
- More than half of respondents are the age of 45 and up.

## Geographic Representation

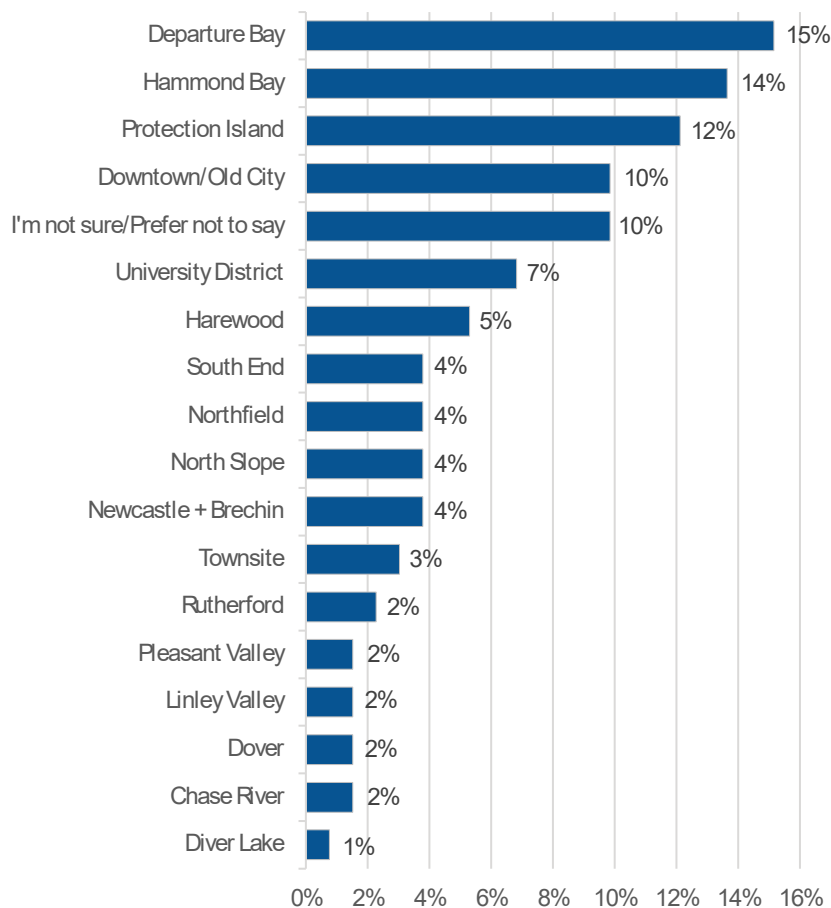
Q. Are you a resident of Nanaimo?



### KEY FINDINGS:

- The majority of respondents live in the City of Nanaimo (94%).

**Q. What neighbourhood do you live in?**



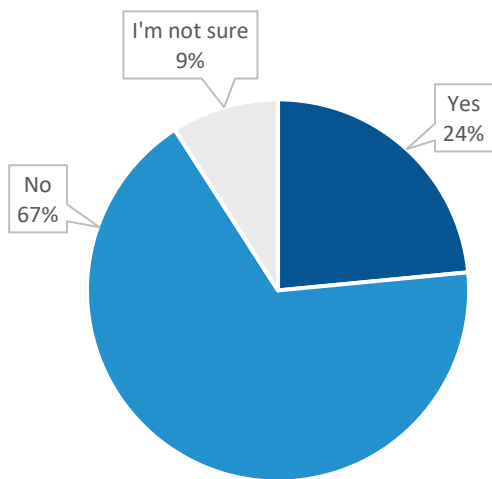
**KEY FINDINGS:**

- (51%) of respondents live in areas that either have or are predicted to experience impacts of sea level rise.
- All neighbourhoods in Nanaimo are represented to some extent through resident survey input.

\* NOTE: Due to rounding the cumulative percentage slightly exceeds 100%.

**Perception of Future Risk / Impact**

**Q. Do you live on or own property that you think may be at risk from coastal flooding, coastal erosion, sea level rise, or other coastal hazards?**



**KEY FINDINGS:**

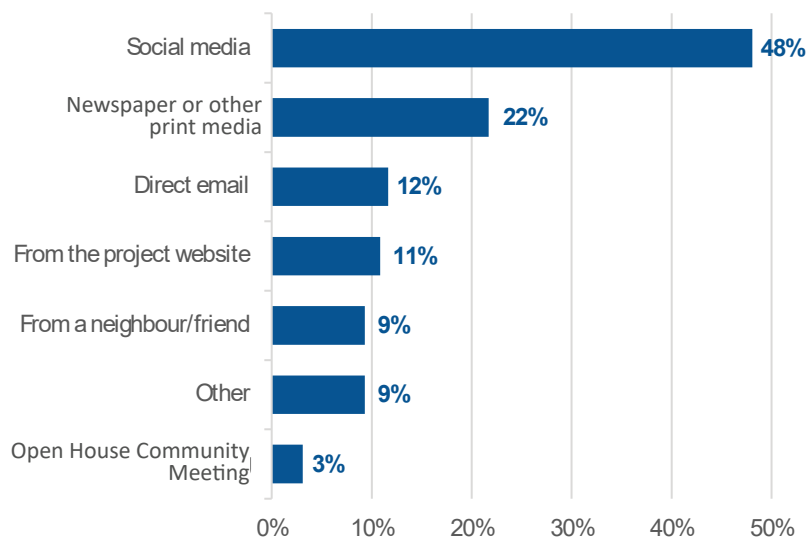
- (24%) of respondents expect to be impacted by coastal flooding, erosion, sea level rise and/or other coastal hazards.



## Round 2 Outreach

### Q13. How did you learn about the survey.

Select all that apply.



#### KEY FINDINGS:

- Respondents learned about the survey through a variety of sources.
- Top ways respondents learned about the survey include **social media**, **newspaper or other print method**, and **direct email**.

\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).



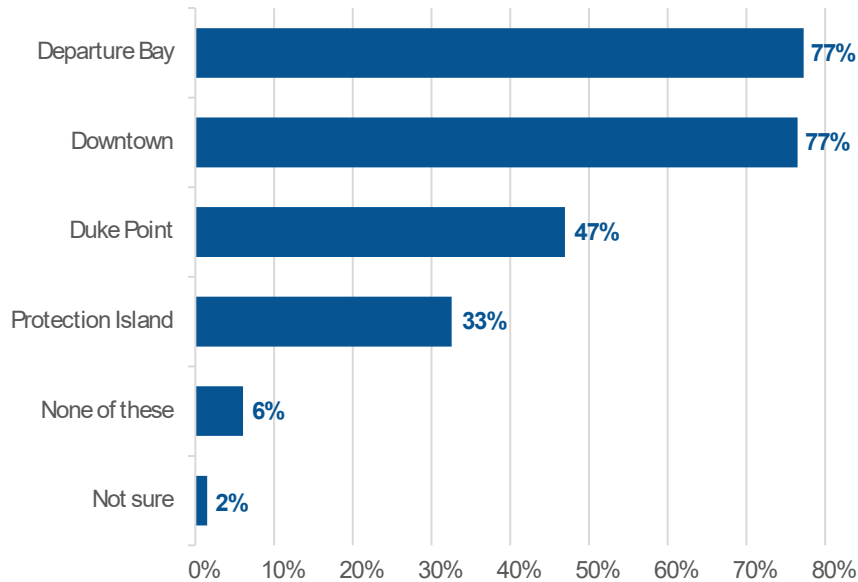
Photo of the Round 2 Engagement Community Meeting Workshop

## 2.2 Areas of Focus

### Vested Interest

**Q1: Which of these areas do you currently use, visit, pass through, or have a personal connections to?**

Select all that apply.



#### KEY FINDINGS:

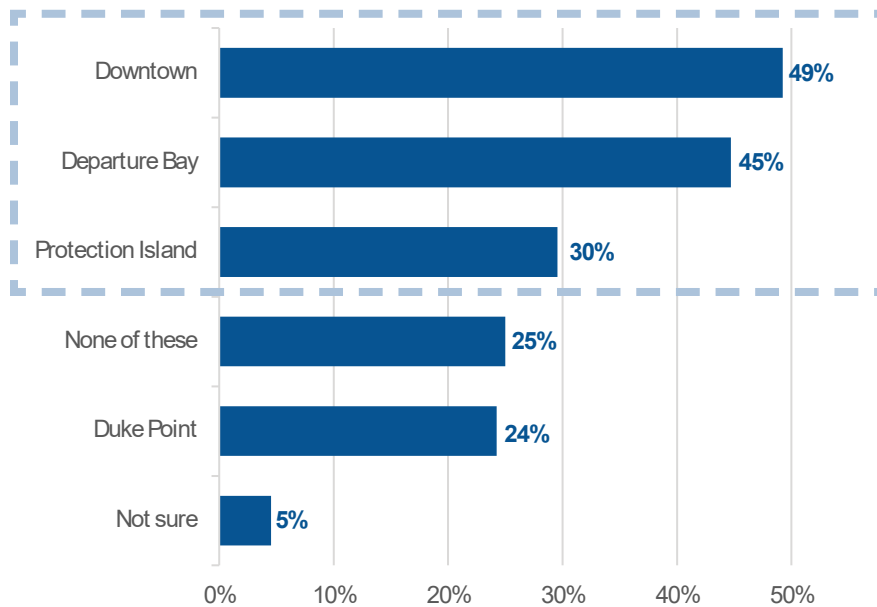
- Most respondents (92%) have a connection-to or pass-through at least one of the four focus areas.
- Departure Bay and Downtown are frequented by the most number of respondents (77%).

\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).

### Areas of Concern

**Q2: Based on your first impression, which areas are you most concerned about sea level rise?**

Select all that apply.



#### KEY FINDINGS:

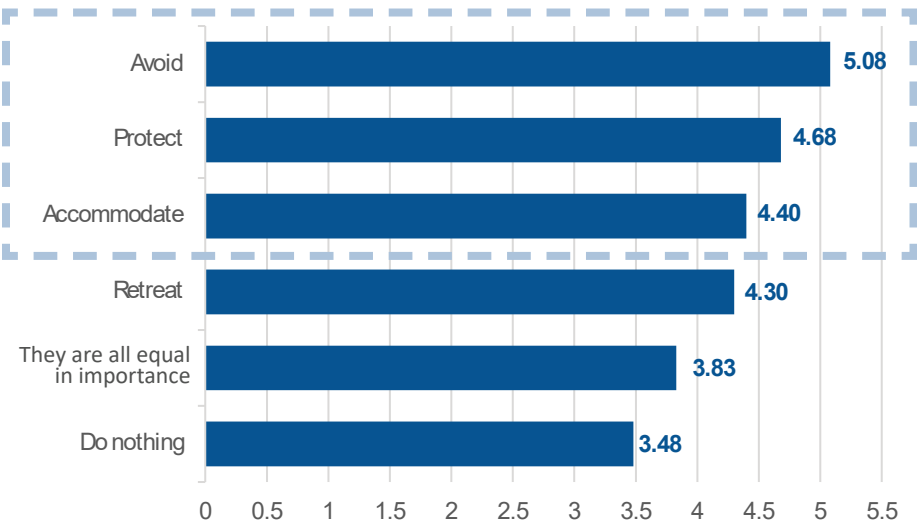
- The area with the highest level of concern for respondents was Downtown (49%), followed by Departure Bay (45%) and Protection Island (30%).

\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).

# 2.3 Approaches to Adaptation

## Adaptation Strategy Priorities

Q3. Which of the following strategies should the City prioritize whenever possible?



### KEY FINDINGS:

- Top 3 adaptation strategies respondents would like the City to prioritize are **Avoid, Protect, and Accommodate.**

\* NOTE: Respondents were asked to rank the 6 adaptation strategy options in order of highest to lowest priority. Scores were assigned to each rank position and divided by the total number of contributors to determine the overall rank.

## Benefits & Disadvantages

Q4. What benefits and disadvantages stand out to you with these options?

### BENEFITS OF THESE OPTIONS

- » Proactive planning and action can lead to future cost savings.
- » Avoid and retreat may be the most cost effective.
- » Soft protection requires a lower investment and added ecological value.
- » Protection may prevent loss of property / assets.

### DISADVANTAGES OF THESE OPTIONS

- » "Do nothing" will cost more in the future and have negative implications.
- » Hard armouring is costly and not always a permanent solution.
- » Private property limitations.
- » Retreat may impact surrounding neighbourhoods.

### OTHER COMMENTS SHARED BY RESPONDENTS

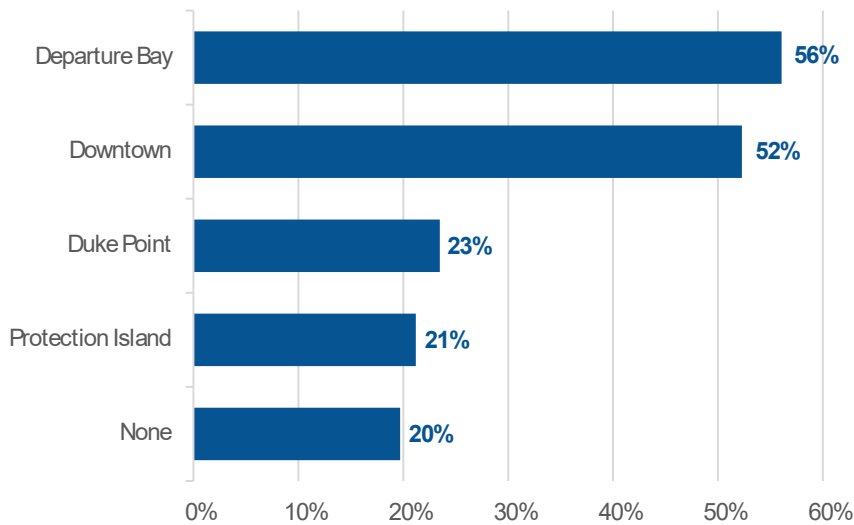
- » Some respondents would like to see approaches used that adapt with the natural coastline and changing processes in each area.
- » Cost is a considerable factor for all approaches for monetary, asset, and sustainable community building.
- » Action is needed to respond to current and future coastal risks impacts.
- » Many respondents prioritize soft protection measures over hard armouring.

## 2.4 Risks and Objectives

### Focus Areas

#### Q5. Which of the areas of focus do you want to review and provide comment on?

Select all that apply.



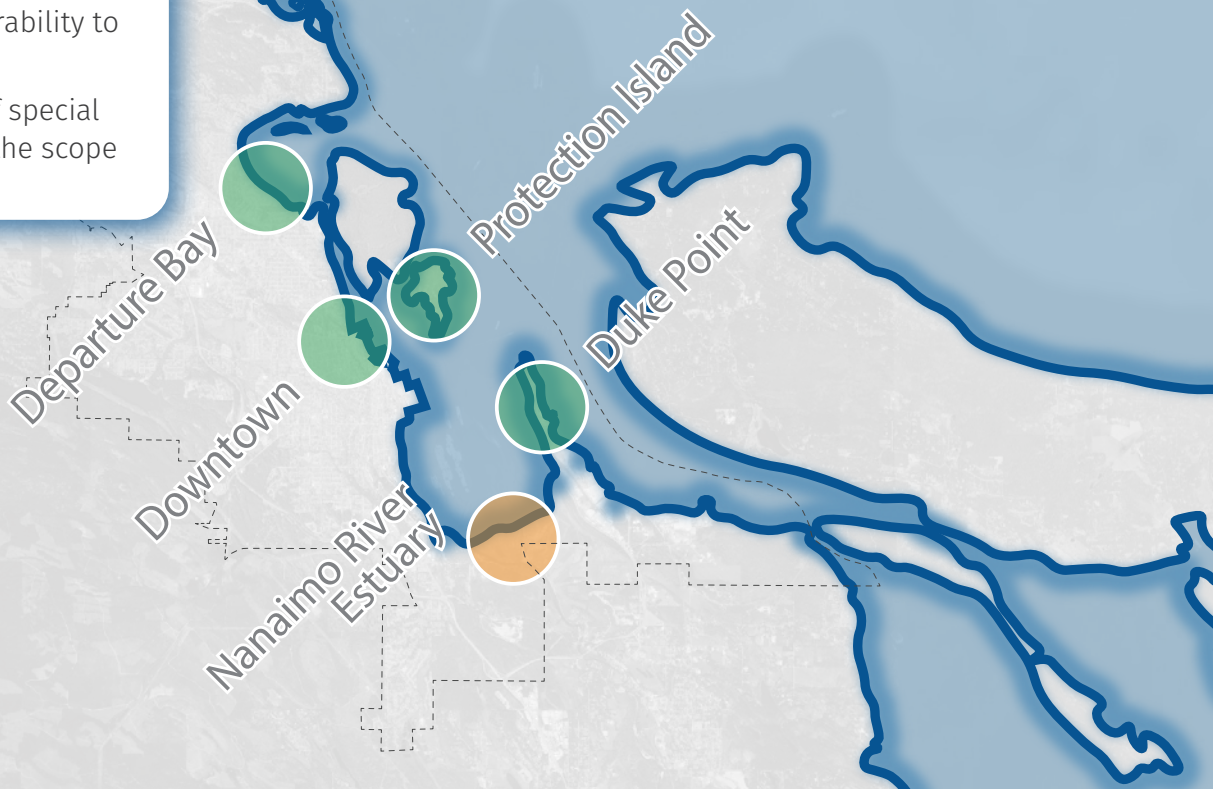
#### KEY FINDINGS:

- Most respondents (80%) were interested in providing comment for one or more focus area.
- More than half of respondents were interested in providing comment for Departure Bay (56%) and Downtown (52%).

\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).

#### LEGEND

-  Areas of the City identified in the 2018 *Sea Level Rise Study* with higher vulnerability to coastal flooding.
-  Additional area of special interest (outside the scope of this study)



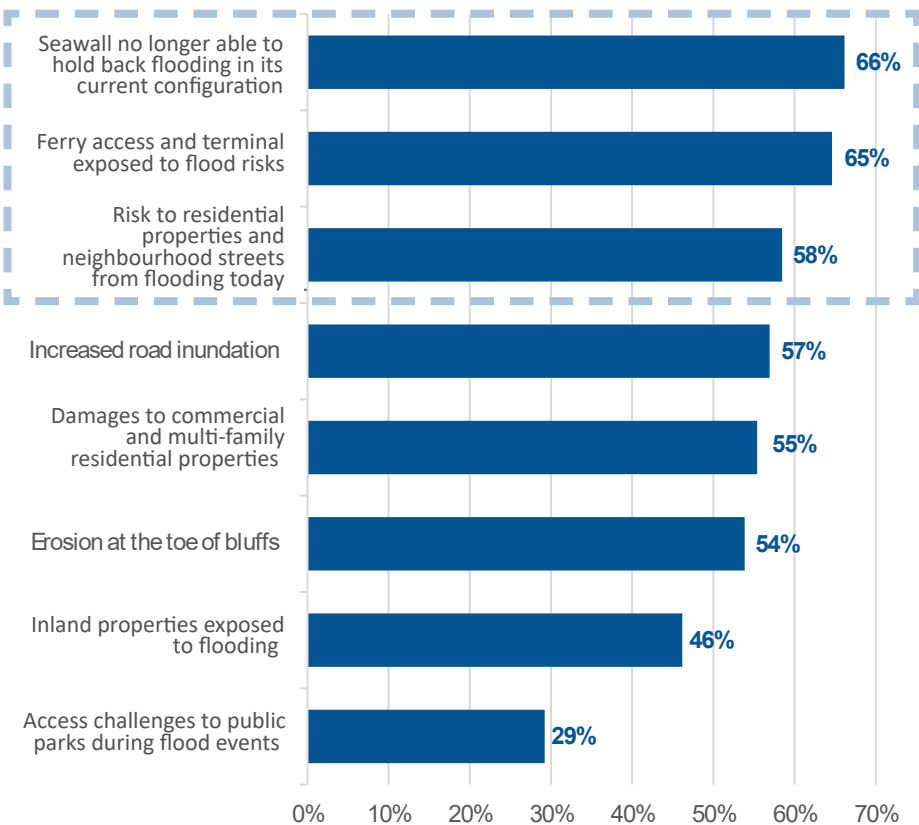


# 2.4.1 Departure Bay

## Risks

### Q6. What risks are you the most concerned about in this area?

Select all that apply.



#### KEY FINDINGS:

- Greatest concerns in the Departure Bay area are the **capability of the seawall to hold back flooding, ferry access and terminal flood risks, and the risk of flooding on residential properties and neighbourhood streets.**

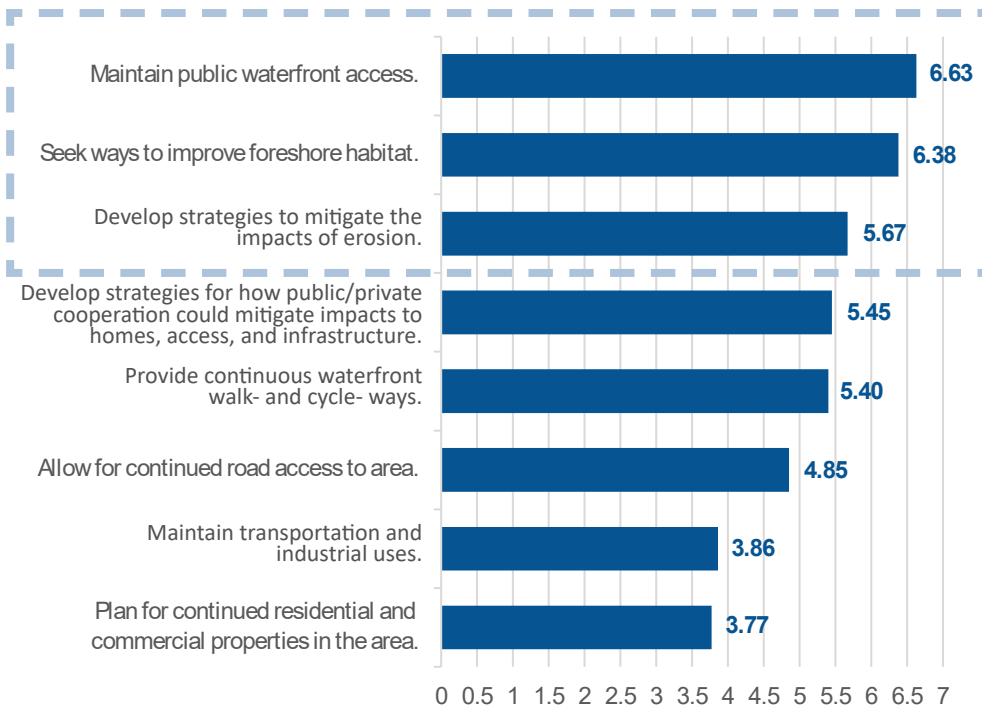
\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).



Photo of a Departure Bay Beach Future Anticipated Water Levels Investigation

## Objectives Priorities

Q7. What objectives resonate the most with you in this area?



### KEY FINDINGS:

- Top 3 objectives for Departure Bay are to **maintain public access to the waterfront, seek ways to improve foreshore habitat, and to develop strategies to mitigate the impacts of erosion.**

\* NOTE: Respondents were asked to rank the objectives in order of highest to lowest resonance. Scores were assigned to each rank position and divided by the total number of contributors to determine the overall rank.

## Other Objectives

Q8. What other objectives should be considered for this area?

- Prioritize preservation and enhancement of the natural shoreline and marine life
- Adapt with coastal processes by prioritizing accommodation and retreat strategies
- Early planning to avoid costly flood-control measures
- Maintain BC Ferries operations, roadways, and essential utilities
- Desire for improved public access and amenity along the waterfront including beach access, shade trees, expanded waterfront walkways, docks, dog park, and commercial amenities integrated into a redesigned shoreline
- Support for revised zoning regulations to control development type and elevation
- Concern about cost implication and responsibility for coastal adaptation measures

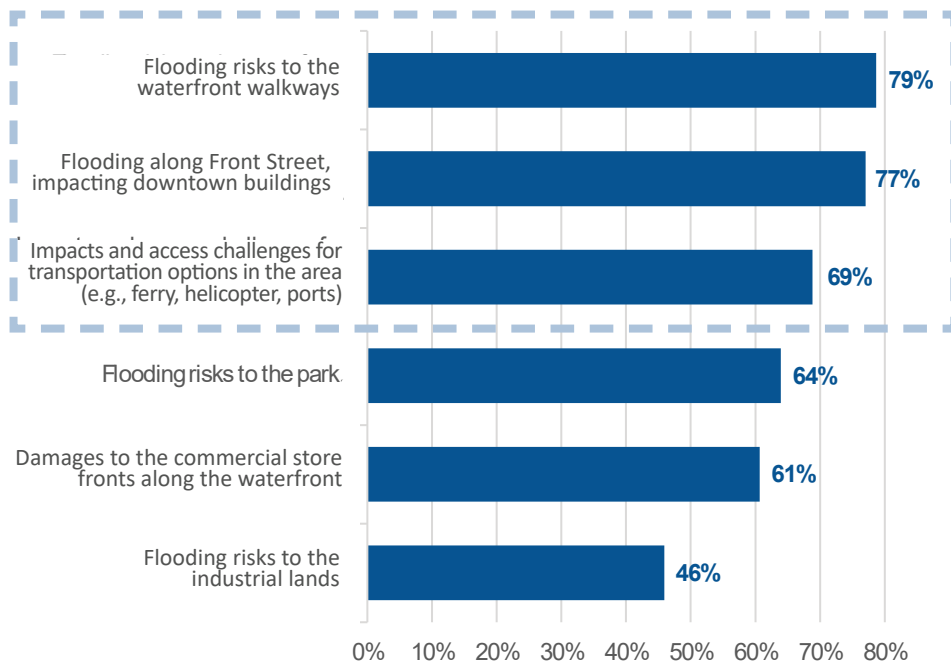


## 2.4.2 Downtown

### Risks

#### Q9. What risks are you most concerned about in this area?

Select all that apply.



#### KEY FINDINGS:

- Greatest concerns in the Downtown area are the **flooding risks to the waterfront walkways**, **flooding along Front Street**, and **impacts and access challenges for transportation options in the area (e.g., ferry, helicopter, ports)**.

\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).



Photo of a Maffeo Sutton Park Future Anticipated Water Levels Investigation

# Objectives Priorities

Q10. What objectives resonate the most with you in this area?



## KEY FINDINGS:

- Top 3 objectives for Downtown are to **maintain public access to the waterfront, provide continuous waterfront walk- and cycle- ways, and to maintain waterfront park and event spaces.**

\* NOTE: Respondents were asked to rank the objectives in order of highest to lowest resonance. Scores were assigned to each rank position and divided by the total number of contributors to determine the overall rank.

# Other Objectives

Q11. What other objectives should be considered for this area?

- Environmental protection and enhancement - replanting native species and removal or mitigation of pollution sources
- Long term sustainable planning with consideration for retreat in particularly low lying areas
- Transportation and active transportation route protection and / or accommodation of seasonal high tides

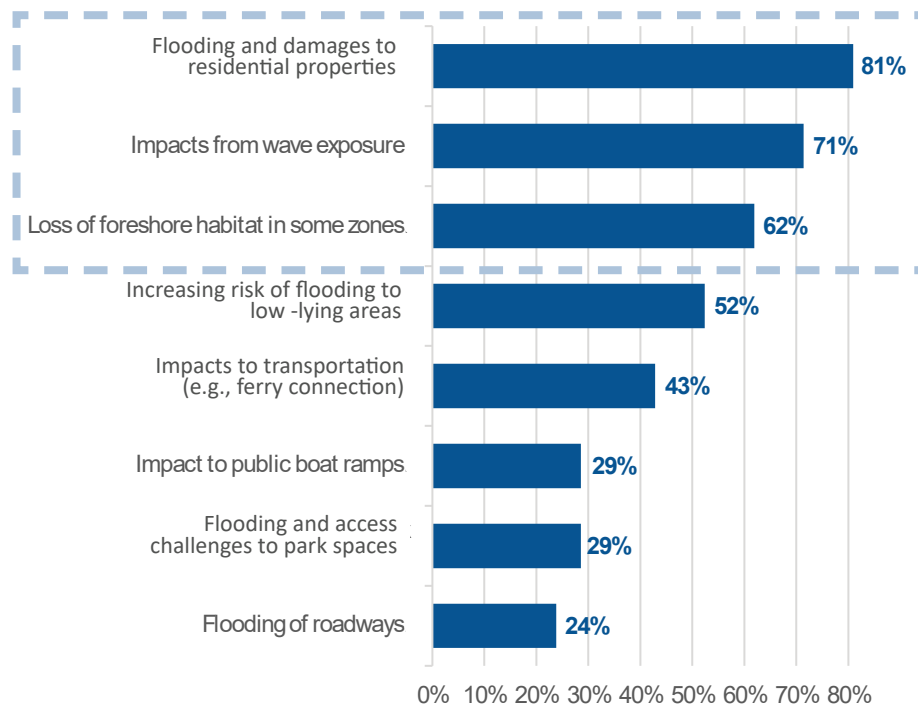


## 2.4.3 Protection Island

### Risks

#### Q12. What risks are you most concerned about in this area?

Select all that apply.



#### KEY FINDINGS:

- Greatest concerns for Protection Island are **flooding and damages to residential properties**, **impacts from wave exposure**, and **loss of foreshore habitat in some zones**.

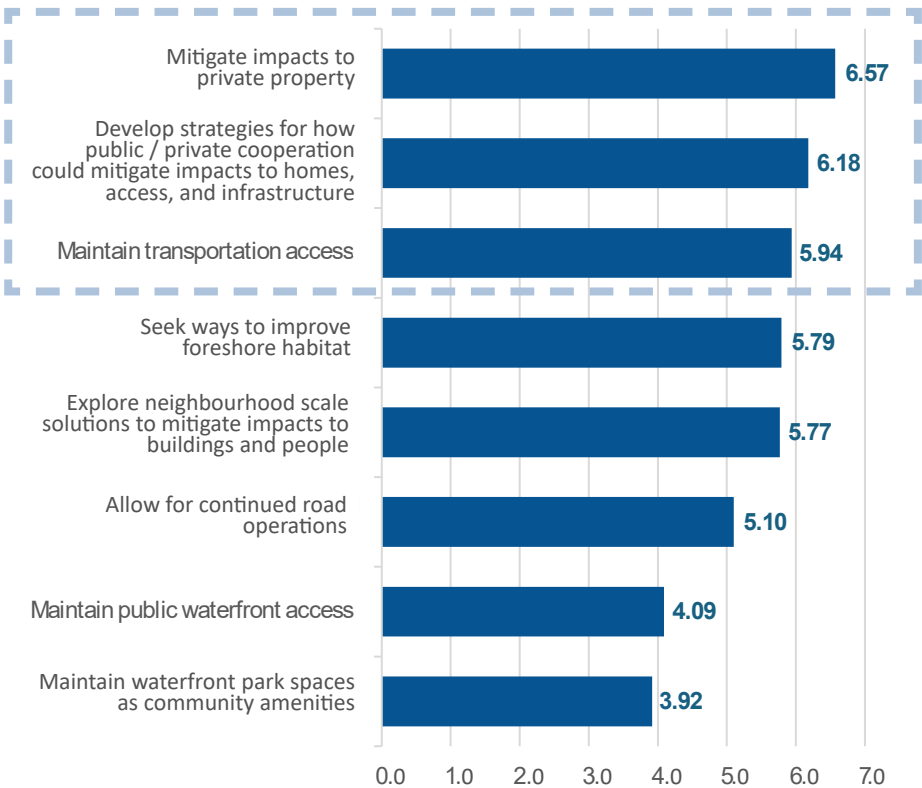
\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).

Photo of Protection Island at Low Tide



# Objectives Priorities

Q13. What objectives resonate the most with you in this area?



## KEY FINDINGS:

- Top 3 objectives for Protection Island are to **mitigate impacts to private property, develop strategies for how public / private cooperation could mitigate impacts to homes, access, and infrastructure, and to maintain transportation access.**

\* NOTE: Respondents were asked to rank the objectives in order of highest to lowest resonance. Scores were assigned to each rank position and divided by the total number of contributors to determine the overall rank.

# Other Objectives

Q14. What other objectives should be considered for this area?

- Maintain emergency accesses and community resources (Mud Bay Dock, Dinghy Dock Ferry, Gallows Point Ramp)
- Limit further development on waterfront lots
- Do nothing, this is the responsibility of private property owners

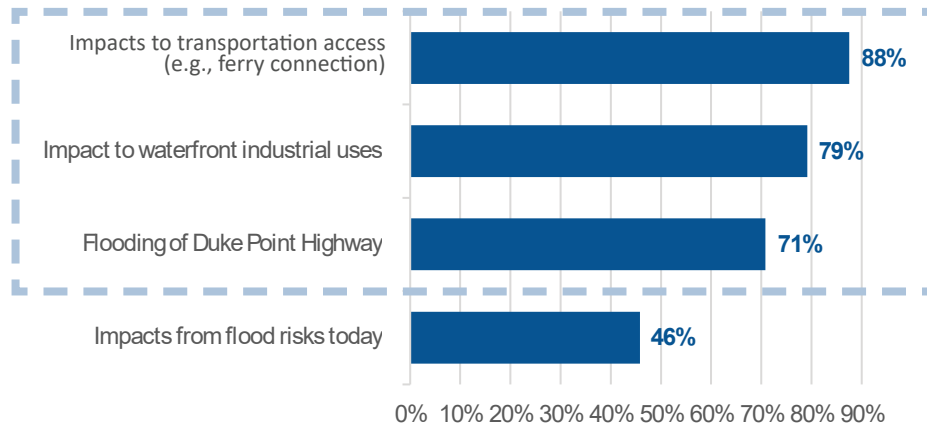


## 2.4.4 Duke Point

### Risks

Q15. What risks are you most concerned about in this area?

Select all that apply.



#### KEY FINDINGS:

- Greatest concerns in the Duke Point area are the **impacts to transportation access (e.g., ferry connection)**, **impact to waterfront industrial uses**, and **flooding of Duke Point Highway**.

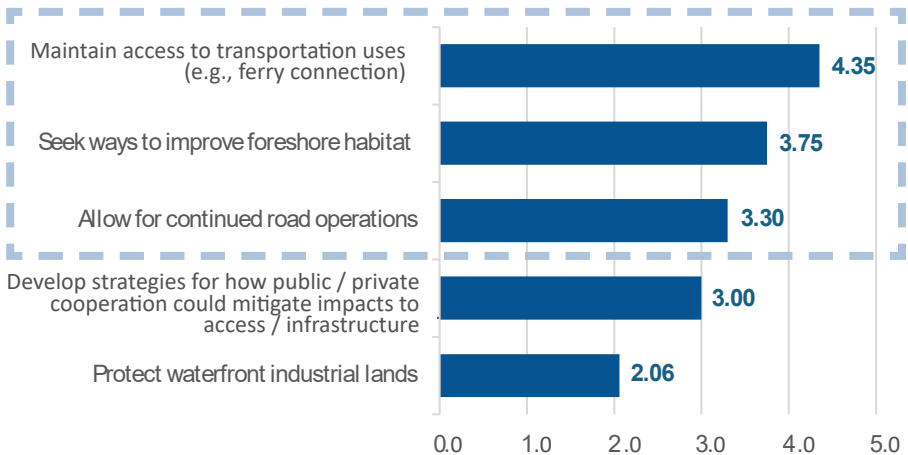
\* NOTE: Respondents were asked to select all that apply. This graph depicts the percent of total respondents that selected each item (therefore, cumulative percentages exceed 100%).



Photo of Duke Point Ferry Terminal

# Objectives Priorities

Q16. What objectives resonate the most with you in this area?



## KEY FINDINGS:

- Top 3 objectives for the Duke Point area are to **maintain access to transportation uses (e.g., ferry connection)**, **seek ways to improve foreshore habitat**, and **allow for continued road operations**.

\* NOTE: Respondents were asked to rank the objectives in order of highest to lowest resonance. Scores were assigned to each rank position and divided by the total number of contributors to determine the overall rank.

# Other Objectives

Q17. What other objectives should be considered for this area?

- Maintain transportation access and connection to BC Ferries
- Protect the coastline from pollution and industrial activities



## SECTION 3

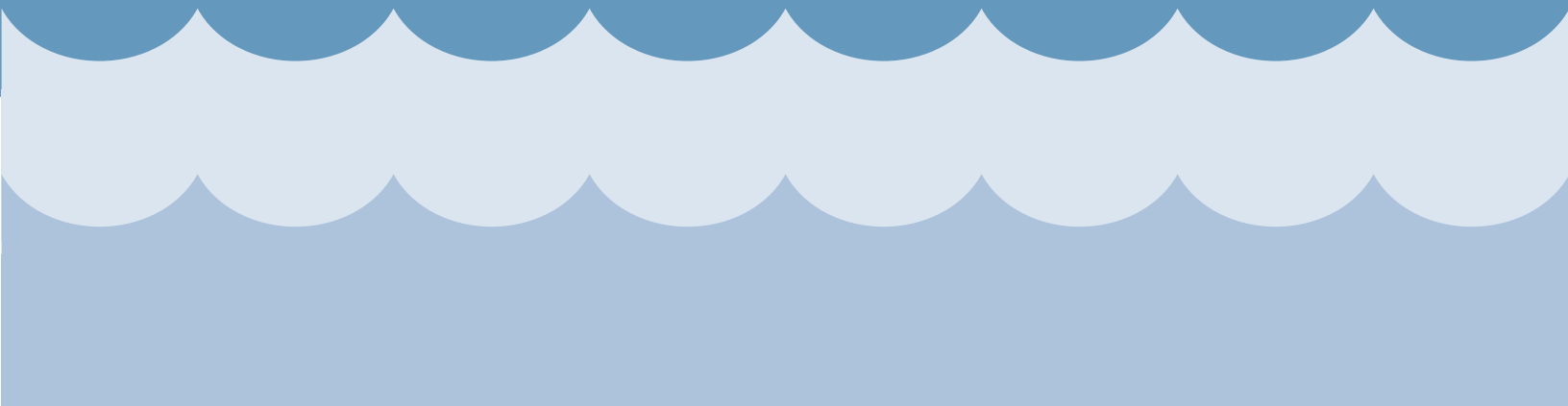
# Next Steps

The feedback heard in Round 2 Engagement will help develop recommendations for adaptation strategies in each of the four focus areas.

Next steps in the public process include:

- Update about what we learned during Round 2 Engagement process (this summary).
- Recommendations development for adaptation strategies in each of the four focus areas. This work will be completed in Summer 2026.
- Continued updates posted to the Project webpage:  
[www.nanaimo.ca/your-government/projects/sea-level-rise-management-plan](http://www.nanaimo.ca/your-government/projects/sea-level-rise-management-plan)

**Thank you for your participation in this process!**

A decorative wavy pattern at the bottom of the page, consisting of a series of light blue and white scalloped shapes that create a wave-like effect.





*Photo of Departure Bay and Surrounding Area*





For project updates and ongoing information about the project please visit:  
[www.nanaimo.ca/your-government/projects/sea-level-rise-management-plan](http://www.nanaimo.ca/your-government/projects/sea-level-rise-management-plan)

# **APPENDIX B**

## **COASTAL ANALYSIS**





Photo source: Pauline Martens

# Nanaimo Sea Level Rise Management Plan

## Appendix B – Coastal Analysis

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## ABBREVIATIONS

| Acronym /<br>Abbreviation | Definition                                        |
|---------------------------|---------------------------------------------------|
| AEP                       | Annual Exceedance Probability                     |
| CD                        | Chart Datum                                       |
| CGVD2013                  | Canadian Geodetic Vertical Datum of 2013          |
| CGVD28                    | Canadian Geodetic Vertical Datum of 1928          |
| DEM                       | Digital Elevation Model                           |
| DWL                       | Designated Water Levels                           |
| EVA                       | Extreme Value Analysis                            |
| FCL                       | Flood Construction Level                          |
| HHWLT                     | Higher High Water Large Tide                      |
| HHWMT                     | Higher High Water Mean Tide                       |
| $H_{rms}$                 | Root-mean Square Wave Height                      |
| $H_s$ or $H_{m0}$         | Significant Wave Height                           |
| JPA                       | Joint Probability Analysis                        |
| LiDAR                     | Light Detection and Ranging                       |
| LLWLT                     | Lower Low Water Large Tide                        |
| LLWMT                     | Lower Low Water Mean Tide                         |
| MWL                       | Mean Water Level                                  |
| SLR                       | Sea Level Rise                                    |
| SWAN                      | Simulating WAVes Nearshore (numerical wave model) |
| $T_p$                     | Peak Wave Period                                  |
| TWL                       | Total Water Level                                 |
| $R_{2\%}$                 | Runup Elevation exceeded by 2% of incident waves  |

## GLOSSARY

| Term                                 | Definition                                                                                                                                        |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Flood Construction Level (FCL)       | Recommended minimum elevation for buildings and structures in flood-prone coastal areas, defined as total water level plus a freeboard allowance. |
| Higher High Water Large Tide (HHWLT) | The average of the highest predicted high water level of each year in a tidal epoch.                                                              |
| Higher High Water Mean Tide (HHWMT)  | The average height of higher high waters over a tidal epoch.                                                                                      |
| Lower Low Water Large Tide (LLWLT)   | The average of the lowest predicted low water level of each year in a tidal epoch.                                                                |
| Lower Low Water Mean Tide (LLWMT)    | The average height of all low waters over a tidal epoch.                                                                                          |
| Mean Sea Level (MSL)                 | The average height of the surface of the sea over a tidal epoch.                                                                                  |
| Peak Wave Period ( $T_p$ )           | The wave period corresponding to the peak of the wave energy spectrum.                                                                            |
| $R_{2\%}$ (Runup)                    | The elevation exceeded by 2% of waves during a storm event. Used as a standard measure of wave runup in coastal engineering.                      |
| Sea Level Rise (SLR)                 | Long-term increase in mean sea level due to climate change and other factors.                                                                     |
| Significant Wave Height ( $H_s$ )    | The average height of the highest one-third of waves in a wave record.                                                                            |

## UNITS AND SYMBOLS

| Term       | Definition                                                      |
|------------|-----------------------------------------------------------------|
| m          | Metres                                                          |
| m CGVD2013 | Metres relative to the Canadian Geodetic Vertical Datum of 2013 |
| m/s        | Metres per second (wind speed)                                  |
| s          | Seconds (wave period)                                           |
| %          | Percent (exceedance probability)                                |



## 1 INTRODUCTION

This appendix documents the coastal processes analysis performed to support the flood hazard mapping and options development for the Nanaimo Sea Level Rise Management Plan. Coastal hazard parameters, including tides, storm surge, relative sea level rise (RSLR), and wind-generated waves, were assessed using observational data, empirical methods, and numerical models.

A joint probability analysis (JPA) of water levels and winds was performed to define storm event annual exceedance probabilities (AEP). The Simulating Waves Nearshore (SWAN) numerical model was used to simulate the wave climate for each selected scenario based on spatially-varied wind fields and water level conditions.

Four regions along the Nanaimo shoreline were selected for assessment and broken into smaller sub-regions to be used for detailed wave investigation. The regions and subregions are as follows:

- Departure Bay: Beach and Ferry Terminal
- Downtown Nanaimo: Port and Waterfront
- Duke Point: North and South
- Protection Island: Studied in transects of shoreline

Flood hazards at Protection Island were assessed using empirical formulae for wave runup. Non-hydrostatic numerical modelling with XBeach was used to assess the flood hazards at Departure Bay, Downtown Nanaimo, and Duke Point. The outputs from the analysis in each region is used in the flood hazard assessment to generate the wave effects mapping and FCL development.

## 2 DESIGN WATER LEVELS AND WIND CONDITIONS

This section summarizes the methods and assumptions used to develop the design water levels and wind conditions for the coastal inundation modelling. The analysis incorporates astronomical tides, storm surge, RSLR, and wind conditions. Wind conditions were evaluated, as wind-generated waves contribute to coastal flooding through wave setup and wave runup. The joint probability analysis (JPA) of water levels and wind conditions provides the basis for defining the design scenarios. The data sources and assumptions for each component are described in the following sections.

In this study, elevations are referenced to CGVD2013 (Canadian Geodetic Vertical Datum of 2013) unless otherwise stated. Based on Benchmark M14C9042 at Nanaimo Harbour (Fisheries and Oceans Canada, 2026a), the relationship between CGVD2013, Chart Datum (CD) and the Canadian Geodetic Vertical Datum of 1928 (CGVD28) is:

$$Elevation_{CGVD2013} = Elevation_{CD} - 2.86 \text{ m}$$

$$Elevation_{CGVD2013} = Elevation_{CGVD28} + 0.16 \text{ m}$$

## 2.1 Water Levels

The design water levels account for the combined effects of tides, storm surge, and RSLR. Each component is discussed in the sections below.

### 2.1.1 Astronomical Tides

The Strait of Georgia experiences a semi-diurnal tidal regime, with two high tides and two low tides of similar height occurring each lunar day. The tidal range fluctuates through the month between spring tide conditions (periods with highest high tides and lowest low tides resulting in the greatest tidal range) and neap tide conditions (period with lower high tides and higher low tides resulting in the smallest tidal range). The elevations of high tide and low tide, therefore, are not consistent at a site and are often referenced to tidal datums computed based on data collected over a tidal epoch, for example higher high water large tide (HHWLT).

Tidal elevations were based on the Nanaimo Harbour water level gauge (Station ID 07917) located offshore of downtown Nanaimo (Fisheries and Oceans Canada, 2026b). Tidal datums at the Nanaimo Harbour station are presented in Table 2.1.

**Table 2.1 Nanaimo Harbour (Station ID 07917) tidal datums (Fisheries and Oceans Canada, 2026b).**

| Datum                                | Elevation (m CGVD2013) |
|--------------------------------------|------------------------|
| Highest Astronomical Tide            | 2.22                   |
| Higher High Water Large Tide (HHWLT) | 2.15                   |
| Higher High Water Mean Tide (HHWMT)  | 1.61                   |
| Mean Water Level (MWL)               | 0.22                   |
| Lower Low Water Mean Tide (LLWMT)    | -1.68                  |
| Lower Low Water Large Tide (LLWLT)   | -2.84                  |
| Lowest Astronomical Tide             | -3.03                  |

### 2.1.2 Total Water Level (Storm Surge and Tide)

Storm surge refers to the water level increase caused by low atmospheric pressure and wind during storm events. Total water level is the combined effect of astronomical tide and storm surge. Design total water levels for Nanaimo were estimated by evaluating the joint probability

of storm surge and tides using water level observations from Point Atkinson (Station ID 07795), located approximately 53 km northeast of Nanaimo (Fisheries and Oceans Canada, 2026c). Point Atkinson was selected because of its long term observed water level record. The Revised Joint Probability Method (Mazas et al., 2014) was applied to the 1950 and 2024 record after removing the long-term sea level rise trend. The resulting total water levels were then adjusted to represent conditions at Nanaimo based on the vertical difference in HHWLT between the Point Atkinson and Nanaimo Harbour stations. Design water levels, reported as AEP, for selected return periods at Nanaimo under present day conditions (i.e., without adjustments for RSLR) are summarized in Table 2.2.

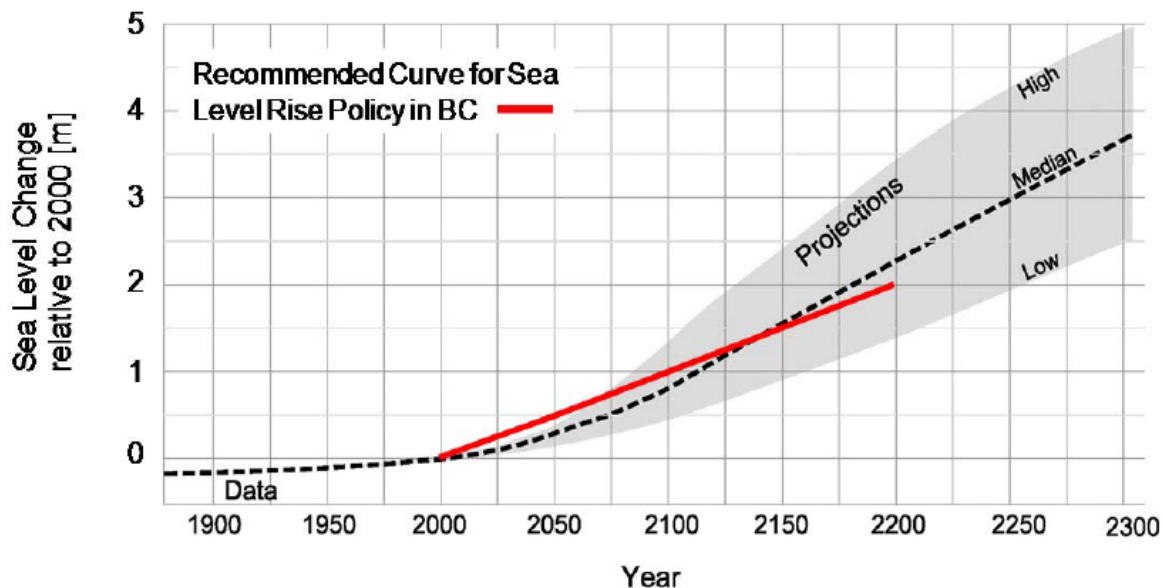
**Table 2.2 Nanaimo Harbour (Station ID 07917) present-day designated water levels (DWL).**

| AEP (%) | Return period (years) | Elevation (m CGVD2013) |
|---------|-----------------------|------------------------|
| 50      | 2                     | 2.56                   |
| 20      | 5                     | 2.66                   |
| 10      | 10                    | 2.73                   |
| 5       | 20                    | 2.79                   |
| 2       | 50                    | 2.87                   |
| 1       | 100                   | 2.92                   |
| 0.5     | 200                   | 2.97                   |

## 2.2 Relative Sea Level Rise

Global climate change is expected to increase sea levels through the melting of continental icesheets and alpine glaciers, and through thermal expansion of the ocean as water temperatures rise. RSLR is the combined effect of global sea level rise (SLR) and localized vertical land movement. Localized vertical land movement includes isostatic rebound, tectonic uplift, and sediment consolidation.

The BC Provincial Sea Dike Guidelines (BC Ministry of Environment, 2011b) recommend a sea level rise allowance of 1.0 m by the year 2100 relative to the year 2000 (Figure 2.1). This corresponds to an average increase of 10 mm/year.



**Figure 2.1 Sea level change predictions (MOE 2011).**

In this study, the RSLR scenarios are not tied to a specific calendar year, but are intended to represent broad planning horizons:

- 0.0 m: Present day
- 0.5 m: Medium term
- 1.0 m: Long term
- 2.0 m: Very long term

The 1.0m RSLR scenario is intended to represent the BC provincial guidance allowance used for flood construction levels (FCL) planning to the year 2100 (BC Ministry of Environment, 2011a).

## 2.3 Winds

Environment and Climate Change Canada (ECCC) operate several wind and wave buoy stations in the Strait of Georgia (Figure 2.2). Entrance Island, the closest offshore wind station to the study area with a sufficiently long period of record, was selected to derive the design wind conditions. Other available stations were considered but not selected because they were either located farther from the study area (Halibut Bank, Sand Heads CS, Ballenas Island), located inland (Nanaimo Airport) and therefore not representative of offshore conditions, or had an insufficient period of record for extreme value analysis (Southern Georgia Strait buoy). Wind events recorded at Entrance Island and Southern Georgia Strait buoy showed similar response, providing confidence that Entrance Island is representative of local offshore wind conditions.



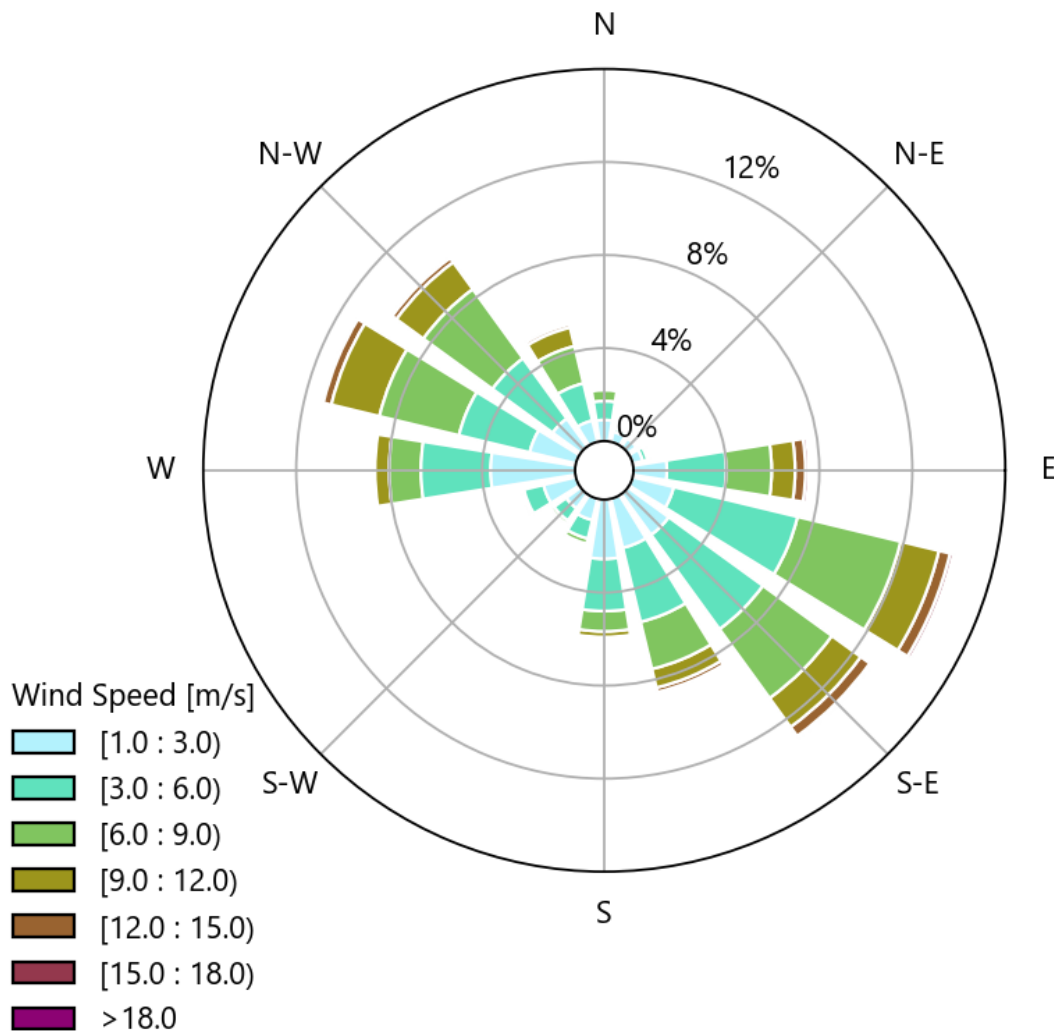


**Figure 2.2 Wind station locations in the Strait of Georgia.**

The local wind climate can be visualized using a wind rose – a graphic representation of winds for specified areas, utilizing directional bins around the cardinal<sup>1</sup> and intercardinal<sup>2</sup> compass points to show the direction from which the winds blow (meteorological convention) and the magnitude and frequency for a given interval of time. The wind rose for the Entrance Island wind station from 1994 to 2025 is shown in Figure 2.3. The winds at Entrance Island are predominantly northwesterly and southeasterly directed in alignment with the longitudinal axis of the Strait of Georgia.

<sup>1</sup> North (N), east (E), south (S), and west (W)

<sup>2</sup> North-northeast (NNE), northeast (NE), east-northeast (ENE), east-southeast (ESE), southeast (SE), south-southeast (SSE), south-southwest (SSW), southwest (SW), west-southwest (WSW), west-northwest (WNW), northwest (NW), north-northwest (NNW)



**Figure 2.3 Wind rose for Entrance Island from 1994 to 2025.**

Local winds were based on measured data from the Entrance Island wind station (Climate ID 1022689) located ~11 km from Nanaimo offshore of Vancouver Island (Figure 2.2). An extreme value analysis (EVA) was conducted on wind data collected from 1994-2025 to estimate the design wind speeds for directions from which the site is most exposed: northwesterly, northerly, northeasterly, easterly, and southeasterly (Table 2.3). Winds from other directions are infrequent at the wind station due to the sheltering of Vancouver Island and are unlikely to produce large waves along the Nanaimo shoreline.

**Table 2.3 Design wind speed at Entrance Island.**

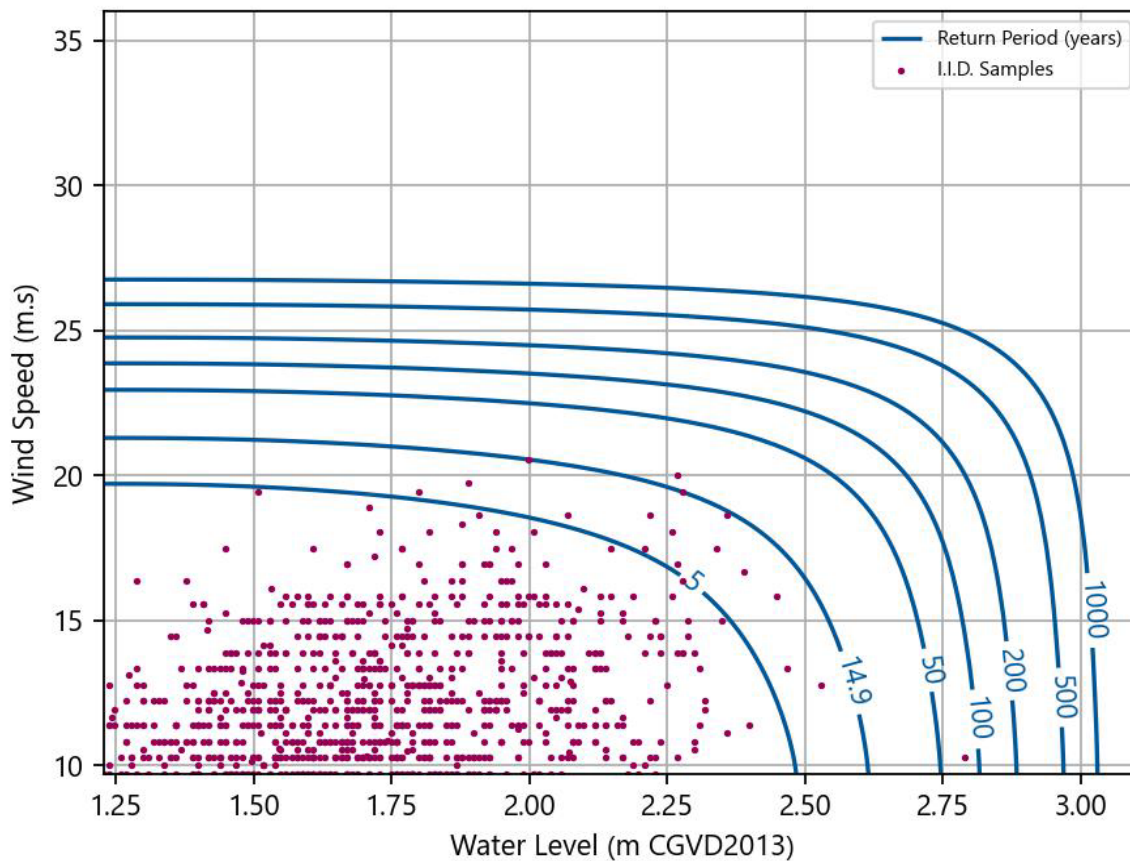
| AEP (%) | Return Period (years) | NW (m/s) | N (m/s) | NE (m/s) | E (m/s) | SE (m/s) |
|---------|-----------------------|----------|---------|----------|---------|----------|
| 50      | 2                     | 19.0     | 16.5    | 11.5     | 19.0    | 19.2     |
| 20      | 5                     | 20.1     | 18.8    | 14.1     | 20.0    | 20.4     |
| 10      | 10                    | 21.2     | 20.6    | 16.1     | 20.5    | 21.2     |
| 5       | 20                    | 22.7     | 22.4    | 18.0     | 21.0    | 21.9     |
| 2       | 50                    | 25.3     | 24.8    | 20.7     | 21.6    | 22.8     |
| 1       | 100                   | 27.9     | 26.7    | 22.6     | 22.0    | 23.4     |
| 0.5     | 200                   | 31.5     | 28.5    | 24.6     | 22.3    | 24.0     |

## 2.4 Joint Probability Analysis

The preceding sections characterize the total water level and wind climate independently. However, coastal inundation depends on the combined occurrence of elevated water levels and wave conditions generated by winds over the Strait of Georgia (Section 4.2). Accordingly, the dependence between total water level and wind speeds were evaluated using a JPA to define the design events for the coastal inundation modelling (Section 3).

Hourly total water levels at Point Atkinson (Station ID 07795; Section 2.1) and wind speeds at Entrance Island (Climate ID 1022689; Section 2.3) were used in the analysis. In the absence of nearshore wave measurements for the project area, wind speed is used as a proxy for wave occurrence. A bivariate extreme-value model, following Mazas and Hamm (2017), was used to estimate the joint occurrence of extreme winds and water levels. Unlike the independent analyses presented in the preceding sections, this approach explicitly accounts for the dependence between water levels and winds, avoiding unrealistic combinations that may result from separate univariate analyses.

Figure 2.4 shows the JPA results for easterly wind events and water level at Nanaimo. The blue curves represent combinations of total water level and wind speed associated with selected return period, while the pink dots represent the independent and identically distributed (IID) events used in the analysis.



**Figure 2.4 Joint probability of water levels at Nanaimo and wind speeds from the east.**

It is important to acknowledge that the JPA curves illustrated in Figure 2.4 are based on wind-water level pairings for events with easterly winds. I.I.D. samples are filtered to include samples with both an extreme wind speed and water level, as well as an easterly wind direction. Therefore, the extreme water levels and wind speeds presented differ from those presented in Table 2.2 and Table 2.3.

### 3 DIGITAL ELEVATION MODEL (DEM)

The DEM used for the 2D wave modelling and the flood mapping was derived from the best available topographic and bathymetric datasets available for the study area.

The topographic portion of the DEM was derived from the 2019 LidarBC dataset. The lidar data were reviewed and subjected to quality assurance procedures prior to use. Although more recent lidar datasets were available, the 2019 dataset was considered the most appropriate for this study. A limitation of using topographic data from 2019 is that the surface conditions could



have changed since the lidar was flown. The bathymetric portion of the DEM was derived from the CHS NONNA data.

The bathymetric and topographic DEMs were merged to produce a continuous elevation surface. Gaps between the two surfaces within the intertidal zones were filled by interpolation. Although this approach is appropriate for 2D wave modelling, the interpolated portions of the DEM do not represent surveyed elevations and should be interpreted accordingly.

## 4 COASTAL INUNDATION MODELLING

This section describes the coastal inundation modelling completed to simulate nearshore wave conditions, wave runup, and coastal inundation for the design scenarios. The modelling approach combines regional SWAN wave simulations, empirical wave runup calculations, and detailed non-hydrostatic XBeach modelling to assess coastal flood hazards along the Nanaimo shoreline.

### 4.1 Modelling Methodology

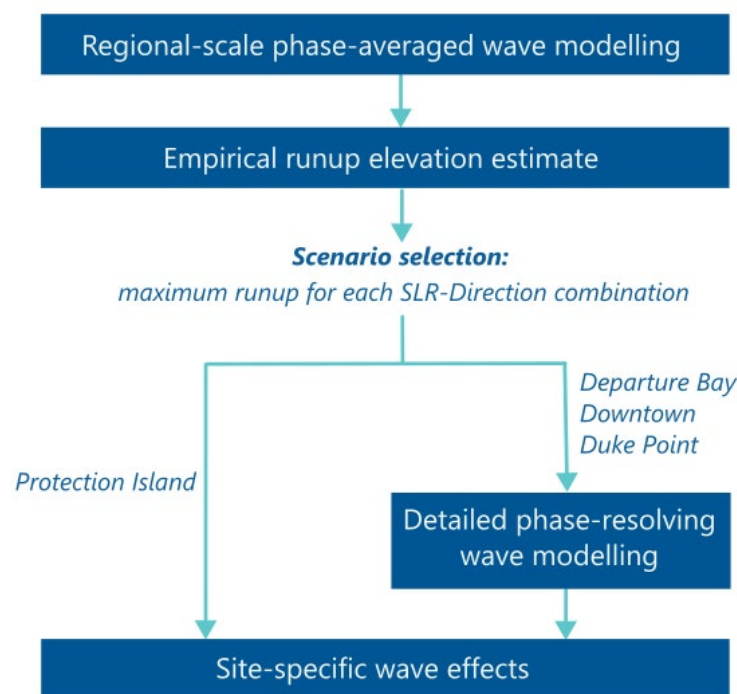
The design water levels and wind conditions, and RSLR scenarios developed in Section 2 were combined to define the modelling scenarios used for the coastal inundation assessment. Four RSLR scenarios were considered to represent present-day and future planning conditions. For each RSLR scenario, five AEPs were evaluated. Because wave generation and coastal exposure depend on wind direction, five wind directions were considered for each AEP. For each AEP and wind direction, four wind–water level combinations derived from the joint probability analysis were evaluated. In total, 400 unique scenarios were considered. The modelling scenarios are summarized below:

- 4 RSLR scenarios: 0.0 m, 0.5 m, 1.0 m, 2.0 m
- 5 AEPs: 6.7% (1-in-15 year), 2.0% (1-in-50 year), 1.0% (1-in-100 year), 0.5% (1-in-200 year), 0.2% (1-in-500 year)
  - 4 wind–water level combinations per AEP
- 5 directions: NW, N, NE, E, SE

SWAN wave simulations were completed for all scenarios to estimate nearshore wave conditions. Four shoreline regions were identified for flood hazard assessment and mapping including Departure Bay, Downtown Nanaimo, Duke Point, and Protection Island. For each shoreline region, wave conditions simulated by SWAN were extracted at a representative offshore location and combined with a representative shoreline profile to estimate wave runup

using empirical equations. The empirical runup calculations were used as a screening analysis to identify the governing scenario for each RSLR and wind direction.

The governing scenarios for Downtown, Departure Bay and Duke Point sites were subsequently evaluated using non-hydrostatic XBeach modelling, which explicitly simulates wave transformation, wave runup, and coastal inundation process over the site-specific bathymetry and topography. For Protection Island, empirical wave runup calculations were considered appropriate because the shoreline geometry is relatively simple and could be adequately represented using empirical methods. The overall modelling workflow is illustrated in Figure 4.1 and described in the following sections.



**Figure 4.1 Wave modelling workflow.**

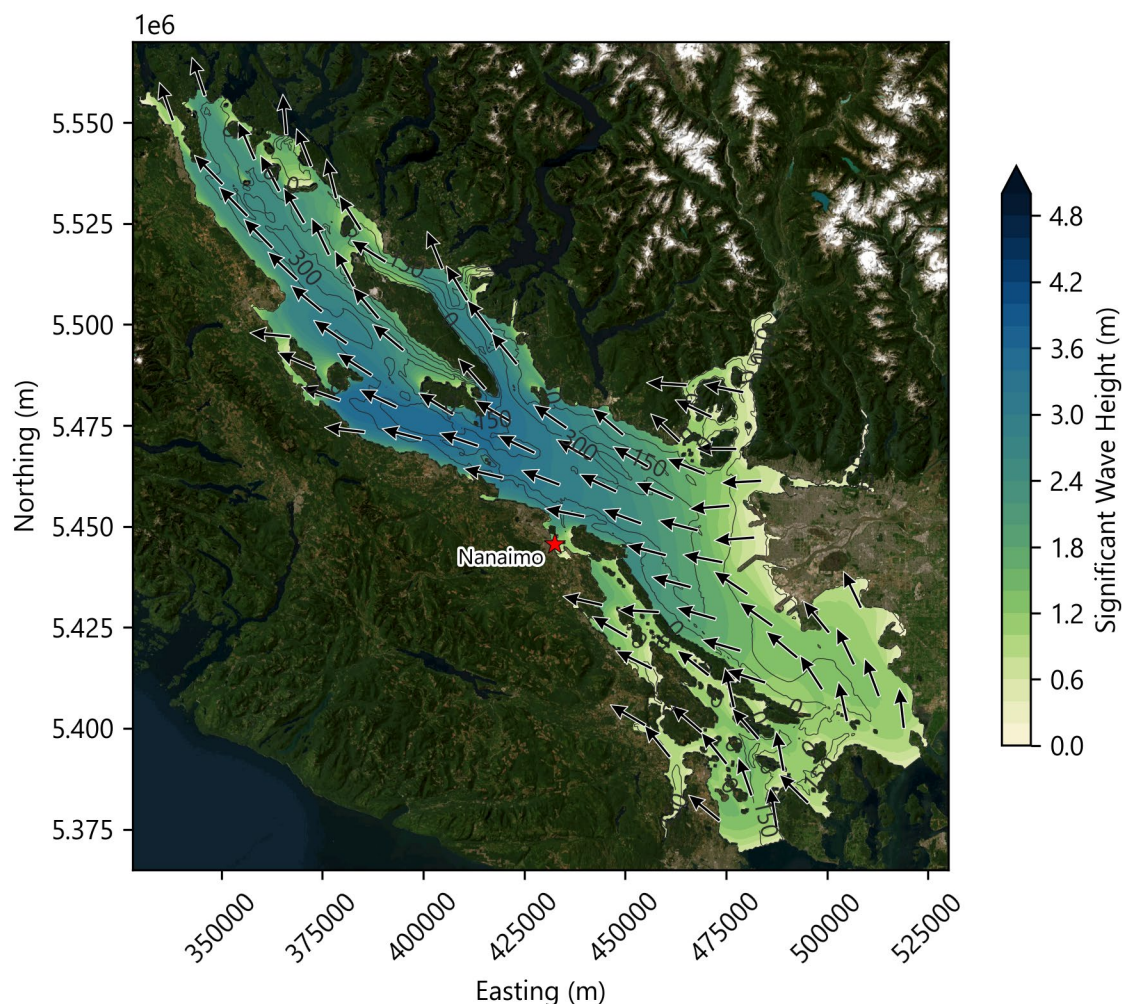
## 4.2 Nearshore Wave Climate

Waves in the Strait of Georgia are predominantly wind-generated. Wind-wave development is influenced by wind speed and direction, fetch, bathymetry, and shoreline orientation. The wind and water level conditions derived from the joint probability curves (Section 2.4) were used as inputs to a nearshore wave transformation wave model.

A numerical SWAN wave model was developed to simulate wave generation, propagation, and transformation of wind-generated waves from the Strait of Georgia to the Nanaimo shoreline.

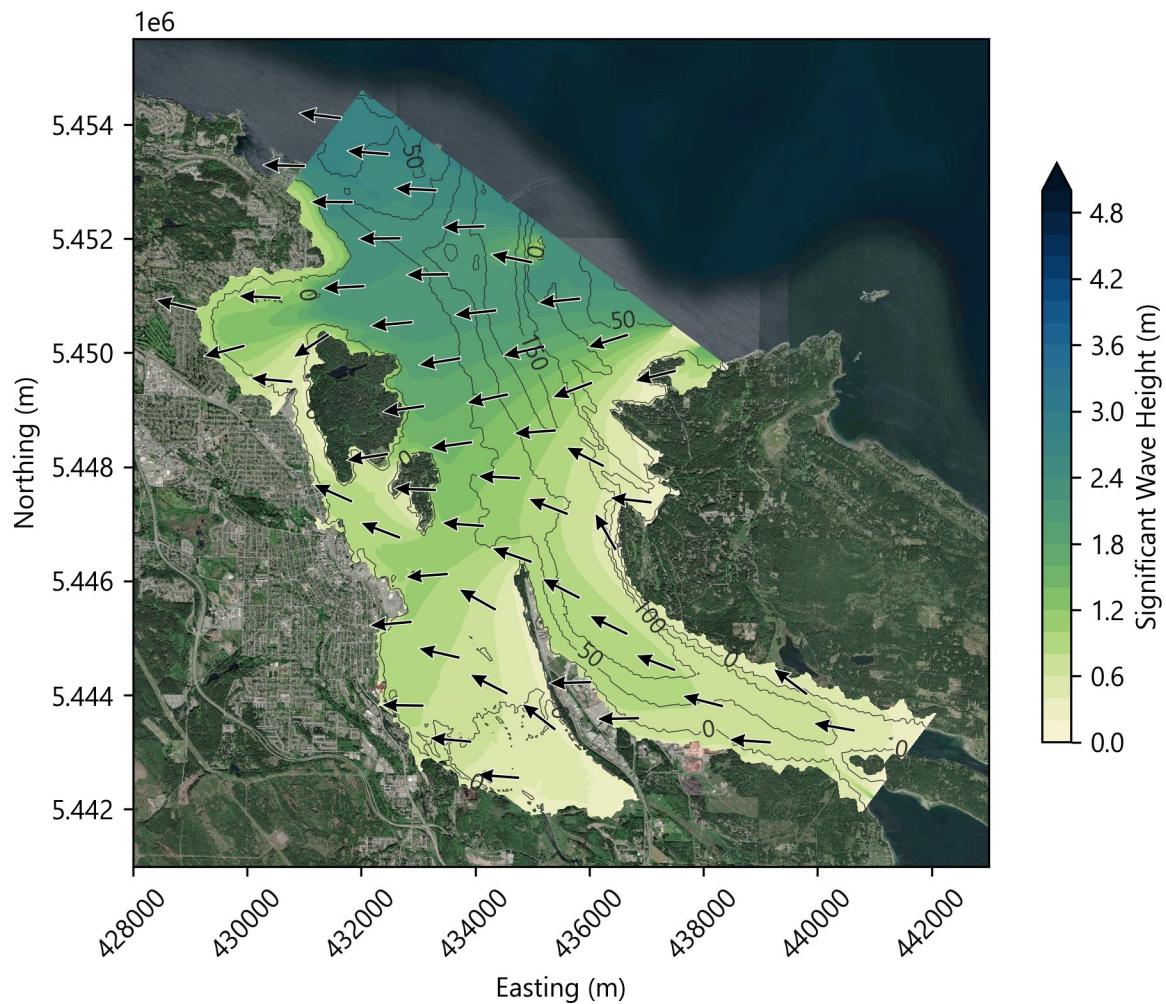
SWAN incorporates physical processes such as wave propagation, wave generation by wind, white-capping, shoaling, wave breaking, bottom friction, sub-sea obstacles, wave setup and wave-wave interactions in its computations (Booij et al., 2004). Version 41.51 was used for this study.

Two model grid resolutions were used for the analysis: a coarse regional model (500 m resolution) of the Strait of Georgia and a nested fine local model (50 m resolution) covering the Nanaimo shoreline. A spatially varied wind field representing regional extreme wind conditions was applied and scaled to design wind speeds at Entrance Island derived from the JPA (Section 2.4). Figure 4.2 and Figure 4.3 show the simulated significant wave heights for the easterly 0.5% AEP scenario for the Strait of Georgia and the Nanaimo shoreline, respectively.



**Figure 4.2 SWAN-simulated  $H_s$  and wave direction for 1.0 m RSLR 0.5% AEP easterly event (coarse grid). Vectors show mean wave direction every 20 grid cells.**





**Figure 4.3 SWAN-simulated  $H_s$  and wave direction for 1.0 m RSLR 0.5% AEP easterly event (resolved grid). Vectors show mean wave direction every 20 grid cells.**

Spectral wave parameters were extracted from the SWAN model, including significant wave height ( $H_s$ ), peak wave period ( $T_p$ ), mean wave direction, and directional spreading<sup>3</sup>. These parameters were used as inputs to the local wave effects assessment described in the following section.

<sup>3</sup> Goda (2000) describes irregular waves as being composed of “many component waves propagating in various directions”, therefore, directional spreading is a concept used to describe the “distribution of wave energy ... in the direction[al]” space.



### 4.3 Nearshore Wave Effects

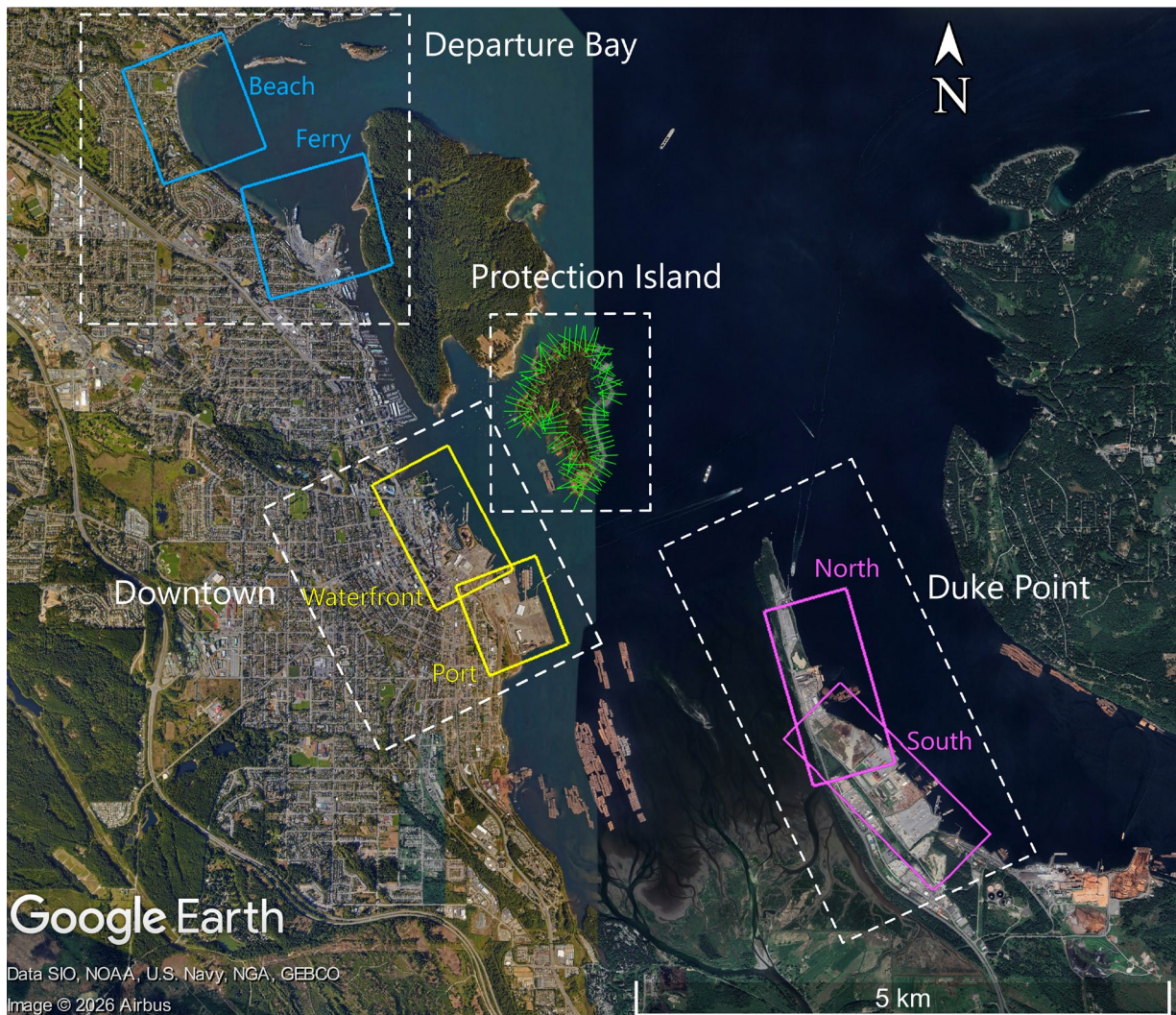
Following SWAN simulation, local wave effects were evaluated for four shoreline regions identified for flood hazard assessment and mapping. The study areas comprise Departure Bay, Downtown Nanaimo, Duke Point, and Protection Island. To facilitate the detailed assessment, each region was further subdivided into smaller modelling domains or representative shoreline transects:

- Departure Bay: Beach and Ferry Terminal
- Downtown Nanaimo: Port and Waterfront
- Duke Point: North and South
- Protection Island – Representative shoreline transects

Non-hydrostatic XBeach modelling was undertaken for the Departure Bay, Downtown Nanaimo, and Duke Point domains to simulate nearshore wave transformation, wave runup, inundation, and overland wave heights over the site-specific bathymetry and topography. These shoreline areas contain ports, ferry terminals, and other urban infrastructure where a detailed process-based assessment was needed.

For Protection Island, wave runup was estimated using empirical equations applied to representative shoreline transects. The shoreline consists predominantly of residential foreshore properties with relatively uniform shoreline characteristics, for which empirical wave runup calculations were considered appropriate for the flood hazard assessment.

The XBeach modelling domains and representative transects used for the empirical wave runup calculation at Protection Island are shown in Figure 4.4.



**Figure 4.4 Modelling regions (white dashed border) with detailed modelling domains (solid coloured border) and runup transects (solid green lines). Adapted from Google Earth.**

### 4.3.1 Non-Hydrostatic Wave Modelling

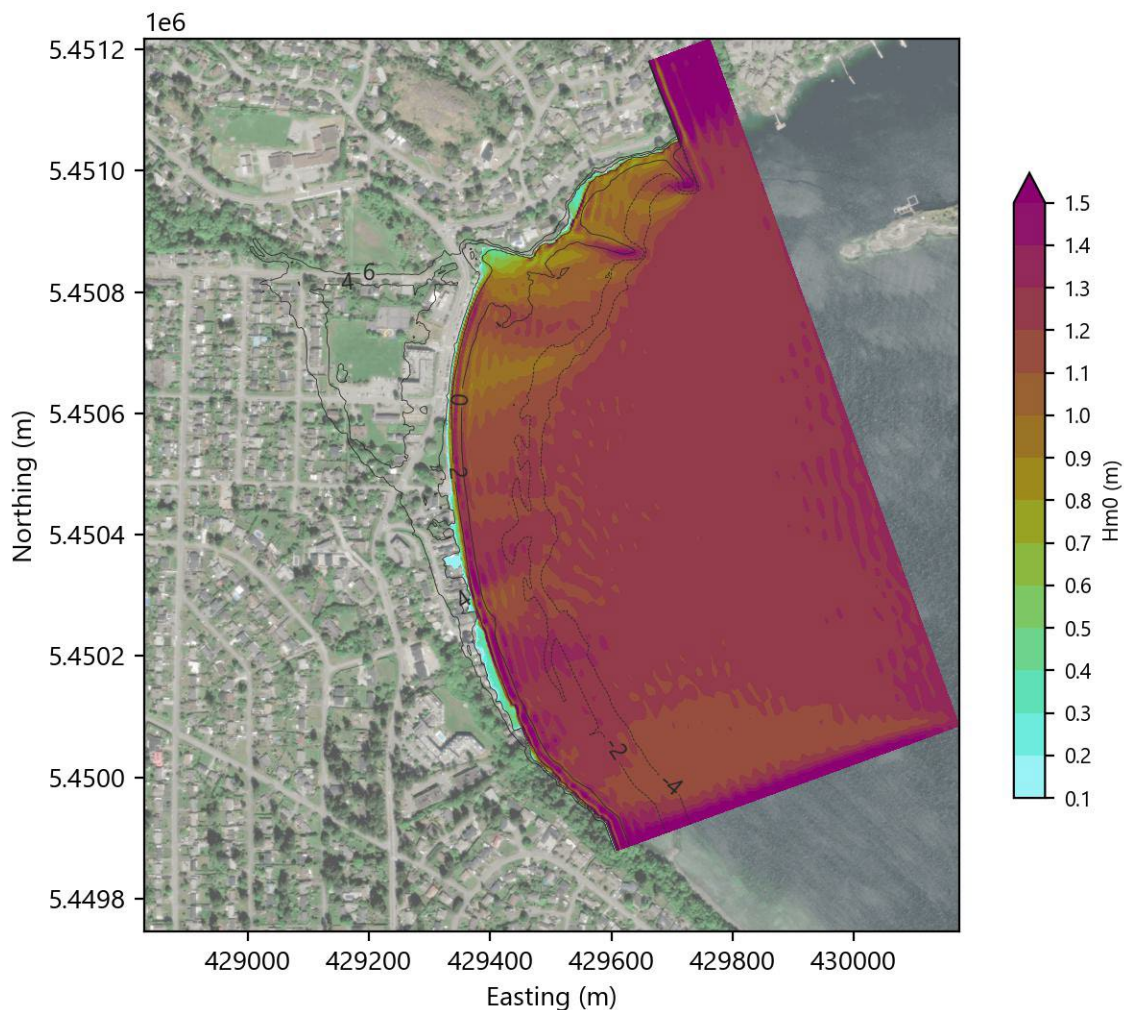
Nearshore wave transformation at Departure Bay, Downtown Nanaimo, and Duke Point was simulated using the numerical model XBeach. XBeach is an open source numerical model used to assess hydrodynamic and morphodynamic processes on coastlines for a variety of domain sizes and time scales (Deltares, 2018). *XBeach v1.24.6057 (Halloween release)* was used in this study.

The two-dimensional XBeach models were run in non-hydrostatic mode with sediment transport disabled, as the objective of the study was to assess wave transformation and coastal inundation

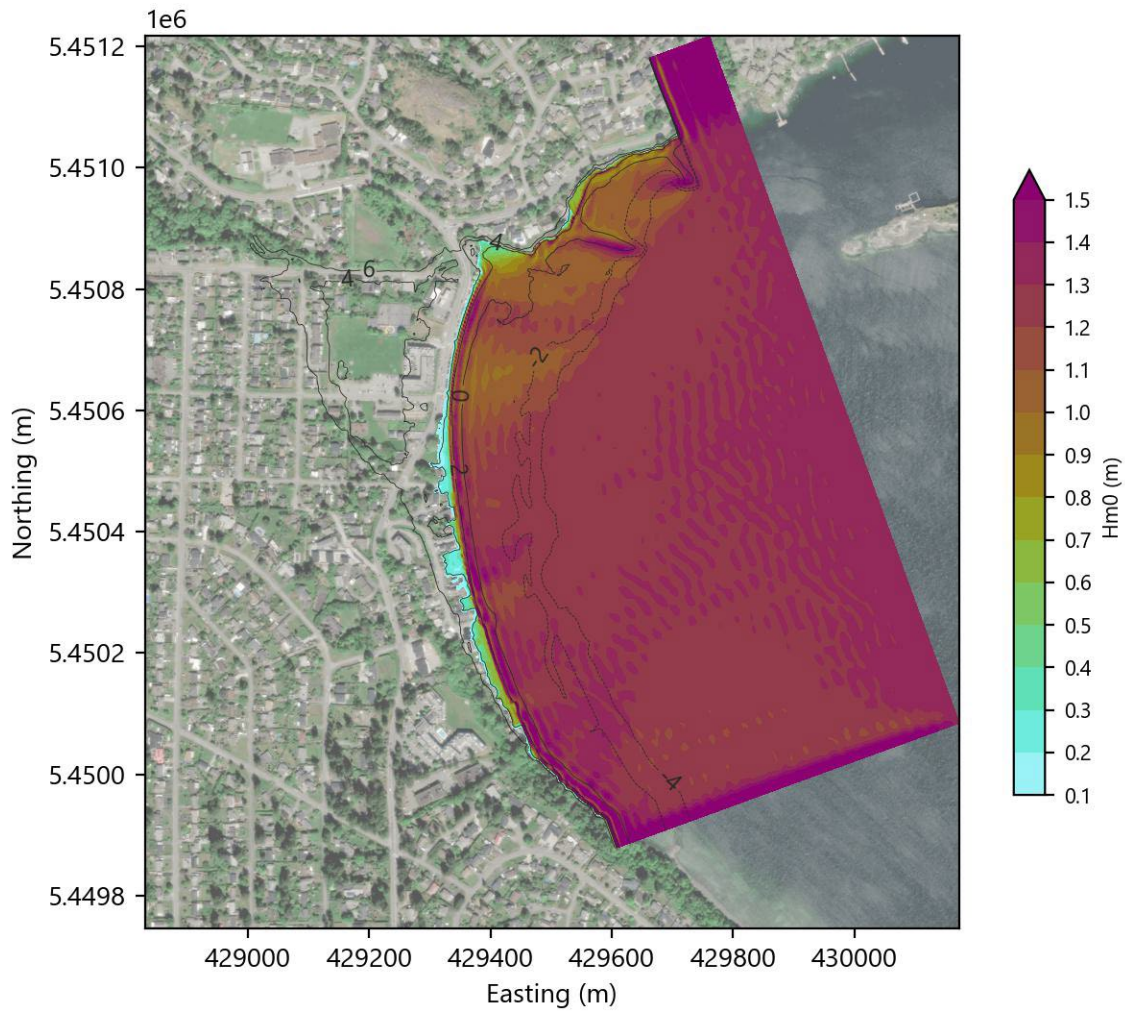


rather than shoreline morphology. The model bathymetry and topography were derived from the DEM described in Section 3. Offshore wave conditions from the SWAN model (Section 4.2) were applied as model boundary conditions. The lateral extents of each model domain were extended to create a uniform shoreline and reduce model error due to irregularities at the outer boundaries. Model results are not considered for these modified sections of shoreline.

The model outputs included wave crest elevations, significant wave height ( $H_{m0}$ ), wave runup, and inundation extent. Wave crest elevations were subsequently used in the flood hazard assessment to generate the wave effects mapping and FCL development. Simulated significant wave heights ( $H_{m0}$ ) at the Departure Bay Beach domain for the 0.5% AEP scenario are presented for RSLR of 0 m (Figure 4.5), 0.5 m (Figure 4.6), 1 m (Figure 4.7), and 2 m (Figure 4.8).

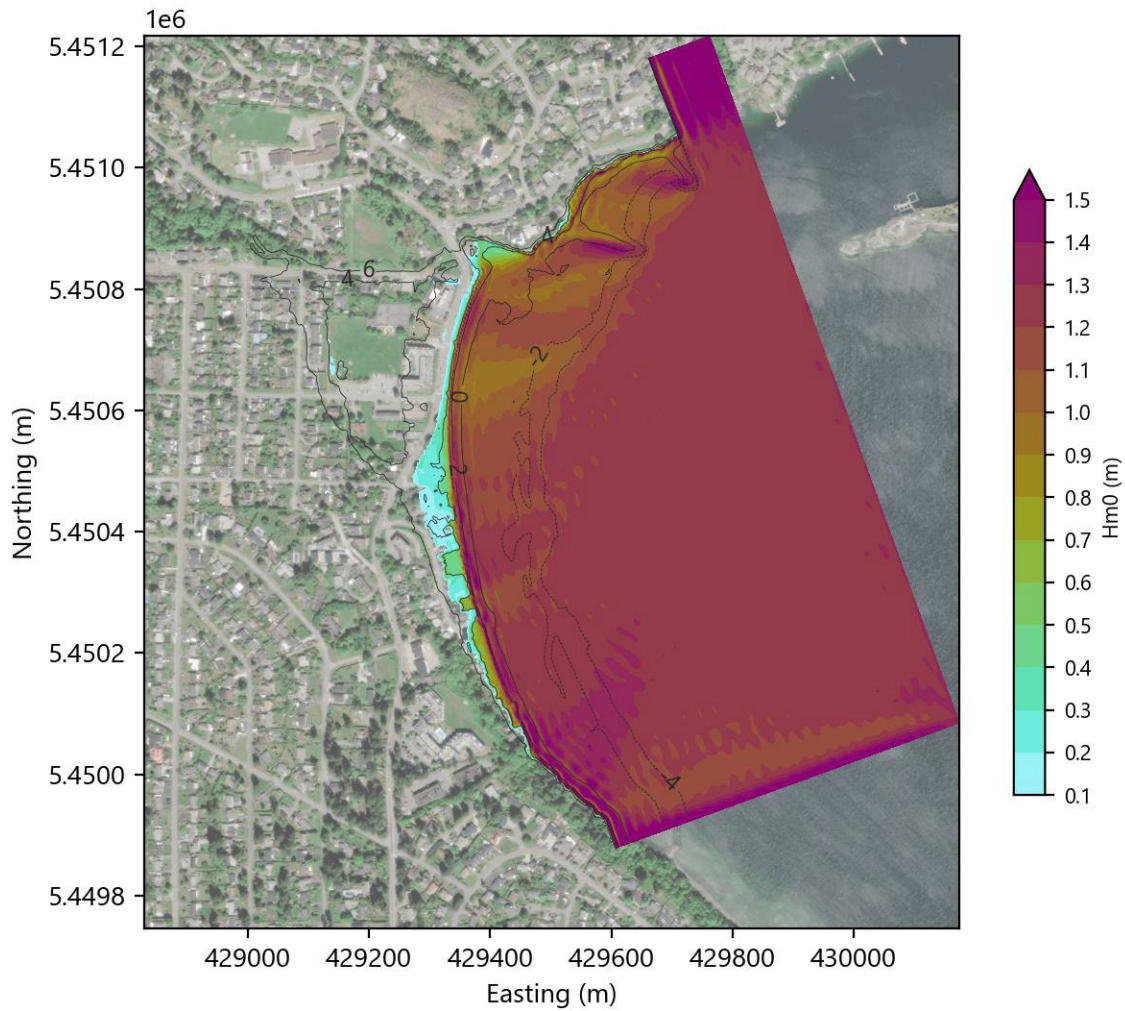


**Figure 4.5 XBeach-simulated  $H_{m0}$  for 0.0 m RSLR 0.5% AEP easterly event at Departure Bay - Beach**

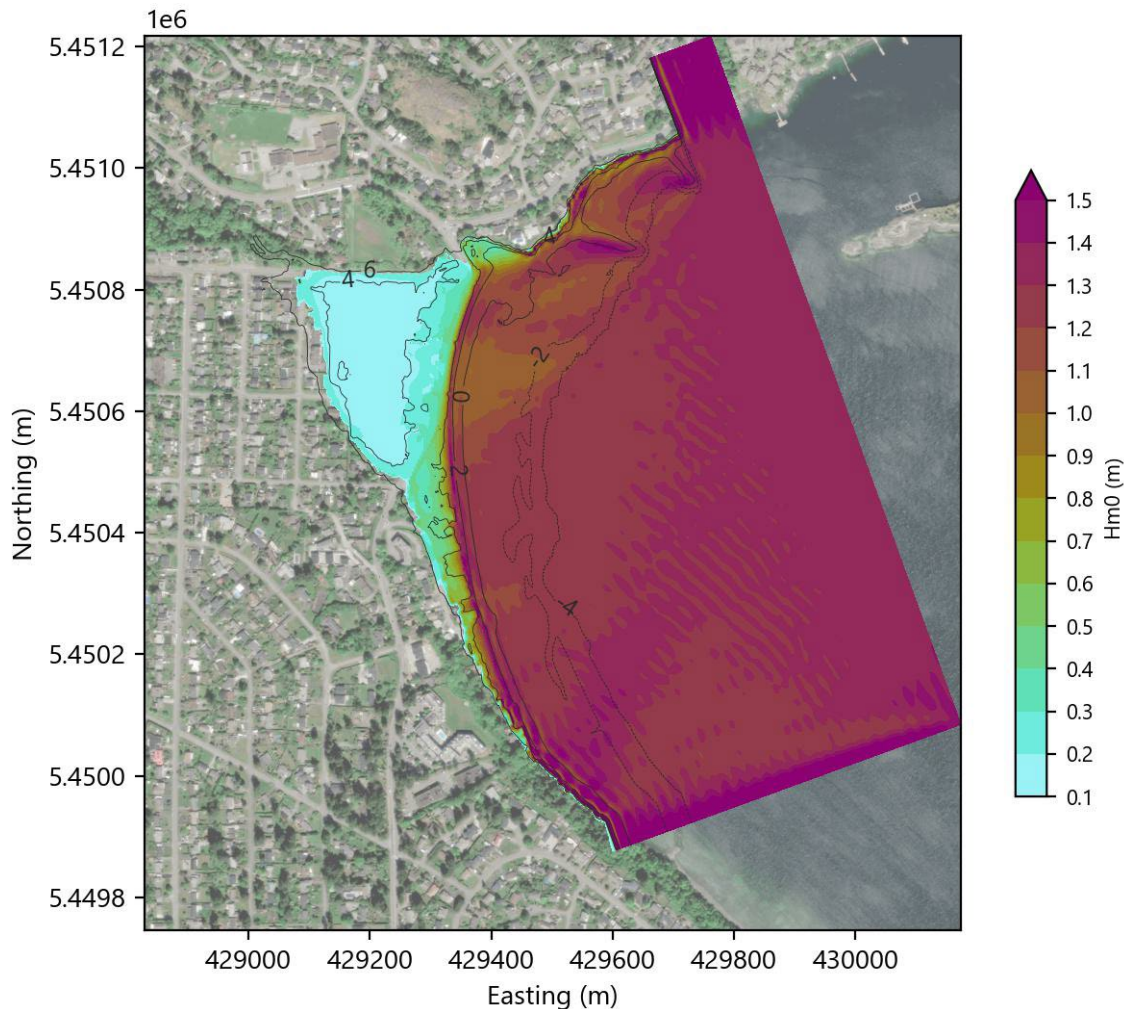


**Figure 4.6 XBeach-simulated  $H_{m0}$  for 0.5 m RSLR 0.5% AEP easterly event at Departure Bay - Beach.**





**Figure 4.7 XBeach-simulated  $H_{m0}$  for 1.0 m RSLR 0.5% AEP easterly event at Departure Bay - Beach.**



**Figure 4.8 XBeach-simulated  $H_{m0}$  for 2.0 m RSLR 0.5% AEP easterly event at Departure Bay - Beach.**

Within the Departure Bay Beach domain, the offshore significant waves heights show little variation between RSLR cases for the same storm event. However, the inundation extents and wave exposure nearshore is more sensitive and increases with RSLR. Scenarios with RSLR and a higher mean sea level mean that water can flow over beaches and shoreline protective features, such as seawalls, more readily. As the inundation depth increases with RSLR, so can the size of the waves that propagate overland.

### 4.3.2 Empirical Runup Calculation

Flood hazards at Protection Island were estimated using empirical wave runup formulae. Wave runup expressed as the 2% exceedance runup elevation ( $R_2\%$ ), representing the elevation

exceeded by 2% of incident waves. The resulting  $R_2\%$  values were combined with the design still water levels to estimate total water levels (TWLs) for wave effects mapping and the development of flood construction levels (FCLs).

Wave runup was estimated along 89 cross-shore transects distributed approximately every 50 m along the shoreline. Each transect incorporated the local foreshore slope, shoreline characteristics, and nearshore wave conditions derived from the SWAN model. Two empirical methods were applied:

- EurOtop (2018): applicable to engineered and natural sloping shorelines.
- Stockdon et al. (2006): applicable to natural, dissipative sandy beaches.

For each transect, the empirical method considered most appropriate for the shoreline conditions was applied to estimate  $R_2\%$ . The resulting runup elevations were added to the design still water level to calculate the TWL used to generate the wave effects mapping and FCL development.

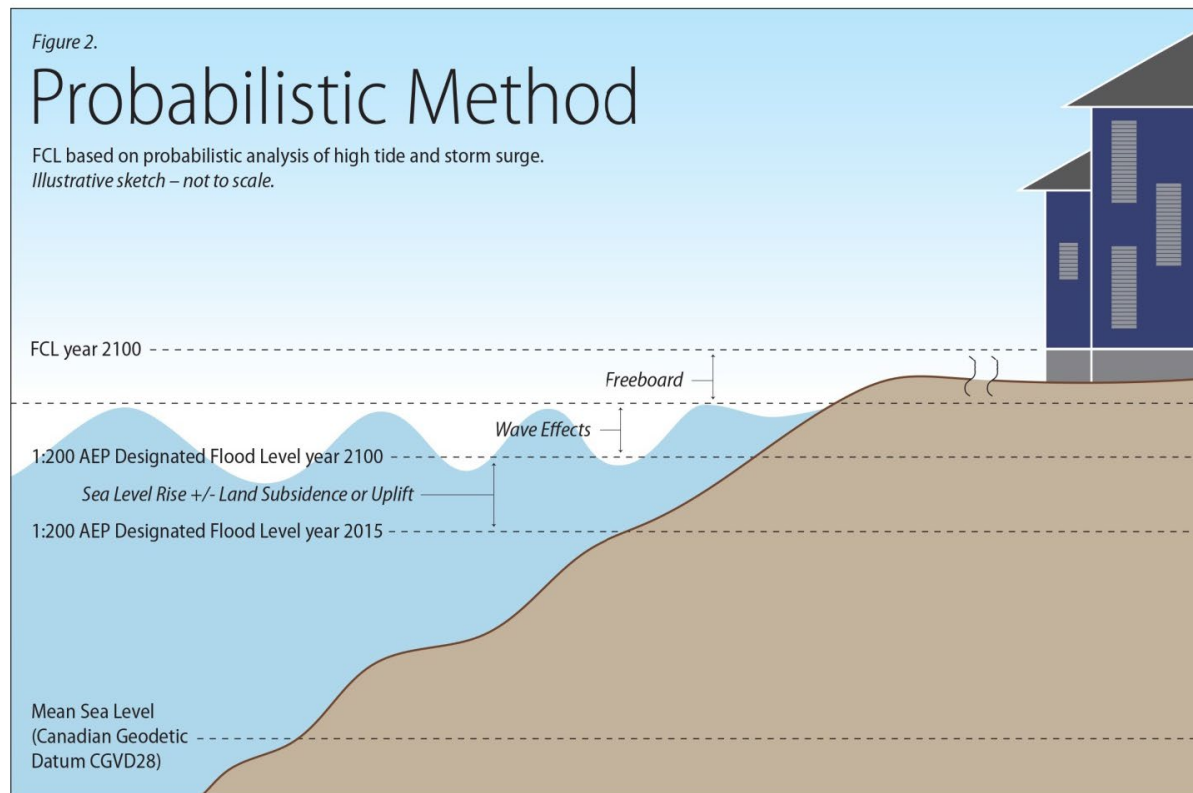
## 5 FLOOD CONSTRUCTION LEVEL

The FCL represents the recommended minimum building elevation to reduce the likelihood of flood damage during extreme water level events. It is determined by combining the design still water level, relative sea level rise (RSLR), wave runup, and freeboard to define the design coastal flood elevation.

The FCL methodology follows the probabilistic method described in the Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use (BC Ministry of Environment, 2011a) and the 2018 amendment by the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BCMFLNRORD). Consistent with provincial guidance and illustrated in Figure 5.1, the FCL is composed of:

- 0.5% AEP (1-in-200 year) still water level (Section 2.1)
- 1.0 m RSLR allowance (Section 2.2)
- 0.5% AEP (1-in-200 year) wave run-up determined from coastal inundation assessment (Section 4)
- 0.6 m freeboard to account for uncertainty and localized effects

The resulting FCL represents the recommended minimum building elevation for the 0.5% AEP (1-in-200 year) coastal flood event, including projected sea level rise to 2100, wave effects, and freeboard.



**Figure 5.1 Components of FCL (adapted from BCMFLNRORD, 2018).**

## 6 LIMITATIONS AND USE CONSIDERATIONS

The inundation, FCL, and risk assessment results are subject to the following limitations:

- Design forcing: The analysis is based on probabilistic design water levels and wind conditions derived from historical observations. The selected design events represent the best available estimates but are subject to uncertainty associated with the statistical analyses and future climate conditions.
- Representative shoreline conditions: Representative shoreline transects were used for the empirical wave runup calculations. Local variations in foreshore geometry or shoreline characteristics between transects may not be fully represented.
- Wind data uncertainty: Design wind conditions were derived primarily from the Entrance Island wind record. Although this station provides the best available representation of offshore wind conditions for the study area, spatial variability in extreme wind events may influence local wave conditions.





- DEM: The DEM represents the best available topographic and bathymetric information at the time of the study. Surface conditions may have changed since the surveys were completed, and uncertainties in the underlying datasets may influence the mapped flood extents and wave effects.
- Static shoreline assumption: The analysis assumes present day shoreline morphology and does not account for future erosion, sediment transport, or other dynamic coastal processes that could affect flood exposure over time.

## 7 REFERENCES

- BC Ministry of Environment (2011a). *Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Sea Dike Guidelines*. [online] Available from: [https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/sea\\_dike\\_guidelines.pdf](https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/sea_dike_guidelines.pdf).
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- Mazas, F., Kergadallan, X., Garat, P., and Hamm, L. (2014). Applying POT methods to the Revised Joint Probability Method for determining extreme sea levels. *Coastal Engineering*, 91, 140–150. doi:10.1016/j.coastaleng.2014.05.006.



Stockdon, H. F., Holman, R. A., Howd, P. A., and Sallenger Jr., A. H. (2006). Empirical parameterization of setup, swash, and runup. *Coastal Engineering*, 53(7), 573–588. doi:10.1016/j.coastaleng.2005.12.005.

# **APPENDIX C**

## **FLOODPLAIN MAPS**



Notes to User

1. Study Area
- The study area includes selected shorelines within the City of Nanaimo. The associated report should be read and understood prior to use of the maps:  
*Northwest Hydraulic Consultants Ltd. (2026). City of Nanaimo's Sea Level Rise Management Plan. Technical Report*
2. Vertical Datum
- All elevations are in metres referenced to the Canadian Geodetic Vertical Datum of 2013 (CGVD2013), consistent with provincial LiDAR datasets. Previous floodplain mapping completed for the City of Nanaimo in 2018 also used CGVD2013. Some City datasets and records reference elevations in CGVD1928. Where comparison between datums is required, elevations in CGVD2013 should be converted to CGVD1928 by subtracting 0.16 for the study area.
3. Design Flood Event
- The design event used in the Flood Construction Level (FCL) maps represent the combined effect of a 0.5% AEP (1-in-200-year) joint tide, storm surge, and wave run-up ( $R_2\%$ ) with sea level rise.
4. FCL Mapping
- Floodplain maps present the FCL and delineated FCL extents under the design flood conditions.
- a. FCLs were calculated as the sum of the design still water level, 1.0 m sea level rise, wave run-up ( $R_2\%$ ), and the applicable freeboard allowance.

b. The freeboard allowance accounts for uncertainty and localized variation in water level, including shoreline conditions and data accuracy. A 0.6 m freeboard was applied in all mapped areas.

c. A Joint probability analysis combing waves and water levels was used to determine the critical wave conditions for each study area. Potential critical conditions were first screened using offshore spectral wave model results and empirical wave run-up equations to identify combinations producing the largest total water level, defined as the design still water level plus wave effects. These conditions were then simulated using the nearshore XBeach model to refine wave run-up estimates for FCL mapping. In a few cases, the combined wave run-up and joint probability water level resulted in a lower elevation than the design still water level without wave effects. Where this occurred, the design still water level was applied as the controlling elevation to avoid underestimation of flood levels.

d. Wave run-up heights were calculated using simulated wind-generated waves, with  $R_2\%$  defined as the elevation exceeded by 2% of waves, equivalent to one in fifty waves. These estimates account for shoreline slope, profile, roughness, and incident wave conditions.

e. The wave-effect zone was delineated by extending wave run-up inland from the design still water level plus freeboard contour until it intersected with the ground surface. Within this zone, FCLs reflect the combined effect of design still water level, sea level rise, wave run-up, and freeboard. Outside this zone, FCLs are based on still water level plus sea level rise and freeboard only, with no wave effects included.

f. Where a property or development site lies between two adjacent FCL isolines, the higher of the two values should be applied.

g. How to read the maps:
  - The light blue line shows the design still water level plus freeboard, excluding wave effects.
  - The dark purple line shows the wave runoff zone.
  - Numbers along isolines indicate the recommended FCL elevation at that location.
  - Coloured shading represents wave run-up height categories for  $R_2\%$ , defined as less than 1 m, 1 to 2 m, 2 to 3 m, and greater than 3 m.

h. A site-specific wave run-up assessment by a Qualified Professional may be warranted where:
  - mapped results show a wide range in run-up values,
  - shoreline conditions are highly dynamic or differ substantially within the generalized segment or from adjacent areas, including slope, depth, or roughness,
  - the project involves high-consequence infrastructure or multi-lot development
5. Limitations of Mapping
- The FCL and wave effects mapping results are based on BC floodplain mapping guideline design scenarios. Flood events more extreme than the design event are possible but are expected to occur less frequently. Design values are based on historic water level conditions, present shoreline conditions, and projected sea level rise, using a combination of metocean analysis and numerical wave and wave run-up modelling. While this and similar approaches are commonly used to characterize future hazards, actual future conditions may differ from those represented. Additional hazards from other sources may exist, and local conditions may change over time. The analysis assumes present-day shoreline conditions and does not account for future erosion, sediment transport processes, or construction of coastal protection works. Localized stormwater, tributary flooding, or groundwater conditions may influence flood extents.
6. Accuracy
- The accuracy of simulated flood levels is limited by the reliability of historic tide and surge records, wind data, wave data, and available elevation data. In some locations, localized topographic or hydraulic features may be generalized in the floodplain mapping. The map should therefore be considered an administrative planning tool that illustrates expected flood elevations and floodplain boundaries for the design event, rather than a definitive representation of any specific future flood. A Qualified Professional should be consulted for site-specific hazard assessment and mitigation, particularly for high-consequence developments such as subdivisions or critical infrastructure.
7. Residual Risk
- Industry standard methods and best practices were applied in the preparation of the floodplain maps. However, actual flood levels and extents may differ from those shown. Residual flood risk exists beyond the mapped limits, particularly during events more extreme than the design event. Northwest Hydraulic Consultants Ltd. and City of Nanaimo do not assume liability for variations in flood levels or extents relative to those depicted on the maps.
8. Coastal Flooding Diagram
- The diagram shown on the index map provides a simplified explanation of the drivers of coastal flooding. In addition to reviewing the diagram, map users should refer to and understand these map notes prior to using the maps.
9. Future Design Water Level Extent
- The design flood inundation extent (or future design water level extent), at 3.97 m elevation, is the combined 0.5% AEP (1-in-200-year) joint tide, storm surge and sea level rise elevation. It excludes waves and freeboard.
10. Protection Island Specific Map Notes
- For map notes specific to Protection Island, refer to map sheet two.

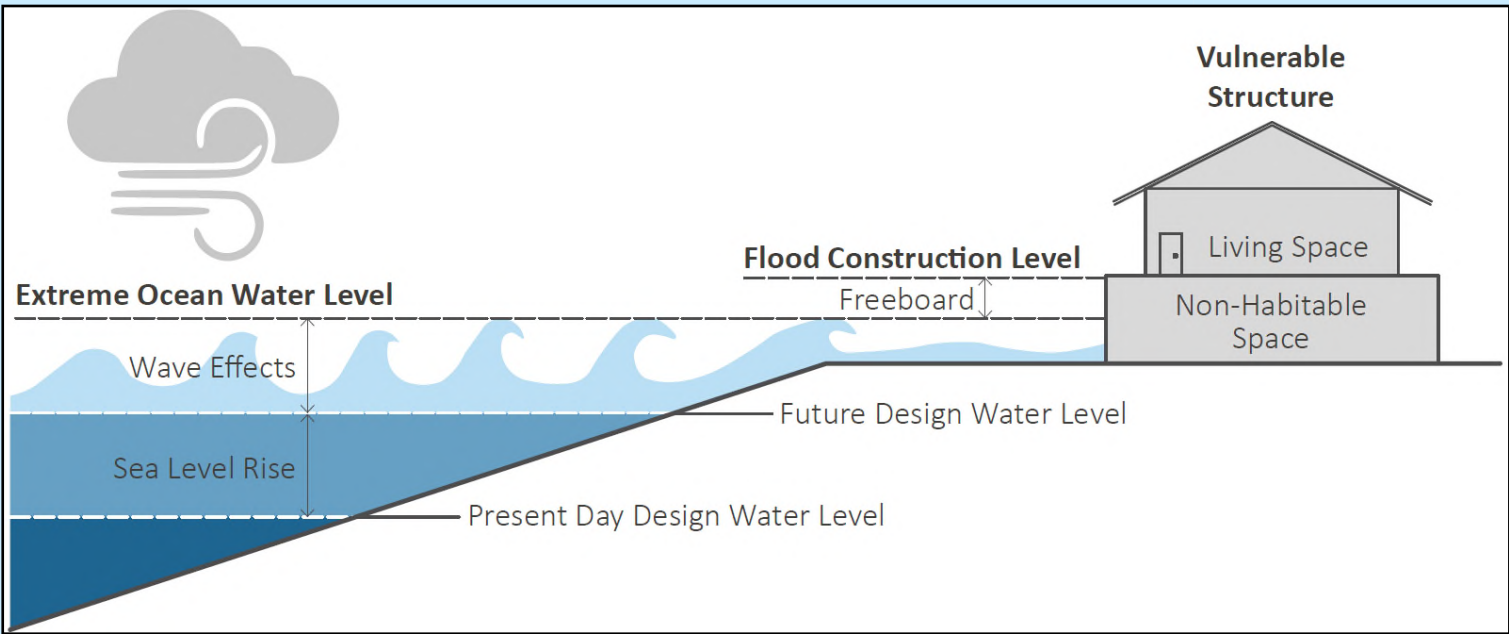
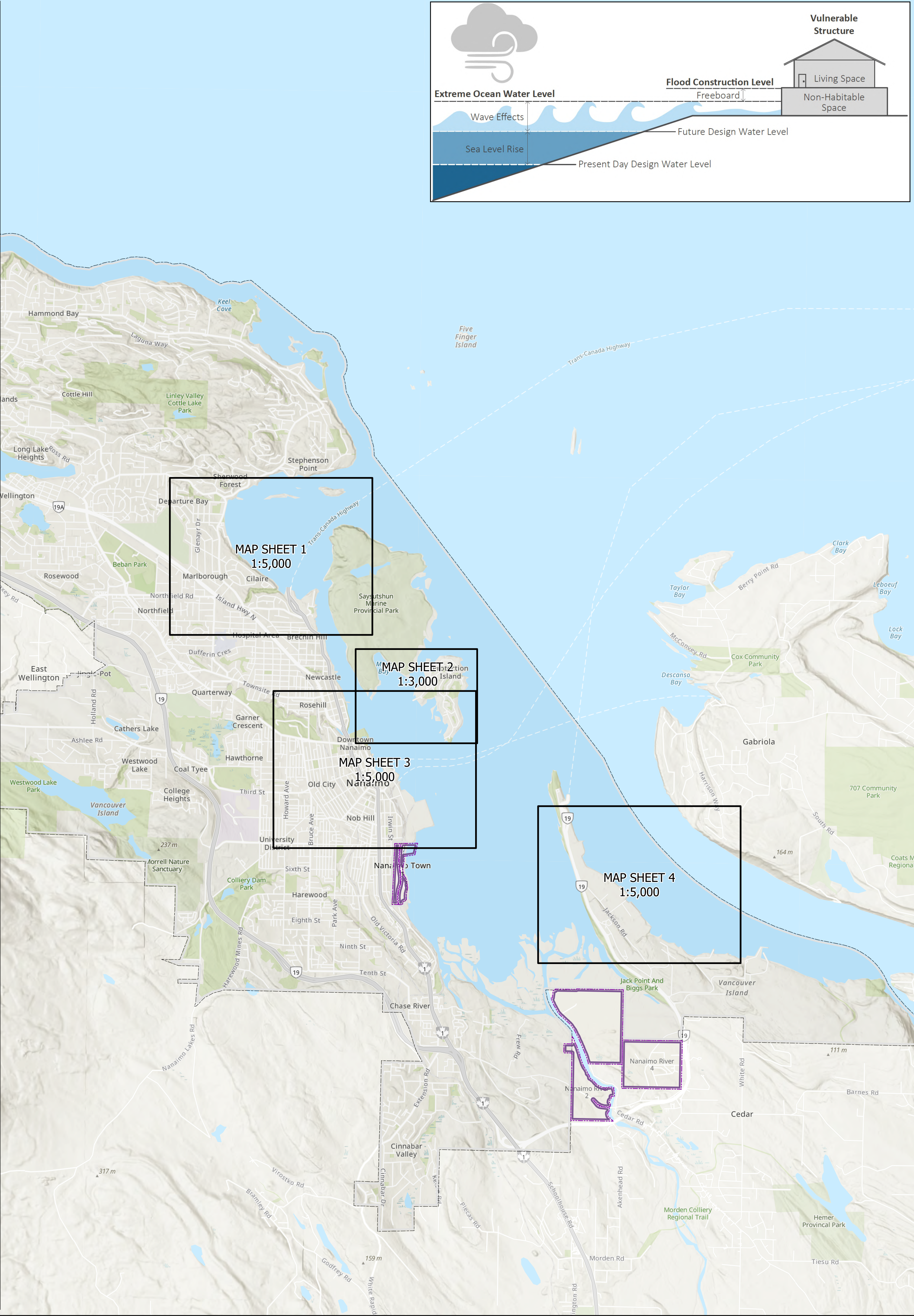
Data Sources

1. Design still water levels are based on and Extreme Value Analysis of Canadian Hydrographic Service tide gauge records, primarily Point Atkinson (CHS ID 7795), with local adjustments derived from Nanaimo Harbour (CHS ID 7917). Joint probability analysis of tide and storm surge was used to estimate 0.5% AEP (1-in-200-year) design still water levels.
2. Joint Probability of water levels and winds, using Entrance Island (Climate ID 1022689), was used to model nearshore wave climate with spectral wave model SWAN.
3. The digital elevation model (DEM) used for mapping was developed from the following datasets to produce a continuous bare-earth surface referenced to CGVD2013:
  - 2019 Provincial LiDAR from GeoBC.
  - Canadian Hydrographic Service NONNA10 bathymetry.
4. Orthophoto Imagery
- Orthophotos were obtained from City of Nanaimo (2024) and were used to provide contextual reference for shoreline features and land use.
5. GIS Data
- Parcel boundaries, road networks, streams, and lakes were compiled from municipal provincial and federal open data sources, including the City of Nanaimo, BC Data Catalogue, Natural Resources Canada.

Disclaimer

This coastal flood hazard mapping has been prepared by **Northwest Hydraulic Consultants Ltd.** for the **City of Nanaimo**. The information and data contained herein represent Northwest Hydraulic Consultants Ltd.'s professional judgment in light of the knowledge and information available at the time of preparation. The work was carried out in accordance with generally accepted engineering and geoscience practices and applicable professional guidelines.

The mapping products are intended to inform land use planning, floodplain management, emergency preparedness, and climate adaptation in the **City of Nanaimo**. They should be interpreted as planning-level information. A Qualified Professional should be consulted to confirm local conditions and undertake site-specific hazard assessment prior to development.



- MAP SHEET

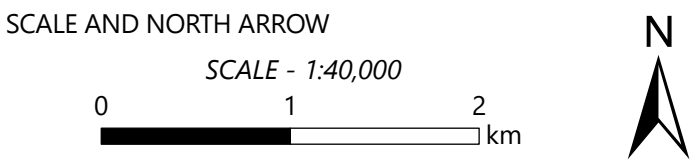
FIRST NATIONS ADMINISTRATIVE AREA

CITY OF NANAIMO

DATA SOURCES  
Basemaps from Esri. Reference data from GeoBC

|                            |            |                     |
|----------------------------|------------|---------------------|
| ENGINEER<br>VCCM           | GIS<br>BLH | REVIEWER<br>PDO     |
| NHC PROJECT No.<br>3010048 |            | DATE<br>26-AUG-2026 |

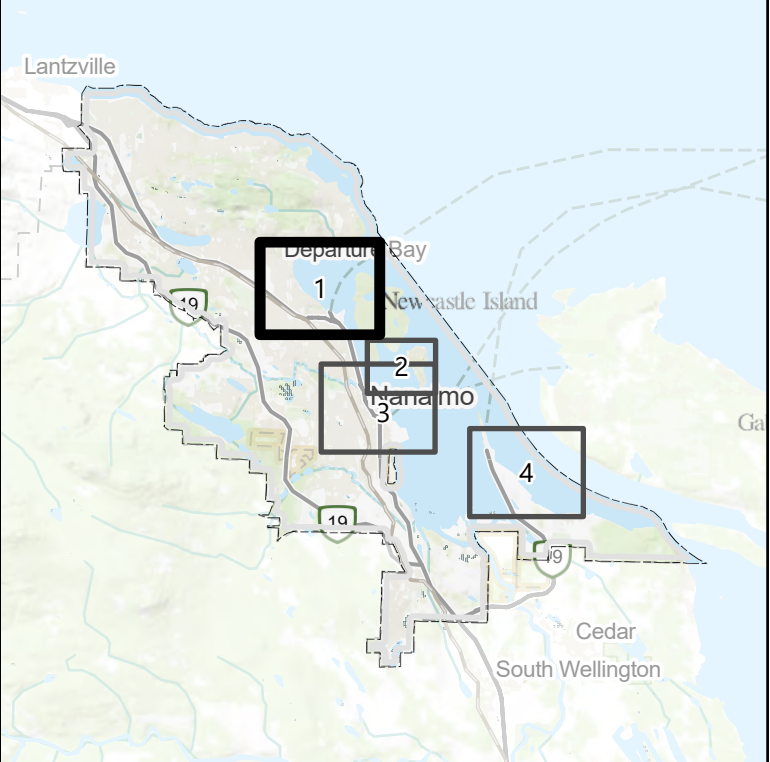
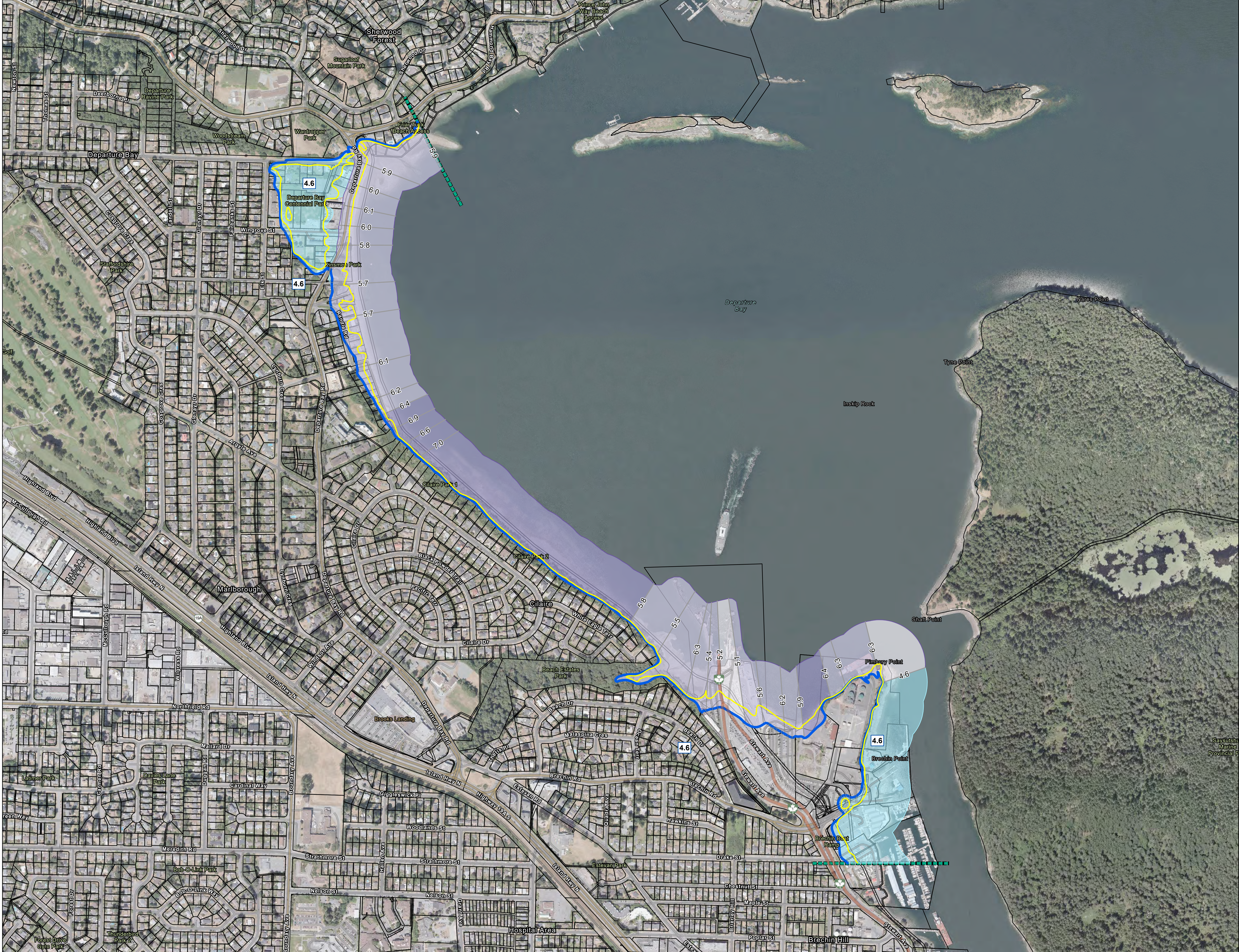
COORD SYS. AND DATUM  
HORIZ: NAD 1983 CSRS UTM ZONE 10N  
VERT: CGVD2013  
UNITS: METRES



CITY OF NANAIMO  
SEA LEVEL RISE MANAGEMENT PLAN

FLOOD CONSTRUCTION LEVEL  
INDEX MAP





FIRST NATIONS ADMINISTRATIVE AREA

CITY OF NANAIMO

EXTENT OF 2024 IMAGERY

PROPERTY PARCEL BOUNDARY

MAPPING LIMIT

DESIGN FLOOD CONSTRUCTION LEVEL (FCL)  
COMPRISED OF THE 200 YEAR JOINT TIDE,  
STORM SURGE, AND WAVE RUN-UP (R<sub>2%</sub>)  
WITH 1 m OF SEA LEVEL RISE (SLR), (m)

DESIGN FLOOD INUNDATION EXTENT  
INCLUDING SLR AND FREEBOARD

DESIGN FCL ZONE  
INCLUDING SLR AND FREEBOARD (m)

FCL EXTENT

VERTICAL WAVE RUNUP (m)

< 1.0

1.0 - 2.0

2.0 - 3.0

> 3.0

FUTURE DESIGN WATER LEVEL EXTENT  
200 YEAR DESIGN WATER LEVEL  
INCLUDING SLR AND EXCLUDING  
WAVE EFFECTS AND FREEBOARD (m)

AREA NOT MODELLED

PLEASE REFER TO THE MAP SERIES INDEX SHEET,  
INCLUDING MAP NOTES, FOR SPECIFIC MAPPING  
AND REPORT INFORMATION

DATA SOURCES  
2024 imagery from City of Nanaimo within data extents, and Esri elsewhere;  
Basemap labels from Esri; Inset basemap from Esri; Reference data from  
GeoBC

|                                                                                              |            |                     |
|----------------------------------------------------------------------------------------------|------------|---------------------|
| ENGINEER<br>VCCM                                                                             | GIS<br>BLH | REVIEWER<br>PDO     |
| NHC PROJECT No.<br>3010048                                                                   |            | DATE<br>26-AUG-2026 |
| COORD SYS. AND DATUM<br>HORIZ: NAD 1983 CSRS UTM ZONE 10N<br>VERT: CGVD2013<br>UNITS: METRES |            |                     |
| SCALE AND NORTH ARROW<br>SCALE - 1:5,000<br>0 100 200 300 m<br>N                             |            |                     |



CITY OF NANAIMO  
SEA LEVEL RISE MANAGEMENT PLAN

FLOOD CONSTRUCTION LEVEL MAP  
SHEET 1 OF 4



Notes to User

1. Study Area
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2. Vertical Datum
- All elevations are in metres referenced to the Canadian Geodetic Vertical Datum of 2013 (CGVD2013), consistent with provincial LiDAR datasets. Previous floodplain mapping completed for the City of Nanaimo in 2018 also used CGVD2013. Some City datasets and records reference elevations in CGVD1928. Where comparison between datums is required, elevations in CGVD2013 should be converted to CGVD1928 by subtracting 0.16 for the study area.
3. Design Flood Event
- The design event used in the Flood Construction Level (FCL) maps represent the combined effect of a 0.5% AEP (1-in-200-year) joint tide, storm surge, and wave run-up ( $R_2\%$ ) with sea level rise..
4. FCL Mapping
- Floodplain maps present the FCL and delineated FCL extents under the design flood.
- a. FCLs were calculated as the sum of the design still water level, 1.0 m sea level rise, wave run-up, and the applicable freeboard allowance.

b. The freeboard allowance accounts for uncertainty and localized variation in water level, including shoreline conditions and data accuracy. A default freeboard of 0.6 m was applied in all areas. In wave exposed areas where calculated wave run-up exceeded 0.3 m, freeboard was reduced to as low as 0.3 m to avoid double counting uncertainty already inherent in the empirical run-up methods, while maintaining a minimum combined allowance of wave run-up plus freeboard of 0.6 m.

c. Wave run-up heights were estimated at shoreline transects using empirical methods. The empirical calculations use nearshore wave conditions derived from spectral wave model together with local foreshore slope, roughness, and water depth during the design event. Wave run-up is defined by  $R_2\%$ , the elevation exceeded by 2% of waves, equivalent to one in fifty.

d. The wave effect zone was delineated by extending wave run-up inland from the design still water level plus freeboard contour until it intersected with the ground surface, to a maximum inland extent of 30 m. Within this zone, FCLs reflect the combined effects of design still water level, sea level rise, wave run-up, and freeboard. Outside this zone, FCLs are based on still water level plus sea level rise and freeboard only, with no wave effects included.

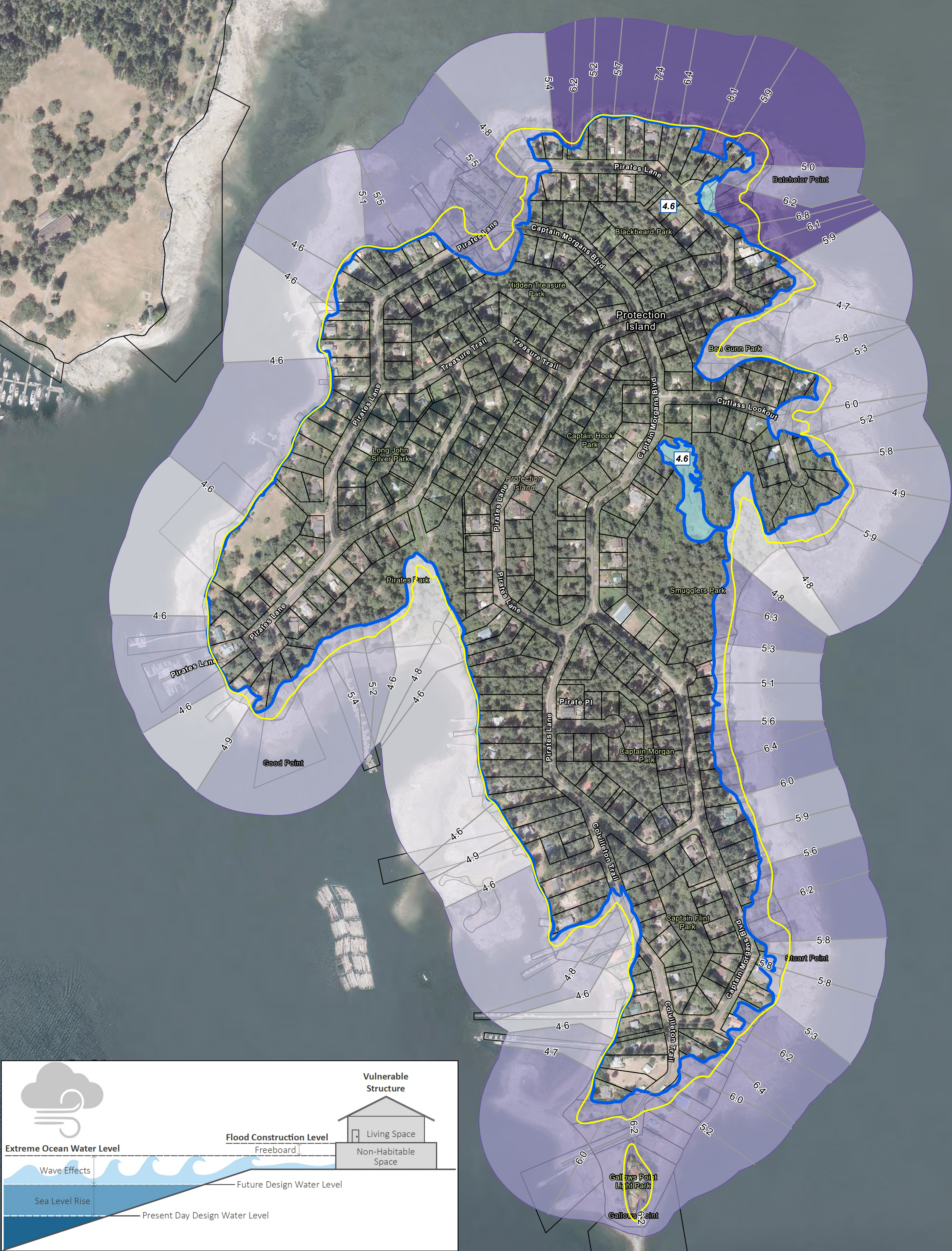
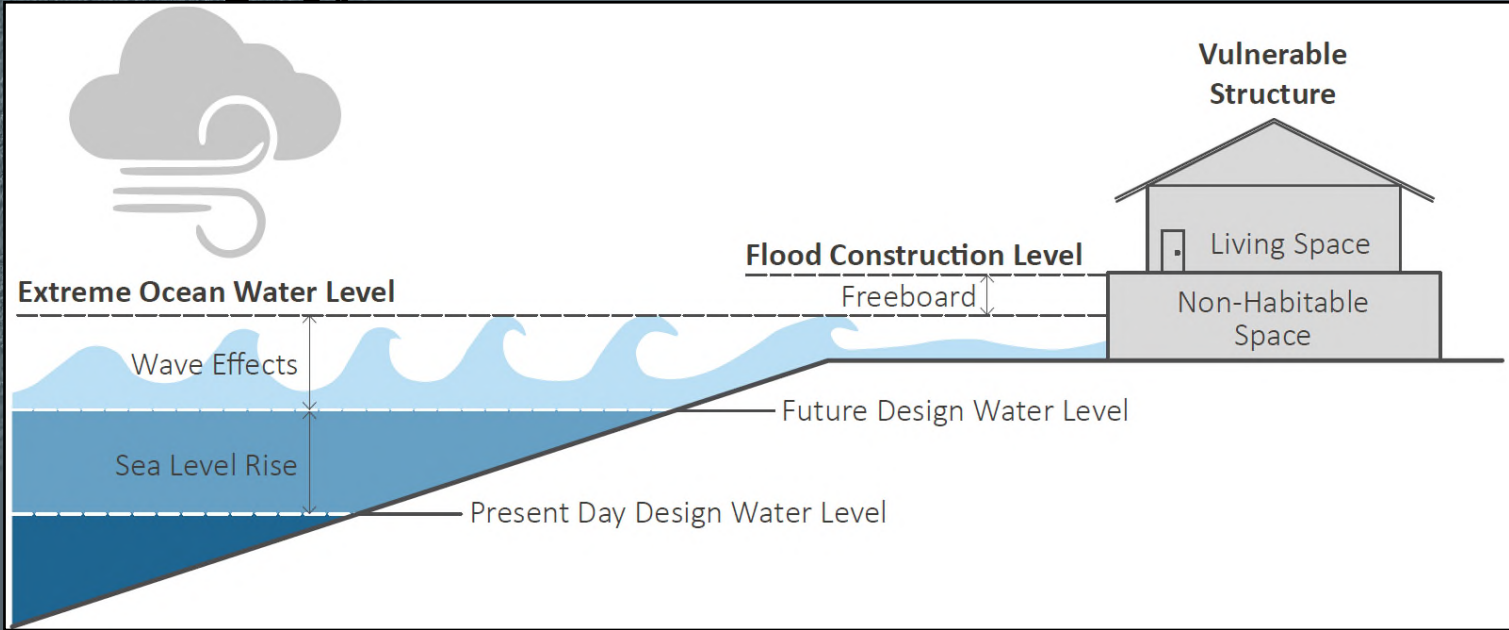
e. Where a property or development site lies between two adjacent FCL isolines, the higher of the two values should be applied.

f. How to read the maps:
  - The light blue line shows the design still water level plus freeboard, excluding wave effects.
  - The dark purple line shows the wave runoff zone.
  - Numbers along isolines indicate the recommended FCL elevation at that location.
  - Coloured shading represents wave run-up height categories for  $R_2\%$ , defined as less than 1 m, 1 to 2 m, 2 to 3 m, and greater than 3 m.

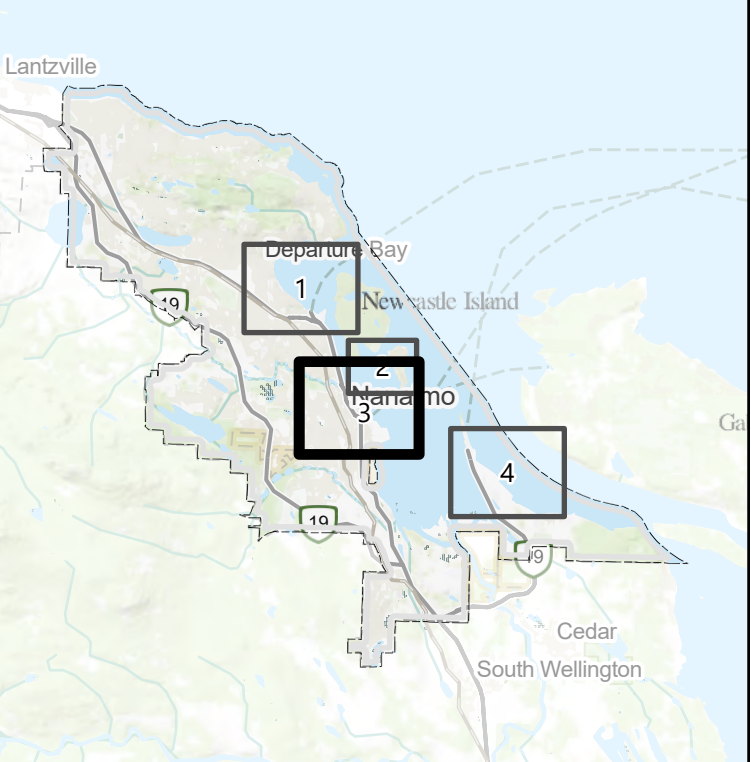
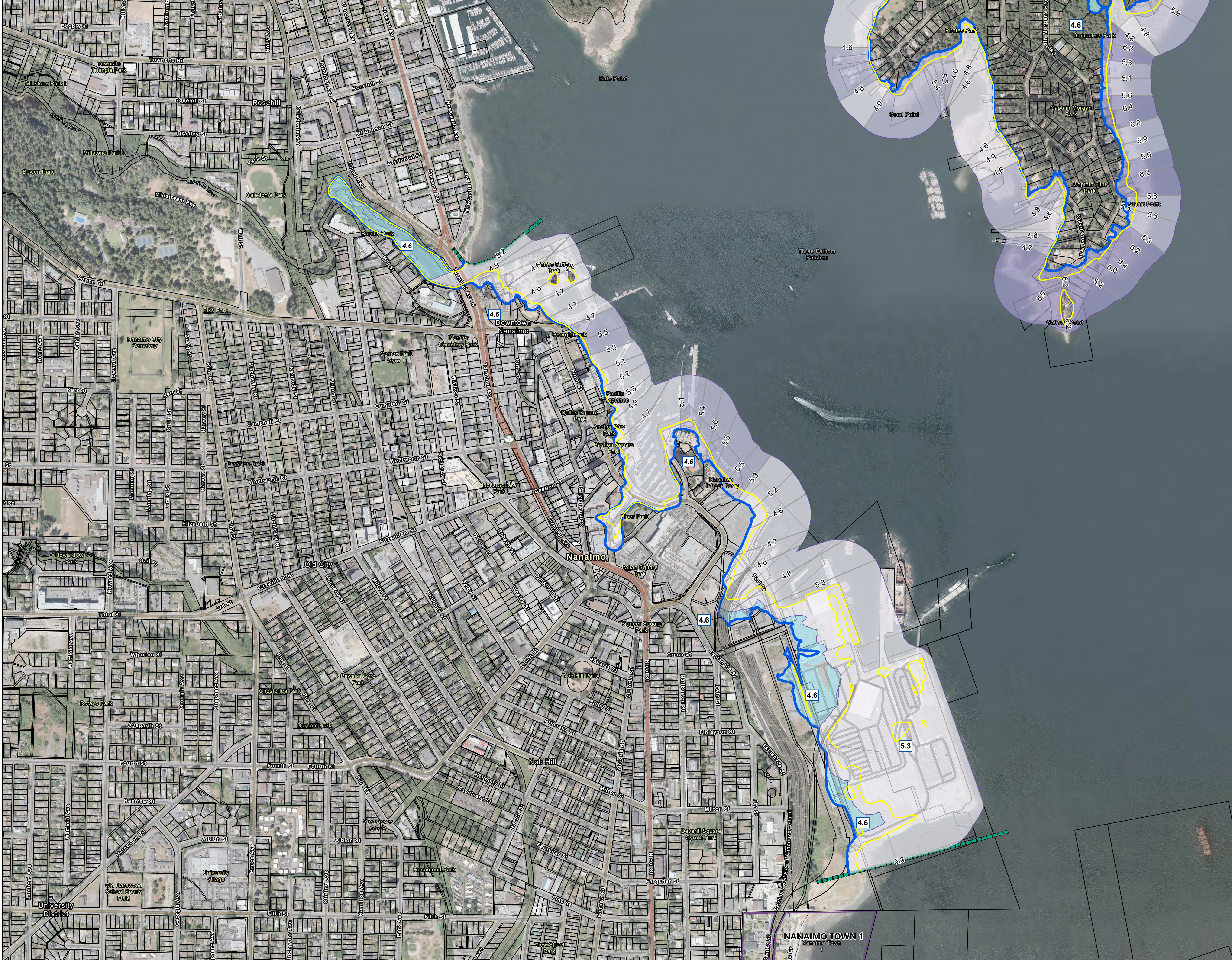
g. Mapping results are based on applying representative shoreline conditions over generalizing shoreline segments. As a result, local variations in wave run-up may not be fully captured. A site-specific wave run-up analysis by a Qualified Professional may be warranted where shoreline conditions vary substantially within a mapped segment or relative to adjacent areas, or where the project involves high-consequence infrastructure or multi-lot development.
5. Limitations of Mapping
- The FCL and wave effects mapping results are based on guideline design scenarios. Flood events more extreme than the design event are possible but are less frequent and less likely. Design values are based on historic water level conditions, present shoreline conditions, and projected sea level rise using a combination of metocean analysis, numerical wave modelling, and empirical run-up equations. While these approaches are commonly used to characterize future hazards, actual future conditions may differ from those represented. Additional hazards from other sources may exist, and local conditions may change over time. The analysis assumes present day shoreline conditions and does not account for future shoreline erosion, sediment transport processes, or the construction of coastal protection works. Localized stormwater, tributary flooding, or groundwater effects may also influence flood extents.
6. Accuracy
- The accuracy of simulated flood levels is limited by the reliability of historic tide and storm surge records, wind data, empirical run-up equations, and available elevation data. In some locations, localized topographic or hydraulic features may be generalized in the floodplain mapping. The maps should therefore be considered an administrative planning tool that illustrates expected flood elevations and floodplain boundaries for the design event, rather than a definitive representation of any specific future flood. A Qualified Professional should be consulted for site-specific hazard assessment and mitigation, particularly for high-consequence developments such as subdivisions or critical infrastructure.
7. Residual Risk
- Industry standard methods and best practices were applied in the preparation of the floodplain maps. However, actual flood levels and extents may differ from those shown. Residual flood risk exists beyond the mapped limits, particularly during events more extreme than the design event. Northwest Hydraulic Consultants Ltd. and the City of Nanaimo do not assume any liability for variations in flood levels or extents relative to those depicted on the maps.
8. Coastal Flooding Diagram
- The diagram shown on the index map provides a simplified explanation of the drivers of coastal flooding. In addition to reviewing the diagram, map users should refer to and understand these map notes prior to using the maps.
9. Future Design Water Level Extent
- The design flood inundation extent (or future design water level extent), at 3.97 m elevation, is the combined 0.5% AEP (1-in-200-year) joint tide, storm surge and sea level rise elevation. It excludes waves and freeboard.
10. Map Notes for Downtown, Departure Bay and Duke Point
- For map notes specific to Downtown, Departure Bay and Duke Point, please see index map sheet.
11. Disclaimer
- Refer to index map for the project mapping disclaimer.

Data Sources

1. Design still water levels are based on and extreme value analysis of Canadian Hydrographic Service tide gauge records, primarily Point Atkinson (CHS ID 7795), with local adjustments derived from Nanaimo Harbour (CHS ID 7917). Joint probability analysis of tide and storm surge was used to estimate 0.5% AEP (1-in-200-year) design still water levels.
2. Joint Probability of water levels and winds, using Entrance Island (Climate ID 1022689), was used to model nearshore wave climate with spectral wave model SWAN.
3. Wave effects on shoreline FCLs are based on numerical wave modelling using SWAN and empirical wave run-up analysis. Wave run-up was estimated using  $R_2\%$  exceedance values calculated with EurOtop (2018) and Stockdon et al. (2006) methods applied to cross-shore transects along the shoreline.
4. The digital elevation model (DEM) used for mapping was developed from the following datasets to produce a continuous bare-earth surface referenced to CGVD2013:
  - 2019 Provincial LiDAR from GeoBC.
  - Canadian Hydrographic Service NONNA10 bathymetry.
5. Orthophoto Imagery
- Orthophotos were obtained from City of Nanaimo (2024) and were used to provide contextual reference for shoreline features and land use.
6. GIS Data
- Parcel boundaries, road networks, streams, and lakes were compiled from municipal provincial and federal open data sources, including the City of Nanaimo, BC Data Catalogue, Natural Resources Canada.







**FIRST NATIONS ADMINISTRATIVE AREA**

**CITY OF NANAIMO**

**EXTENT OF 2024 IMAGERY**

**PROPERTY PARCEL BOUNDARY**

**MAPPING LIMIT**

**DESIGN FLOOD CONSTRUCTION LEVEL (FCL)**  
COMPRISED OF THE 200 YEAR JOINT TIDE, STORM SURGE, AND WAVE RUN-UP (R<sub>s</sub>%) WITH 1 m OF SEA LEVEL RISE (SLR), (m)

**DESIGN FLOOD INUNDATION EXTENT INCLUDING SLR AND FREEBOARD**

**DESIGN FCL ZONE INCLUDING SLR AND FREEBOARD (m)**

**FCL EXTENT**

**VERTICAL WAVE RUNUP (m)**

- < 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0

**FUTURE DESIGN WATER LEVEL EXTENT**  
200 YEAR DESIGN WATER LEVEL INCLUDING SLR AND EXCLUDING WAVE EFFECTS AND FREEBOARD (m)

**AREA NOT MODELLED**

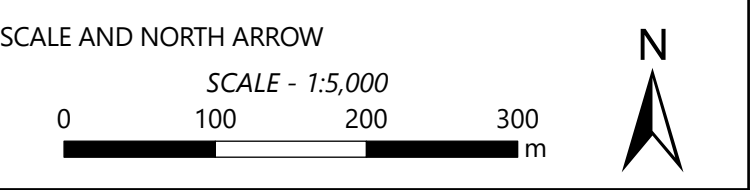
PLEASE REFER TO THE MAP SERIES INDEX SHEET, INCLUDING MAP NOTES, FOR SPECIFIC MAPPING AND REPORT INFORMATION

**DATA SOURCES**  
2024 imagery from City of Nanaimo within data extents, and Esri elsewhere;  
Basemap labels from Esri; Inset basemap from Esri; Reference data from GeoBC

|                  |            |                 |
|------------------|------------|-----------------|
| ENGINEER<br>VCCM | GIS<br>BLH | REVIEWER<br>PDO |
|------------------|------------|-----------------|

|                            |                     |
|----------------------------|---------------------|
| NHC PROJECT No.<br>3010048 | DATE<br>26-AUG-2026 |
|----------------------------|---------------------|

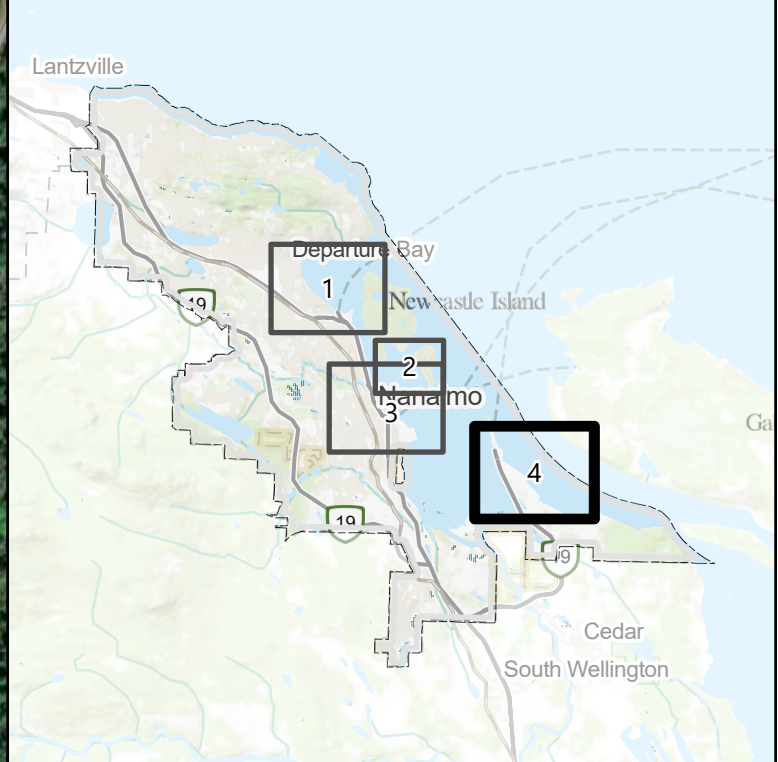
COORD SYS. AND DATUM  
HORIZ: NAD 1983 CSRS UTM ZONE 10N  
VERT: CGVD2013  
UNITS: METRES



**CITY OF NANAIMO**  
**SEA LEVEL RISE MANAGEMENT PLAN**

**FLOOD CONSTRUCTION LEVEL MAP**  
**SHEET 3 OF 4**





**FIRST NATIONS ADMINISTRATIVE AREA**

**CITY OF NANAIMO**

**EXTENT OF 2024 IMAGERY**

**PROPERTY PARCEL BOUNDARY**

**MAPPING LIMIT**

**DESIGN FLOOD CONSTRUCTION LEVEL (FCL)**  
COMPRISED OF THE 200 YEAR JOINT TIDE,  
STORM SURGE, AND WAVE RUN-UP (R<sub>s</sub>%)  
WITH 1 m OF SEA LEVEL RISE (SLR), (m)

**DESIGN FLOOD INUNDATION EXTENT**  
INCLUDING SLR AND FREEBOARD

**DESIGN FCL ZONE**  
INCLUDING SLR AND FREEBOARD (m)

**FCL EXTENT**

**VERTICAL WAVE RUNUP (m)**

- < 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0

**FUTURE DESIGN WATER LEVEL EXTENT**  
200 YEAR DESIGN WATER LEVEL  
INCLUDING SLR AND EXCLUDING  
WAVE EFFECTS AND FREEBOARD (m)

**AREA NOT MODELLED**

PLEASE REFER TO THE MAP SERIES INDEX SHEET,  
INCLUDING MAP NOTES, FOR SPECIFIC MAPPING  
AND REPORT INFORMATION

**DATA SOURCES**  
2024 imagery from City of Nanaimo within data extents, and Esri elsewhere;  
Basemap labels from Esri; Inset basemap from Esri; Reference data from  
GeoBC

|                                                                                              |            |                     |
|----------------------------------------------------------------------------------------------|------------|---------------------|
| ENGINEER<br>VCCM                                                                             | GIS<br>BLH | REVIEWER<br>PDO     |
| NHC PROJECT No.<br>3010048                                                                   |            | DATE<br>26-AUG-2026 |
| COORD SYS. AND DATUM<br>HORIZ: NAD 1983 CSRS UTM ZONE 10N<br>VERT: CGVD2013<br>UNITS: METRES |            |                     |
| SCALE AND NORTH ARROW<br>SCALE - 1:5,000<br>0 100 200 300 m<br>N                             |            |                     |



**CITY OF NANAIMO**  
**SEA LEVEL RISE MANAGEMENT PLAN**

**FLOOD CONSTRUCTION LEVEL MAP**  
**SHEET 4 OF 4**



# **APPENDIX D**

## **RISK ASSESSMENT**

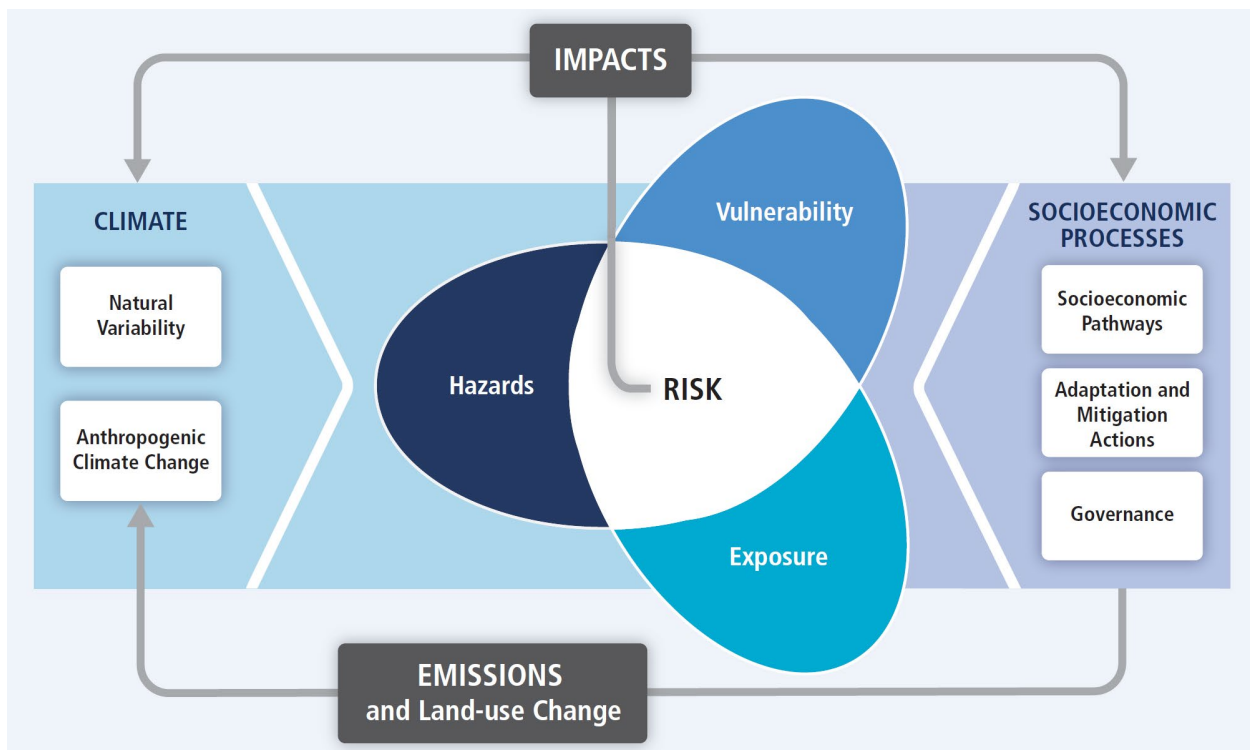


# APPENDIX D: RISK ASSESSMENT

## 1 INTRODUCTION

This appendix describes the technical analyses undertaken to assess the flood risk assess flood risk and support the options analysis. Flood risk is the potential for consequence (impact) where something of value is at stake and the outcome is uncertain. Risk is often represented as a probability of occurrence of hazardous events (likelihood) or trends multiplied by the impacts (or consequences) if these events or trends occur. Figure 1.1 shows how risk results from the interaction of vulnerability, exposure and hazard (IPCC, 2014). In this context, exposure is defined as how likely it is that a consequence variable will be flooded, and vulnerability is defined as how susceptible an asset is to negative consequences of exposure.

This study evaluated the flood risk for three main assets: buildings, roads, and critical water, sewer and sanitary infrastructure.



**Figure 1.1 Definition of hazards, exposure, vulnerability and risk (excerpt from IPCC (2014) Figure 19-1).**

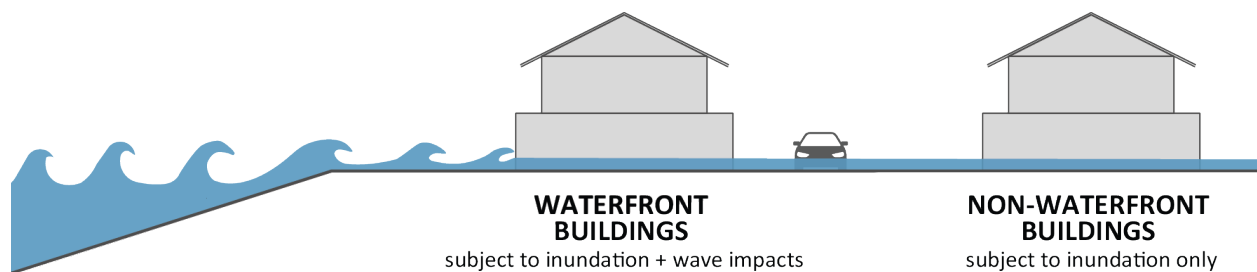
The assessment considered wave effects and inundation depth across a range of flood likelihoods and relative sea-level rise scenarios. Buildings were assessed quantitatively using an economic risk analysis, roads were assessed semi-quantitatively, and critical infrastructure was assessed for exposure only. The following subsections outline the methodologies employed to calculate tangible risks and exposures.

## 2 BUILDINGS – QUANTITATIVE RISK ASSESSMENT

The buildings within the study areas were assessed quantitatively, in order to calculate expected annual damages (EADs) for given storm events. The below sections outline the creation of the datasets, and the methods employed to calculate risk.

### 2.1 Methodology

The overall risk assessment methodology is based on procedures from the *Federal Flood Damage Estimation Guidelines for Buildings and Infrastructure* (NRCan, 2021) and *Legislated Flood Assessments in a Changing Climate in BC* (EGBC, 2018). First, GIS methods were used to assess both the still water and wave effect flood exposure of key assets across the full range of modelled hazard scenarios. Flood damages were then estimated based on the severity of the hazard (e.g., depth, wave height) and the vulnerability of each asset. For a given asset, the maximum of the still water and wave effect damages was retained. Figure 2.1 shows how the buildings are impacted by coastal inundation and waves.



**Figure 2.1 Definition of waterfront assets for application of the qualitative consequence scale for buildings.**

#### 2.1.1 Asset Dataset Creation

The building footprints used for the analysis were provided by the City of Nanaimo. The building footprints were removed from the study areas where they do not intersect the flood hazard rasters, and were not within one of the four study areas. Further to this, the buildings were



quality checked against aerial imagery, with buildings that do not currently exist and floating buildings being removed from the analysis. 167 buildings were retained for use in the analysis.

The received data was attributed with building type. The categories were more granular than is needed to assign vulnerability curves, and as such, were generalized into the following categories: residential – strata; residential – single-family dwelling; commercial; industrial; institutional. Where categories were more ambiguous, such as 'general', the buildings were reviewed using a combination of BC Assessment data and local knowledge to ensure that the correct generalized building type was assigned.

The elevation of each building was required for the CanFlood analysis. To achieve this, the lowest DEM elevation at a given building, as taken from the 2019 LidarBC DEM, was assigned to the buildings. For select large strata, industrial and commercial buildings within the study area that had the potential to be significant drivers of the overall damages, and be subject to a larger range of DEM elevations, the elevations were manually checked. For smaller buildings, which mostly consisted of residential single-family dwellings, the DEM elevations were spot-checked.

The finished first floor (FFE) elevations of the buildings were assumed based on the generalized building types. All single-family dwellings, were assumed to have an FFE of 0.6 m above DEM, and all other buildings were assumed to have an FFE at the DEM level. All single-family dwellings on Protection Island were assumed to not have a basement, and all single-family dwellings in Departure Bay were assumed to have a basement with a floor 2.1 m below the FFE. These assumptions are based on local knowledge and a research project conducted by NHC (2025).

### **2.1.2 Vulnerability Curve Assigning**

Still water building vulnerability functions developed for the Lower Mainland Flood Risk Assessment (IBI Group and Golder Associates Ltd., 2020) and the Provincial Flood Damage Assessment Study for the City of Calgary (IBI Group, 2015) were applied to the assets in the study area for use in CanFlood for the still water risk analysis. Multiple vulnerability functions were applied to each asset to estimate losses associated with building repairs and contents. Building repairs refers to restoration work following basement, common areas, garage, and main floor damages, for both residential and non-residential buildings. Content damages include residential damages as well as inside and outside equipment and stock for non-residential buildings.

These functions were built specifically for buildings in Metro Vancouver, the Fraser Valley, and Calgary. Despite being derived from other regions, they provide a reasonable approximation of potential flood damages considering the existing building stock in Nanaimo. While these vulnerability functions are based on similar building types as those in Nanaimo, there are regional differences in construction costs. Additionally, since these functions were developed in 2020, there has been significant escalation in provincial construction costs and household goods

inflation. Therefore, the vulnerability functions were scaled to 2025 Nanaimo values using the general approach described by NRCan (2021), applying a total scaling factor of +32%. Infinitely large damage caps were assigned to the curves, which instead leads to the caps being derived from the curves themselves. This was done in an effort to not cap the buildings at the BC Assessment value, as this can lead to the replacement costs of buildings being artificially lowered in buildings or neighbourhoods with lower property values.

As the available CanFlood vulnerability curves express damage as a function of flood depth they are most representative of still water or low-velocity flood conditions. However, the curves do not account for additional damage from wave action. In buildings that were deemed to be within the wave effect zone, multiple buildings are subject to direct impacts from waves. For these scenarios, we assessed damages using coastal vulnerability curves available from the northeastern United States (U.S. Army Corps of Engineers, 2015). As the published curves are represented as a percentage damage to buildings and contents, dollar values were assigned to the curves using percentages of maximum damages from the still water curves.

It should be noted that no wave effect curves are available for industrial or commercial buildings. For these buildings, only the risk from still water inundation will be reported on.

### **2.1.3 Still water Risk Analysis**

Natural Resources Canada's CanFlood flood risk modelling toolbox was utilized for the still water building risk modelling. CanFlood is an open source QGIS plugin that contains tools to automate modelling tasks and utilizes a standardized data format to enhance reproducibility and future expansion of the assessment. Asset data inventories, vulnerability curves, and still water WSE rasters are input to determine the exposure and risk of the structures in the study area.

### **2.1.4 Wave Effect Risk Analysis**

Since wave effects cannot be modelled in the CanFlood software, a spreadsheet analysis was conducted. Asset data inventories, vulnerability curves, and significant wave height WSE rasters are input to determine the exposure and risk. Buildings were only included in the analysis if they were deemed to be in the wave effect zone, which is 50 m back from the shoreline. An iterative analysis found that this is sufficient to capture properties that would be subject to wave effects.

## **2.2 Results**

The EAD for each sea level rise scenario across each study area is shown in Figure 2.2. The impacts of individual buildings for each study area, and under each SLR scenario is shown in Table 2.1 through Table 2.5.



**Table 2.1 Building EAD by RSLR scenario**

|                   | RSLR Scenario |             |              |              |
|-------------------|---------------|-------------|--------------|--------------|
|                   | 0 m           | 0.5 m       | 1 m          | 2 m          |
| All Study Areas   | \$41,885      | \$2,595,632 | \$15,172,799 | \$41,227,528 |
| Departure Bay     | \$14,603      | \$1,561,328 | \$7,987,374  | \$14,817,115 |
| Protection Island | \$27,282      | \$642,558   | \$1,528,601  | \$5,016,211  |
| Downtown          | \$0           | \$390,828   | \$3,057,096  | \$12,077,762 |
| Duke Point        | \$0           | \$918       | \$2,599,727  | \$9,316,441  |

**Table 2.2 Building Damages per Return Period – Departure Bay**

|      | SLR Scenario |             |              |              |
|------|--------------|-------------|--------------|--------------|
| AEP  | 0 m          | 0.5 m       | 1 m          | 2 m          |
| 6.7% | \$0          | \$2,734,598 | \$14,788,152 | \$27,567,612 |
| 2%   | \$207,138    | \$4,255,374 | \$16,638,423 | \$29,797,600 |
| 1%   | \$470,636    | \$5,461,557 | \$17,452,594 | \$30,392,020 |
| 1%   | \$631,872    | \$7,321,879 | \$18,056,130 | \$31,070,271 |
| 0%   | \$777,274    | \$8,778,617 | \$18,784,094 | \$31,626,944 |

**Table 2.3 Building Damages per Return Period – Downtown**

|      | SLR Scenario |             |             |              |
|------|--------------|-------------|-------------|--------------|
| AEP  | 0 m          | 0.5 m       | 1 m         | 2 m          |
| 6.7% | \$0          | \$668,215   | \$5,598,576 | \$22,375,249 |
| 2%   | \$0          | \$1,379,083 | \$6,879,875 | \$25,059,654 |
| 1%   | \$0          | \$1,520,394 | \$7,490,546 | \$26,015,686 |
| 1%   | \$0          | \$1,646,262 | \$7,996,793 | \$27,008,195 |
| 0%   | \$0          | \$1,797,303 | \$8,691,631 | \$28,393,886 |

**Table 2.4 Building Damages per Return Period – Protection Island**

|      | SLR Scenario |             |             |              |
|------|--------------|-------------|-------------|--------------|
| AEP  | 0 m          | 0.5 m       | 1 m         | 2 m          |
| 6.7% | \$174,628    | \$1,181,479 | \$2,808,501 | \$9,334,685  |
| 2%   | \$399,436    | \$1,384,089 | \$3,308,891 | \$9,845,109  |
| 1%   | \$534,390    | \$1,418,668 | \$3,611,361 | \$10,391,774 |

|    |           |             |             |              |
|----|-----------|-------------|-------------|--------------|
| 1% | \$617,883 | \$1,641,588 | \$3,988,715 | \$11,039,314 |
| 0% | \$715,633 | \$2,053,083 | \$4,438,952 | \$11,627,759 |

**Table 2.5 Building Damages per Return Period – Duke Point**

| AEP  | SLR Scenario |           |              |              |
|------|--------------|-----------|--------------|--------------|
|      | 0 m          | 0.5 m     | 1 m          | 2 m          |
| 6.7% | \$0          | \$0       | \$4,596,656  | \$17,441,863 |
| 2%   | \$0          | \$0       | \$7,425,238  | \$17,674,167 |
| 1%   | \$0          | \$0       | \$8,425,770  | \$17,787,225 |
| 1%   | \$0          | \$1,168   | \$9,420,490  | \$17,895,527 |
| 0%   | \$0          | \$268,606 | \$10,256,327 | \$18,008,161 |

For the present day (SLR of 0 m), there are no buildings at risk in the Downtown and Duke Point study areas. Some buildings in Departure Bay start to get inundated at the 2% AEP scenario, whereas buildings on Protection Island become inundated at the 6.7% AEP scenario. The EADs for all study areas remain low for this SLR scenario.

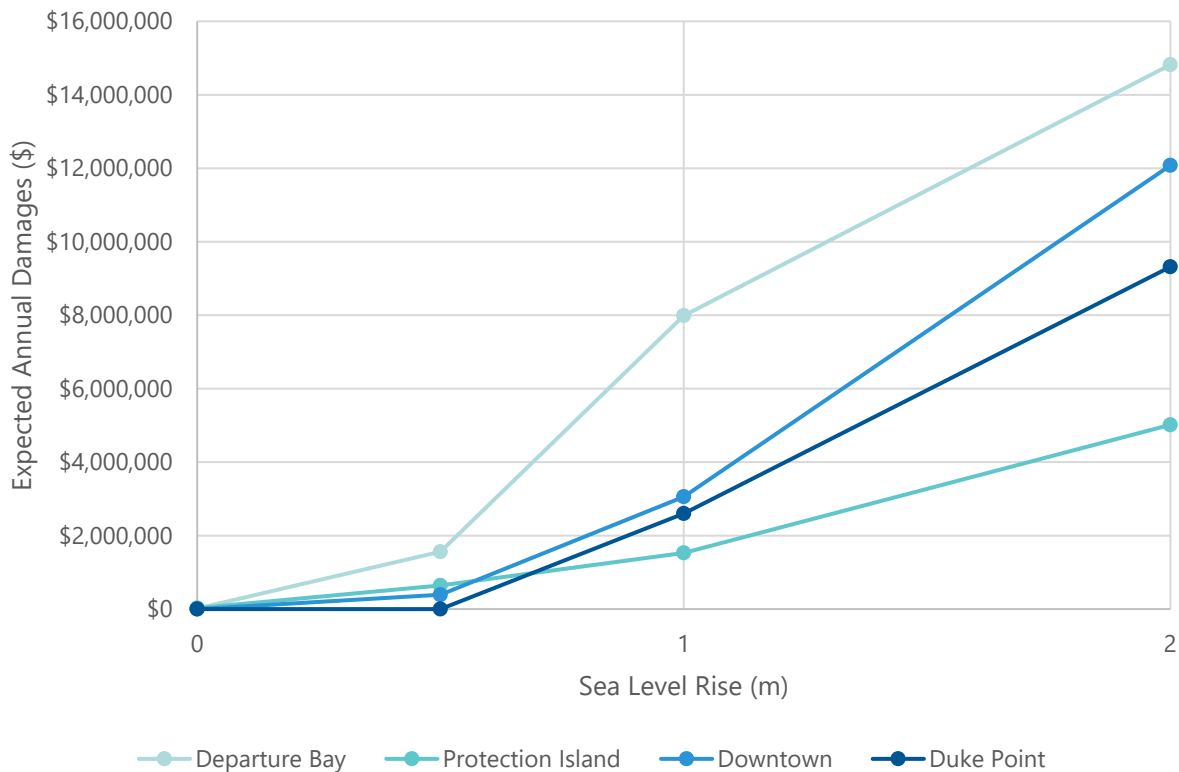
For the 0.5 m SLR scenario, buildings in Duke Point become inundated at the 0.5% AEP scenario (although the damages remain minor), and buildings in all other study areas become inundated at the 6.7% AEP scenario. There is an increase in EAD across all study areas, with the most pronounced increase being in Departure Bay, due to the significant increase in inundation extents that start to occur at this SLR scenario.

For the 1 m SLR scenario, there is a significant increase in EADs across all study areas, being most pronounced for the Duke Point study area, as significant damages start to occur to large industrial buildings. All study areas see buildings being inundated during 6.7% AEP storms.

For the 2 m SLR scenario, there is again a significant increase of 272% in EADs across all study areas. This is due to greater flooding extents and wave heights across all study areas, however the increase is greatest in the Duke Point and Downtown study areas, and is largely driven by increasing damages to large commercial, industrial, and institutional buildings.

Of particular note is the effect of building generalizations. For example, the single-family dwelling damages for Departure Bay are partially driven by basement damages. The results of a future study could be refined by doing a detailed analysis of all buildings within a study area, to determine the presence of a basement and the FFE.





**Figure 2.2 Building EAD by SLR Scenario**

### 3 MUNICIPAL INFRASTRUCTURE - IMPACT AND SEMI-QUANTITATIVE RISK ASSESSMENT

Two categories of municipal infrastructure were assessed – roads, and water-related utility infrastructure. The road dataset is a GIS line dataset derived from the authoritative provincial Digital Road Atlas, and the water-related utility infrastructure is a GIS point dataset derived from a municipal dataset provided by the City.

#### 3.1 Methodology

The methodologies varied between the road and water-related utility infrastructure, given that the roads were assessed using a semi-quantitative risk analysis, and the water-related utility infrastructure were assessed using an impact analysis. For both the road and water-related utility infrastructure analyses, assets were assessed with respect to wave height and still water inundation, and were considered impacted once a certain threshold had been reached. Further details on this are within the following sections.

### 3.1.1 Roads

The nearshore wave height was used to determine the consequence scale for waterfront roads (Figure 3.1 and Table 3.1). Roads were assessed on a segment-by-segment basis. A segment in GeoBC's Digital Road Atlas is a centre-line section of road that either connects two intersections or is a smaller section of a longer portion of road. This means that, if a small portion of the segment intersects the area of inundation or the wave effect zone, the entire segment is considered to be inundated based on guidance in the EurOtop Manual (EurOtop, 2018) (Figure 3.2).

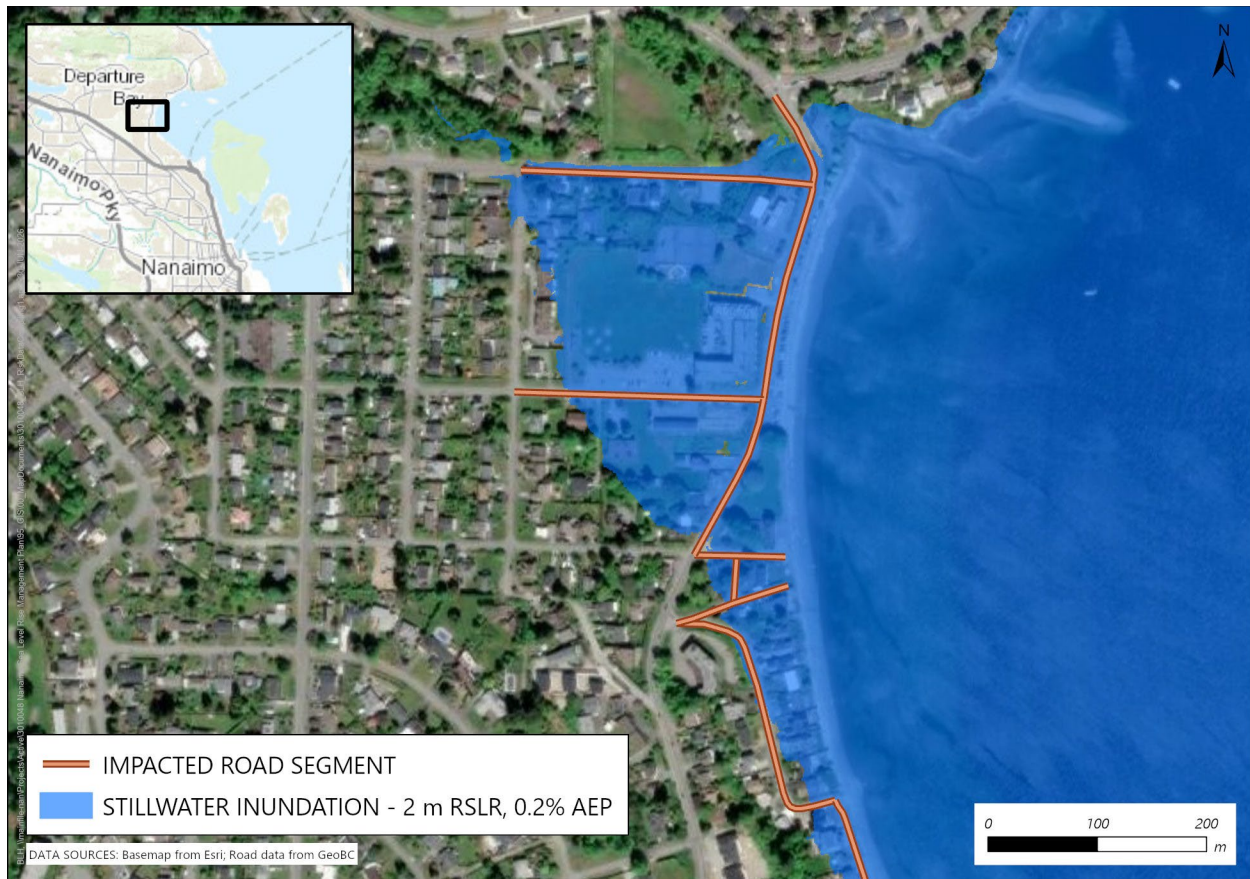


**Figure 3.1 Identification of roads that are likely to have consequential impacts under different scenarios based on flood inundation and wave effects.**

**Table 3.1 Qualitative consequence scale for roads.**

| Consequence Description | Wave Height (m)                                 | Depth (m)                                            |
|-------------------------|-------------------------------------------------|------------------------------------------------------|
|                         | Waterfront Asset Located Inside Wave Runup Zone | Non-Waterfront Asset Located Outside Wave Runup Zone |
| Insignificant           | 0.3                                             | 0.05                                                 |
| Minor                   | 0.5                                             | 0.1                                                  |
| Moderate                | 1                                               | 0.3                                                  |
| Major                   | 2                                               | 0.8                                                  |
| Extreme                 | 3                                               | 1.2                                                  |





**Figure 3.2 Impacted road segments in Departure Bay beach area at 2m SLR, 0.2% AEP**

Risk to roads was calculated using the rating scales in Table 3.2. Risk rating scales are qualitative descriptions of the severity of risks. Severity is determined by the potential consequence of a future risk and the likelihood of that event happening. Each risk is considered step-by-step or one-at-a-time using the likelihood scale and consequence scale to come up with a final risk rating. As an example, if a risk (e.g. destabilisation of the foundation of a building or other infrastructure located in the coastal flood zone) arising from a hazard (e.g. increased flooding or wave loading due to SLR) has a consequence rating of 'insignificant' and a likelihood rating of 'rare' then using the example risk rating in Table 3.2, the risk should have a 'low' rating.

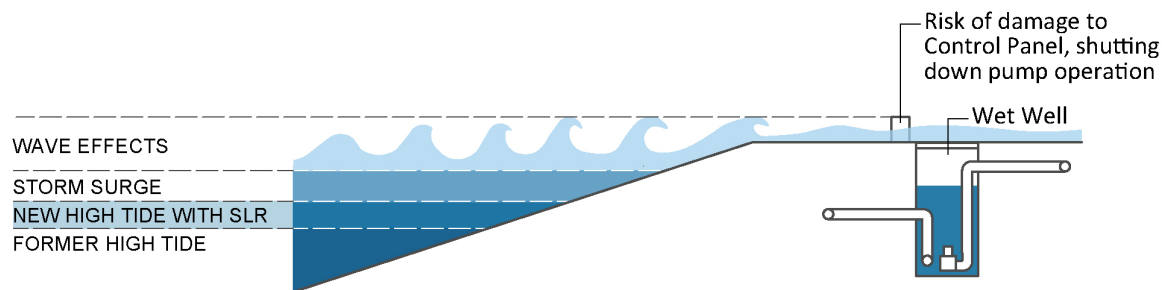
**Table 3.2 Risk rating scale.**

|            |                | Consequences  |          |          |          |          |
|------------|----------------|---------------|----------|----------|----------|----------|
|            |                | Insignificant | Minor    | Moderate | Major    | Extreme  |
| Likelihood | Almost Certain | Moderate      | Moderate | High     | High     | High     |
|            | Likely         | Low           | Moderate | High     | High     | High     |
|            | Possible       | Low           | Moderate | Moderate | High     | High     |
|            | Unlikely       | Low           | Low      | Moderate | Moderate | Moderate |

|  |      |     |     |     |     |          |
|--|------|-----|-----|-----|-----|----------|
|  | Rare | Low | Low | Low | Low | Moderate |
|--|------|-----|-----|-----|-----|----------|

### 3.1.2 Water-Related Utility Infrastructure

Given that there is a significant range in the type of infrastructure data that was assessed, a binary impact analysis was conducted on the water, sanitary and stormwater infrastructure. It was assumed that if either the significant wave height or still water depth is greater than 0.6 m, then the point is impacted. The 0.6 m threshold is assumed to be the depth at which infrastructure gets damaged for infrastructure that is above ground, such as pump stations. Figure 3.3 shows how pump stations are impacted by coastal inundation. This approach is consistent with other regional and national scale flood studies.



**Figure 3.3 Definition of waterfront assets for application of the qualitative consequence scale for pump stations.**

The lists of infrastructure types that were included in the analysis for sanitary, stormwater, and water features is shown in below. It should be noted that, as some of the impacts are driven by unclassified features, and all features are assumed to be impacted at the same significant wave height or still water depth, further study would be needed to improve the accuracy of these results.

#### Sanitary Infrastructure Features

- Sanitary Manholes
- Sanitary Network Structures
- Sanitary Fittings
- Unknown
- Sanitary System Valves
- Sanitary Catch Basins
- Tee
- Tap
- Cross
- Coupling
- Cap
- Reducer
- Cleanout
- Pig Loader
- Unknown Manhole
- Drop
- Standard
- Sanitary Control Valve
- Pump Station
- Valve Chamber



### Stormwater Infrastructure Features

- |                           |                          |                       |
|---------------------------|--------------------------|-----------------------|
| • Storm Manholes          | • Coupling               | • Cleanout            |
| • Storm Catch Basins      | • Tee                    | • Standard            |
| • Storm Fittings          | • Unknown                | • Catch Basin Manhole |
| • Storm Inlet and Outlets | • Standpipe              | • Chamber             |
| • Cap                     | • CURB                   | • Oil Interceptor     |
| • Tap                     | • NONCURB                |                       |
| • Reducer                 | • Storm Inlet and Outlet |                       |

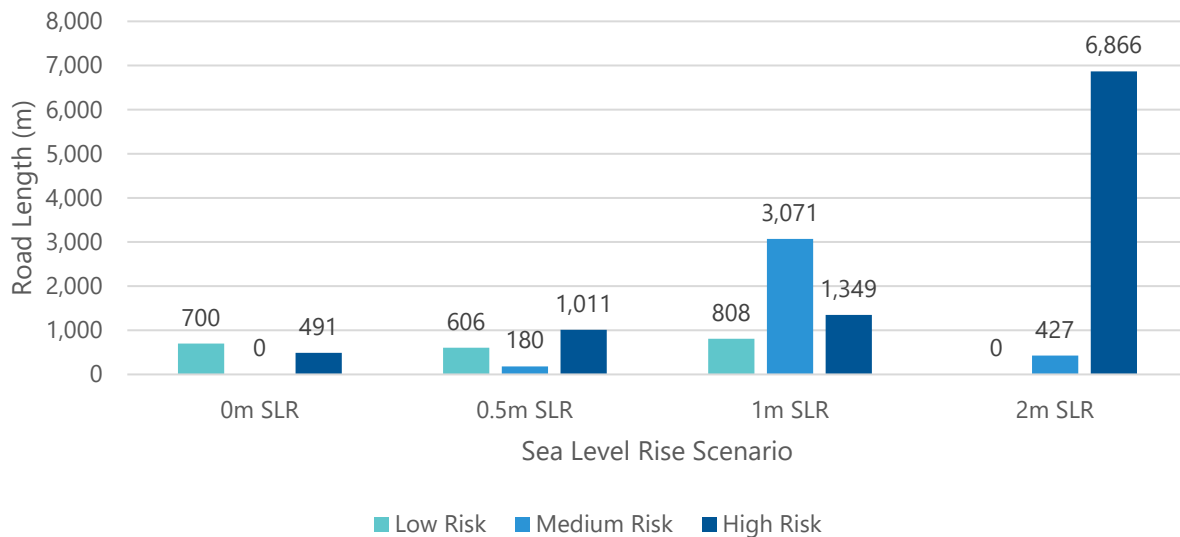
### Water Infrastructure Features

- |                         |                  |                       |
|-------------------------|------------------|-----------------------|
| • Water Fittings        | • Cap            | • Private             |
| • Water System Valves   | • Standpipe      | • City                |
| • Water Control Valves  | • Tee            | • Open                |
| • Water Meters          | • Unknown        | • Closed              |
| • Surge Release Station | • Coupling       | • Water Control Valve |
| • Tap                   | • Cross          |                       |
| • Reducer               | • Water Flushout |                       |

## 3.2 Results

### 3.2.1 Roads

The risk to roads in all study areas will increase with SLR, with a trend towards the high-risk category. Under current sea level conditions, there are 1.2 km of road at risk throughout all study areas, with 490 m of that being at high risk. This increases to 1.8 km (with 1.0 km at high risk) with 0.5 m of SLR, 5.2 km (with 1.3 km at high risk) with 1 m of SLR, and 7.3 km (with 6.9 km at high risk) with 2 m of SLR. Under the 2m SLR scenario, the study area with the most roads at high risk is Duke Point with 2.4 km, followed by Departure Bay with 1.9 km. It should be noted that Roads were assessed on a segment-by-segment basis (i.e. if a given point on a road is high risk, the whole road segment was considered high risk). This increase in risk to roads with SLR has the potential to significantly disrupt transportation around the City of Nanaimo, cut off major routes during large storm events (such as Departure Bay Road and Front Street), and increase damages to roads. An overview of the risk to roads for all study areas can be seen in Figure 3.4. The length of roads at risk for each scenario is summarized in Table 3.3 to Table 3.6.



**Figure 3.4 Total Length of Road at Risk by SLR Scenario**

**Table 3.3 Length of Road at Risk for 0 m RSLR scenario**

| Study Area    | Length of Road at Risk (m) |             |            |
|---------------|----------------------------|-------------|------------|
|               | Low Risk                   | Medium Risk | High Risk  |
| Protection    | 0                          | 0           | 275        |
| Duke Point    | 0                          | 0           | 0          |
| Downtown      | 292                        | 0           | 216        |
| Departure Bay | 409                        | 0           | 0          |
| <b>Total</b>  | <b>700</b>                 | <b>0</b>    | <b>491</b> |

**Table 3.4 Length of Road at Risk for 0.5 m RSLR scenario**

| Study Area    | Length of Road at Risk (m) |             |              |
|---------------|----------------------------|-------------|--------------|
|               | Low Risk                   | Medium Risk | High Risk    |
| Protection    | 0                          | 0           | 275          |
| Duke Point    | 88                         | 0           | 0            |
| Downtown      | 158                        | 0           | 507          |
| Departure Bay | 361                        | 180         | 229          |
| <b>Total</b>  | <b>606</b>                 | <b>180</b>  | <b>1,011</b> |



**Table 3.5 Length of Road at Risk for 1 m RSLR scenario**

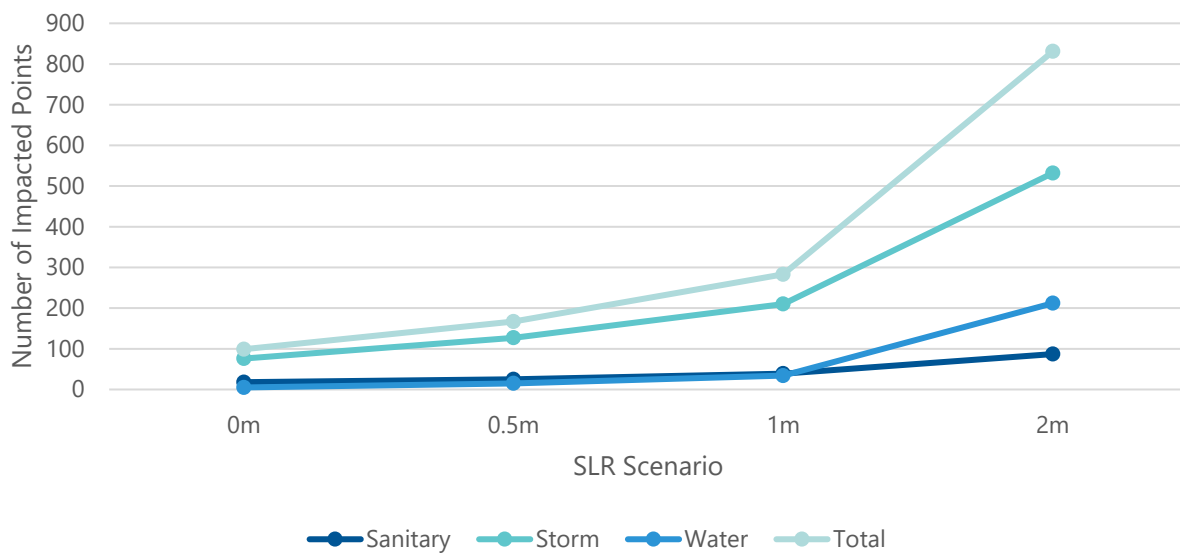
| Study Area    | Length of Road at Risk (m) |              |              |
|---------------|----------------------------|--------------|--------------|
|               | Low Risk                   | Medium Risk  | High Risk    |
| Protection    | 540                        | 441          | 275          |
| Duke Point    | 0                          | 1,738        | 0            |
| Downtown      | 0                          | 209          | 665          |
| Departure Bay | 268                        | 682          | 409          |
| <b>Total</b>  | <b>808</b>                 | <b>3,071</b> | <b>1,349</b> |

**Table 3.6 Length of Road at Risk for 2 m RSLR scenario**

| Study Area    | Length of Road at Risk (m) |             |              |
|---------------|----------------------------|-------------|--------------|
|               | Low Risk                   | Medium Risk | High Risk    |
| Protection    | 0                          | 0           | 1,500        |
| Duke Point    | 0                          | 0           | 2,444        |
| Downtown      | 0                          | 372         | 1,031        |
| Departure Bay | 0                          | 55          | 1,891        |
| <b>Total</b>  | <b>0</b>                   | <b>427</b>  | <b>6,866</b> |

### 3.2.2 Water-Related Utility Infrastructure

The number of impacted water, stormwater, and sanitary infrastructure points increase both with SLR and with AEP, when amalgamating results across all study areas. Figure 3.5 shows that the impacts of a 0.2% AEP storm on all assessed water-related utility infrastructure increase with increasing SLR. The increase is gradual from 0 m SLR until 1 m SLR, however there is a significant jump in the amount of impacted infrastructure at 2 m SLR, which is an increase of 739%. Detailed information on the amount of impacted points in each of these categories is summarized in Table 3.7 to Table 3.18.



**Figure 3.5 Combined Infrastructure - Impacted Water-Related Utility Infrastructure by SLR Scenario Across All Study Areas (0.2% AEP)**

**Table 3.7 Number of Sanitary Infrastructure Features at Risk – Departure Bay**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 12  | 16    | 23  | 35  |
| 2% AEP   | 12  | 16    | 25  | 37  |
| 1% AEP   | 12  | 18    | 25  | 38  |
| 0.5% AEP | 13  | 20    | 26  | 40  |
| 0.2% AEP | 14  | 20    | 29  | 42  |

### Sanitary Infrastructure

**Table 3.8 Number of Sanitary Infrastructure Features at Risk – Downtown**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 3   | 3     | 3   | 22  |
| 2% AEP   | 3   | 3     | 4   | 26  |
| 1% AEP   | 3   | 3     | 5   | 28  |
| 0.5% AEP | 3   | 3     | 6   | 28  |
| 0.2% AEP | 3   | 3     | 7   | 29  |



**Table 3.9 Number of Sanitary Infrastructure Features at Risk – Protection Island**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 0   | 0     | 0   | 7   |
| 2% AEP   | 0   | 0     | 0   | 7   |
| 1% AEP   | 0   | 0     | 0   | 7   |
| 0.5% AEP | 0   | 0     | 1   | 7   |
| 0.2% AEP | 0   | 0     | 1   | 7   |

**Table 3.10 Number of Sanitary Infrastructure Features at Risk – Duke Point**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 1   | 2     | 2   | 3   |
| 2% AEP   | 1   | 2     | 2   | 6   |
| 1% AEP   | 1   | 2     | 2   | 7   |
| 0.5% AEP | 1   | 2     | 2   | 8   |
| 0.2% AEP | 1   | 2     | 2   | 9   |

### Water infrastructure

**Table 3.11 Number of Water Infrastructure Features at Risk – Departure Bay**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 0   | 0     | 2   | 11  |
| 2% AEP   | 0   | 0     | 2   | 15  |
| 1% AEP   | 0   | 1     | 2   | 17  |
| 0.5% AEP | 0   | 2     | 2   | 24  |
| 0.2% AEP | 0   | 2     | 2   | 27  |

**Table 3.12 Number of Water Infrastructure Features at Risk – Downtown**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 2   | 2     | 7   | 68  |
| 2% AEP   | 2   | 3     | 8   | 81  |
| 1% AEP   | 2   | 3     | 10  | 84  |
| 0.5% AEP | 2   | 6     | 15  | 92  |
| 0.2% AEP | 2   | 6     | 15  | 102 |

**Table 3.13 Number of Water Infrastructure Features at Risk – Protection Island**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 2   | 2     | 4   | 54  |
| 2% AEP   | 2   | 2     | 9   | 56  |
| 1% AEP   | 2   | 2     | 11  | 57  |
| 0.5% AEP | 2   | 2     | 13  | 59  |
| 0.2% AEP | 2   | 3     | 13  | 63  |

**Table 3.14 Number of Water Infrastructure Features at Risk – Duke Point**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 1   | 1     | 4   | 12  |
| 2% AEP   | 1   | 1     | 4   | 14  |
| 1% AEP   | 1   | 1     | 4   | 15  |
| 0.5% AEP | 1   | 3     | 4   | 18  |
| 0.2% AEP | 1   | 4     | 4   | 20  |

### Stormwater Infrastructure

**Table 3.15 Number of Stormwater Infrastructure Features at Risk – Departure Bay**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 17  | 26    | 49  | 148 |
| 2% AEP   | 20  | 30    | 61  | 173 |
| 1% AEP   | 21  | 32    | 63  | 179 |
| 0.5% AEP | 22  | 39    | 69  | 192 |
| 0.2% AEP | 24  | 44    | 79  | 203 |

**Table 3.16 Number of Stormwater Infrastructure Features at Risk – Downtown**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 35  | 42    | 84  | 208 |
| 2% AEP   | 37  | 46    | 87  | 218 |
| 1% AEP   | 40  | 55    | 96  | 227 |
| 0.5% AEP | 41  | 59    | 100 | 236 |
| 0.2% AEP | 42  | 71    | 111 | 239 |



**Table 3.17 Number of Stormwater Infrastructure Features at Risk – Protection Island**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 2   | 4     | 6   | 26  |
| 2% AEP   | 2   | 4     | 8   | 28  |
| 1% AEP   | 2   | 4     | 8   | 28  |
| 0.5% AEP | 2   | 4     | 9   | 28  |
| 0.2% AEP | 3   | 4     | 10  | 28  |

**Table 3.18 Number of Stormwater Infrastructure Features at Risk – Duke Point**

| AEP      | 0 m | 0.5 m | 1 m | 2 m |
|----------|-----|-------|-----|-----|
| 6.7% AEP | 6   | 6     | 8   | 39  |
| 2% AEP   | 6   | 7     | 9   | 47  |
| 1% AEP   | 6   | 7     | 9   | 50  |
| 0.5% AEP | 7   | 8     | 9   | 55  |
| 0.2% AEP | 7   | 8     | 10  | 62  |

The increase in impacted features is not consistent across all study areas. In Duke Point, the number of all impacted features increases across all categories with increasing AEP at 2 m SLR, but remains mostly static at all other SLR scenarios. This is due to significant inundation not occurring at Duke Point until 1 m SLR is reached, and becoming more severe at 2 m SLR.

For Downtown, although there is an increase in water and stormwater features with increasing SLR and AEP, this does not occur with sanitary features. There is consistent damage across all AEPs at 0 m and 0.5 m SLR, but this increases at 1 m SLR, with a significant increase at 2 m SLR. For all of the feature types, there is a significant increase in the number of impacted features once 2 m SLR is reached.

For Protection Island, there are no sanitary features impacted until a 0.5% AEP storm, at 1 m SLR. This number increases significantly once 2 m SLR is reached. A similar pattern can be seen for water infrastructure, where impacts begin to occur with a 0.2% AEP storm, at 0.5 m SLR, increase slightly for all scenarios at 1 m SLR, and increase significantly for all scenarios at 2 m SLR. Storm water infrastructure is impacted at all AEPs for all SLR scenarios, and there is a significant increase in impacted infrastructure at 2 m SLR.

For Departure Bay, for both sanitary and stormwater infrastructure, there are impacts for all SLR scenarios, which rise gradually with increasing storm severity, with significantly higher impacts for 2 m SLR. For water infrastructure, there are no impacts until a 2% AEP storm at 0.5 m SLR, however the impacts remain relatively low until 2 m SLR.

## 4 SUMMARY OF RISK ASSESSMENT FINDINGS

In summary, the risk assessment shows that the impacts and risk from the still water inundation and wave effects of coastal flooding will increase at every modelled SLR scenario, with the most significant increases occurring at 2 m SLR. These findings are consistent for all modelled consequence variables, in all study areas. These findings provide the basis for identifying and evaluating adaptation options in Section 9 in the main report.

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# **APPENDIX E**

## **PHASE 2 EROSION MONITORING PLAN**





Photo source: SuavAir

# Nanaimo Sea Level Rise Management Plan

## Phase 2 Erosion Monitoring: Baseline Conditions

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## EXECUTIVE SUMMARY

This report presents the baseline assessment for a coastal erosion monitoring program along four identified focus areas in Nanaimo. The City of Nanaimo retained Northwest Hydraulic Consultants to conduct an erosion monitoring study as part of Phase 2 of the Nanaimo Sea Level Rise Management Plan. The main objectives for the baseline erosion assessment are to establish a baseline shoreline position and initial erosion rates along the identified high erosion hazard shorelines, and provide recommendations for a long-term monitoring plan.

This study consists of a field assessment and topographic survey, a review of background studies and surveys, an analysis to calculate erosion rates, and a characterization of the morphology and shoreline conditions to identify coastal processes and erosion drivers. The baseline shoreline position is based on a topographic survey conducted for this project in 2026 and the initial erosion rates were calculated using the GeoBC lidar from 2019 and the topographic survey from 2026. Erosion rates are calculated using the Digital Shoreline Analysis System (DSAS) maintained by the U.S. Geological Survey (USGS) (Himmelstoss et al., 2024).

The field assessment and erosion rates indicate that the coastal bluffs along the North Shore and Cilaire focus area are particularly prone to erosion. NHC recommends continued monitoring of the erosional shorelines within these two focus areas to establish erosion rates and anticipate any required mitigation measures. The monitoring should include 1) a lidar-based drone survey following the same data collection settings as the survey performed for this initial baseline assessment, and 2) a field-based assessment to determine locations of undercutting, bluff scarping and slope failure. NHC's initial recommendation is that monitoring of erosional shorelines be conducted every 5 years, with the next assessment in 2031. At that time, the monitoring frequency should be adjusted as needed based on the outcome of the assessment.

The Departure Bay and Protection Island focus areas show fewer signs of erosion at present. This is due to a combination of shoreline hardening and the presence of bedrock, which reduce the potential for erosion along the shorelines. The sedimentary deposits along these shorelines might become more prone to erosion with relative sea level rise (RSLR) over the next several decades as areas that were previously not subject to waves and tides become exposed, especially at any low-sloping bedrock shorelines with bluffs on top. Continued monitoring of shoreline erosion at these areas is not currently recommended, but should be revisited 10 to 20 years from now.

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## ABBREVIATIONS

| Acronym / Abbreviation | Definition                               |
|------------------------|------------------------------------------|
| CD                     | Chart Datum                              |
| CGVD2013               | Canadian Geodetic Vertical Datum of 2013 |
| CHS                    | Canadian Hydrographic Survey             |
| DSAS                   | Digital Shoreline Analysis System        |
| HHWMT                  | Higher High Water Mean Tide              |
| Lidar                  | Light Detection and Ranging              |
| NHC                    | Northwest Hydraulic Consultants          |
| RSLR                   | Relative Sea-Level Rise                  |

## SYMBOLS AND UNITS OF MEASURE

| Symbol / Unit of Measure | Definition                     |
|--------------------------|--------------------------------|
| km                       | Kilometer                      |
| m                        | Meter                          |
| $U_d$                    | Digitizing error               |
| $U_o$                    | Orthorectification error       |
| $U_p$                    | Resolution error               |
| $U_T$                    | Shoreline position uncertainty |
| uncy                     | Uncertainty                    |
| yr                       | Year                           |

## GLOSSARY

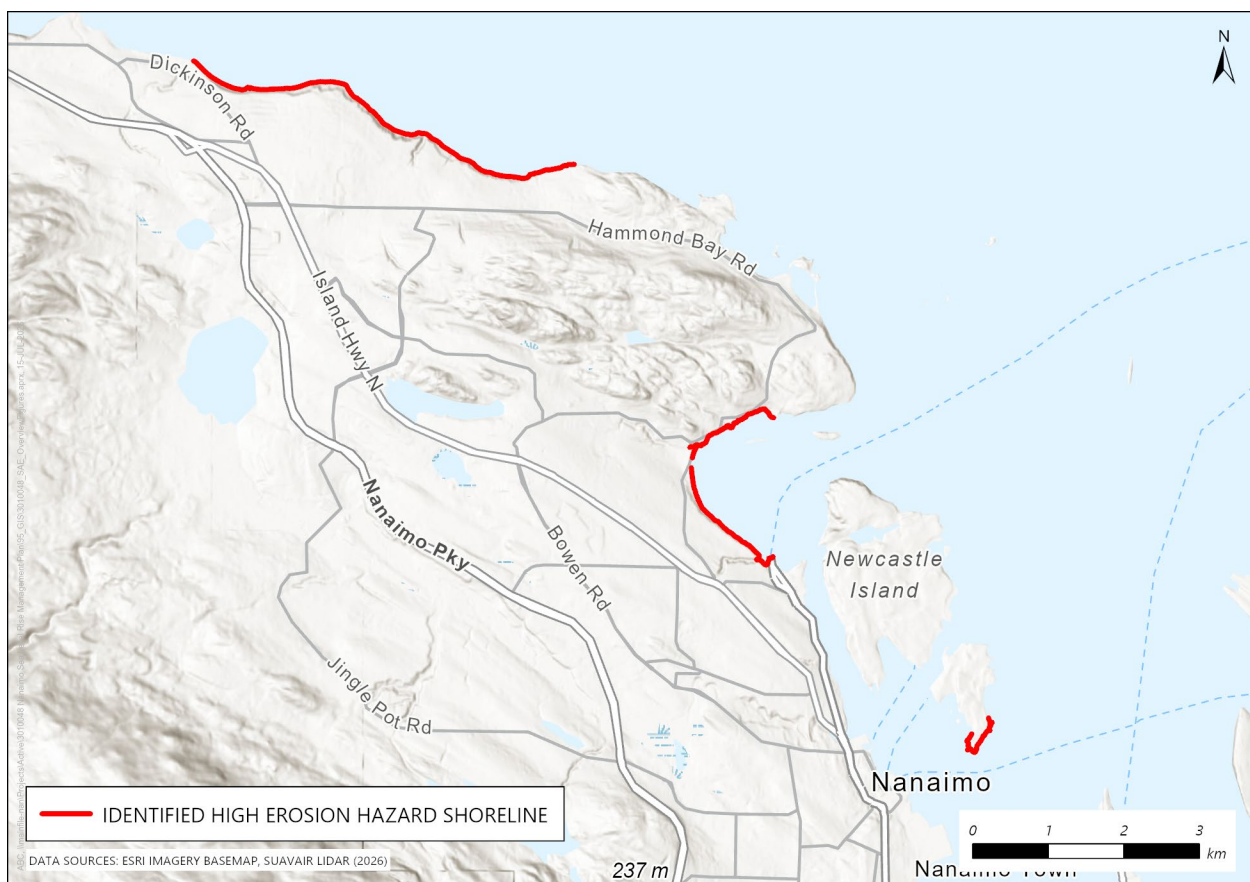
| Term                     | Definition                                                                                                                                                                                                      |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ArcGIS Pro               | Geographic information software developed by ESRI to visualize, analyze and compile spatial data                                                                                                                |
| Backshore                | The beach zone above high tide, typically supratidal, experiences runup only during storms.                                                                                                                     |
| Bluff                    | Steep slope or cliff along the shoreline composed of unconsolidated sediment from glacial or fluvial origin. The bluff can be vegetated or, due to erosion and slope failure, consist of a steep exposed scarp. |
| Coastal Accretion        | Accumulation of sediment on the beach due to continuous net deposition, resulting in a (vertical or horizontal) buildup of the beach zone                                                                       |
| Coastal Erosion          | The loss or displacement of land, or the long-term removal of sediment and rocks along the coastline due to the action of waves, currents, tides, waterborne ice, or impacts of storms.                         |
| Deposition               | The process by which sediment settles, or is added to a beach and its surroundings.                                                                                                                             |
| Geomorphic processes     | In the context of coastal geomorphology, these are any processes that influence beach morphology, primarily including erosion and deposition.                                                                   |
| Geomorphology            | The study of landforms and the processes that cause and alter landforms.                                                                                                                                        |
| Georeference             | Aligning geographic data, such as an orthophoto, to a known earth coordinate system for the purposes of spatial analyses (ESRI, n.d.).                                                                          |
| Hazard                   | A process or phenomenon that may cause adverse environmental, social and economic impacts. Hazards can be characterized by their location, intensity or magnitude, frequency and probability (UNDRR, 2017).     |
| Hydro-physical processes | Hydrologically-driven processes that influence coastal geomorphology.                                                                                                                                           |
| Longshore Transport      | The movement of beach sediment, specifically sand, downcoast due to nearshore waves moving at oblique angles to the shoreline (Kahl et al., 2024).                                                              |



|                                  |                                                                                                                                                                                                                                                                                     |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Natural (sediment-based)         | Sediment-based shoreline segment without any form of shoreline protection that is in its natural state. This classifier does not apply to any bedrock shorelines.                                                                                                                   |
| Nature-based Protection          | Shoreline protection that can consist of sediment-based, vegetation-based, or hybrid solutions to work within a naturally dynamic system and increase resiliency to the impacts of climate change, while also supporting and protecting biodiversity and human well-being.          |
| Nearshore                        | The beach zone that extends from where waves break to low water level, experiencing most of the breaking waves.                                                                                                                                                                     |
| Offshore                         | The area seaward and beyond where waves break.                                                                                                                                                                                                                                      |
| Orthoimagery                     | Digitized aerial photographs geometrically corrected to have the same scale throughout the image (ESRI, n.d.)                                                                                                                                                                       |
| Risk                             | The potential adverse impacts of an event or process on society, or factors of human settlement, including life and infrastructure, in a specific period of time. Risk is determined probabilistically as a function of hazard, exposure, vulnerability and capacity (UNDRR, 2017). |
| Shoreline                        | General term for the boundary between land and ocean, commonly defined at the high-water mark.                                                                                                                                                                                      |
| Substandard shoreline protection | Any failed or partially failed shoreline protection or landscaped structures, especially when signs of erosion are present behind the protection                                                                                                                                    |
| Vulnerability                    | Conditions that increase the susceptibility of an individual, community, asset or system to the impacts of hazards. Vulnerability can be influenced by physical, social, economic and environmental factors or processes (UNDRR, 2017).                                             |

## 1 INTRODUCTION

This report presents the baseline erosion hazard assessment for a coastal erosion monitoring program along the City of Nanaimo's shoreline. The City of Nanaimo retained NHC to conduct the Nanaimo Sea Level Rise Management Plan, and this assessment is part of Phase 2 of the project. The objectives of this survey are to establish baseline erosion rates and drivers and inform future monitoring indicators, frequencies and protocols as part of a long-term monitoring plan. This baseline assessment is focused on the shorelines identified in Figure 1.1. These areas were chosen in consultation with the City of Nanaimo, based on a known history of coastal erosion issues and shoreline protection measures.



**Figure 1.1 Erosion monitoring study area – identified high erosion hazard shorelines.**

This study included a topographic drone survey by SuavAir – producing the 2026 lidar and orthoimagery used in analyses - and a field assessment conducted by a geomorphologist to establish baseline conditions. The field assessment provided the information needed to characterize the morphology and shoreline conditions, and to identify coastal processes and



erosion drivers. Erosion rates and topographic change were established by comparing the 2026 SuavAir lidar survey with previous lidar surveys.

The erosion rates are based on a shift in shoreline position that may be either retreat or advance of the shoreline as a result of sediment erosion (removal) or accretion (accumulation), respectively (Mangor et al., 2017). The net rate of change provides an indication of the speed with which progressive erosion (negative rate) or accretion (positive rate) of the shoreline is occurring. Shoreline change is generally understood to be driven by wave and tidal action, relative sea-level change, beach sediment supply, and anthropogenic alterations to shoreline morphology and structures (Burningham and Fernandez-Nunez, 2020). The rate at which shoreline change occurs indicates the level of hazard from erosion and the potential for future change to the shoreline position.

## 1.1 Vertical Datum

For this assessment, elevations are referenced to Canadian Geodetic Vertical Datum of 2013 (CGVD2013), unless otherwise stated. Where elevations in chart datum (CD) needed to be converted to CGVD2013, the following conversion was applied based on the Nanaimo Harbour (Station ID 7917) Benchmark M14C9042.

$$Elev_{CGVD2013} = Elev_{CD} - 2.86 \text{ m}$$

$$Elev_{CGVD2013} = Elev_{CGVD28} + 0.16 \text{ m}$$

## 2 BACKGROUND REVIEW

NHC reviewed a range of available data and studies to inform this assessment. This included previous lidar surveys, orthoimagery, oblique air photos of the shoreline, surficial geology maps and water level records.

### 2.1 Geospatial Data

The following geospatial datasets were used to inform the geomorphic hazard assessment:

- Topographic surveys
  - GeoBC lidar (2019) – used to produce 2019 digital elevation model (DEM)
  - GeoBC lidar (2024).
  - City of Nanaimo lidar (2025).
  - SuavAir lidar (2026) – used to produce 2026 DEM
- Orthoimagery
  - Regional District of Nanaimo (2002).
  - Regional District of Nanaimo (2022).

- City of Nanaimo (2024).
  - SuavAir (2026).
- Satellite imagery
  - Vantor Vivid Advanced imagery (2025)
- Oblique photos
  - ShoreZoneBC (2023). Oblique shoreline photos of the Nanaimo shoreline.
- Surficial geology map
  - GSC (1963). *Nanaimo, British Columbia Surficial Geology*. [Map]. GSC, Dept. of Mines and Technical Surveys, Surveys and Mapping Branch.
- Previous shoreline mapping
  - PSF (2026). Resilient Coasts for Salmon. [Dataset].

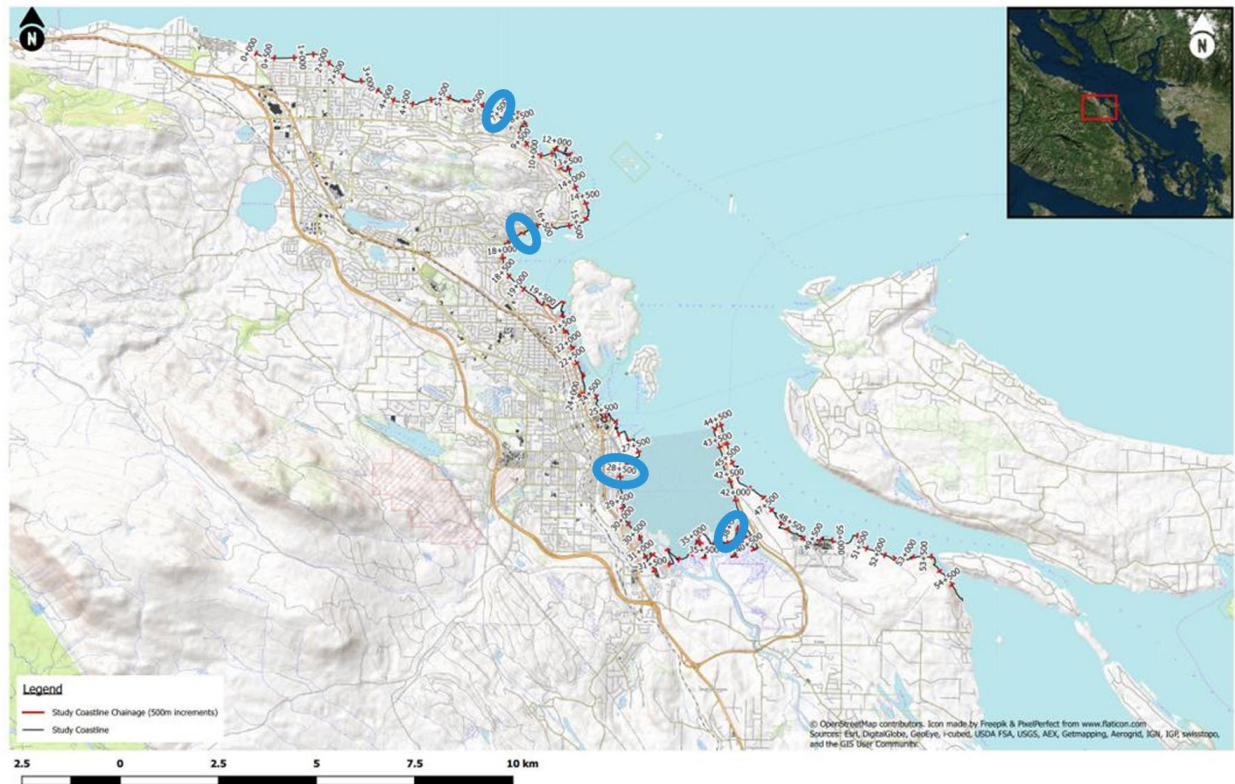
The GeoBC lidar from 2024 had significant data quality issues at the time the erosion assessment was done and was therefore not used. The City of Nanaimo lidar from 2025 has limited intertidal extents, making the data less usable for the purpose of this study. The analyses presented in Section 3 relied on the 2019 GeoBC Lidar, 2026 SuavAir Lidar & imagery, surficial geology map and 2026 PSF shoreline mapping.

## 2.2 Previous Sea Level Rise Study

Associated Engineering (AE et al., 2018) performed an erosion analysis as part of the sea level rise study conducted in 2018. The report estimated shoreline change along 8 transects using visual estimation and determined areas of high shear stress using numerical modelling. The visual assessment was based on georeferenced imagery and orthoimagery from 1996 and 2016.

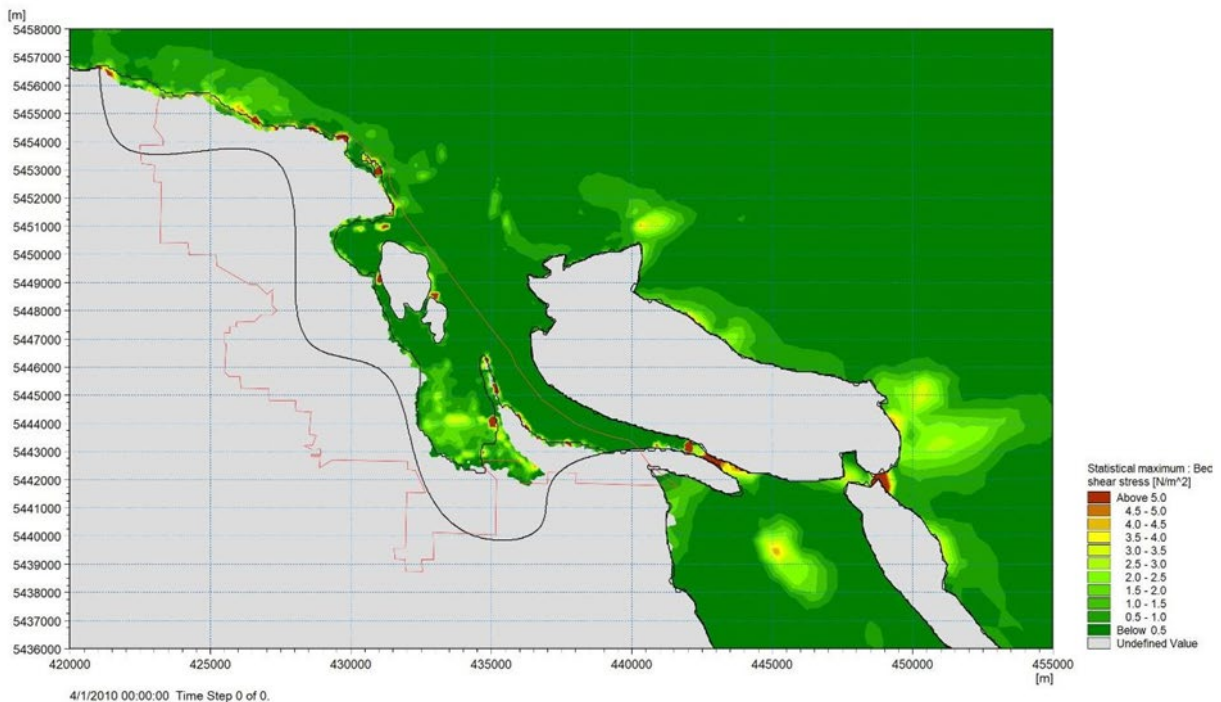
The coastline was classified into man-made coastline, natural sedimentary, rocky and sedimentary (with defences). The distance of retreat was determined for eight transects where the historic visible vegetation line could be discerned from the imagery and then converted to an annualised rate (m/yr). Due to the imagery resolution and the georeferencing error for the 1996 imagery, these erosion rates are expected to have a significant error range; erosion less than a few metres was difficult to detect. Additionally, retreat rates could not be calculated for the North Shore due to overhanging tree canopies. A map of the project chainage and the approximate locations of seven of the eight transects is provided in Figure 2.1. The location of the transect on Protection Island is not provided in the report.





**Figure 2.1** Map adjusted by NHC from Sea Level Rise Study (AE et al., 2018). Blue ovals indicate approximate locations of transects assessed by AE. Some locations include multiple transects. Location of transect on Protection Island is not provided in the report.

The numerical modelling focused on a scenario with strong tidal flow and storm wave conditions. The maximum bed shear stress outputs for the storm wave scenario are shown in Figure 2.2. AE (2018) identified 'erosion hotspots' based on these results, however, bed shear stress does not consider the substrate type, thickness, sediment supply or any other morphologic factors. The results do indicate that there are a number of locations along the North Shore that could potentially be more susceptible to erosion depending on the shoreline conditions and morphology.



**Figure 2.2** Maximum bed shear stresses during four-day simulation period in early April 2010 with strong winds and high waves (AE et al., 2018).

## 2.3 Nanaimo Harbour Tidal Levels

Tidal elevations for Nanaimo are based on published information for the Nanaimo Harbour station (ID07917) owned by the Canadian Hydrographic Survey (CHS). NHC used these tidal level measurements to establish the shoreline position presented in Section 3. Table 2.1 presents the tidal elevations as well as highest and lowest recorded values (including storm surge) at the Nanaimo Harbour station. The tides at Nanaimo are semi-diurnal, with two high and two low tides of unequal height each day. The annual mean tide range between Lower Low Water Mean Tide (LLWMT) and Higher High Water Mean Tide (HHWMT) is 3.29 m.

**Table 2.1** Nanaimo Harbour tidal levels.

| Astronomical Tide Level                   | Height CD (m) | Height CGVD2013 (m) |
|-------------------------------------------|---------------|---------------------|
| Highest Recorded Water Level              | 5.70          | 2.84                |
| Highest Astronomical Tide                 | 5.08          | 2.22                |
| Higher High Water Large Tide              | 5.01          | 2.15                |
| HHWMT Higher High Water Mean Tide (HHWMT) | 4.47          | 1.61                |
| Mean Water Level                          | 3.08          | 0.22                |
| Lower Low Water Mean Tide (LLWMT)         | 1.18          | -1.68               |



| Astronomical Tide Level     | Height CD (m) | Height CGVD2013 (m) |
|-----------------------------|---------------|---------------------|
| Lower Low Water Large Tide  | 0.02          | -2.84               |
| Lowest Astronomical Tide    | -0.17         | -3.03               |
| Lowest Recorded Water Level | -0.22         | -3.08               |

### 3 EROSION MONITORING BASELINE

This section presents the baseline erosion hazard assessment for a long-term erosion monitoring plan along four different high erosion hazard shorelines in Nanaimo. The section includes an overview of baseline geomorphic conditions and erosion drivers based on a site assessment, as well as rates of shoreline and topographic change based on topographic surveys from 2019 and 2026.

#### 3.1 Baseline Conditions and Erosion Drivers

NHC established the existing conditions through a background review and field assessment. The field assessment for the North Shore was conducted on April 10 and 18. The area on Protection Island and the areas at Departure Bay and Cilaire were assessed on April 17 and 19, respectively. The assessment consisted of a geomorphologist walking the shoreline near low tide and documenting the existing conditions by collecting photos and field notes.

The field observations were used to create conceptual models of the areas and map the shoreline morphology, sediment and protection works. The shoreline mapping consists of the beach composition, backshore type,<sup>1</sup> and shoreline protection (if any) of the shorelines of interest. Definitions for the different classifiers can be found in the glossary. Classifications are based on lidar, orthoimagery, and field photos.

NHC also referenced previous mapping of shoreline modifications by the Pacific Salmon Foundation (2026) to identify locations of shoreline protection. The following sections present the field observations, conceptual models, and shoreline mapping results to identify baseline coastal processes and shoreline conditions.

##### 3.1.1 North Shore

The North Shore has a known history of coastal erosion and slope instability along the bluff that spans much of the approximately 5.5 km long focus area. Coastal erosion indicators – including

---

<sup>1</sup> Backshore type, or backshore morphology, refers to the landform or structure landward of the mapped shoreline.

undercut shoreline, fresh erosion scarps, and exposed tree roots – were visible at multiple locations along the shoreline (Photo 3.1 to Photo 3.4). The lengths of active coastal erosion at the time of the field assessment are shown in (Figure 3.1, Figure 3.2 and Figure 3.3). The bluff consists of compacted sedimentary deposits, prone to erosion from wave action at the toe of the bluff (Photo 3.5, Photo 3.6 and Photo 3.7). The sedimentary deposits along the North Shore include marine/glaciomarine sand and gravel that overlie basal till consisting of sand and silt with lenses of gravel (GSC, 1963). Certain sections of the bluff consist of slowly erodible and well-compacted silt and clay deposits (Photo 3.5 and Photo 3.6). Bluff toe erosion, or erosion at the base of the bluff, can over steepen the bluff slope, leading to failure of the bluff and substantial sediment movement (Photo 3.6 and Photo 3.7). Sediment from bluff failures is deposited at the toe of the bluff, where it can be reworked at high tides and transported alongshore. The cycle of toe erosion to oversteepening to collapse to toe erosion drives bluff recession over time.

In addition to this coastal erosion driven process, bluff failure might also occur due to high amounts of runoff from rainfall and geotechnical instabilities. Runoff that infiltrates and seeps through the bluff can lead to soil creep and slope failure. Signs of this process were present along much of the shoreline, with trees angled shoreward, localized areas of slope failure, and water runoff visible along much of the North Shore (Photo 3.8 to Photo 3.12). Approximate locations of slope failure are indicated on Figure 3.1, Figure 3.2 and Figure 3.3.

These two mechanisms both result in shoreline change over time. While one is driven by coastal processes and the other by geotechnical processes, both result in bluff recession and consequently shoreline recession. Sediment at the toe of the bluff can be reworked by tides and waves and transported both alongshore and seawards. This process has likely contributed to the formation of wide intertidal flats along the North Shore, especially at the west end of the focus area. However, tidal flat formation can also be driven by the presence of less erodible substrate or an armouring layer of sediment at or near sea level.

There are a few sections with shoreline protection along the North Shore, such as riprap or lockblock walls (Figure 3.4, Figure 3.6 and Figure 3.8). The protection is frequently in poor condition, with rocks dislodged from the placement or failure of the wall and erosion visible behind and above the riprap. Several factors may result in failure of shoreline protection, including the following:

- Protection may have been poorly designed: if the structure was not designed to withstand site specific conditions, failure could occur during storms. For riprap, this may mean armour rock being undersized, the thickness of the placement was not sufficient or a filter layer may not have been included.
- Protection was poorly constructed: if it is constructed poorly, the structure can fail within the design life. This can be the result of improper selection of building materials (for instance, smaller than designed armour rock or poor quality concrete) or improper construction (for instance, insufficient interlocking of armour rock or a placement that



does not meet the designed thickness). In both cases, storms and wave action can lead to dislodging of riprap, failure of the seawall, and scouring and undermining of the riprap or seawall.

- Protection has passed its intended design life and has not been maintained or repaired.

There are instances where erosion is visible in sections adjacent to substandard protection. This can be caused by the presence of shoreline protection (e.g., end effect scour or shoreline lowering), but it may not be related to the condition of the protection. These sections are marked as substandard protection. In some places, the bluff has receded behind what was a riprap placement (Photo 3.14). The latter sections were marked as unprotected.

There is one section along the North Shore with nature-based protection; it is located east of Oar Road and west of the Seaboldt Rotary Park along the interceptor maintained by the Regional District of Nanaimo (RDN) (Photo 3.15). This is a hybrid form of nature-based protection that includes a cobble placement and four headlands to protect a previously exposed section of pipeline. NHC was involved in the design and construction of this project.

Towards the east of this section, the shoreline consists of bedrock (Figure 3.8 and Figure 3.9). This shoreline has a low erosion hazard and the shoreline position of the bedrock sections is unlikely to change due to erosion. However, sea level rise might result in erosion of any sedimentary deposits on top of the bedrock that are not currently subjected to waves and tides, especially along any low sloping bedrock shorelines.

The North Shore bluffs have a high coastal exposure and are exposed to waves from the north and east, and to a lesser degree from the west. Due to the long fetch from the north and east, waves along the shoreline can be high. Especially at high tide during storms, this can induce significant coastal erosion along the bluffs.





**Photo 3.1    Erosion scarp along shoreline**



**Photo 3.2    Undercutting and exposed tree roots along shoreline.**



**Photo 3.3    Undercutting and exposed tree roots along shoreline.**



**Photo 3.4    Erosion scarp along shoreline.**



**Photo 3.5    Section of the North Shore bluffs with exposed scarp.**



**Photo 3.6    Bluff scarp with evidence of recently deposited sediment at the toe of the bluff.**





**Photo 3.7** Small slope failure resulting in additional erodible sediment at the toe of the bluff.



**Photo 3.8** Trees angling shoreward indicating soil creep.



**Photo 3.9** Trees angling shoreward indicating soil creep.



**Photo 3.10** Location of slope failure along bluff.



**Photo 3.11** Location of slope failure along bluff.



**Photo 3.12** Run off channel at bluff.





**Photo 3.13** Location of slope failure along bluff.



**Photo 3.14** Suspected remnants of old riprap placement. Bluff has receded behind line of boulders.



**Photo 3.15** RDN interceptor protection east of Oar Road.



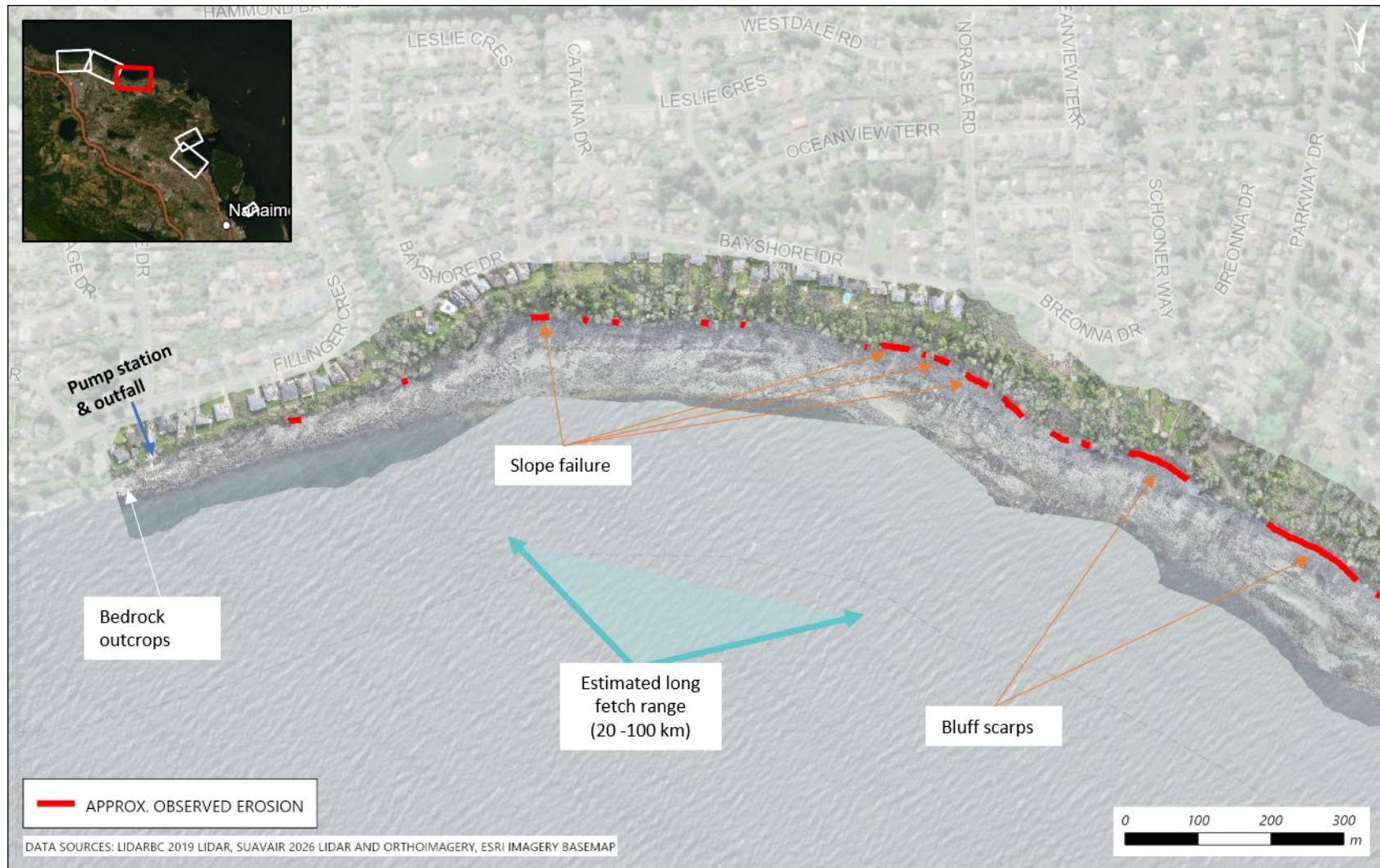


**Figure 3.1** Map of observed features and areas of active erosion along the west side of the North Shore focus area. Slope failure location is approximate.



**Figure 3.2** Map of observed features and areas of active erosion along the center of the North Shore focus area. Slope failure locations are approximate.





**Figure 3.3** Map of observed features and areas of active erosion along the east of the North Shore focus area. Slope failure locations are approximate.



SHORELINE PROTECTION & BEACH COMPOSITION



Figure 3.4 Shoreline protection and beach composition mapped along the west side of the North Shore focus area.

BACKSHORE MORPHOLOGY



Figure 3.5 Backshore morphology mapped along the west side of the North Shore focus area.



Figure 3.6 Shoreline protection and beach composition mapped along the center of the North Shore focus area.



Figure 3.7 Backshore morphology mapped along the center of the North Shore focus area.



SHORELINE PROTECTION & BEACH COMPOSITION



Figure 3.8 Shoreline protection and beach composition mapped along the east side of the North Shore focus area.

BACKSHORE MORPHOLOGY



Figure 3.9 Backshore morphology mapped along the east side of the North Shore focus area.

### 3.1.2 Departure Bay

The focus area within Departure Bay is located on the northwest side of the bay and is around 1.2 km in length. There is a bluff along Departure Bay, with bedrock outcrops at multiple points along the shoreline (Photo 3.16, Photo 3.17, Figure 3.12). In places, the bluff appears to be located on top of the bedrock (Photo 3.18). The bedrock outcrops create a rocky shoreline with steep slopes and pocket beaches (Photo 3.19, Photo 3.20 and Photo 3.21). Departure Creek enters the bay at the west end of the focus area (Photo 3.22, Figure 3.10). The creek actively reworks the beach gravel and has created a fluvial fan with bars and channels. Part of the west side of the focus area is lower lying, and most of the shoreline along this section has been hardened with riprap or seawalls (Photo 3.23, Figure 3.11). Most of the protection along this section appears to be in good condition for the purpose of erosion protection. There are two sections mapped as substandard riprap, one where cobble has been piled up adjacent to a seawall, and one section with what looks like a landscaped rock wall. The surficial geology along the shoreline of this area is similar to the North Shore, with marine/glaciomarine sand & gravel overlaying basal till, but combined with areas of bedrock outcrop (GSC, 1963).

The coastal erosion along the Departure Bay focus area appears limited at present. There was some erosion at the east end of the focus area, along two bluff sections without shoreline protection (Photo 3.24, Figure 3.10) and some localized erosion on the east side of a property close to Departure Creek (Photo 3.25, Figure 3.10). The bluff along Departure Bay does not show significant signs of coastal erosion at present. However, an increase in sea level could potentially result in erosion, especially along areas where the bluff is currently on top and behind bedrock outcrops and not subject to waves and tides.

The bedrock along this section of Departure Bay reduces the erosion potential and its position in the bay means that it is also relatively sheltered from waves (Figure 3.10). The longest fetch direction is from the east, with some exposure to southeastern waves (Figure 3.10). This combination makes the bluff much less prone to erosion than the bluffs along the North Coast and Cilaire.





**Photo 3.16** Departure Bay bluff next to Departure Creek. The toe of the bluff is protected by a low seawall (left) and bedrock outcrops (right).



**Photo 3.17** Example of bluff on top of and behind bedrock. Remnant concrete wall present to the right of the photo.



**Photo 3.18** Example of bluff located on top of bedrock.



**Photo 3.19** The center section of Departure Bay consists of rocky shorelines with bedrock outcrops and angular cobble and boulders.



**Photo 3.20** The center section of Departure Bay consists of rocky shorelines with bedrock outcrops and relatively steep slopes.



**Photo 3.21** Pocket beach along the center section of Departure Bay with a steep gravel beach sheltered by rocky headlands on each side.





**Photo 3.22** Departure Creek at the west end of the Departure Bay focus area.



**Photo 3.23** Examples of shoreline protection along the lower lying west end of the Departure Bay focus area.



**Photo 3.24** Coastal erosion along bluff at the east end of the Departure Bay focus area.



**Photo 3.25** Localized area of erosion near Departure Creek





SHORELINE PROTECTION & BEACH COMPOSITION



Figure 3.11 Shoreline protection and beach composition mapped along the Departure Bay focus area.

BACKSHORE MORPHOLOGY



Figure 3.12 Backshore morphology mapped along the Departure Bay focus area.



### 3.1.3 Cilaire

The Cilaire focus area is located on the southwest side of Departure Bay and is around 1.5 km in length. The shoreline along Cilaire mainly consists of basal till with sand, silt, and lenses of gravel (GSC, 1963). The bluff along most of the Cilaire shoreline is actively eroding and in places shows signs of slope failure and soil creep. The bluff spans from the south end of Battersea Road to Northfield Creek (Photo 3.26, Figure 3.13).

Coastal erosion in the form of undercutting of the shoreline, fresh erosion scarps, and exposed tree roots was visible at multiple locations along the shoreline (Photo 3.27 to Photo 3.30). The lengths of active coastal erosion at the time of the field assessment are shown in Figure 3.13. Similar to the processes described for the North Shore, undercutting of the toe of the bluff from wave action can over steepen the bluff slope, leading to failure of the bluff. Sediment from bluff failures can be reworked at high tides and transported alongshore. This process leads to bluff recession over time.

In addition to this coastal erosion driven process, bluff failure might also occur due to high amounts of runoff from rainfall and geotechnical instabilities. Runoff that infiltrates and seeps through the bluff can lead to soil creep and slope failure. Signs of this process were present along multiple sections of the bluff, with trees angled shoreward, localized areas of slope failure, and water runoff visible (Photo 3.31, Photo 3.32). Approximate locations of slope failure are indicated on Figure 3.13.

These two mechanisms both result in shoreline change over time. While one is driven by coastal processes and the other by geotechnical processes, both result in bluff recession. Tides and waves rework any sediment that accumulates at the toe of the bluff and transport it alongshore and offshore. This process has resulted in a wide intertidal area within Departure Bay (Figure 3.13). The combination of coastal erosion and geotechnical driven slope failure increases the rate of shoreline recession.

The section adjacent to Battersea Road has a row of boulders in front of the bluff that would help break waves at high tide (Photo 3.33). These boulders could be remnant riprap protection. There are other sections of bluff where boulders appear to be placed along the existing shoreline to provide protection to the toe of the bluff (Photo 3.34, Photo 3.35). There is one section of bluff where the toe and part of the bluff slope was armoured with riprap (Photo 3.36) and one section where it appears the bluff slope was armoured some time ago (Photo 3.37). The armouring in Photo 3.36 appears to have been placed in response to a slope failure. Sandbags were used as a form of protection at a beach access point at the south of the Cilaire focus area (Photo 3.38).

The north side of Cilaire from Battersea Road to Kinsmen Park is low lying. Most of the properties closest to the beach along Randle Road have a form of shoreline protection. In multiple instances, the protection appears to be substandard (low walls) (Photo 3.39). Some

properties have no shoreline protection, and based on the position of the beach wrack (driftwood, seaweed & kelp) the waves run up to the lawn (Photo 3.40). The riprap along Battersea Road is in poor condition and partly consists of concrete slabs (Photo 3.41, Photo 3.42). Erosion was visible in between some of the riprap, and certain sections lacked riprap rock (Photo 3.41, Photo 3.43).





**Photo 3.26** Cilaire focus area with low lying areas along Randle and Battersea Road on right and bluff along Cilaire in the distance.



**Photo 3.27** Undercutting and exposed tree roots along shoreline.



**Photo 3.28** Undercutting and exposed tree roots along shoreline.



**Photo 3.29** Undercutting with a low erosion scarp along shoreline.



**Photo 3.30** Low bluff scarp with variable erosion rates.



**Photo 3.31** Exposed bluff scarp with evidence of slope failure at toe of the bluff.





**Photo 3.32** Exposed bluff scarp with evidence of slope failure at toe of the bluff.



**Photo 3.33** Row of boulders in front of bluff adjacent to Battersea Road.



**Photo 3.34** Section of bluff with what appear to be placed boulders.



**Photo 3.35** Section of bluff with what appear to be placed boulders.



**Photo 3.36** Riprap protection along part of the bluff where there appears to have been a slope failure.



**Photo 3.37** Bluff slope with rock armouring that has started to become overgrown with vegetation.





**Photo 3.38 Beach access point with sandbags as shoreline protection.**



**Photo 3.39 Example of low walls as shoreline protection along Randle Road.**



**Photo 3.40 Example of section with no shoreline protection along Randle Road. Wrack line is close to shoreward edge of lawn.**



**Photo 3.41 Riprap along Battersea Road.**

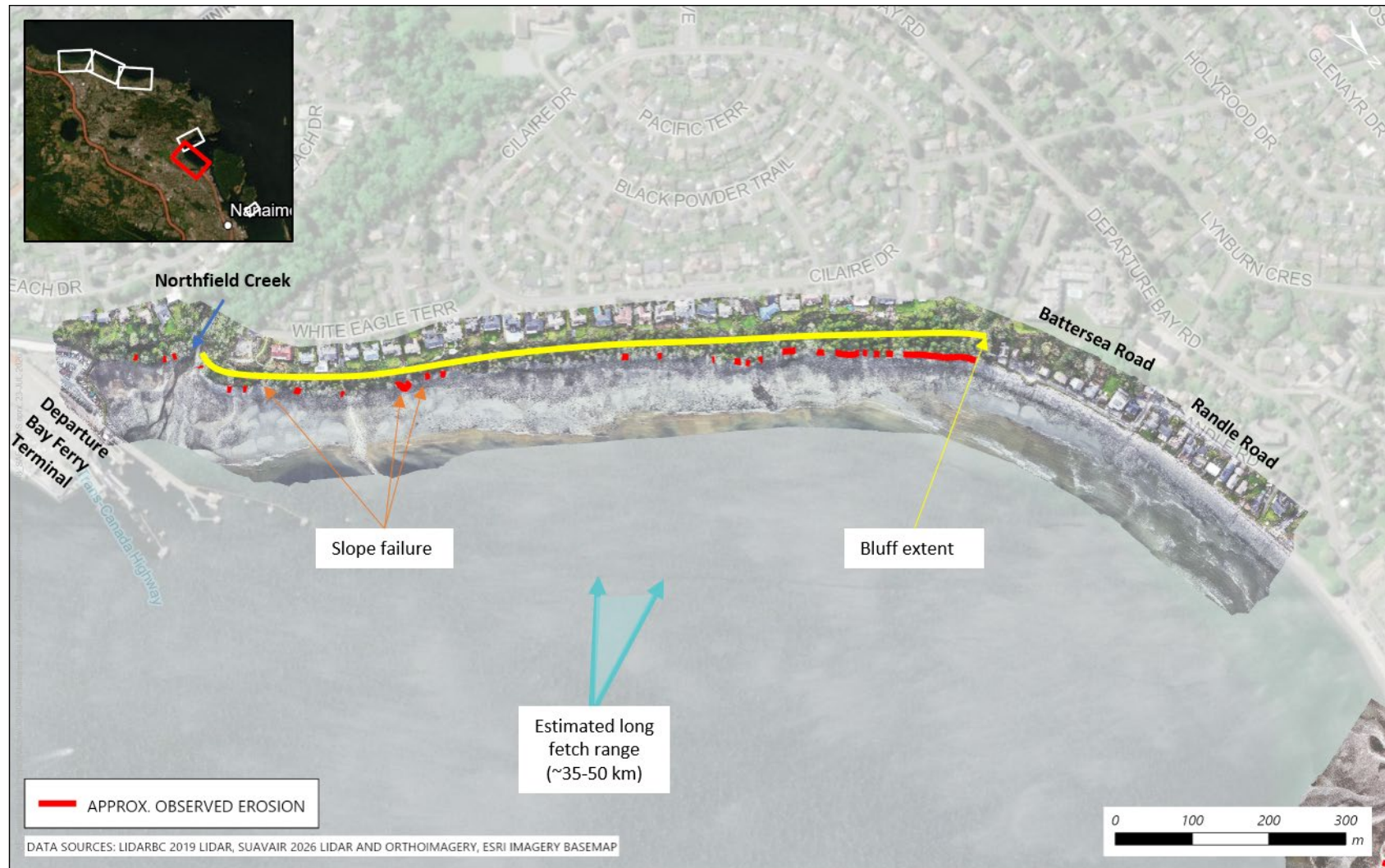


**Photo 3.42 Riprap along Battersea Road.**



**Photo 3.43 Section of Battersea Road where riprap is missing.**





**Figure 3.13 Map of observed features and areas of active erosion along Cilaire focus area. Slope failure locations are approximate.**



SHORELINE PROTECTION & BEACH COMPOSITION



Figure 3.14 Shoreline protection and beach composition mapped along the Cilaire focus area.

BACKSHORE MORPHOLOGY



Figure 3.15 Backshore morphology mapped along the Cilaire focus area.

### 3.1.4 Protection Island

Protection Island is a small island located around 1 km northeast of Nanaimo. The focus area is approximately 300 m in length and is located at the south end of the island (Figure 3.16). The surficial geology along Protection Island consists of stony, loamy, and clayey marine veneer commonly less than 5 ft in thickness on top of bedrock, with bedrock outcrops along the shoreline (GSC, 1963).

The east side of the focus area on Protection Island is entirely armoured with riprap or seawalls (Photo 3.44, Figure 3.17 and Figure 3.18). Most of the riprap sections appear in good condition. The seawall at the center of this area in Photo 3.44 and Photo 3.45 extends into the intertidal zone and the foundation of the seawall has become exposed over time. At the time of the field assessment, the foundation was exposed by around 11 inches, indicating that there has been at least this amount of beach lowering since the construction of the seawall.

The southeast of Protection Island was previously protected by a seawall. This seawall failed some time ago and riprap was placed behind part of the seawall to mitigate the erosion that was occurring (Photo 3.46 and Photo 3.47). Signs of this erosion are still visible at the top of the riprap in Photo 3.48. NHC suspects this erosion occurred before the riprap placement and is not ongoing. The south side of this seawall has no riprap behind it, and scouring occurred directly behind the failed seawall during recent storms (Photo 3.49, pers. comm. J. Beaubier, 17-Apr-2026). This scour was caused by waves breaking on the seawall slabs and removing the rock and sediment from behind the slabs.

There was no active erosion observed within the focus area at the time of the site assessment other than the scour at the south end of the island (Figure 3.16). The west side of the focus area is relatively sheltered from waves and the fetch on this side is limited (Figure 3.16). This area consists of a bay and a gravel and sand spit that extends towards the west that is partially vegetated with salt marsh (Photo 3.50, Photo 3.51, Figure 3.16).





**Photo 3.44** East side of Protection Island viewed from the northeast end.



**Photo 3.45** Seawall with exposed foundation (~11 inches).



**Photo 3.46** Riprap behind failed seawall at southeast end of Protection Island.



**Photo 3.47** Failed seawall and riprap at southeast end of Protection Island with accretion of sand and organics in between



**Photo 3.48** Riprap at the southeast end of Protection Island with visible erosion at top of bank. Erosion is suspected to have occurred prior to riprap placement.



**Photo 3.49** Scour behind seawall slabs at south end of Protection Island.





**Photo 3.50 Spit on west side of Protection Island with salt marsh vegetation.**



**Photo 3.51 Bay on west side of Protection Island with salt marsh vegetation along part of the shoreline.**





**Figure 3.16 Map of observed features and areas of active erosion within focus area on Protection Island.**



SHORELINE PROTECTION & BEACH COMPOSITION



Figure 3.17 Shoreline protection and beach composition mapped along the Protection Island focus area.

BACKSHORE MORPHOLOGY



Figure 3.18 Backshore morphology mapped along the Protection Island focus area.



## 3.2 Topographic Change

Erosion and accretion within the intertidal area can be visualized by creating a topographic change surface using the 2019 GeoBC and 2026 SuavAir elevation surfaces. This topographic change surface highlights locations where the beach has lowered or raised over time.

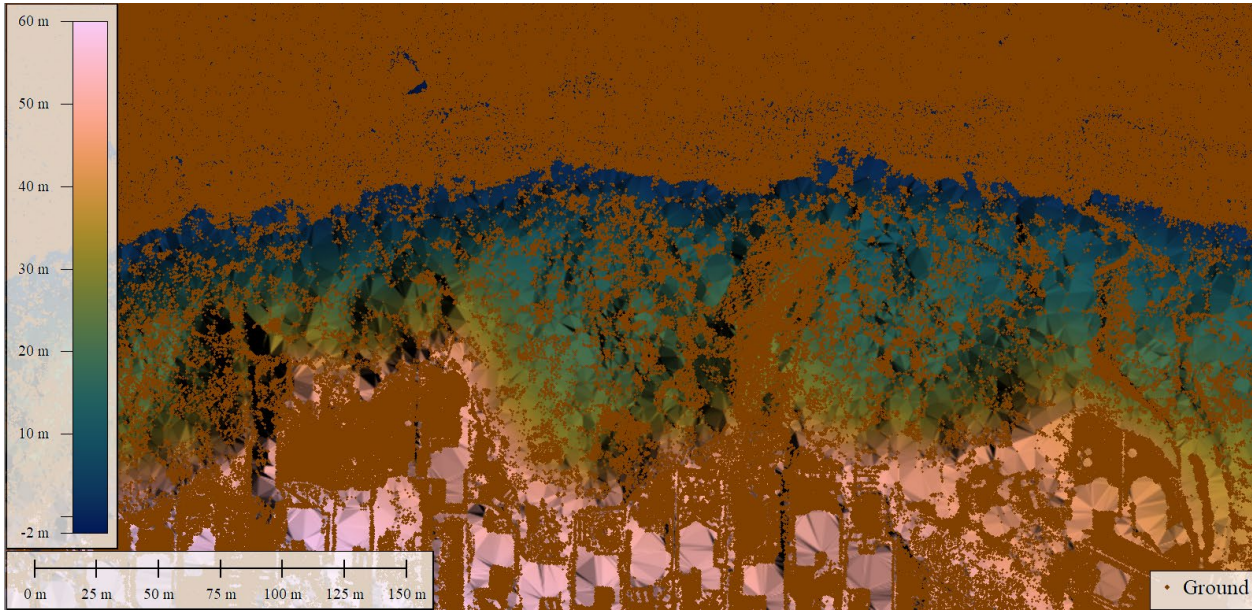
### 3.2.1 Methodology

NHC generated DEM surfaces for 2019 and 2026 with a 0.5 m grid size. The 2019 DEM was then subtracted from the 2026 DEM (DEM 2026 – DEM 2019) to create a change surface for the 7-year period between these surveys.

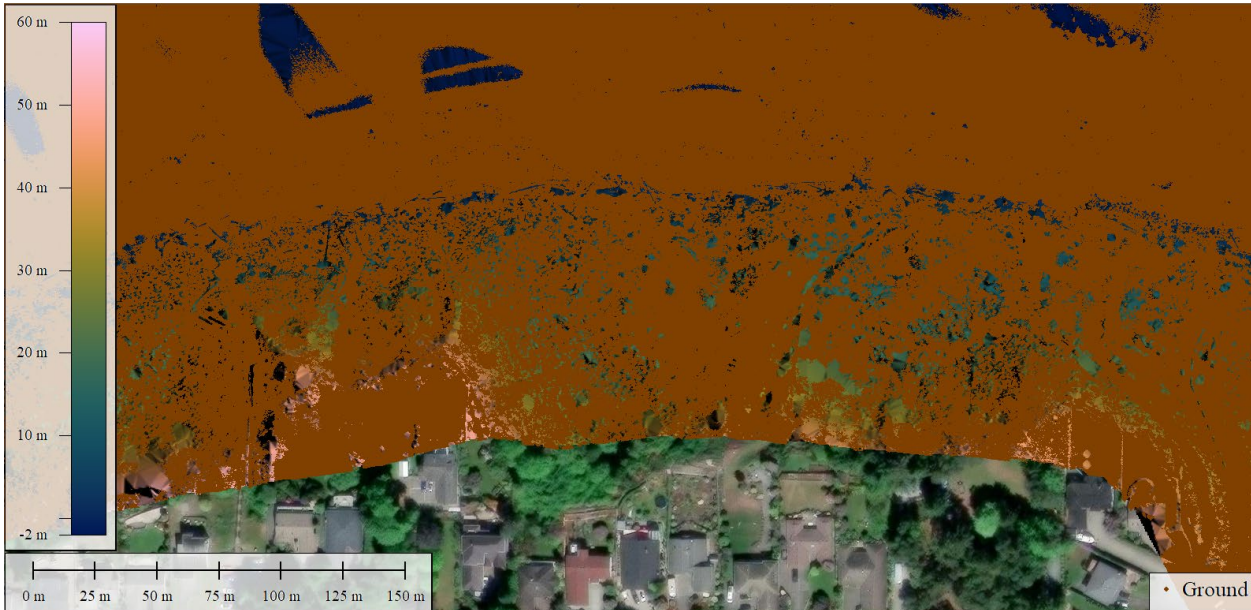
The DEM surfaces are derived from lidar point returns and gridded at a specified grid size to create a surface. Due to the difference in data collection standards, the number of bare earth points per grid cell is lower for the GeoBC survey than for the SuavAir survey, especially on the vegetated, steep bluff slopes, where there are few bare earth points (Figure 3.19 and Figure 3.20). This is mainly because the GeoBC data is flown at higher altitude and faster speeds, resulting in a lower point density than a drone-based lidar survey. The difference in point density results in larger areas of interpolation between points on the GeoBC surface on the bluff slopes, producing a more triangulated surface. The drone survey DEM with a higher point density better captures the variable topography. This difference in point density and interpolation areas between surveys results in artificial differences in elevation on the bluff slopes when comparing the DEM surfaces that are not representative of real change.

During future monitoring, topographic surveys can be collected with the same data collection settings as the 2026 SuavAir survey. This would produce a more realistic change surface that is not as heavily influenced by the differences in data resolution. To minimize the unrealistic changes in the difference surface for the GeoBC and SuavAir surveys, the topographic change results are presented for any elevation changes larger than 0.15 m and any unrealistic areas of change on the bluff slopes have been removed.





**Figure 3.19** Ground points (upper) and DEM surface with 0.5 m grid size (lower) for the 2019 GeoBC survey.



**Figure 3.20** Ground points (upper) and DEM surface with 0.5 m grid size (lower) for the 2026 SuavAir survey.



### 3.2.2 Results

The topographic change figures are presented per area in Figure 3.24 through Figure 3.29. Figure 3.21 to Figure 3.23 provided zoomed in views of areas with significant change. Due to the data issues affecting the bluffs described in Section 3.3.2, areas along the backshore have been removed from the topographic change results. Any unvegetated areas are less affected by the data issues and are more certain to represent actual change.

Areas of change along the North Shore include the nature-based shoreline protection project at Oar Road and the outfall in front of Seabold Rotary Park, as well as the shifting of bars on the tidal flats in front of the North Shore (Figure 3.21). There has been accretion behind the headlands that were constructed in 2023 and at the outfall there has been erosion on the east side and accretion on the west side. For Departure Bay and Cilaire, clear areas of change are the mouth of Departure Creek and Northfield Creek (Figure 3.22, Figure 3.23). Changes on east side of Protection Island include lowering of the beach in front of the riprap placements and accretion south of the seawall that is built out onto the beach (Figure 3.29). On the west side, there has been accretion on the beach north of the groyne and erosion on the beach on its south side (Figure 3.29).



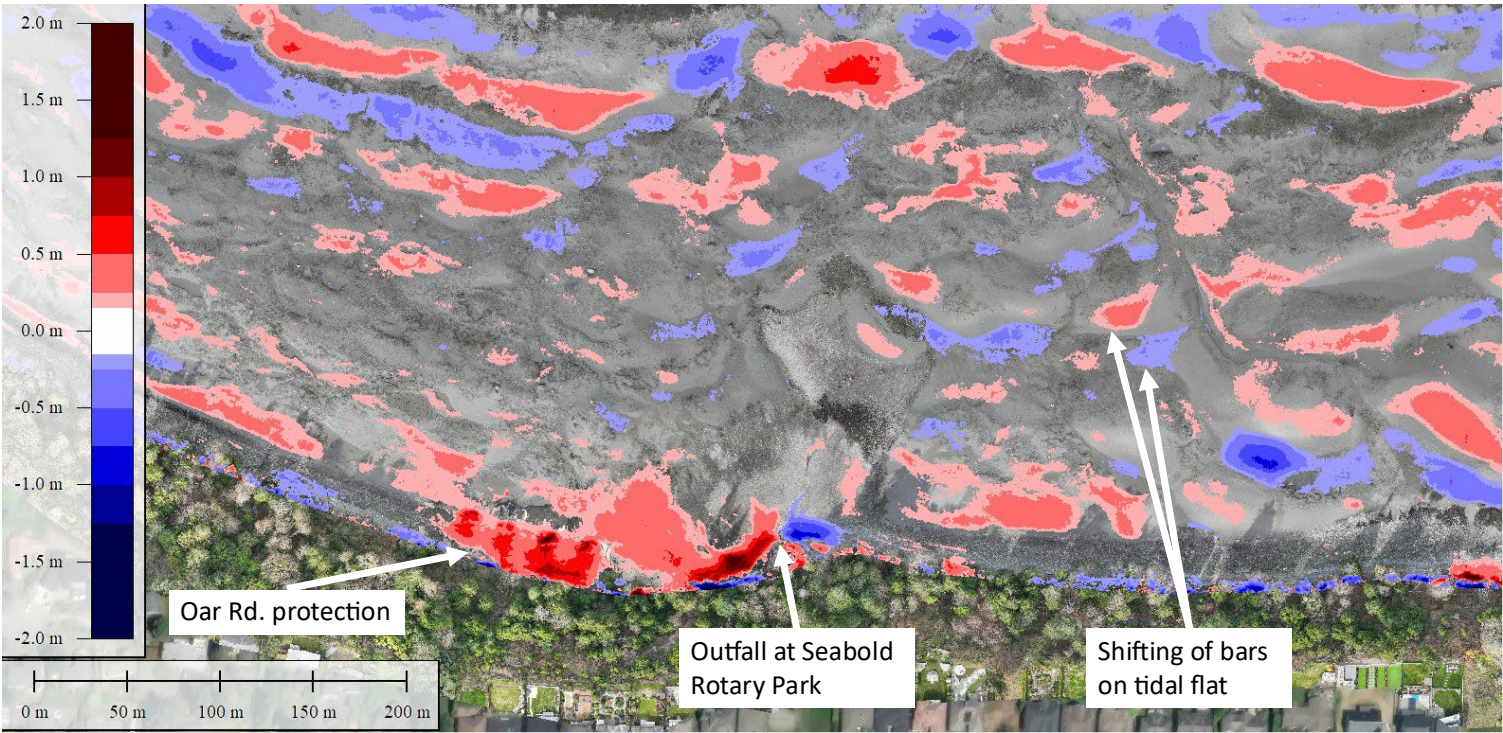


Figure 3.21 Topographic change along the North Shore at Oar Road and Seabold Rotary Park.

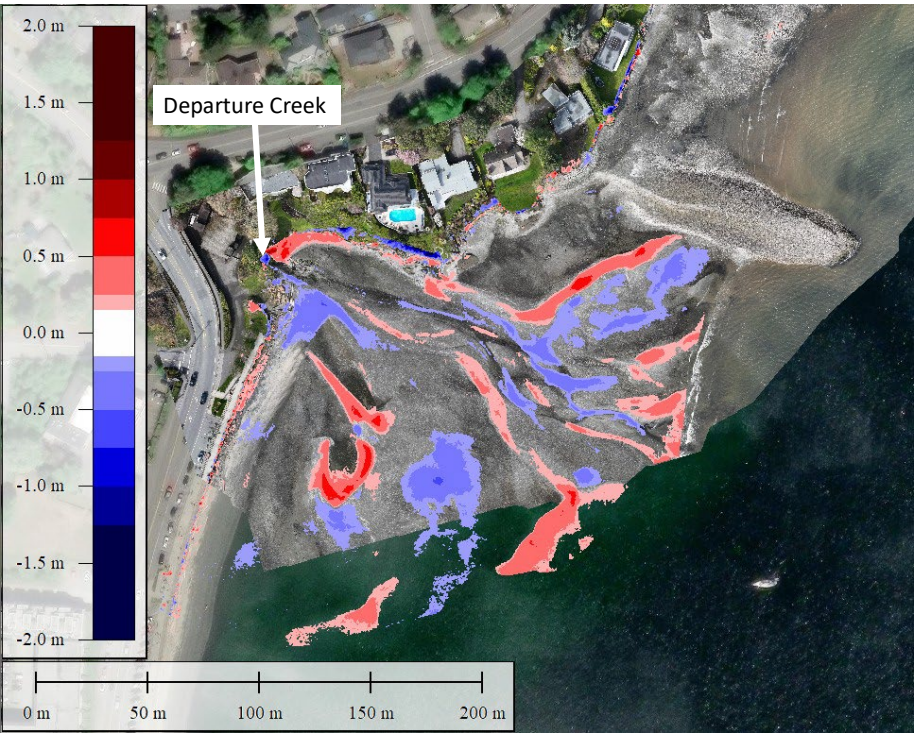


Figure 3.22 Topographic change at the mouth of Departure Creek in Departure Bay.

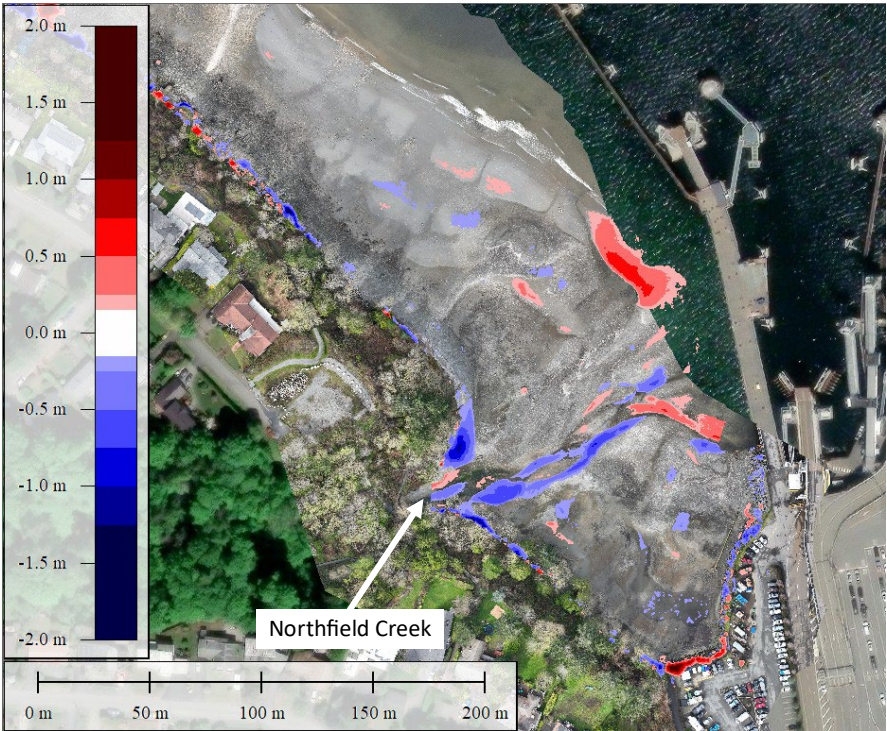


Figure 3.23 Topographic change at the mouth of Northfield Creek at Cilaire.



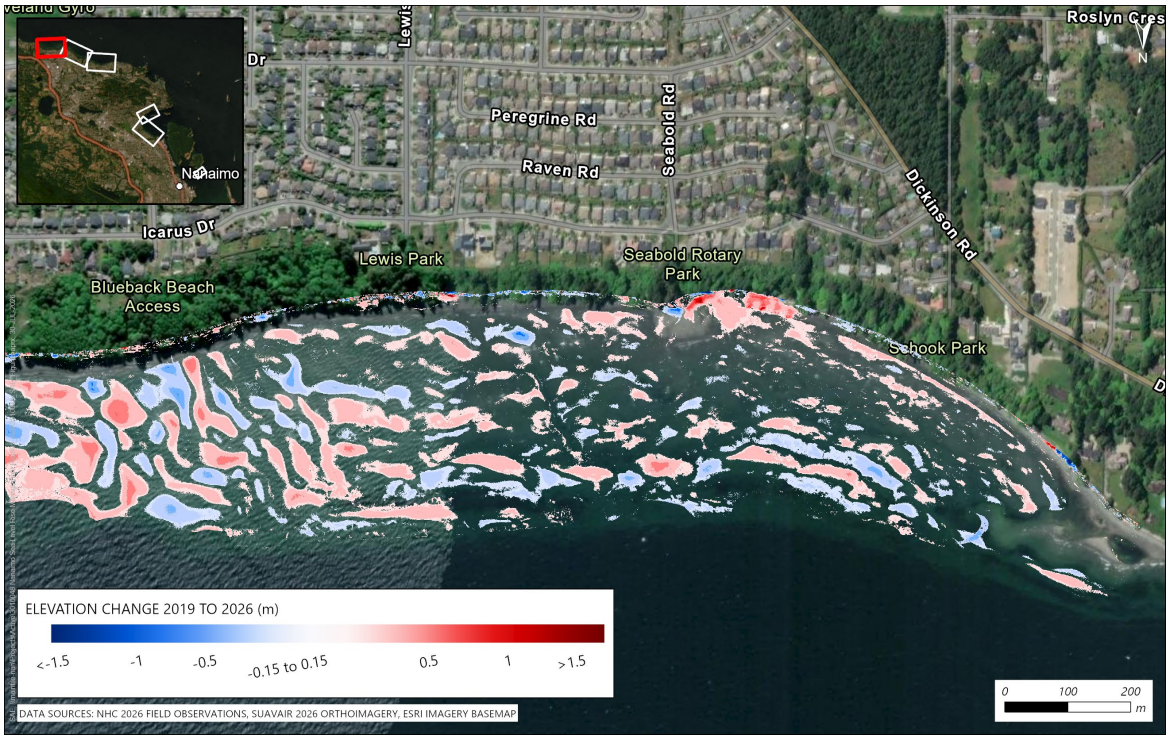


Figure 3.24 Elevation change at the west end of the North Shore focus area between 2019 (GeoBC Lidar) and 2026 (SuavAir Drone Survey Lidar).



Figure 3.25 Elevation change at the center of the North Shore focus area between 2019 (GeoBC Lidar) and 2026 (SuavAir Drone Survey Lidar).

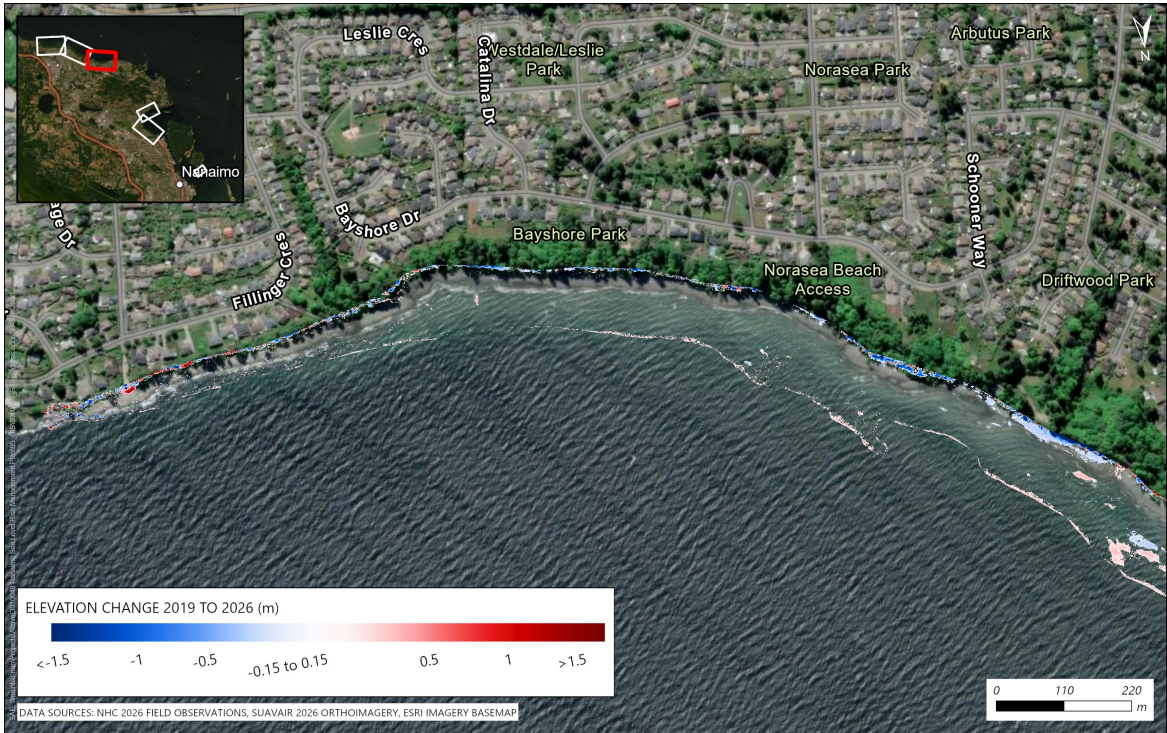


Figure 3.26 Elevation change at the east end of the North Shore focus area between 2019 (GeoBC Lidar) and 2026 (SuavAir Drone Survey Lidar).



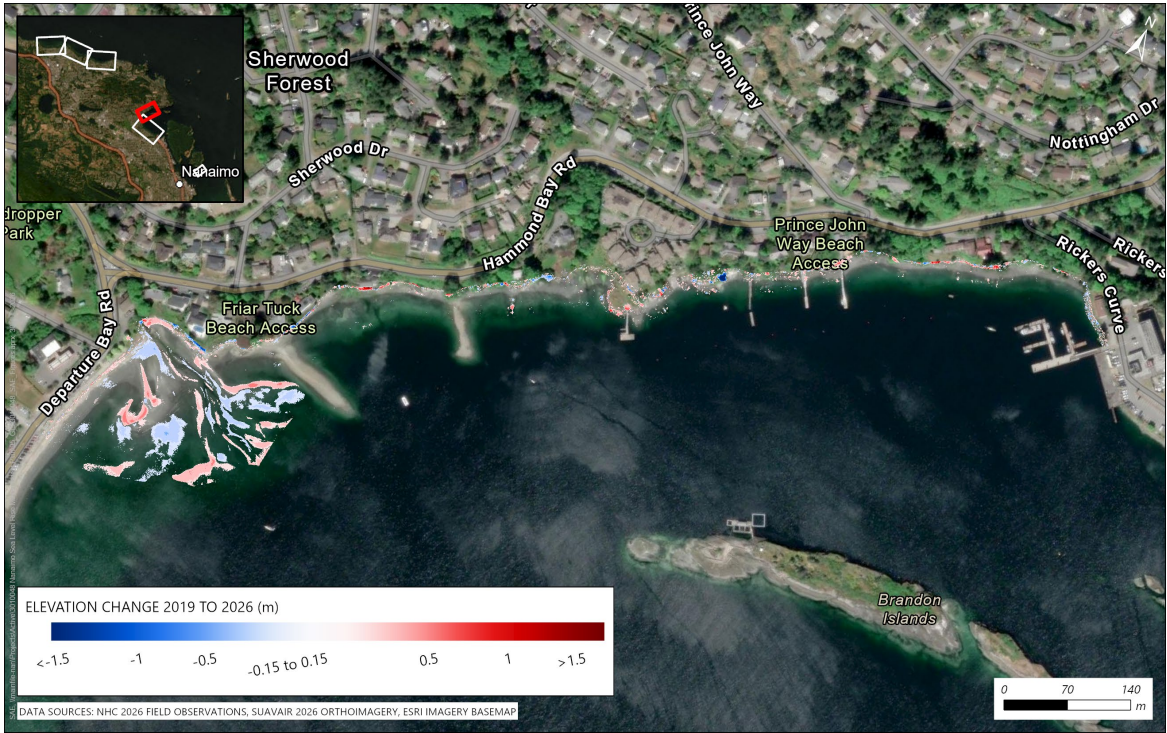


Figure 3.27 Elevation change at the Departure Bay focus area between 2019 (GeoBC Lidar) and 2026 (SuavAir Drone Survey Lidar).



Figure 3.28 Elevation change at the Cilaire focus area between 2019 (GeoBC Lidar) and 2026 (SuavAir Drone Survey Lidar).



Figure 3.29 Elevation change at the Protection Island focus area between 2019 (GeoBC Lidar) and 2026 (SuavAir Drone Survey Lidar).



### 3.3 Shoreline Change Rates

The shoreline change rates, or erosion rates, are based on a shift in the shoreline position. Shoreline change represents the retreat or aggradation of the shoreline as a result of sediment erosion or accretion (Mangor et al., 2017). The rate of change provides an important indication of the speed with which the erosion (negative rate) or accretion (positive rate) of the shoreline is occurring.

#### 3.3.1 Methodology

The shoreline position is approximated by the mean higher high water tide contour (HHWMT). This represents the average elevation of the highest daily tide over a 19-year period and is near the vegetation boundary along the Nanaimo shoreline. While the HHWMT provides a reasonable estimate overall, there may be locations where the shoreline is not well represented due to survey differences and processing accuracy limitations (as discussed in Section 3.2.1). During future monitoring, topographic surveys can be collected with the same data collection settings as the 2026 SuavAir survey. This would minimize any artificial differences in HHWMT contours.

The HHWMT at Nanaimo Harbour is 4.37 m CD or 1.61 m CGVD2013. Comparing the contour line at the HHWMT elevation for topographic surveys from multiple successive years reveals lateral shoreline change. NHC determined the shoreline change using the GeoBC lidar survey from 2019 and the SuavAir lidar drone survey from 2026 by generating contours at the HHWMT elevation for both digital elevation models (DEM's).

NHC then calculated shoreline change rates using the Digital Shoreline Analysis System (DSAS v6.1), a software developed by USGS. This tool determines the rate of change in the shoreline position along shore perpendicular transects using digitized shorelines. For this study, transects were created at approximately 10 m spacing along the shoreline. A negative-valued transect indicates landward movement of the shoreline (erosion), and a positive-valued transect indicates seaward movement (accretion).

##### 3.3.1.1 Uncertainty

The shoreline position uncertainty ( $U_T$  in meters) is dependent on the digitizing error ( $U_d$ ), the orthorectification error ( $U_o$ ), and the resolution error ( $U_p$ ) (Overbeck et al., 2020). Since contour lines derived from topographic surveys are used as shorelines in this assessment, no shorelines were digitized and the digitizing error ( $U_d$ ) can be considered zero. The horizontal accuracy of the lidar is equal to the orthorectification error ( $U_o$ ). The resolution error ( $U_p$ ) is the resolution of the DEM created from the lidar, which NHC deemed appropriate for the point density. The errors associated with both shorelines are summarized in Table 3.1.

The shoreline position uncertainty ( $U_T$ ) is calculated as:

$$U_T = \sqrt{U_d^2 + U_o^2 + U_p^2}$$

**Table 3.1 Shoreline errors.**

| Error (m)                                                | North Shore |            | Departure Bay |            | Cilaire    |            | Protection Island |            |
|----------------------------------------------------------|-------------|------------|---------------|------------|------------|------------|-------------------|------------|
|                                                          | 2019        | 2026       | 2019          | 2026       | 2019       | 2026       | 2019              | 2026       |
| Digitizing ( $U_d$ )                                     | 0           | 0          | 0             | 0          | 0          | 0          | 0                 | 0          |
| Orthorectification ( $U_o$ ) <sup>1</sup>                | 0.351       | 0.067      | 0.351         | 0.050      | 0.351      | 0.028      | 0.351             | 0.036      |
| Resolution ( $U_p$ )                                     | 0.5         | 0.25       | 0.5           | 0.25       | 0.5        | 0.25       | 0.5               | 0.25       |
| <b>Shoreline position uncertainty (<math>U_T</math>)</b> | <b>0.6</b>  | <b>0.3</b> | <b>0.6</b>    | <b>0.3</b> | <b>0.6</b> | <b>0.3</b> | <b>0.6</b>        | <b>0.3</b> |

1. Horizontal accuracy was not available for the LidarBC 2019 lidar. Accuracy is assumed to meet the Canadian Quality Level 1 – the minimum requirement for airborne LiDAR data acquisition in Canada (NRCan and Public Safety Canada, 2022). As such, horizontal accuracy is assumed to be a minimum of 35.1 cm.

The shoreline position uncertainties ( $U_T$ ) for 2026 (uncy A) and 2019 (uncy B) are then used to calculate the uncertainty of the end point rate (EPRunc) for each shoreline area of interest (Himmelstoss et al., 2021). The end point rate represents the distance between shoreline positions divided by the time elapsed, presented in meters per year. The resulting end point rate uncertainty is approximately 0.1 metres per year, calculated as:

$$EPRunc = \frac{\sqrt{(uncy A)^2 + (uncy B)^2}}{date A - date B}$$

### 3.3.2 Results

Along the combined 10,547 m of shorelines, 1020 transects were cast with approximately 1 transect every 10 m. Of these transects, 279 (27%) measured erosion, 97 (10%) measured accretion, and 644 (63%) had no change detected outside the uncertainty of this analysis. The following tables present the shoreline change results by shoreline study area, with Table 3.2 highlighting relative shoreline change trends, Table 3.3 highlighting the 5-year average erosion and accretion, and Table 3.3 Mean 5-year erosion and accretion results by shoreline.

| Shoreline         | Mean 5-Year Erosion | Mean 5-Year Accretion |
|-------------------|---------------------|-----------------------|
| Cilaire           | -1.0                | 1.0                   |
| Departure Bay     | -1.0                | 1.2                   |
| North Shore       | -1.1                | 1.7                   |
| Protection Island | -1.2                | 1.1                   |

Table 3.4 highlighting the most extreme 5-year erosion and accretion.



**Table 3.2 Shoreline change results by shoreline, as percent of total shoreline transects.**

| Shoreline         | Erosion | Accretion | No detected change |
|-------------------|---------|-----------|--------------------|
| Cilaire           | 18%     | 7%        | 74%                |
| Departure Bay     | 12%     | 9%        | 79%                |
| North Shore       | 37%     | 9%        | 54%                |
| Protection Island | 15%     | 16%       | 69%                |

**Table 3.3 Mean 5-year erosion and accretion results by shoreline.**

| Shoreline         | Mean 5-Year Erosion | Mean 5-Year Accretion |
|-------------------|---------------------|-----------------------|
| Cilaire           | -1.0                | 1.0                   |
| Departure Bay     | -1.0                | 1.2                   |
| North Shore       | -1.1                | 1.7                   |
| Protection Island | -1.2                | 1.1                   |

**Table 3.4 Maximum 5-year erosion and accretion results by shoreline.**

| Shoreline         | Max. 5-Year Erosion | Max. 5-Year Accretion |
|-------------------|---------------------|-----------------------|
| Cilaire           | -3.6                | 3.9                   |
| Departure Bay     | -3.3                | 3.1                   |
| North Shore       | -6.7                | 9.9                   |
| Protection Island | -2.3                | 6.3                   |

### 3.3.2.1 North Shore Shoreline Change

Figures 3.1 to 3.3 show observed erosion and the calculated shoreline change across the North Shore, scaled to average change over a 5-year period. Of the transects detecting shoreline movement along the North Shore (46% of transects), the majority (37%) show shoreline erosion between 2019 and 2026. The shoreline has eroded up to 9.2 m (+/- 0.7 m) over the whole 7-year period, scaled to a maximum of 6.7 m (+/- 0.5 m) of erosion over a 5-year period. Erosion is likely associated with the bluff morphology that characterizes much of the backshore along the North Shore.

For the most part, shoreline erosion calculated along transects corresponds well to field observations of erosion along the whole shoreline extent. Shoreline transects showing accretion in an area of observed erosion are likely the result of bluff failure depositing sediment along the shoreline, as discussed further in Section 3.1.1. and 3.1.4.



Figure 3.30 5-year shoreline change along the North Shore, west extent.



Figure 3.31 5-year shoreline change along the North Shore, center extent.



Figure 3.32 5-year shoreline change along the North Shore, east extent.



### 3.3.2.2 Departure Bay Shoreline Change

A relatively small portion (21%) of the transects along Departure Bay detected shoreline movement outside the uncertainty range. These transects reveal both accretion and erosion, with slightly more erosion detected along the shoreline (12% compared to 9%), as seen in Figure 3.33. Notably, the most extreme accretion and erosion occurred near the fluvial fan of Departure Creek, where it is common for sediment to be deposited, reworked, and redistributed.

Erosional transects do not align with field observations along Departure Bay. Erosion observed in the field would not be captured by the shoreline change assessment if it occurred before 2019. Additionally, if observed erosion resulted in less than 0.7 m of shoreline movement between 2019 and 2026 (or 0.5 m over 5 years), it would be within the uncertainty range of this assessment and thus not included in the shoreline movement results. Further, the locations of observed erosion were determined from geo-tagged field photos and are thus subject to GPS inaccuracies.



**Figure 3.33 5-year shoreline change along Departure Bay.**

### 3.3.2.3 Cilaire Shoreline Change

There has been moderately more erosion than accretion along Cilaire where shoreline change was detected since 2019, although both processes have been occurring (Figure 3.34). Like

Departure Bay, the most extreme erosion detected is proximate to a fluvial fan (Northfield Creek), where sediment is expected to be reworked.

The shoreline change results line up reasonably well with field observations of erosion. As noted in the above sections, misalignments could be due to changes occurring pre-2019, not being detectable outside the shoreline change assessment uncertainty, or GPS inaccuracy from geo-tagged field photos. The accretional transect within the observed erosion towards the south-east end of the shoreline is likely due to bluff failure depositing additional sediment on the beach and moving the shoreline seaward (Photo 3.32).



**Figure 3.34 5-year shoreline change along Cilaire.**

### 3.3.2.4 Protection Island

Shoreline change results indicate little change in the shoreline position on the east side due to the shoreline hardening along this side. Notable erosion is occurring along the west and south beaches. While erosion was observed landward of the failed seawall in the field, this area did not appear to be erosional based on the shoreline change rates.

The groyne at the south of the island appears to overtop at high tides based on the beach wrack behind the groyne. It is suspected that sediment from the eroding shoreline on the south side of the groyne is deposited on the north side of the groyne during overtopping events, resulting in



erosion on the south side and accretion on the west side. The erosion on the west side of Protection Island is likely due to longshore transport moving sediment towards the south to the accretionary spit.



**Figure 3.35 5-year shoreline change along Protection Island study shoreline.**

## 4 LONG-TERM MONITORING RECOMMENDATIONS

This report provides a baseline assessment for a long-term coastal erosion monitoring program. The assessment includes an initial assessment of topographic change and erosion rates along the previously identified focus areas of the North Shore, Departure Bay, Cilaire, and Protection Island. By monitoring these areas over time, the City of Nanaimo can determine which areas have the highest erosion hazard and are changing most rapidly. This information can help support coastal zone management decision-making, for instance, when reviewing development applications or determining community-based strategies for shoreline protection.

The shoreline change monitoring indicator used in this study is the higher high water mean tide (HHWMT) elevation contour (also called mean higher high water). This is the average elevation of the highest daily tide over a 19-year period. This elevation is near the vegetation boundary in most areas, although in some areas the vegetation boundary is located further inland (for instance along rocky shorelines, areas of high wave runup, or highly accretionary shorelines). A

shift in the position of this contour indicates movement of sediment at the top of the beach along the shoreline position. This can either result in advance of the shoreline due to accretion, or result in retreat of the shoreline due to erosion.

In addition to shoreline change, this study also assessed topographic change. While monitoring the HHWMT contour provides information on a shift in the shoreline position, it does not capture beach lowering that might be occurring seaward of the shoreline position. The shoreline position may be fixed by presence of controls, bluffs, shore protection, bedrock outcrops, but erosion may still be occurring and resulting in increasing vulnerability. Therefore, NHC recommends monitoring both the change in shoreline position and topography.

**NHC recommends a recurring 5-year monitoring assessment of coastal erosion along the North Shore and Cilaire focus areas to monitor the coastal erosion rates and bluff retreat.**

The long-term monitoring plan should include:

- 1) A lidar-based drone survey following the same data collection settings as the survey performed for the initial baseline assessment conducted as part of this study to calculate the change in shoreline position and topography, and
- 2) A field-based assessment to determine locations of undercutting, bluff scarping and slope failure.

NHC's initial recommendation is that monitoring of erosional shorelines be conducted every 5 years, with the next assessment in 2031. At that time, the monitoring frequency should be adjusted as needed based on the outcome of the assessment.

The Departure Bay and Protection Island focus areas show fewer signs of erosion at present. This is due to a combination of shoreline hardening and the presence of bedrock, which reduce the potential for erosion along the shorelines. The sedimentary deposits along these shorelines might become more prone to erosion with relative sea level rise (RSLR) over the next several decades as areas that were previously not subject to waves and tides become exposed, especially at any low-sloping bedrock shorelines with bluffs on top. Continued monitoring of shoreline erosion at these areas is not currently recommended, but should be revisited 10 to 20 years from now.

Additionally, NHC has the following suggestions that the City of Nanaimo can consider as part of future coastal zone planning. These suggestions can help mitigate the risk of coastal erosion along the focus areas.

- **Consider performing a current regional geotechnical assessment of bluff stability for the bluff length along the North Shore and Cilaire.** During the site assessment, the bluff showed signs of slope creep and slope instability. NHC recommends that a current regional geotechnical assessment is performed to identify vulnerable locations and determine whether improvement of drainage patterns can decrease the probability of slope failure at these sites. Poor drainage during high intensity run-off events can



increase the chance of slope failure, and signs of runoff-induced channelling and erosion were observed at various locations along the North Shore and Cilaire bluffs. HBT Agra completed a regional geotechnical review of the existing shoreline slope stability (1993). A current assessment can help inform projections of bluff retreat due to the combined factors of coastal erosion and slope stability.

- **Maintaining a minimum 40 m coastal erosion setback from the bluff crest along the North Shore and Cilaire bluffs for any future developments, as per the North Slope Development Policy.** This helps prevent further developments from being constructed within the zone that could be at risk of coastal erosion within an approximate 50-year timeline. Larger setbacks are required due to geotechnical hazards as part of the North Slope Development Policy (City of Nanaimo, 1993).
- **Identifying priority areas and options for erosion mitigation works along actively eroding shorelines and shorelines with substandard shoreline protection.** This could include exploring options for a combined city and community-based shoreline protection project along Battersea and Randle Road, within the Cilaire focus area. The shoreline protection for this area could potentially use a nature-based approach. The riprap is in particularly poor condition along Battersea Road, and there is potential for undercutting of the road embankment if no mitigation measures are taken. The shoreline protection along part of Randle Road is substandard and a community-based shoreline protection project could provide opportunities to mitigate both the coastal erosion and flood risk.

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## CLOSURE

We trust this report meets your needs. If you have any questions or requests, please feel free to contact the undersigned.

Sincerely,

**Northwest Hydraulic Consultants Ltd**