SNUNEYMUXW – CITY OF NANAIMO

Climate Hazard Mapping and Assessment

Overview Report

This company meets high standards of social and environmental impact.

Cette entreprise respecte des normes sociales et environnementales élevées.

11 December 2025

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Ebbwater would like to acknowledge that this report was written at the Ebbwater Consulting Inc. office (and home offices), which are located primarily on the unceded and traditional Territory of the Coast Salish Peoples.

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Cover Photo: Nanaimo River near the mouth at Snuneymuxw First Nation Nanaimo River Reserve No. 4, 10 March 2025. Image by Ebbwater Consulting Inc.

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South Fork Dam, Winter.

1. Introduction

In 2024, the City of Nanaimo (the City) retained Ebbwater Consulting Inc. (Ebbwater) and its team to conduct a climate hazard mapping and assessment project for the Snuneymuxw First Nation (SFN) and the City as a renewal of Nanaimo's Hazard, Risk, and Vulnerability Assessment. The project area includes the City and four SFN reserves (Nanaimo Town 1, Nanaimo River 2, Nanaimo River 3, Nanaimo River 4). The hazards considered in this project include various types of flooding (riverine/lake, coastal, stormwater), atmospheric extremes (extreme heat, severe winter conditions, drought, windstorm), wildfire, and landslide/debris flow. The hazards are assessed quantitatively for present-day conditions, and under climate change based on the availability and extents of climate scenarios and other studies. Qualitative statements, based on data and science, describe how the hazards are expected to change over the next 5 to 10 years.

The project was conducted in line with guidance associated with the Provincial Emergency and Disaster Management Act (EDMA). EDMA integrates the Sendai Framework for Disaster Risk Reduction[1] and the UN Declaration on the Rights of Indigenous Peoples[2]. This project focuses on Sendai Priority 1: Understanding Risk. It was conducted in full collaboration with SFN community members, with whom the project team shared knowledge to support their input into emergency management activities[3].

1.1 Project Goal and Objectives

The project goal was to **assess and map climate hazards to support disaster response and resilience efforts in the area**. To meet the project goal, the project team outlined the following objectives:

1. Identify, assess, and map priority climate hazards.
2. Expand understanding of the hazards by integrating Indigenous perspectives and considering hazard interactions.
3. Recommend how increased understanding of hazard can support decisions, including at the regional level.

1.2 Risk Based Approach for Assessment

Risk is the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society, or a community, determined probabilistically as a function of hazard, exposure and vulnerability (GFDRR, 2016; UNDRR, 2017). Risk based approaches to disaster management, where the reduction of risk is the goal, is best practice, and is reflected in government legislation (see above).

As illustrated in Figure 1-1, risk is defined by the total area of a triangle, whose vertices are hazard (in this case climate hazards), exposure (the things communities care about that are exposed to the climate hazards) and vulnerability (how susceptible the exposed elements are to the climate hazards[4]). This project fits within the lens of risk reduction by supporting an understanding of climate hazards, including how they are changing.

This project took a deep dive in **understanding a subset of climate hazards**. It is assumed that future projects in the region will examine other natural (e.g. earthquake) and non-natural hazards (i.e. human-caused), as well as exposure and vulnerability components of risk.

Figure 1-1: "Riskier Future" triangle. Adapted from GFDRR, 2016.

1 Weblink: https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030. Accessed 31 July 2025.

2 Weblink: https://www.ohchr.org/en/indigenous-peoples/un-declaration-rights-indigenous-peoples Accessed 31 July 2025. Adopted in BC as the (Weblink: https://www2.gov.bc.ca/gov/content/governments/indigenous-people/new-relationship/united-nations-declaration-on-the-rights-of-indigenous-peoples Declaration on the Rights of Indigenous Peoples Act - Province of British Columbia, Accessed 31 July 2025).

3 Indigenous Engagement Requirements – Interim Guidance. Emergency and Disaster Management Act. September 4, 2024. British Columbia Ministry of Emergency Management and Climate Readiness. Weblink: https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/emergency-preparedness-response-recovery/local-government/ier_guide.pdf. Accessed 29 July 2025.

4 This vertex can also include other natural hazards such as earthquakes and disease, as well as non-natural hazards such as material spills and cyber-attacks.

1.3 Overall Project Approach

To achieve the project objectives and considering the risk reduction lens, we first conducted a screening-level process to prioritize the climate hazards that were most important to the Snuneymuxw First Nation and the City of Nanaimo. This was followed with more detailed analyses for 10 priority hazards. Dependent on the complexity of the hazard and data availability, there were limitations on how different hazards could be mapped and assessed under climate change. In addition to consideration of individual climate hazards, we looked at how they interact and potentially reinforce each other (an analysis of multi-hazard interactions).

More information on our methods is in the accompanying Background Report, and more quantitative and spatial details are in the technical appendices completed for each climate hazard study (see right-hand side of Figure 1-2). The first three hazards were lumped into one "atmospheric hazards" appendix as their data sources, study area, methods, and limitations were the same or similar.

The summary of findings, including simplified maps, are summarized and provided in this report, which is accompanied by the Map Book (see left-hand side of Figure 1-2).

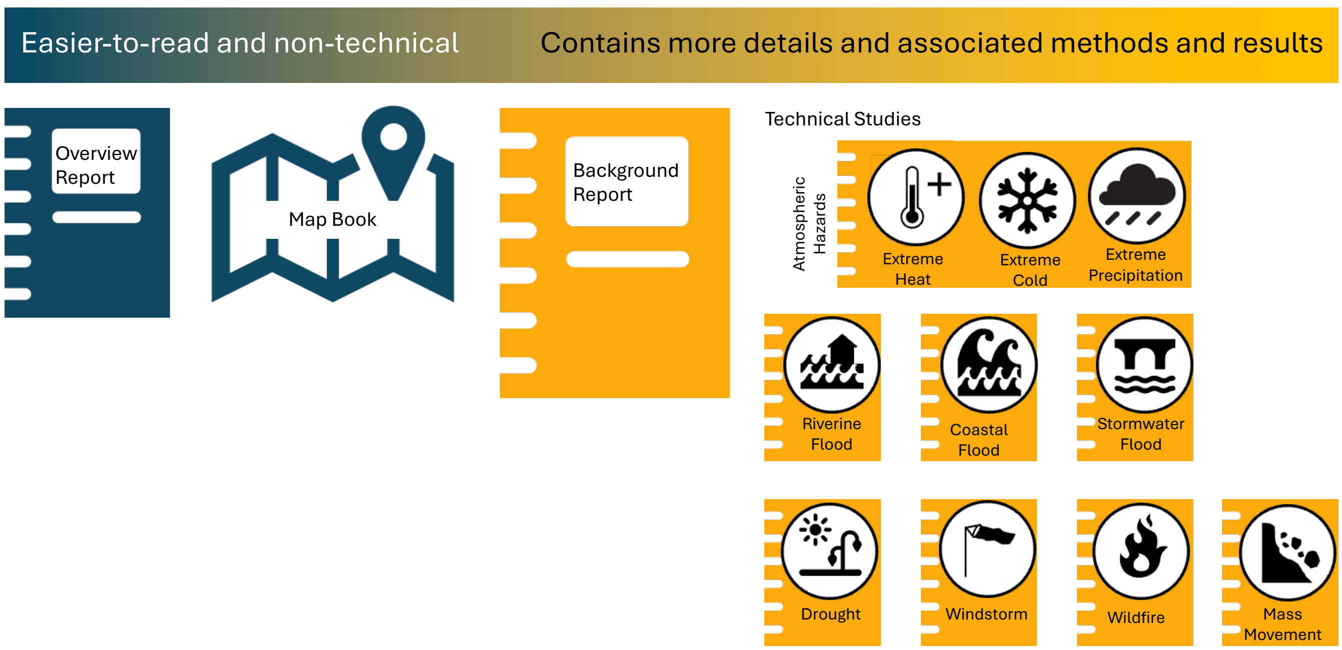


Figure 1-2: Project outputs.

We stress that the project results show that climate hazards in the project area are substantial, and that not all the details are in this Overview Report. Therefore, we encourage decision-makers to consider the full information provided. The value of **knowing about the hazards is critical** to understanding risk.

The remainder of this overview report provides a summary of the project area (Section 2), climate hazards (Section 3), Snuneymuxw First Nation perspectives (Section 4), approach (Section 5), multi-hazard interactions (Section 6), results summary (Section 7), limitations (Section 8), and conclusion recommendations (Section 9). This is followed by individual hazard summaries. A Snuneymuxw First Nation statement (Water is Life, provided by Elder Jerry Brown) is provided on page 46, which is followed by a list of references.

2. Project Area

The project area is located on the east coast of Vancouver Island in British Columbia, nestled between the coastal mountains to the west and the Salish Sea to the east (Figure 2-1). The landscape includes rocky shorelines, forested uplands, and river valleys. The project area was considered in terms of a local study area (LSA), as well as the larger regional study area (RSA). The RSA was used to understand how changes in upstream watersheds could affect the LSA.

The LSA is approximately 125 km^2 in size and is defined by the boundaries of the City of Nanaimo (including parts of the Salish Sea), as well as Snuneymuxw First Nation Reserves. Reserve 1 is located along the coast, opposite Duke Point; Reserves 2, 3, and 4 are contiguous and are located within the Nanaimo River Estuary. The LSA has a coastline that is approximately 87 km long and its land-based area (93 km^2 in size) is primarily residential and waterfront (63%), and agriculture rural residential (approximately 13%) according to Nanaimo's Zoning Bylaw (No. 4500)[5].

The RSA is defined by the watersheds that contribute flow to the LSA, including the Nanaimo, Millstone, and Chase Rivers. It is 1254 km^2 in size and landcover, apart from the LSA, is primarily forest. The RSA covers approximately 13% of the Snuneymuxw First Nation Territorial boundary (see Figure 2-1 inset). SFN perspectives are discussed in Section 4, including examples of specific impacts experienced from climate hazards on Reserves 1 to 4.

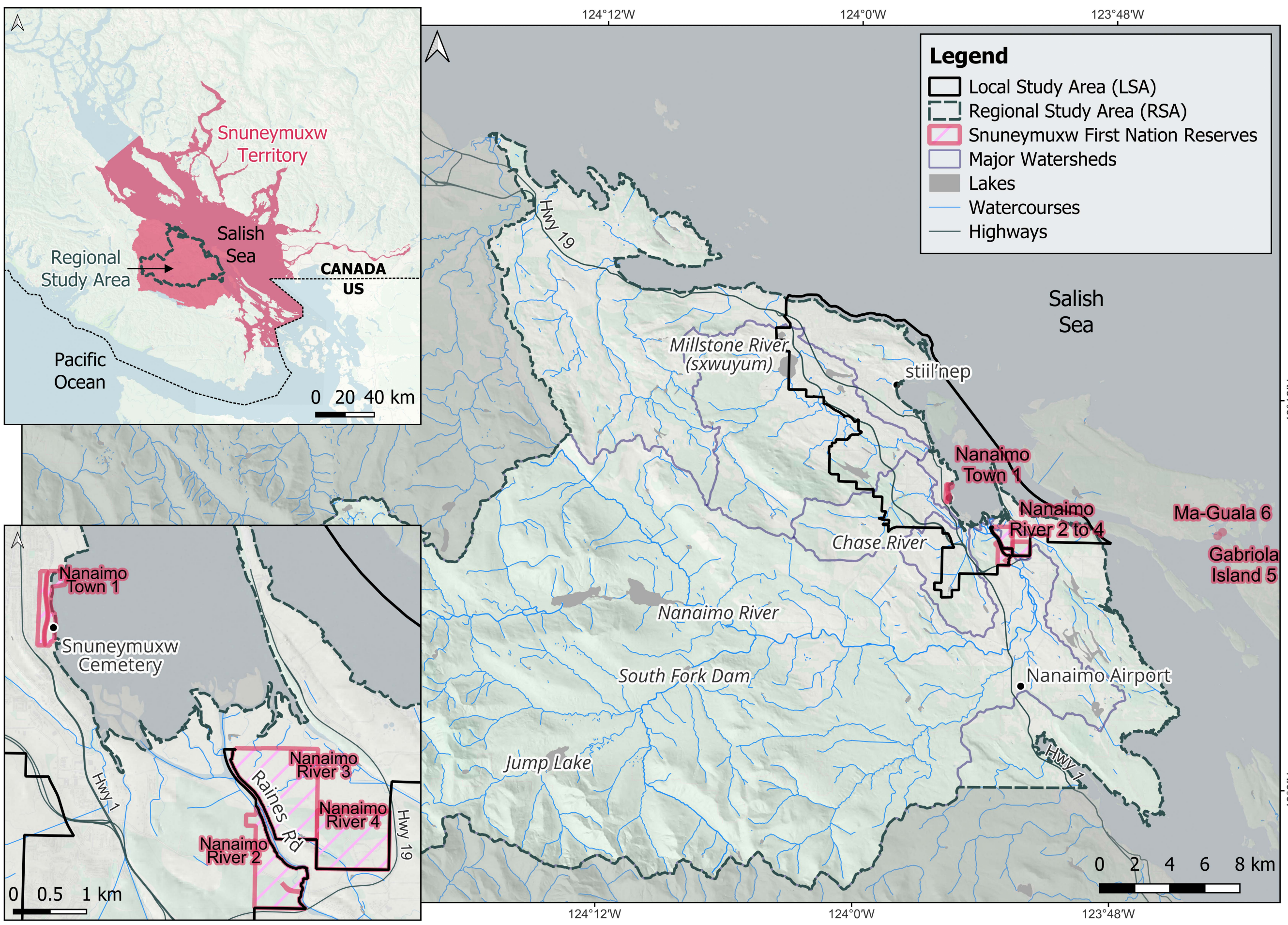


Figure 2-1: Project area with local study area (LSA) and regional study area (RSA) boundaries, along with Snuneymuxw Territory (provided by SFN) and First Nation Reserves.

5 Weblink: https://www.nanaimo.ca/bylaws/ViewBylaw/4500.pdf. Accessed 5 July 2025.

2.1 Snuneymuxw Nation Profile

The snuneymuxw are one of the Coast Salish peoples who have lived along the eastern coast of Vancouver Island since time immemorial. Their name means “Great People” in their language, hul’q’umi’num’[6]. Since time immemorial, the snuneymuxw have enacted sovereignty over their territory which spans from the Central Coast of Vancouver Island to the Fraser River, and was never ceded. The snuneymuxw built villages, cultivated fields, enact fisheries in both the rivers and ocean, and gather food and medicines from the lands and waters. One of their ancient village sites (stilln’nep, shown in Figure 2-1) in what is now called Departure Bay, has been an important site that holds both spiritual and village-site significance to snuneymuxw. In 1854, the snuneymuxw signed a treaty with the British Crown to protect snuneymuxw land, snuneymuxw villages, trade and commerce, and rights to hunt and fish. However, over time, the promises in the treaty were not honoured or enacted, and much of snuneymuxw land was taken without consent.

Today, the Snuneymuxw First Nation has nearly 2,000 members. They are working hard to:

- Protect their land and waters
- Revitalize their language and culture
- Build strong relationships with local governments
- Create opportunities for education, housing, and health

The City of Nanaimo “respectfully acknowledges that the City boundary lies within the Traditional Territory of the Snuneymuxw First Nation” (City of Nanaimo, 2022) and recognizes the snuneymuxw sarlequnn Treaty of 1854. The City is a growing urban centre with a population of over 100,000 residents, serving as a regional hub for central and northern Vancouver Island. The community is diverse, with a mix of long-established neighbourhoods and newer developments. Key characteristics of the community include a strong emphasis on sustainability and livability (City of Nanaimo, 2022) .

2.2 Current and Future Climate

The region falls within a temperate maritime climate zone, heavily moderated by the Pacific Ocean. The climate is characterized by mild, wet winters and warm, dry summers. The regional study area receives an average annual precipitation of approximately 1800 mm, with the majority falling between October and March. In the Nanaimo River watershed, snowfall accounts for almost 25% of total precipitation. However, precipitation at lower elevations and in coastal areas is substantially less (average annual precipitation at the Nanaimo airport is 1150 mm), and a much smaller fraction falls as snow.

Figure 2-2 shows the monthly precipitation totals (including rainfall and snowfall fractions), as well as maximum, mean, and average monthly temperatures. The data is based on climate model outputs for the RSA, for the recent past (i.e. approximately the 1990s) and the future (approximately the “2050s”) periods (see Section 5.2 for details).

6 Weblink: Snuneymuxw First Nation - Snuneymuxw First Nation, accessed 2 June 2025.

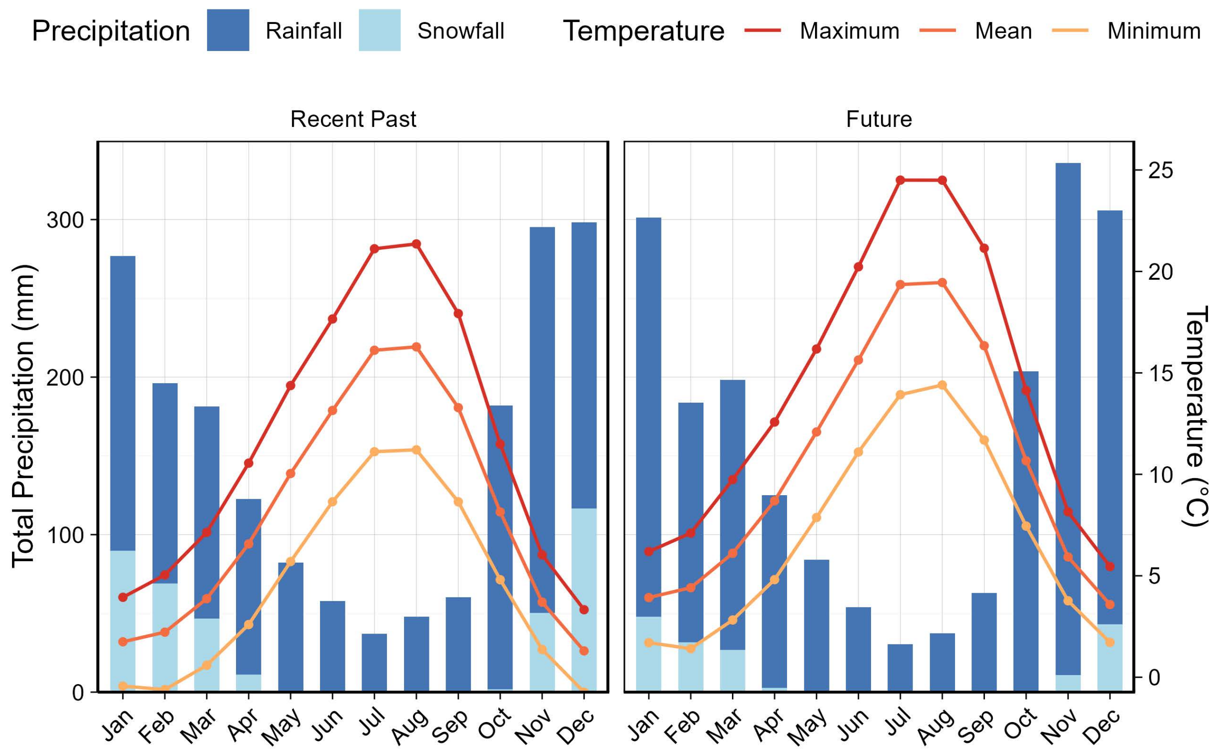


Figure 2-2: Nanaimo airport climograph for the recent past period and future periods.

The climate change projections shown in Figure 2-2 are updated but are generally consistent with those presented in the City's Climate Change Resilience Strategy (Integral and others, 2020). Climate projections for the regional study area indicate substantial changes in average conditions for the future period, including mean annual temperature and precipitation increases of approximately 2.3°C and 4-6% compared to the recent past period, respectively. We note that, globally, even small increases in average temperature lead to significant increases in the frequency and intensity of extreme events (IPCC, 2021).

For the project area, relative sea levels are projected to increase by approximately 13 cm by 2050 (this is the median value obtained from James et al. (2021)[9]; see the Coastal Flood Hazard Study for details).

While there is high confidence in the direction of the changes noted above, there is also substantial uncertainty with these numbers. The uncertainty is related to the global climate models (GCMs) used to make the projections, and the trajectory of greenhouse gas emissions, which is the main cause of climate change (IPCC, 2023).

8 All climate change projection values in our analyses correspond to Representative Concentration Pathway 8.5, and were obtained from PCIC (2023). See the Background Report for details.

9 These updated values are substantially lower than those previously used by the City. See the Coastal Flood Hazard Study for details.

3. What Are Climate Hazards?

Climate hazards are a subset of natural hazards that are driven by atmospheric conditions, which are being disturbed by long-term climate change, and manifested through short-term weather. The next sections discuss weather and climate, climate change, climate hazards assessed, drivers and modulators, and special implications).

3.1 Weather and Climate

Weather refers to the short-term state of the atmosphere; it is extremely variable both in space and time. In contrast, climate describes the long-term patterns of weather at a given location and period. Climate can be described in statistical terms as the central tendencies and variability of relevant weather observations such as temperature, precipitation, atmospheric pressure, humidity, and winds. Climate can also be described statistically as the combinations of these elements, such as weather types and phenomena like the El Niño Southern Oscillation (ENSO) (see Section 3.4 for more details), that are typical of local and regional areas, or Earth as a whole, for any period (World Meteorological Organization (WMO), 2018). Like weather, climate can be variable. However, it does not change day-to-day because it is based on longer time scales and averages. Therefore, it is important to distinguish between short-term internal climate variability and longer-term climate change.

What is climate change?

Climate change refers to a persistent, long-term change in the state of the climate, measured by changes in average conditions and/or its variability (Planton et al., 2013). Therefore, measuring climate change requires long-term observations of climate parameters, to distinguish between long term trends and shorter-term variations[10] (Bush & Lemmen, 2019).

Although the global climate has always been oscillating, global average temperatures have been rising steadily for decades. Human-caused global warming due to greenhouse gas emissions has reached 1.1°C (IPCC, 2021). This warming pattern has been experienced differently around the world, with different regions warming at different rates (e.g., the Canadian Arctic is warming about three times faster than the global rate) (Bush & Lemmen, 2019).

3.2 Climate Hazards Assessed

Long-term climatic changes can lead to an increase in the probability of many extreme weather events through the intensification of the hydrologic cycle (Herring et al., 2015; Huntington, 2006) and other ocean-land-atmosphere system processes (see Background Report for more details). Climate hazards are those natural hazards that are linked with the ocean-land-atmosphere system, and climate change. Individual climate hazards can be categorized and described in different ways, and they are increasing in number as climate change progresses[11]. For this project we assessed the 10 climate hazards described in Table 3-1. (Section 5 explains how we chose them).

10 WMO has recommended using 30-year periods to calculate and communicate climate statistics to account for long term patterns.

11 See "City Climate Hazards". C40 Cities Climate Leadership Group. Weblink: https://www.c40.org/wp-content/static/other_uploads/images/545_Hazards_2015_infographic_C40_v2_3_.original.pdf?1457524014#:%7E:text=The%20City%20Climate%20Hazard%20Taxonomy,Framework%20and%20Taxonomy%20(CRAFT). Accessed 5 August 2025.

Table 3-1: Climate hazards assessed as part of this project.

Climate Hazard	Simplified Description
Extreme Heat	Occurs when temperatures are significantly above average for an extended period.
Extreme Cold	A period of abnormally cold weather, which can be associated with severe winter conditions (e.g., blizzard, snowfall, ice, etc.).
Extreme Precipitation	Unusually intense or prolonged precipitation (focusing on rainfall) that exceeds typical levels for a given area.
Riverine Flood	Occurs when water levels overflow from river channels onto land that is normally dry. This includes lakes and stream environments.
Coastal Flood	Occurs when ocean water levels are higher than normal due to storm surge, tides, waves, wind effects, and sea level rise. It is linked with coastal erosion.
Stormwater Flood	Occurs when precipitation cannot infiltrate or be conveyed by drainage infrastructure. It is also called local, pluvial, or flash flooding.
Drought	Occurs when there is a deficiency of precipitation over an extended period, resulting in a water shortage.
Windstorm	Wind gusts and high wind speed, that is often associated with heavy rain.
Wildfire	Unplanned fires occurring on forest or range lands, which burns forest vegetation, brush, etc. and can spread to developed areas.
Mass Movement	Occurs when material such as rock, debris, and soil moves downslope.

3.3 Drivers and Modulators

Based on scientific knowledge supported by literature reviews, and what we heard during project meetings (see Section 4), we developed a simplified way of understanding the important drivers and modulators at play in the regional study area, described below.

Drivers: These are based on atmospheric processes that occur over different time and spatial scales. Both influence atmospheric characteristics such as pressure, temperature, precipitation, cloud cover, wind, and humidity over the project area. These characteristics can create the conditions for climate hazards to occur.

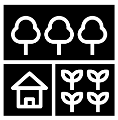
Large-scale climate processes occur over months to years and setup phenomena such as seasonal atmospheric river system conditions (e.g., in winter, moist pacific air masses travel from thousands of kilometres away to the project area) as well as the El Niño Southern Oscillation (ENSO) (see Section 3.4 for more information).

Local hydroclimate processes govern weather patterns, which are more chaotic and occur over days, such as an individual rainstorm.

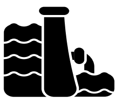
The drivers of climate hazards are one focus of this project, as these local and large-scale processes are directly impacted by climate change. The drivers affect the hazards across the whole region. In summary, the drivers support understanding of how hazards vary over time.

Modulators: For this project, we consider three quasi-stable and quasi-permanent factors that affect how hazards are manifested on the ground.

Watershed physical characteristics are the drainage features and topography (elevation, fluxes, air temperature and rain/snow fractions, and the flow of water and sediment in river channels and on the landscape).



Land cover change refers to alterations in the physical and biological aspects of the land surface. It affects hazard regimes by disturbing energy, water and soil, and vegetation across the landscape. This could be caused by natural processes (e.g., wildfire) or, more commonly, human activities (e.g., logging). Land cover change implies a shift from one type of cover to another (e.g., forest to agriculture) or a significant modification within a cover type (e.g., forest degradation).



Infrastructure and extractive modifications can exacerbate hazards often through engineered alterations to the landscape, water systems, or hazard processes themselves. This typically occurs with the intent to manage resources, enable development, or mitigate specific hazard impacts (which can have unintended consequences such as create impacts elsewhere). Examples include constructing and operating physical structures such as dams and dikes, coastal terminals, and mines.

The modulators of hazard affect how a hazard varies spatially (i.e., how the hazard might be more or less severe in one part of the region). The modulators are not directly impacted by climate change. In summary, the modulators support understanding of how hazards vary over space.

The drivers and modulators described above, and how they interact, is shown in Figure 3-1. Our way of presenting these interactions is simplified and is intended to help organize and explain how hazards affect the project area; it is not intended to capture the full complexity of hazard interactions within the project area.

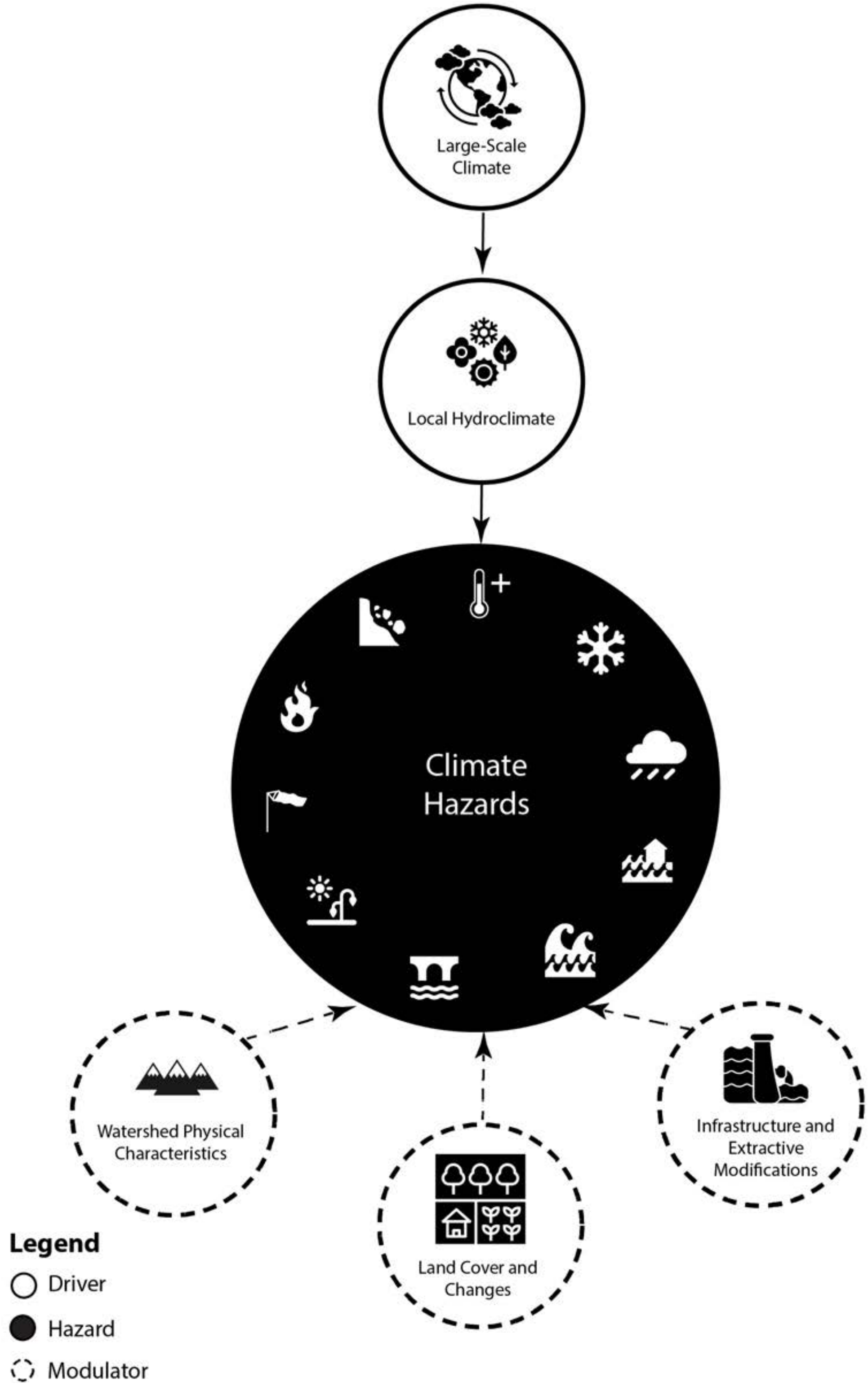


Figure 3-1: Overview of how drivers and modulators generate climate driven hazards. The figure shows the 10 priority hazards that were addressed in this project. More details on this simplified model are in the Background Report.

Human interventions influence both drivers and modulators. Drivers and modulators create different hazard characteristics such as their duration, seasonality, warning time, extent, likelihood, etc. These characteristics are further explored in Section 5.

3.4 Implications of Large-Scale Climate Processes

Large-scale climate processes are global circulation patterns that distribute and move heat and moisture across the planet. These processes are part of the natural variability inherent in the ocean-land-atmosphere system. Example manifestations of these processes that occur as extreme weather phenomena in BC are atmospheric rivers, and the polar vortex (see the Background Report for more details).

Scientists have established significant relationships between weather phenomena at widely separate locations on Earth. Measurement of variables such as sea surface temperature and atmospheric pressure over specific regions are used to characterize these distinct patterns, called 'teleconnections'. A well-known teleconnection that affects large parts of the globe is the El Niño Southern Oscillation (ENSO)[12]. This and other teleconnections, such as the Pacific Decadal Oscillation, and the Arctic Oscillation, can cause significant shifts in the local weather and climate of the project area. Teleconnections may be tracked using indices based on the variables measured to characterize them.

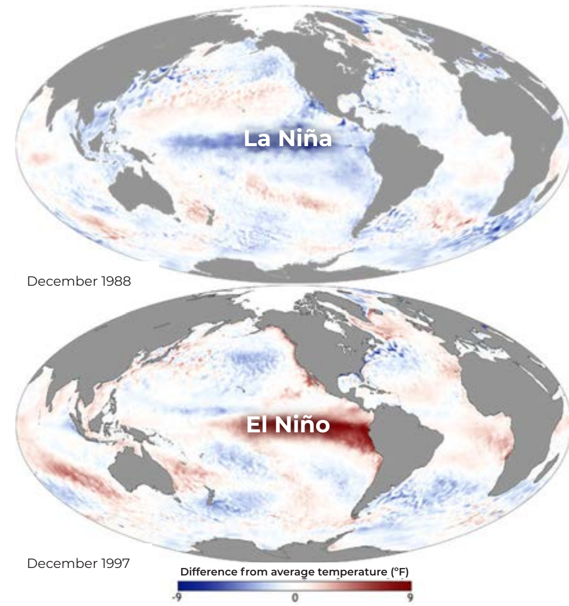


Figure 3-2: Differences in average temperature between past La Niña (top) and El Niño (bottom) months. Source: National Oceanic and Atmospheric Administration.

Each of the opposite phases of the ENSO are associated with the potential for more extreme weather conditions (Figure 3-2). In BC's south coast including Vancouver Island, the El Niño (positive phase) and La Niña (negative phase) tend to have opposite conditions with respect to temperature and precipitation (Bush & Lemmen, 2019b), as shown in Table 3-2[13].

Table 3-2: Basic ENSO phase changes, relative to normal conditions, for Vancouver Island.

Climate Parameter	El Niño	La Niña
Temperature	Warmer	Cooler
Precipitation	Drier	Wetter

Strong ENSO patterns can often be forecasted many seasons in advance of its strongest impacts on weather and climate. Therefore, ENSO and other teleconnection indices can be useful tracking tools to support emergency management activities.

The effects of ENSO phases on climate hazards depends on their seasonal timing. The following climate hazards assessed in this project could be directly affected by strong ENSO phases:

- Atmospheric hazards: **Extreme heat** and **extreme cold** are more likely to occur during El Niño and La Niña, respectively. **Extreme precipitation** is more likely under La Niña.
- Flood hazards (e.g., **riverine** and **stormwater**): These are both more likely during La Niña, as a result of their linkage with extreme precipitation.
- **Wildfire** and **drought**: These are more likely during El Niño, as a result of their strong linkage with temperature and precipitation.

There is evidence that ENSO phases may intensify in future with climate change (England et al., 2014; Sun et al., 2023), meaning that the above climate hazards may experience more extremes. Furthermore, the influences of the ENSO are likely to affect other climate hazards, through the multi-hazard interactions explained in Section 6.

12 "What is the El Niño–Southern Oscillation (ENSO) in a nutshell?". Weblink: https://www.climate.gov/news-features/blogs/enso/what-el-nino-southern-oscillation-enso-nutshell. Accessed 7 August 2025.

13 We note that the information in the table is based on long-term trends, and does not mean that, for example, an extreme precipitation event cannot occur on Vancouver Island during an El Niño (i.e. potentially dryer) phase.

4. Snuneymuxw First Nation Perspectives

For the Snuneymuxw, the arrival of non-Indigenous people to the area, and their expansion across the globe, is strongly linked to the hazard modulators and drivers shown in Figure 3-1. The project team learned about these perspectives during engagement events held on 7 October 2024, and 10-11 March 2025. In our visits, one message was made clear: Human decisions have disrupted the balance of natural systems (i.e., "Mother Earth"), and especially water (see the attachment for a statement about these subjects).

For example, humans have altered watershed characteristics in the region through unsustainable forestry practices. Their development has encroached upon natural land covers and destroyed wildlife habitat. Human interventions such as the building of dams and coastal infrastructure have altered water patterns, affecting fish habitat and contributed to erosion.

> **"The reality today is that climate and environmental changes are affecting us all… We now need to give more than we take. We must allow Earth the opportunity to heal and catch her breath. We seek to restore deep respect for the land and all living things–a responsibility that has always been ours."**
>
> ***himuth***, JERRY BROWN, SFN ELDER

Climate hazards have worsened due to climate change. The resulting changes challenge the livelihoods of SFN community members, who continue to value natural systems to uphold their cultural practices and livelihoods.

4.1 Climate-Related Impacts

The following are examples of how climate hazards are impacting Snuneymuxw communities broadly, right now:

- Extreme weather is leading to loss of their land and clean water sources.
- Changing weather patterns interrupt the availability of traditional foods like fish, wildlife, and Indigenous plants, impacting food security and nutrition.
- Wildfires and changing forest ecosystems are affecting access to traditional food sources and disturbing cultural practices and ceremonies.

The community has limited means to repair their shoreline due to coastal erosion or repair homes due to severe weather patterns. All of the above is leading to mental health issues.

> **"We eat, live and breathe with our environment which makes us vulnerable to climate change impacts."**
>
> ***shw'uy'sulwut***, TERENA GOOD, SFN ENVIRONMENTAL HEALTH NAVIGATOR

4.2 Specific Issues

During visits with the community, we heard about the following specific issues related to flood hazards.

At Nanaimo Town Reserve 1, the Snuneymuxw cemetery (see inset map in Figure 2-1) has experienced stormwater and coastal flooding. From their perspective, human influences are the most important causes for this flooding. Due to climate change, improper care of the land, and development patterns in areas upstream from the watershed, flood flows have increased. Surface flooding has occurred due to poor stormwater drainage[14]. On the coastal side, they have observed an increased rate of erosion, which is due in part to sea level rise, but likely more so due to development encroaching into the ocean from reaches located on north and south of the site (e.g., the Nanaimo Ferry Terminal[15] and sawmill, respectively). This is a high concern for the community as the flooding and erosion has exposed human remains. In other areas of the reserve, coastal flooding threatens shorelines including potentially damaging a major sewage trunk.

At Nanaimo River Reserve 3, coastal flooding that occurs during king tides, and also when river levels on the Nanaimo River are higher than normal, has shut down Raines Road (see inset map in Figure 2-1) and flooded homes. This occurs in part as high river levels convey large volumes of water through nearby sloughs. SFN members have expressed concern that saltwater intrusion could be getting worse with sea level rise and is thought to be damaging hayfields[16]. There is also a perceived threat related to breaching dams upstream (Jump Lake, shown in Figure 2-1, is of particular concern, as it is impounded by the Jump Lake Dam).

Figure 4 -1: Snuneymuxw First Nation Elder shares how coastal flooding and erosion have increased in past decades and taken land away from the cemetery.

14 This issue has largely been solved in the first of a two-phase project to address stormwater and coastal flooding at the site.

15 This is the infrastructure that is used today by BC Ferries (Gabriola Island Service) and Hullo Ferries (Vancouver service). The infrastructure was built over 40 years ago.

16 The City is working with SFN and the Regional District of Nanaimo within the current sea level management planning process.

5. Approach Used to Assess and Understand Hazards

This section briefly describes the process and methods used to identify and better understand climate hazards in the project area. We first considered all known climate hazards in the region; then we characterized and prioritized these to make best use of project resources. Finally, we mapped and assessed 10 hazards in greater detail.

5.1 Hazard Characterization and Prioritization

We conducted a screening-level assessment of 25 climate hazards currently identified in provincial guidance (Emergency Management BC, 2020) within the project area. We described the hazards based on a consistent framework that captured key characteristics (Table 5-1).

Table 5-1: Relative hazard characteristics applied in the prioritization process.

Characteristic	What does it describe?	Qualifiers
Extent	Does the hazard usually occur over a larger area or is it more localized?	Regional, local, both
Consequence	What are the consequences if the hazard occur?	Low, medium, high
Occurrence Type	Does the hazard usually occur as an abrupt, individual event, or does it persist in an area over time?	Shock or chronic
Duration	How long does the hazard last?	Hours, days, months
Seasonality	When is the hazard most likely to occur during the year?	Summer, fall, winter, spring
Warning / Onset Time	How long beforehand are communities likely to know that the hazard is coming?	Day, week
Likelihood	How likely is the hazard to occur on an annual basis?	Very unlikely, unlikely, likely, very likely, almost certain

The initial screening involved research and information synthesis. Building on this foundation we established a multi-stage hazard characterization process, in which hazards were further reviewed and ranked. The ranking process was guided by the following key criteria:

- Which hazards have the highest estimated risk (based on a combination of likelihood and consequence)?
- Can the hazard lead to emergency declarations?
- Is the hazard mappable, and does relevant base data exist to assess it?

From the ranking process, we developed a list of nine preliminary priority hazards. Our characterization and prioritization was shared with City of Nanaimo personnel in a meeting held in April 2024, and with Snuneymuxw First Nation Elders in a meeting in October 2024. The review process was intended to confirm the list and ensure that relevant issues of concern were not overlooked or minimized.

The results of the characterization and prioritization process were refined during later stages of the project based on more detailed mapping and assessment. These results are provided in the hazard summaries (see pages 25 to 45). During later stages, we added extreme precipitation as a standalone hazard (it had initially been considered as part of the stormwater flood hazard)[17].

17 Upon more detailed assessment and review of the hazards, we decided that extreme precipitation interacted substantially with other hazards, independently from stormwater flood hazard. We wanted to explore these important interactions separately.

5.2 Mapping and Assessment

Hazard science, mapping, and assessment are part of the first step in understanding risk (see Sendai Priority 1, discussed in Section 1.2). Mapping is a powerful tool that can support decision makers, emergency managers, and planners by creating a consistent understanding of issues. Furthermore, since hazards do not follow jurisdictional boundaries, maps can provide a common view of their spatial distribution over large areas. Through a "regionalization" process, practitioners can use mapping and assessment results to support risk and resilience—as well as preparedness, mitigation, and response actions—with their neighbours.

However, the process of mapping and assessment is challenging due to the diversity of hazard characteristics (outlined in Table 5-1). As a result, the data sources used to characterize hazards can vary substantially. We developed tailored approaches for each hazard following these guiding principles:

1. Use the most recent, practicable, and available data.
2. At a minimum, map the extent of the hazard (or components thereof) across relatively common boundaries (i.e., either the LSA and/or the RSA).
3. Assess the characteristics described in Table 5-1, and where possible, even more detailed characteristics.
4. For each hazard, assess common characteristics for past and future time periods.

These principles allowed us to systematically assess the climate hazards including their future trends. Our tailored mapping and assessment approaches are summarized in Table 5-2, which also provides relative comparisons of the data analysis complexity and confidence in the future trends of the hazard.

How did mapping nuances differ?

As an example, the data analysis complexity was low for the extreme heat and extreme cold hazards. This is because spatially distributed, high-resolution, modelled data was obtained for the recent past and future from the Pacific Climate Impacts Consortium (PCIC)[18], a regional climate service. While substantial technical programming skills and data management resources were required from our consulting team, the analyses for temperature-related hazards were relatively straightforward. Furthermore, temperature projections from GCMs are relatively more certain compared to projections for precipitation. This results in a high confidence in future trends for temperature (IPCC, 2007).

As another example, mapping and assessment for drought hazard was based in part on PCIC modelling outputs, but also on a range of other data sources. This is because drought is a complex hazard that includes physical processes, human infrastructure—and more importantly—human decisions to manage water supply and demand. This makes data analysis complexity very high. Some aspects of drought hazards could be mapped (e.g., seasonal temperature and precipitation projections) but no summary map was produced to spatially visualize the hazard. The confidence in future drought trends was moderate. This was because, despite the complexities outlined above, the data obtained provided a relatively robust understanding of water supply and demand.

18 Weblink: https://www.uvic.ca/pcic/. Accessed 6 August 2025.

Table 5-2: Mapping and assessment relative complexity and mapping process among the priority climate hazards.

Hazard	Mapping and Assessment Approach	Relative Comparisons[1]	
		Data Analysis Complexity	Confidence in Future Trends
Extreme Heat	Based on PCIC modelling output	Low	High
Extreme Cold	Based on PCIC modelling output	Low	High
Extreme Precipitation	Based on PCIC modelling output	Moderate	Moderate
Riverine Flood	Based on other consultant's modelling and mapping with enhancements	High	Moderate
Coastal Flood	Based on other consultant's modelling and mapping	High	Moderate
Stormwater Flood	High-Level observed data provided by City staff and PCIC modelling output; no detailed mapping	High	Low
Drought	Based on PCIC modelling output and a range of other sources; no detailed mapping	Very high	Moderate
Windstorm	Based on point data monitoring locations; no detailed mapping	Very high	Low
Wildfire	Original modelling incorporating field-based data validation	High	High
Mass Movement	Original modelling	High	Moderate

Note 1: The Background Report contains details on the criteria used for the relative comparisons. The criteria for data analysis complexity was based on a five-point scale, and the confidence in future trends was based on a three-point scale.

Figure 5-1 illustrates the resulting key differences and similarities in our mapping and assessment approaches. This is shown in terms of the type of spatial information (different options are shown along the vertical side) and temporal information (different time periods are shown along the horizontal side) used.

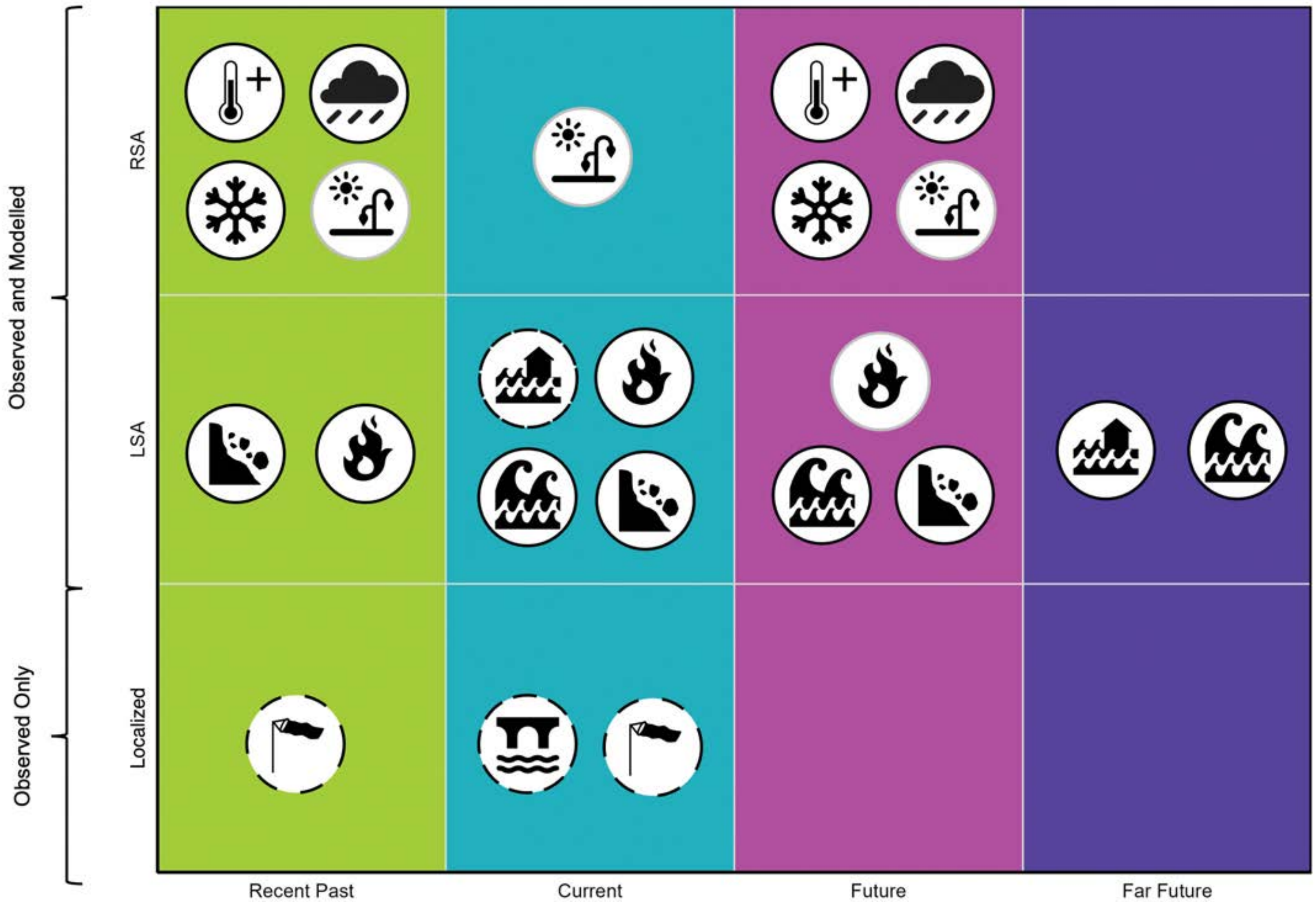


Figure 5-1: Spatial coverage and temporal scale of hazard data used. Note that icons with a grey circle denote hazards for which only a portion of the hazard's components were available, which prevented mapping the given time period. Icons that have a dashed outline indicate that datasets were not consistent or complete across the hazard study area.

Two hazards (i.e., stormwater and windstorm) were mostly assessed based on observations that were localized (see bottom row in Figure 5-1). Riverine flood hazard mapping was limited to the LSA's two major rivers. The other hazards were assessed based on observations and modelling (see middle and top rows in Figure 5-1). As mentioned in Section 2, the hazards were assessed based on the local study area (LSA) and/or the regional study area (RSA), depending on the type of data available.

Figure 5-1 also illustrates four different timescales that were used to assess the changes in climate hazards. In general, the "recent past" period refers to data that spanned from the 1950s to 2010. The "current" period refers to data that spanned the years from 2011 to 2025. The "future" period corresponds to data for the period 2041-2070 (or the "2050s"). The "far future" period corresponds to the year 2100.

6. Multi-Hazard Interactions

Multi-hazard interactions are challenging but important to consider. When they occur, they can make emergency situations worse. Additionally, they can stretch emergency management resources depending on the severity of the impacts, and when and where they occur in space and time.

Multi-hazard interactions are diverse and can be defined in many ways. We organized the interactions according to three relationships[19]:

- **Triggering:** Occurs when one hazard causes another hazard. For instance, extreme rainfall can trigger riverine or stormwater flooding.
- **Amplifying:** Occurs when one hazard changes the likelihood or magnitude of future hazards. Following a wildfire, for example, a higher fraction of rain falling on burnt landscape becomes runoff, which contributes to flood conditions or landslip.
- **Coinciding:** Occurs when two or more hazards impact the same area with overlapping time periods or in close succession. For instance, when a heatwave occurs during a drought, the high temperatures worsen the drought impacts.

In our analyses we found that in many cases, hazards interact through more than one of the relationships described above, and with more than one other climate hazard. For example, a recent windstorm caused treefall to enter the water supply reservoir. In combination with high riverine flows, the waterborne logs threatened to destroy the water intake, and the City's water supply (see Figure 6-1).

For each hazard, we developed diagrams to illustrate the triggering and amplifying interactions both when the hazards are the primary source and when they are secondary, as appropriate (see results in the individual hazard summaries). We analysed coinciding hazards together (see results in Section 7.2). We note that the process of assessing multi-hazard interactions is imperfect and requires professional judgment.

Figure 6-1: Example of multi-hazard interactions that threatened the water intake at South Fork Dam. Source: City of Nanaimo.

19 These have been adapted by Gill et al. (2022) and ongoing provincial-scale Disaster and Climate Risk and Resilience Assessment being conducted by the Ministry of Emergency Management and Climate Readiness (EMCR).

7. Mapping and Assessment Results Summary

The hazard summaries contain results specific to each hazard. The following sections summarize general findings from the perspective of comparing the hazards overall, including their interactions.

7.1 Comparison of Individual Hazards

Common findings across the hazards are as follows:

- The hazards occur widely both temporally and spatially in the project area, and they have a range of differing characteristics.
- All of the climate hazards assessed, except for extreme cold, are projected to increase (i.e. get worse) in the future. This will occur through a combination of increasing likelihood, duration, magnitude or severity, stability concern, etc.
- While the confidence in the direction of change noted above is generally moderate to high, the magnitude of change, and the uncertainty in the results supporting the findings, varies from one hazard to another.
- All of the climate change projections are generally consistent with, and validate, recent observations that were shared by project participants during meetings and engagement sessions.
- Considering the technical studies results and information gathered from our field visit, all of the priority climate hazards are of concern to SFN, with extreme cold and mass movement geohazards of potential less concern. We note that almost 50% of SFN Reserves 2, 3 and 4 are within the riverine flood hazard extent for the year 2100, and that all the reserves are directly impacted by coastal flooding.

Notable hazard-specific findings are as follows:

- Extreme heat and extreme cold vary across the RSA according to topographic influences. Relevant processes are reflected in the high-resolution climate change projections (i.e., more extreme heat is projected for lower elevations and vice versa).
- More extreme precipitation is projected across the RSA, and it will continue to be greater at higher elevations. At the same time, more warming is causing a larger proportion of precipitation to fall as rain during the winter months. These influences are reflected in the high-resolution climate change projections.
- The projected changes in extreme temperature and precipitation are likely to influence many other climate hazards due to their primary interactions (see Section 7.2).
- Climate change influences different hazards to different degrees. For example, coastal flood hazard is mostly influenced by climate change in terms of sea level rise. However, this hazard is also heavily influenced by tide cycles, which are independent from climate processes. Human systems and decisions play a significant role in stormwater, drought, and wildfire hazards.

7.2 Multi-Hazard Interactions

Key findings from the overall summary of multi-hazard interactions are as follows:

- Extreme precipitation and coastal flood can trigger, amplify, and coincide with riverine flood, stormwater flood, and mass movement geohazards.
- Extreme heat coincides with eight hazards and amplifies drought and wildfire.
- Riverine flood and windstorm each interact through all three relationships with one hazard each (stormwater flood and coastal flood, respectively).
- Mass movement geohazards can amplify and coincide with the three types of flood hazards (riverine, coastal, and stormwater).

Out of the three relationships that we assessed, the most common one to occur was coincidence between hazards. Therefore, we analysed this interaction in more detail to consider how this could change in the future.

7.2.1 Seasonal Shifts and Increasing Hazard Coincidence

Figure 7-1 summarizes the seasonal shift of individual hazards, and their cumulative coincidence (simultaneous occurrence) in different months of the year. The data is based on a combination of projections obtained and professional judgement, depending on the hazard. It is meant to be used for illustrative purposes only, to understand potential changes in the cumulative trends.

More interacting relationships are likely when the cumulative number of hazards (bottom part of the figure) is darker. Both in the recent past and in the future, the winter months experience the greatest number of simultaneous hazards.

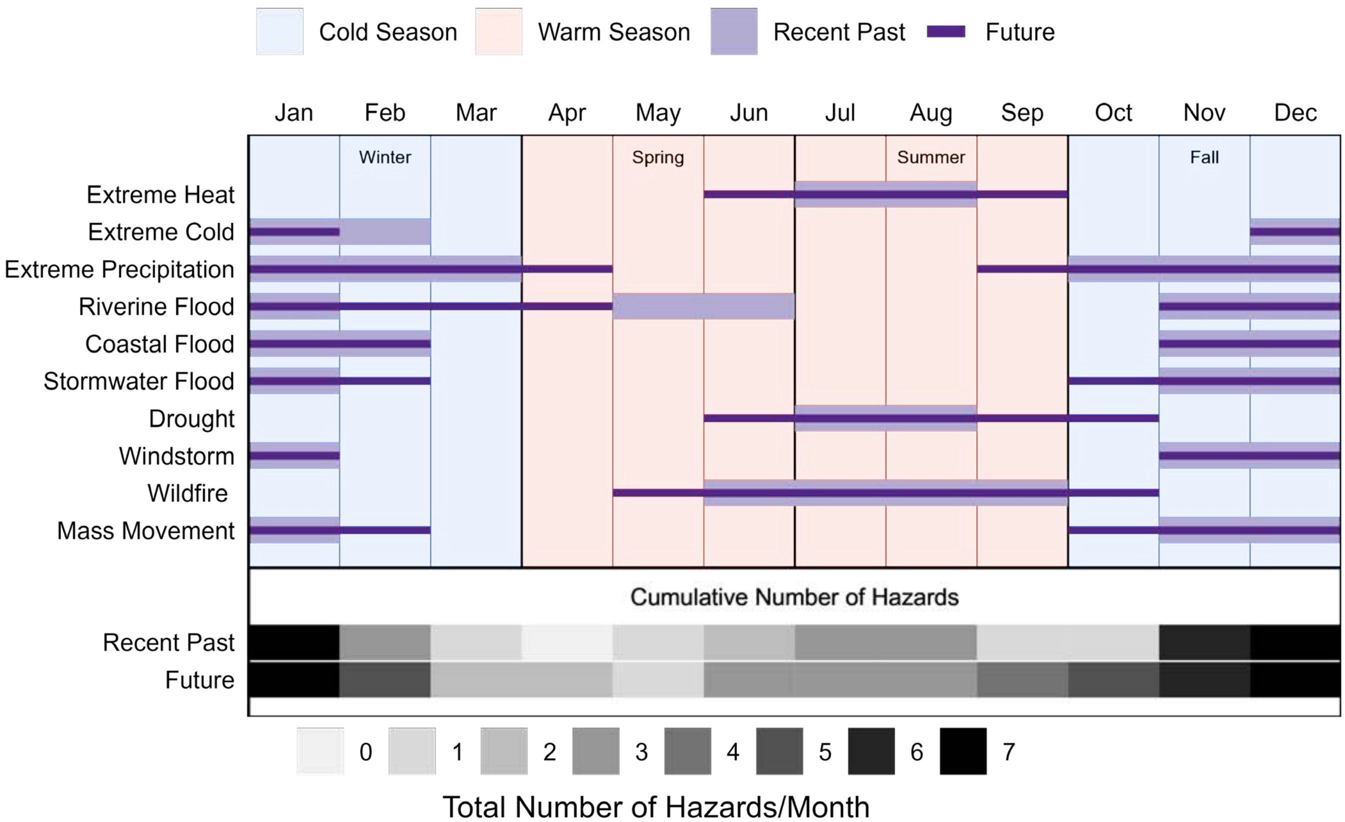


Figure 7-1: Most likely time of occurrence of individual (top) and cumulative (bottom) hazards both in the recent past and future.

According to Figure 7-1, in the recent past:

- There was one month when no climate hazards were likely to occur (i.e. April).
- The remainder of spring and summer seasons experienced up to three climate hazards and they all had the chance of occurring simultaneously in July and August.
- In January and December, up to 7 hazards had the chance of being simultaneous.

In the future:

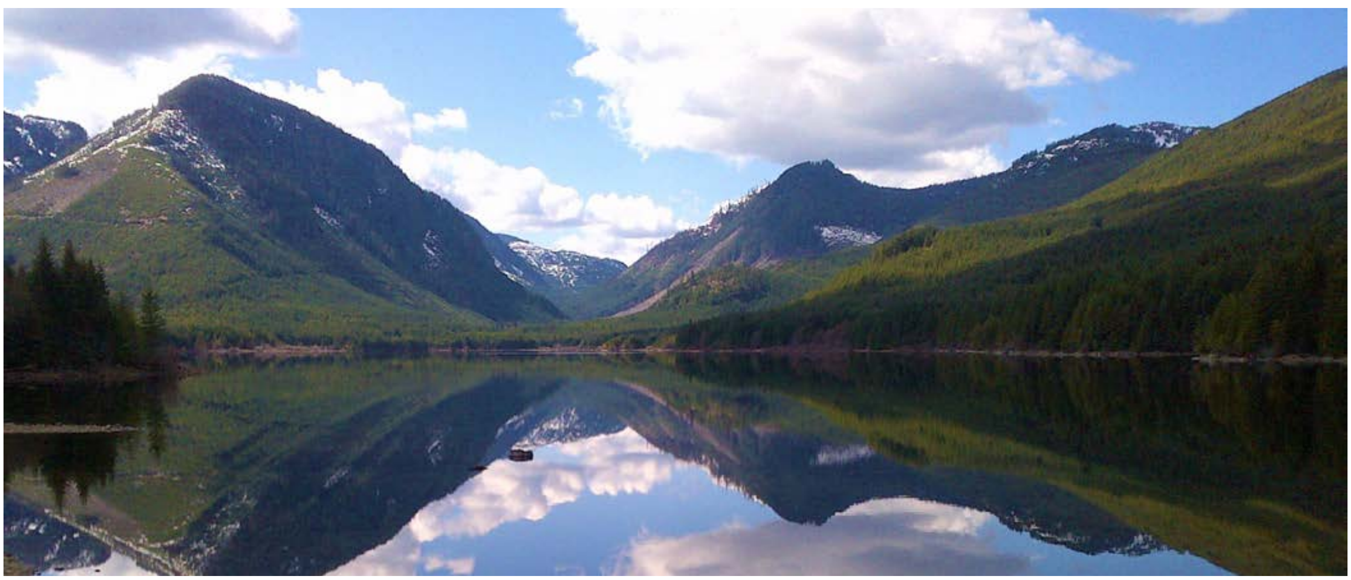
- There may be no months that are free of the possibility of experiencing a climate hazard.
- The chance of simultaneous occurrence of hazards in any given month is not likely to increase (i.e., the maximum number in the recent past and future is seven); however, the number of simultaneous hazards will increase in approximately half of the year (i.e., during the months of February, March, April, June, September and October).
- The total number of hazards per month that will likely occur over the year will increase from 35 to 48 (an increase of 37%).

A multi-hazard probabilistic mapping analysis would be necessary to obtain more certainty on the results presented above.

7.3 Key Takeaways

Below are six key takeaways from the assessment:

1. Climate hazards vary in their characteristics, which means the methods used to understand them through space and time varies substantially. This includes the data analysis complexity as well as uncertainty and confidence in results.
2. Climate change projections show that most climate hazards are getting worse, and this is consistent with local observations.
3. The Snuneymuxw First Nation especially have noticed changes. From their perspective, changes resulting from the climate are one of many they have experienced that are linked to European Settlement on their land.
4. Human decisions are at the centre of several climate hazards that depend on human infrastructure and management systems (e.g., wildfire, drought, and stormwater flood hazards). Humans also influence riverine flood and coastal flood hazards, which can change patterns based on human changes to the landscape. Humans are also responsible for changes in atmospheric hazards, which result from greenhouse gas emissions.
5. The hazards occur widely through the region and seasonally (see next bullet). This highlights the importance of thinking about accessing different areas, and potentially through redundant means, in the case that several hazards coincide.
6. There are many interactions between hazards, and the atmospheric hazards in particular. Since the atmospheric hazards are projected to get worse, the chances of their interactions will also increase. Hazards are likely to occur simultaneously in the future, and there may be no times during the year when a climate hazard is unlikely to occur.



8. Limitations

The mapping and associated assessments were intended to support disaster response and resilience efforts in the project area. To achieve this goal, we utilized a range of data sources and methods, which have limitations:

- All models are simplified representations of complex systems and, as such, possess inherent limitations and assumptions.
- The hazards are generally influenced by natural climate variability. Therefore, this could obscure the effects of long-term climate change in datasets analysed from the recent past.
- Short-term studies may not provide reliable insights for future hazard changes, as they do not account for long-term trends and cumulative effects.
- For a few of the analyses, our team relied on the work of others, which comes with its own set of limitations.

More detailed limitations on individual hazards are contained in the relevant technical studies.

9. Outcomes and Recommendations

This mapping and assessment project had three objectives. They are outlined below along with a description of how these were achieved through the course of this project.

1. **Identify, assess, and map priority climate hazards:** We conducted a screening-level analysis and prioritized 10 climate hazards, for which we conducted detailed hazard studies. We produced detailed maps, a Map Book, a Background Report and this Overview Report.
2. **Expand understanding of the hazards by integrating Indigenous perspectives and considering hazard interactions:** Collectively with the City of Nanaimo and Snuneymuxw First Nation, our team coordinated meetings, a land tour, a watershed tour, and a larger gathering with Elders to discuss climate hazards and other issues of importance to the Snuneymuxw. We conducted an in-depth analysis of interactions, by first defining drivers and modulators, and then identifying and assigning interacting relationships between hazards.
3. **Recommend how the knowledge gained can support decisions, including at the regional level.** The hazard technical studies contain recommendations to improve knowledge and data gathering. We recommend that Snuneymuxw First Nation and the City of Nanaimo continue to collaborate together, and with others, regionally on emergency management and related initiatives.

The Snuneymuxw First Nation and the City of Nanaimo should leverage the information and findings from this project and consider the following as part of the next steps:

1. Make the data public with appropriate educational tools (see next bullet).
2. Use the maps and information to develop tabletop scenarios for preparation and planning purposes. These scenarios could be used to develop simplified engagement materials and activities to be shared with the public.
3. Join or subscribe to sources of weather forecasting information to support preparedness activities. Examples include:
    - The BC and Yukon Integrated Seasonal Climate Bulletin (ISCB) listserv, and participate in seasonal meetings. They provide climate outlooks for the season, including ENSO forecasts, which can be used to obtain an idea of potential hazards that could be heightened in concern over the coming months. Join the listserv by emailing MeteoPac@ec.gc.ca.
    - Nanaimo weather forecast[20] and Weather Alerts[21].
4. While SFN and the City can do little to mitigate the projected changes to the hazards caused by climate change (except join other municipalities and all levels of governments globally to reduce greenhouse gas emissions), they can take several concrete steps to adapt to the changes (see next bullet).
5. Develop a participatory and holistic risk assessment that considers multiple scenarios, hazards (and their interactions), exposure, vulnerability, and consequence in a systematic way. Such an approach can provide more detailed understanding, based on the spatial mapping, to reduce risk. The results can be used to advance the City's Climate Change Resilience Strategy (Integral and others, 2020).
6. Support the Snuneymuxw First Nation to complete a Hazard, Risk and Vulnerability Analysis (HRVA) that meets their specific needs.
7. Use the hazard maps to conduct a probabilistic assessment of multi-hazard interactions to estimate likelihood of different hazards occurring at once.

20 Weblink: https://weather.gc.ca/en/location/index.html?coords=49.166,-123.939. Accessed 4 August 2025.

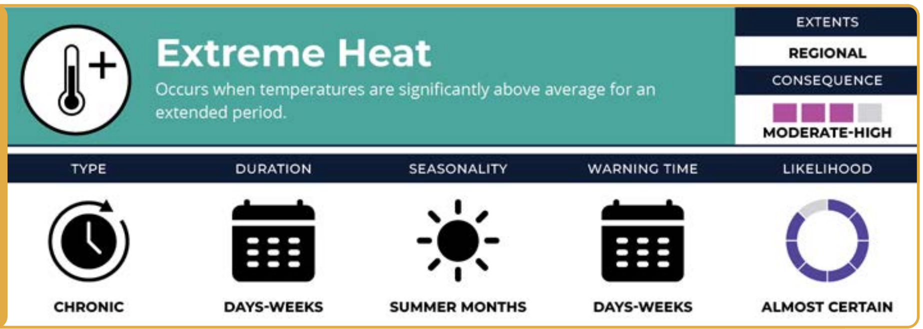
21 Weblink: https://weather.gc.ca/?zoom=3&center=53.53895188,-92.09952587. Accessed 6 August 2025.

10. Individual Hazard Summaries

The summaries on the following pages provide key background and findings for the individual hazards. This page is an example with the questions we sought to answer for each sub-heading and accompanying maps and figures in the summaries.

How do we define the hazard and what are its main characteristics?

These are also described in Table 5-1.



About The Hazard

What are important hazard impacts, and what are its drivers and modulators?

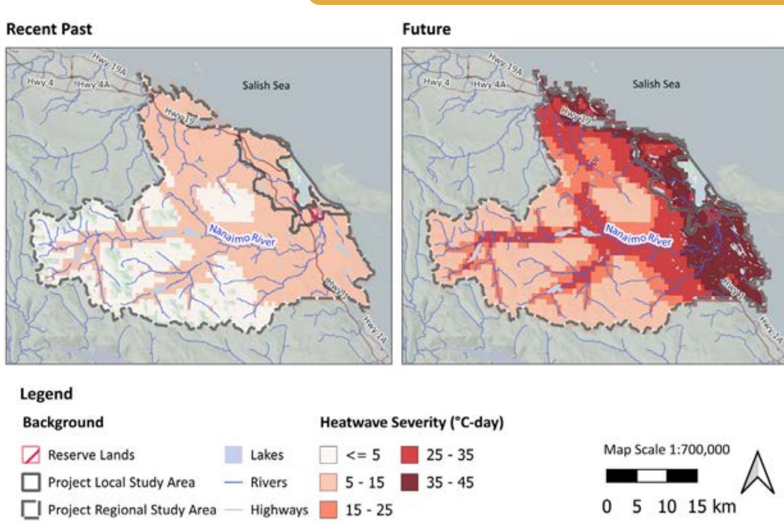
What We Assessed

Recent Past | Future | Far Future

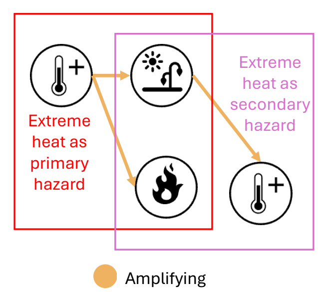
Were the datasets sufficient for mapping and what were the time periods? A grey coloured hazard circle means insufficient data, and dashed outlines indicate inconsistent or incomplete mapping datasets. The time periods that could be mapped are highlighted.

Mapping Results

What are the main temporal and spatial findings? What are the future trends? The Map Book contains more detailed spatial information.



Interactions with Other Hazards



What relationships does the hazard have with other hazards? Do they usually cause other hazards (primary), or are they usually affected by other hazards (secondary)?

Emergency Management Considerations

What actions can emergency managers in the region take to address the hazard given our knowledge of future trends?

Extreme Heat

Occurs when temperatures are significantly above average for an extended period.

EXTENTS	CONSEQUENCE
REGIONAL	MODERATE-HIGH

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
CHRONIC	DAYS-WEEKS	SUMMER MONTHS	DAYS-WEEKS	ALMOST CERTAIN

About the Hazard

Extreme temperatures underly many other hazards, beyond climate hazards. Heatwaves are related to hazards such as air quality degradation, drought, and wildfire, which are linked with human health and ecosystem impacts. Heatwaves are primarily **driven** by persistent large-scale climate systems (high-pressure "heat domes") leading to prolonged high local air temperatures. The local intensity of heatwaves is considerably **modulated** by land use and changes (urban heat island effect due to urbanization and loss of vegetation) and watershed physical characteristics (like proximity to moderating water bodies). Lower elevations are generally warmer than higher elevations. Coastal environments moderate extreme temperature conditions.

What We Assessed

We assessed and mapped a **subset of temperature-based climate indices** to understand changes in frequency, duration, and severity of extreme heat and heatwave events. The climate indices were obtained from PCIC high-resolution (e.g. 800-m horizontal) climate modelling data available over the RSA. Our statistics and maps compared conditions of the recent past (1981-2010) and future (2050s).

Recent Past | Current | Future | Far Future

Challenges

- Global climate models (GCMs) are extremely complex and have large uncertainty, especially at smaller scales.
- The GCM data is "downscaled" to account for regional effects such as from the ocean and mountains; however, this process can introduce further uncertainty through biases in local observed data.
- Results are best interpreted in terms of understanding relative changes between recent past and future conditions.

Mapping Results

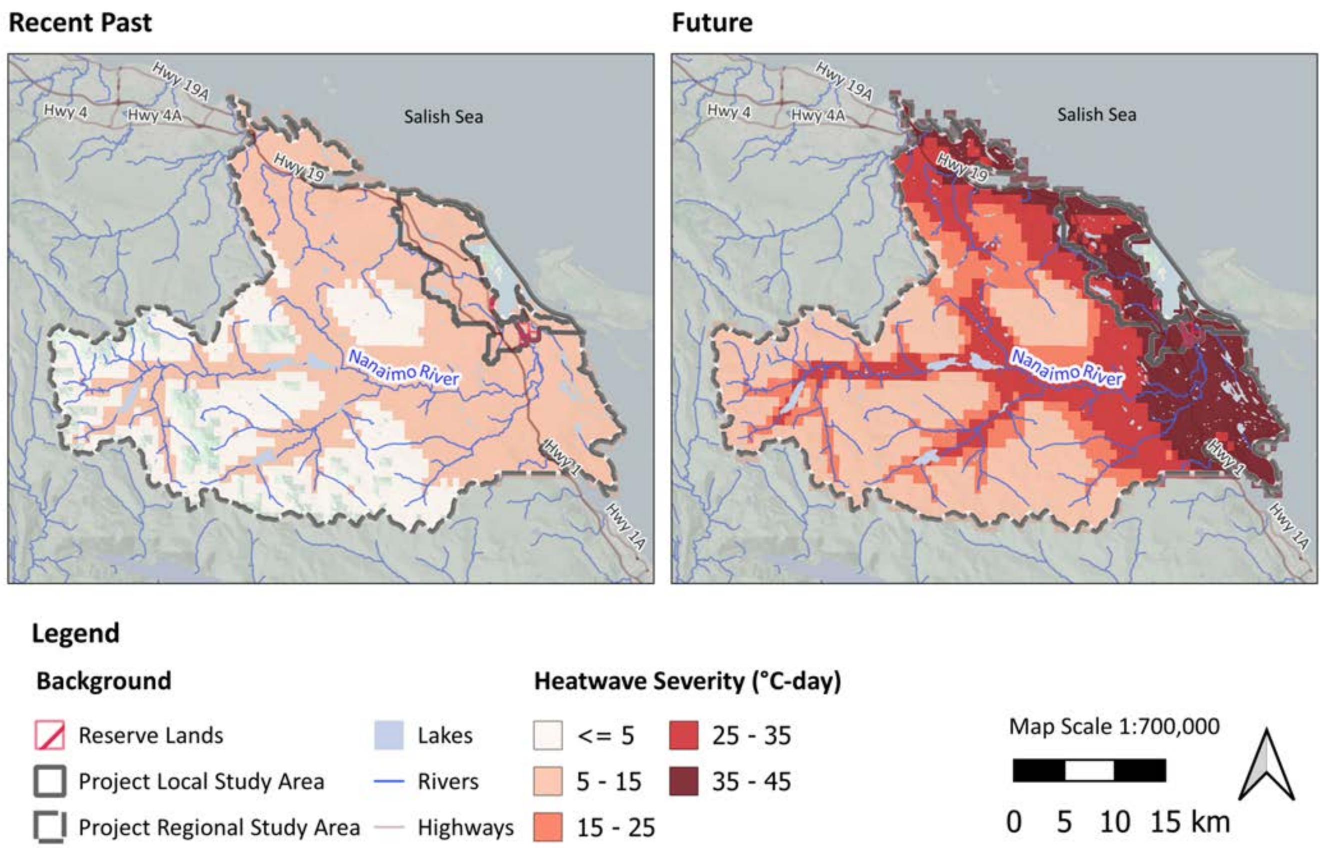
Temperatures are generally higher at lower elevations in the RSA. This corresponds to the eastern (and more populated) LSA, including SFN reserves, where this hazard is a higher concern. The change in heatwave severity is shown in the map in terms of heatwave degree days, for the recent past and for the 2050s. Heatwave degree days is defined as the annual, cumulative daily mean temperature difference above the heat wave definition (see associated technical study).

Climate Change Projections (2050s)

The results suggest that extreme heat conditions are projected to become more severe (i.e., the hottest days in the recent past were 28°C and these will increase to 32°C). Heatwaves are projected to occur more frequently, last longer, be more widespread, and be more widespread and be more severe in the future compared to the recent past:

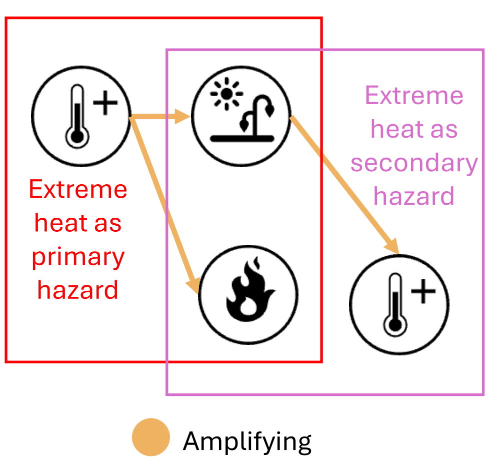
- Whereas approximately one heatwave occurred in the RSA per year in the past (this usually occurred in the lower elevation LSA), all areas of the LSA are projected to experience approximately three to four heatwaves.
- The number of heatwave days per year over the RSA will increase from 0.5 days to approximately 8 days.
- The area affected by a heat wave of moderate severity over the RSA will increase from 902 km^2 to 1254 km^2 (an increase of 39%).
- In the LSA, heatwave severity is projected to increase by up to 400%.

In the next 5-10 years, the above trends are likely to apply, meaning that this hazard is worsening. Furthermore, it interacts directly with seven other priority climate hazards.



Interactions with other Hazards

As a primary hazard, extreme heat can amplify and coincide with wildfires and droughts. It can also coincide with windstorm, stormwater, coastal and riverine flood, and extreme precipitation. In summer, extreme heat is often linked to convective storms that cause extreme precipitation.



Emergency Management Considerations

- Temperature increases are linked to El Niño events, whose forecasting can be used to track upcoming hazard potential (see Provincial resource discussed in Section 9 Recommendations)[22].
- Monitor Nanaimo weather forecast (see Federal resource discussed in Section 9).
- Prepare and plan for cooling areas that can be rapidly opened or deployed, are accessible, and are spread throughout the LSA.

22 The ENSO index is based on long-term average conditions, and it does not mean that an extreme heat event cannot occur during a La Niña phase.

Extreme Cold

A period of abnormally cold weather, which can be associated with severe winter conditions.

EXTENTS	CONSEQUENCE
REGIONAL	MODERATE

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
CHRONIC / SHOCK	DAYS-WEEKS	WINTER	DAYS-WEEKS	LIKELY

About the Hazard

Extreme cold conditions can create snowstorms and blizzards. Extreme cold is primarily driven by the advection of very cold air masses within the local hydroclimate system. This is often linked with specific large-scale climate atmospheric pressure systems such as arctic outflows, and influenced by modes of climate variability such as ENSO and others. The localized intensity of the cold is modulated primarily by watershed physical characteristics. Higher elevations are generally colder; however, local topographic conditions can cause cold air masses to "pool" at lower elevations. Coastal environments moderate extreme temperature conditions.

What We Assessed

We assessed and mapped a subset of temperature-based climate indices to understand changes in frequency, duration, and severity of extreme cold conditions. The climate indices were obtained from PCIC high-resolution (e.g. 800-m horizontal) climate modelling data available for the RSA. Our statistics and maps compared conditions of the recent past (1981-2010) and future (2050s).

Recent Past | Current | Future | Far Future

Challenges

- Global climate models (GCMs) are extremely complex and have large uncertainty, especially at smaller scales.
- The GCM data is "downscaled" to account for regional effects such as from the ocean and mountains; however, this process can introduce further uncertainty through biases in local observed data.
- Results are best interpreted in terms of understanding relative changes between recent past and future conditions.

Mapping Results

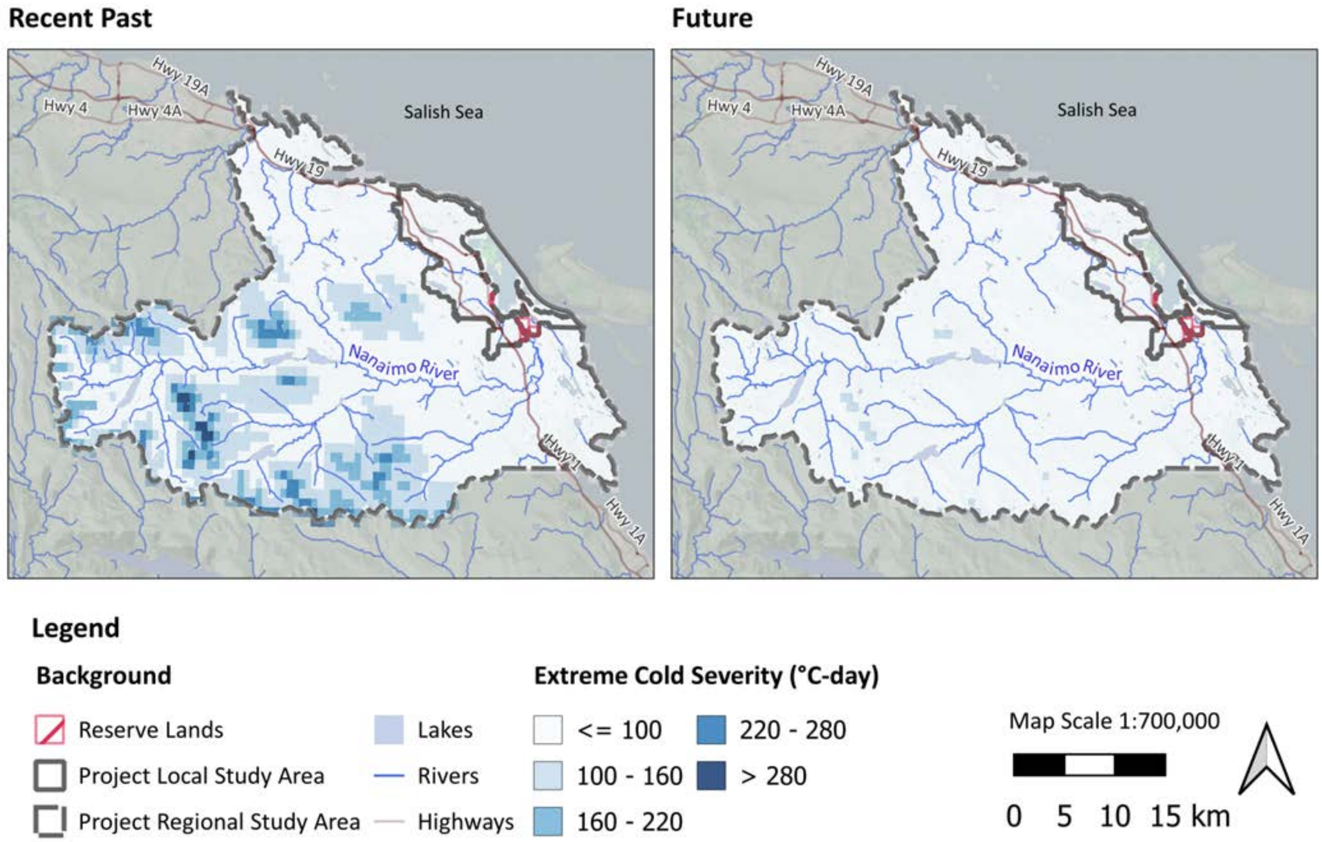
Coldest temperatures generally occur at higher elevations in the RSA. This corresponds to the western (and least populated) area. The change in extreme cold severity is shown on the map in terms of freezing degree days, for the recent past and for the 2050s. The freezing degree days index is defined as the annual total of the number of degrees that a day's average temperature is below 0°C.

Climate Change Projections (2050s)

Extreme cold conditions are projected to become weaker, especially in the lower elevation LSA, where many areas will cease to experience extreme cold conditions in the future. In the RSA compared to the recent past, in the future:

- The number of annual icing days will be reduced by 8.
- Cold spells are likely to last approximately one day instead of one week.
- The temperature of severe cold nights is likely to increase from less than -10°C to approximately -7°C.
- Fewer winter extreme cold conditions are likely to result in fewer blizzards, and less snowfall and snowpack in the upper watershed.

In the next 5-10 years, the above trends are likely to apply, meaning that this hazard is trending toward getting less extreme. This result is an exception for this project. However, by way of its influences on snowpack and hydrology, there are potential negative implications for water supply and environmental values (discussed in the drought hazard summary).



Interactions with Other Hazards

Extreme cold frequently coincides with and determines the fraction of precipitation that falls as snow rather than rain.

It also often coincides with drought conditions and windstorms (like during Arctic outflow events).

Besides influencing precipitation type, no other interactions were identified between extreme cold and the other climate hazards assessed.

Emergency Management Considerations

- Colder temperatures are linked to La Niña events, whose forecasting can be used to track upcoming hazard potential (see Provincial resource discussed in Section 9 Recommendations)[23].
- Monitor Nanaimo weather forecast (see Federal resource discussed in Section 9 Recommendations)
- Prepare and plan for warming/shelter areas that can be rapidly opened or deployed.

23 The ENSO index is based on long-term average conditions, and it does not mean that an extreme cold event cannot occur during an El Niño phase.

Extreme Precipitation

Unusually intense or prolonged precipitation that exceeds typical amounts for a given area.

EXTENTS
LOCAL-REGIONAL

CONSEQUENCE
LOW

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
SHOCK	**HOURS-DAYS**	**WINTER**	**DAYS-WEEKS**	**LIKELY**

About the Hazard

Extreme precipitation can occur as sudden, torrential downpours or persistent heavy rain over time. Its linkages with other priority hazards multiply potential impacts. Extreme precipitation is primarily **driven** by large-scale climate atmospheric systems, such as fall and winter atmospheric rivers that transport moisture-laden air masses from the Pacific Ocean. In summer, warm weather can drive convective precipitation events. The event itself is then **modulated** by watershed physical characteristics (mountain topography causes air masses to rise and cool, causing precipitation) and, to a lesser extent, by proximity to large water bodies. Heavy precipitation can fall as snow, especially at higher elevations. Otherwise, it generally falls as rain.

What We Assessed

We assessed and mapped a subset of precipitation-based climate indices to understand changes in frequency and severity. The climate indices were obtained from PCIC high-resolution (e.g. 800-m horizontal) climate modelling data available for the RSA. Our statistics and maps compared conditions of the recent past (1981-2010) and future (2050s).

Recent Past | Current | Future | Far Future

Challenges

- Global climate models (GCMs) are extremely complex and have large uncertainty, especially at smaller scales.
- The GCM data is “downscaled” to account for regional effects such as from the ocean and mountains; however, this process can introduce further uncertainty through biases in local observed data.
- Results are best interpreted in terms of understanding relative changes between recent past and future conditions.

Mapping Results

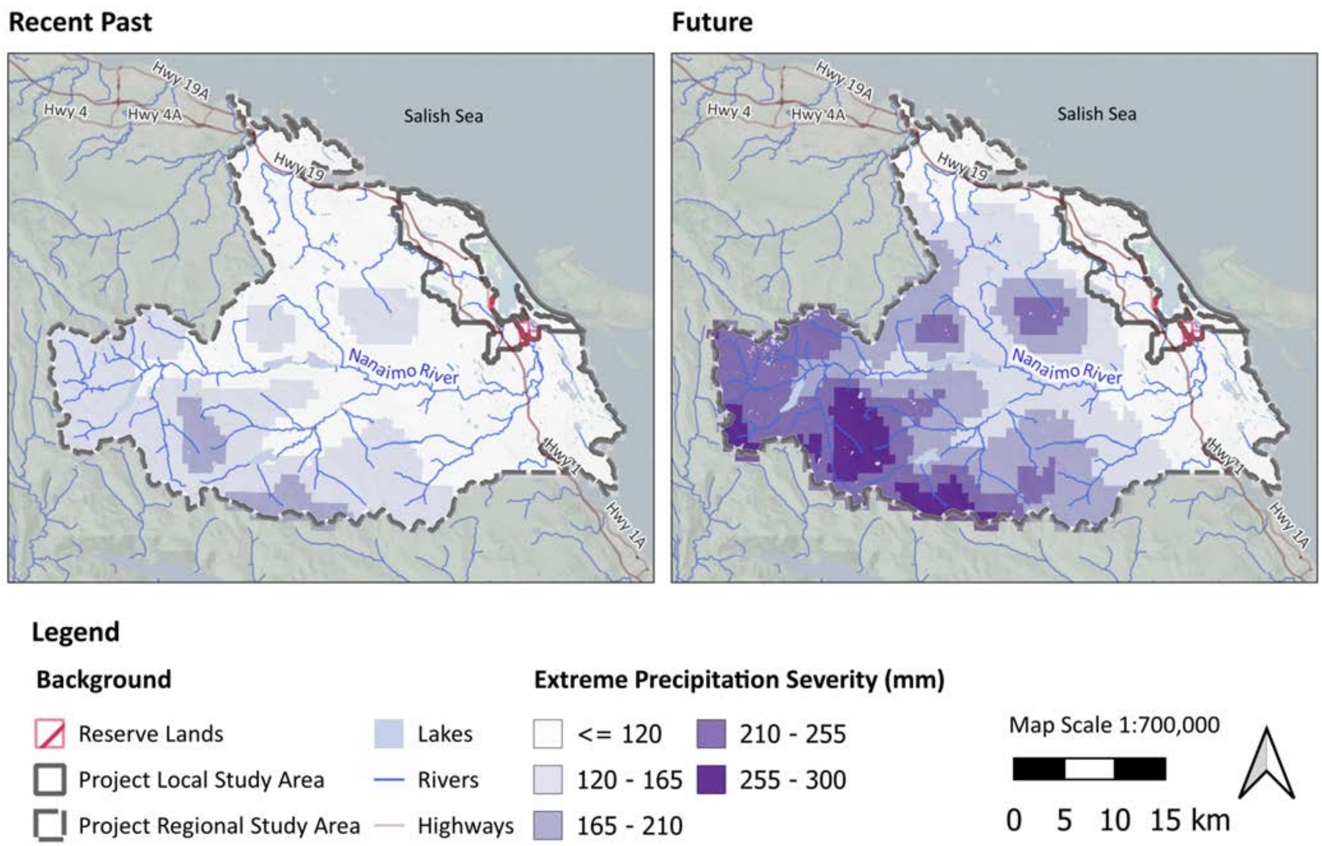
- More precipitation falls in the higher elevation western regions of the RSA (see darker colours on the map), while the LSA experiences slightly less (see lighter colours).
- Water from the higher elevations enters the LSA through river channels (see the riverine flood hazard summary).

Climate Change Projections (2050s)

Very wet and extreme precipitation are likely to become more frequent and severe. Changes in the RSA in the future compared to the recent past are as follows:

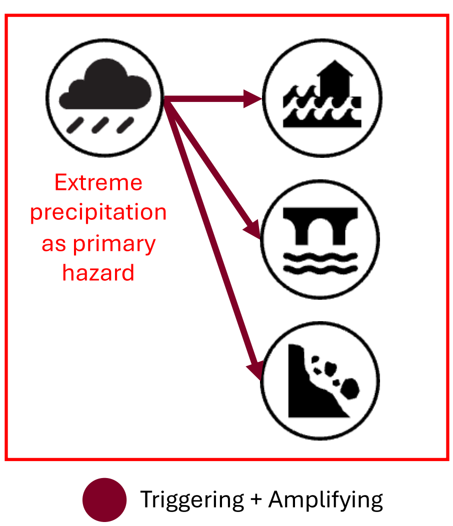
- The number of very wet days (9.1) and extreme wet days (1.8) occurring in a year are projected to increase by 2.4 and 0.9 days, respectively.
- The annual total precipitation falling during very wet days is projected to increase from 361 mm to 477 mm (30% increase).
- The severity of single- and multi-day extreme precipitation events is likely to increase by approximately 10% to 16%.

In the next 5-10 years, the above trends are likely to apply, meaning that this hazard is worsening.



Interactions with Other Hazards

Extreme precipitation directly triggers, amplifies, and coincides with riverine flooding, stormwater flooding, and mass movement geohazards. It often coincides with extreme cold (as snow/ice), coastal flooding, and windstorms (as part of the same weather system). Extreme precipitation events can be succeeded by periods of extreme heat, and they play a crucial role in terminating drought conditions. Extreme precipitation is frequently triggered by or coincides with heatwaves (convective storms).



Emergency Management Considerations

- Higher annual precipitation amounts are linked to La Niña events, whose forecasting can be used to track upcoming hazard potential (see Provincial resource discussed in Section 9 Recommendations)[24].
- Follow weather alerts, local forecasts, and websites to monitor rainfall accumulations.
- Monitor Nanaimo weather forecast (see Federal resource discussed in Section 9 Recommendations)

24 The ENSO index is based on long-term average conditions, and it does not mean that an extreme precipitation event cannot occur during an El Niño phase.

Riverine Flood

Occurs when water levels overflow from river channels onto land that is normally dry. This includes lakes and stream environments.

EXTENTS	CONSEQUENCE
LOCAL-REGIONAL	MODERATE-HIGH

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
SHOCK	HOURS-DAYS	ALL YEAR	DAYS	VERY LIKELY

About the Hazard

River flooding can damage a range of assets that are located in the floodplain, and hazard levels increase with flood depth and velocity. Riverine flooding is primarily **driven** by local hydroclimate processes (intense/prolonged rainfall, rapid snowmelt due to warm air temperatures), with atmospheric rivers being a key mechanism for extreme precipitation. The general conditions for these drivers are influenced by large-scale climate patterns and atmospheric pressure systems. The flood's characteristics are **modulated** by watershed physical characteristics (catchment size, shape, slope, soil type, channel/floodplain geometry), land use and changes (affecting runoff and sediment), and infrastructure and extractive modifications (dams, dikes, channelization).

What We Assessed

Riverine flood hazard mapping was conducted by others and was available for the main stems of the two largest rivers in the LSA, the **Nanaimo River** and **Millstone River**. We mapped the work of others that shows flood hazard extents on these two rivers for an event with an **annual exceedance probability of 0.5%** (a flood with an indicative return period of 200 years). The **flood extents were mapped for current (2018)** and **far future (2100)** conditions under climate change, which included consideration for peak flow increases and 1 m of sea level rise. Our maps include the stream network to provide a sense of potential riverine flood hazard areas.

Recent Past | **Current** | Future | **Far Future**

Challenges

- Floods that occur on tributaries and smaller rivers and creeks (e.g. the Chase River) could also cause impacts.
- Available information is limited to just a few severity scenarios and does not represent the potential for smaller and more frequent, or larger and less likely flood events.
- Studies have been conducted to map and understand dam breaches on the three main rivers; however, dam breach hazard was not considered a priority for this project and was not studied in detail.

Mapping Results

Approximately 99 ha of the Millstone River is prone to flooding, especially in the area of East Wellington and Buttertubs Marsh parks (see inset A on the map).

The Nanaimo River estuary is notably prone to flooding, which includes **49% of the surface area of SFN Reserves 2, 3, and 4** (see inset C on the map).

Climate Change Trends (2100)

- Projected increases in winter rainfall are the main cause for higher riverine flows causing flooding.
- In the Millstone and Nanaimo River watersheds, flood extents are projected to increase by 7.1% and 5.4%, respectively, from current to far future conditions.
- A substantial portion of additional flooded area (i.e. pink colours on the map) is projected to occur in Trumpeter Park (see inset B on the map) in the far future.
- Sea level rise plays a role in estuarine areas of riverine flooding.

In the next 5-10 years, the above trends are likely to apply, meaning that this hazard is trending toward getting worse.

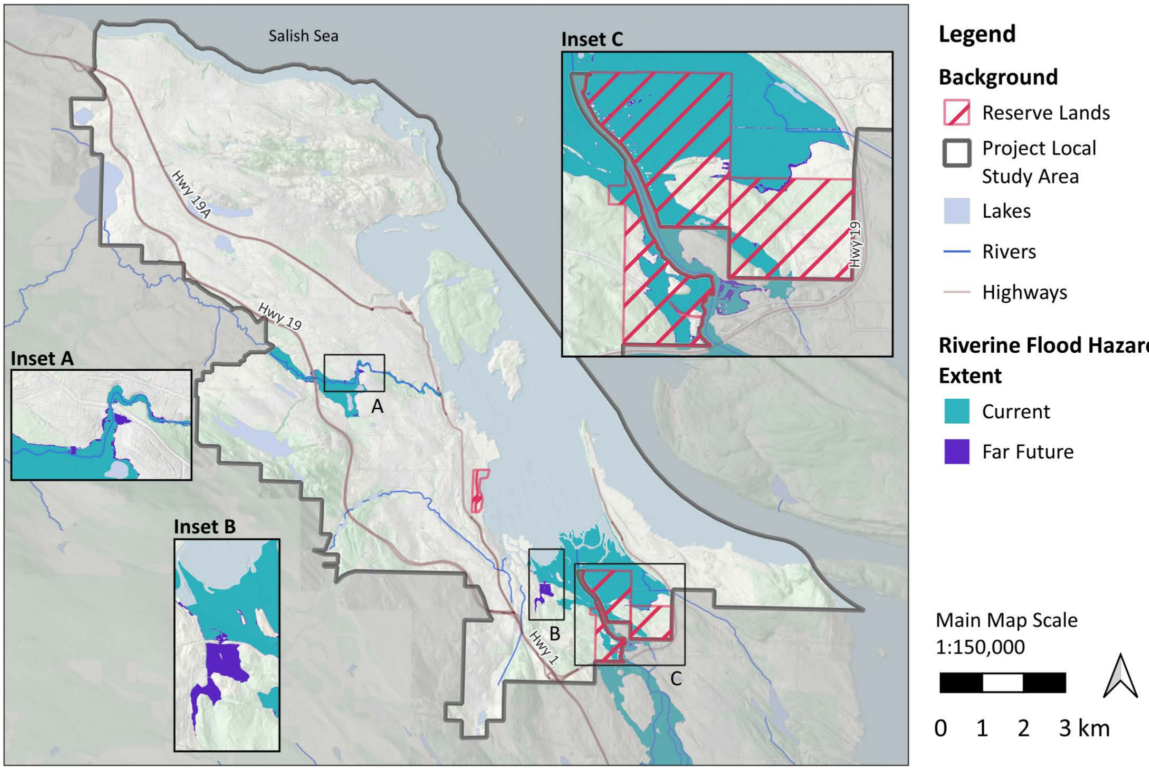
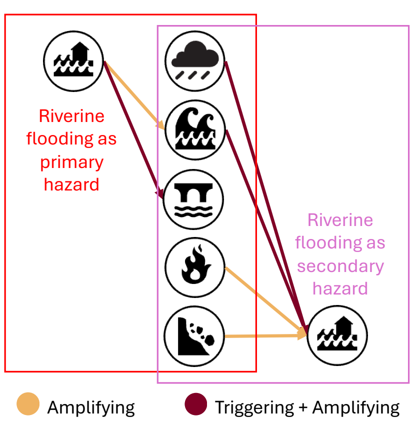


Figure 14-1: Riverine flood hazard within the local study area.

Interactions with Other Hazards

Riverine flooding amplifies and coincides with coastal flooding and triggers, amplifies, and coincides with localized stormwater flooding. It frequently coincides with extreme precipitation and concurrent windstorms. Riverine flooding can be succeeded by periods of extreme heat or the re-emergence/persistence of drought if rainfall is insufficient regionally. Riverine flooding is primarily triggered, amplified, and coincided by extreme precipitation and coastal flooding, which causes backwatering especially in estuaries. Post-wildfire conditions amplify riverine flooding, and mass movement geohazards can amplify and coincide by damming rivers or adding sediment to channels.



Emergency Management Considerations

- Due to its strong linkages with precipitation, riverine flood hazard could potentially increase during La Niña events, whose forecasting can be used to track upcoming hazard potential (see Provincial resource discussed in Section 9 Recommendations)[25].
- Precipitation forecasts should be more closely linked with flow gauging stations, and the existing flood mapping, to improve warning times and preparedness.
- The existing flood maps can be used to identify actions for specific areas in the lead-up to a forecasted flood.
- Flood hazard mapping should be completed on more watercourses.
- Monitor City operated water level gauging stations and Provincial gauging stations on Millstone River at Nanaimo[26] and Nanaimo River at Cassidy[27].

25 The ENSO index is based on long-term average conditions, and it does not mean that an extreme precipitation event cannot occur during an El Niño phase.

26 Weblink: https://wateroffice.ec.gc.ca/report/real_time_e.html?stn=08HB032. Accessed 4 August 2025.

27 Weblink: https://wateroffice.ec.gc.ca/report/real_time_e.html?stn=08HB034. Accessed 4 July 2025.

Coastal Flood

Occurs when ocean water levels are higher than normal due to storm surge, tides, waves, and wind effects. It is linked with coastal erosion

EXTENTS	CONSEQUENCE
LOCAL-REGIONAL	MODERATE

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
SHOCK	HOURS-DAYS	FALL-SPRING	DAYS	ALMOST CERTAIN

About the Hazard

Coastal flooding can damage a range of assets that are located in the floodplain, and hazard levels increase with flood depth and wave velocity. These forces affect shoreline dynamics, which can cause erosion and loss of land. Coastal flooding is **driven** by a range of phenomena. Large-scale low-pressure systems generate storm surges, which increase water levels. Flooding generally occurs during high tides (coupled with storm forces), which are governed by gravitational forces. Sea level rise, caused by large-scale climate change, is steadily increasing total water levels over time. Flood extents are mainly **modulated** by coastal morphological characteristics (slope, bathymetry, natural barriers), and coastal defenses and other construction.

What We Assessed

Coastal flood hazard mapping was conducted by others and was available for shorelines within the LSA, for an event with **annual exceedance probability of 0.5%** (a flood with an indicative return period of 200 years) for current conditions, as well as for **future (2050s)** and **far future (2100)** under climate change. Secondary erosion hazard mapping was also visualized.

Recent Past	Current	Future	Far Future

Challenges

- The current coastal flood mapping product was based on flood construction levels, which ignore the sequential inundation caused by a set of high tides and waves.
- Available information is limited to just a few severity scenarios and does not represent the potential for smaller and more frequent, or larger and less likely flood events.
- More modelling effort is required to understand coastal erosion.
- Climate change conditions did not consider changes in the likelihood and severity of storm surges, which is currently difficult to project.

Mapping Results

In general, the areas with coastal flood hazard under current conditions (see blue areas on the map) include Departure Bay, Duke Point, Downtown Nanaimo and SFN Reserve 1 (see Inset B on the map), Saysutshun Island, and Protection Island. Coastal flooding is relatively widespread in the Nanaimo Estuary and SFN Reserves 2, 3, and 4 (see Insets B and D on the map).

Although the coastline in the project area is relatively stable, there exist coastal erosion hotspots such as North Slope, where erosion and mass movement geohazards are also concerns (not shown on the map, see the relevant technical studies for details).

Climate Change Trends (2100)

Far future sea level rise (shown in pink on the map) is likely to:

- Exacerbate areas of current coastal flooding in limited areas (e.g., Neck Point, Departure Bay, and Protection Island).
- Increase the areas that flood under current conditions by approximately 13% in 2100.

In the next 5-10 years, the above trends are likely to apply, meaning that this hazard is trending toward getting worse.

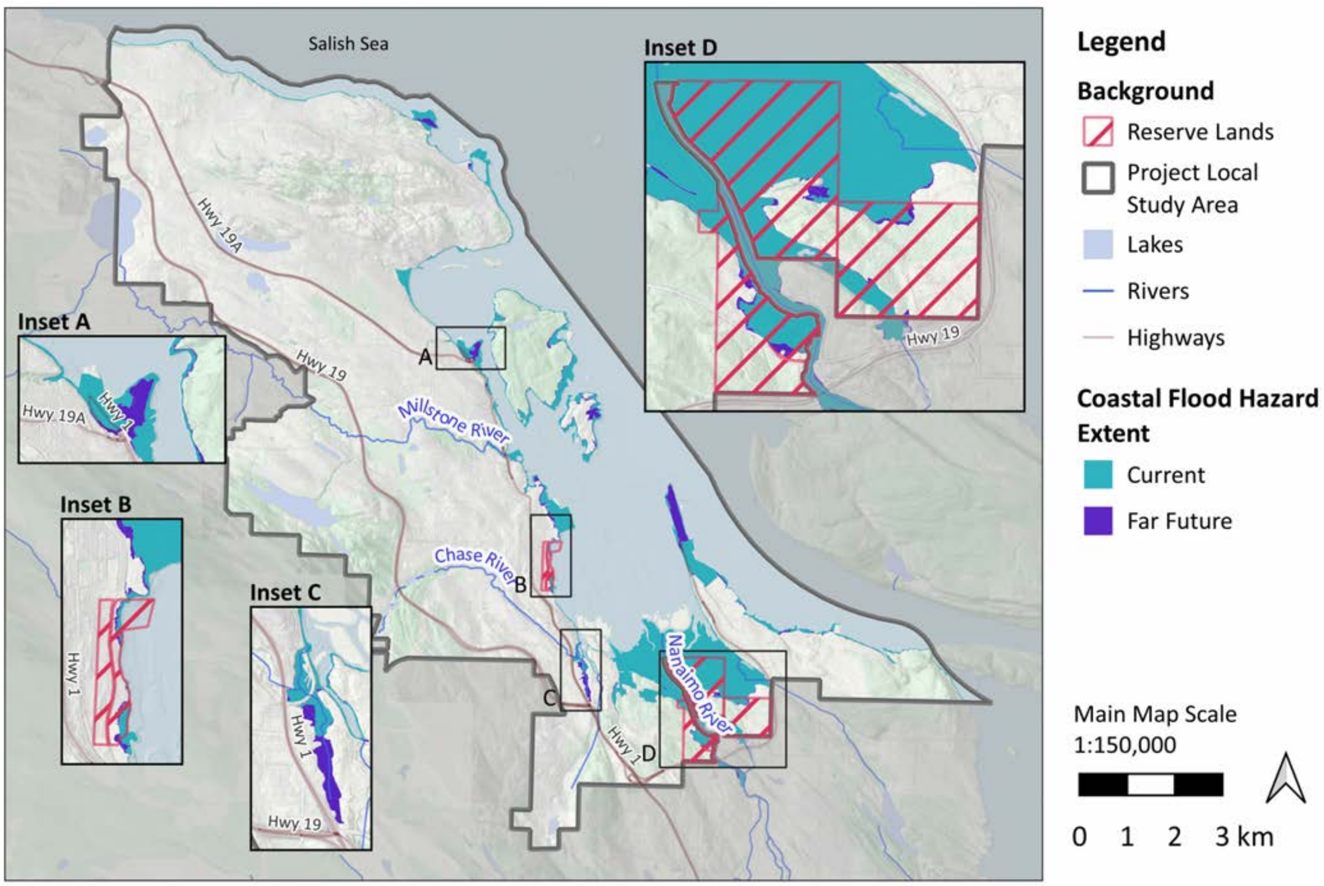
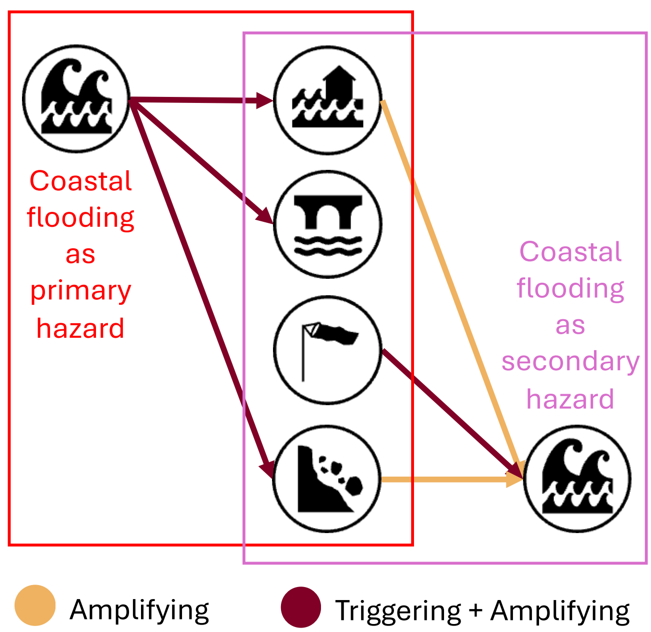


Figure 15-1: Coastal flood hazard within the LSA.

Interactions with Other Hazards

When coastal flooding is primary it triggers, amplifies, and coincides with riverine and stormwater flooding through backwater effects and by adding to total water volume. It is also inherently triggered by, amplified by, and coincides with the windstorms that generate storm surge, and can trigger, amplify, and coincide with coastal mass movements (e.g., cliff erosion). Coastal flooding events can be succeeded by periods of extreme heat or drought. As a secondary hazard, coastal flooding is amplified and coincided by riverine flooding, often coincides with extreme precipitation and stormwater flooding, and is triggered, amplified, and coincided by windstorms. Mass movements like submarine landslides can also trigger or amplify coastal flooding (e.g., tsunamis).



Emergency Management Considerations

- Utilize storm surge forecasts, and the existing flood mapping, to improve warning times and preparedness.
- The existing flood maps can be used to identify actions for specific areas in the lead-up to a forecasted flood.

Stormwater Flood

Occurs when precipitation cannot infiltrate or be conveyed by drainage infrastructure. It is also called local, pluvial, or flash flooding.

EXTENTS
LOCAL-REGIONAL
CONSEQUENCE
MODERATE-HIGH

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
SHOCK	HOURS-DAYS	FALL-SPRING	DAYS	VERY LIKELY

About the Hazard

Stormwater flooding can damage low lying urban areas, such as basement homes, and make roads and trails impassable. It is primarily **driven** by intense rainfall events within the local hydroclimate. The likelihood of such rainfall can be influenced by large-scale climate patterns (fall and winter atmospheric rivers). Stormwater flood events are **modulated** by land use and changes (especially urbanization that increases imperviousness and reduces water infiltration into the ground) and watershed physical characteristics (local topography and soil infiltration capacity). The design and condition of stormwater systems is also critical. When these systems are blocked or flow exceeds their conveyance capacity, local flooding occurs.

What We Assessed

In the face of limited data availability, **we mapped information that provides a sense of the City's understanding of the hazard**. This is shown in the map in terms of the areas covered by stormwater modelling studies, as well as areas of concern (as observed by City ground personnel).

We also mapped projections for extreme rainfall (see the associated technical studies for results). Slightly different indices for extreme precipitation were mapped and are provided in this report under the extreme precipitation hazard section.

Recent Past | **Current** | Future | Far Future

Challenges

- Our reviews of existing studies, done by others, were limited.
- The areas outside of the stormwater systems were not studied, but pluvial flooding can occur where there is no stormwater infrastructure to convey flows.
- There are uncertainties associated with the statistical rainfall data (i.e. intensity-duration-frequency curves), as well as climate change projections.

Mapping Results

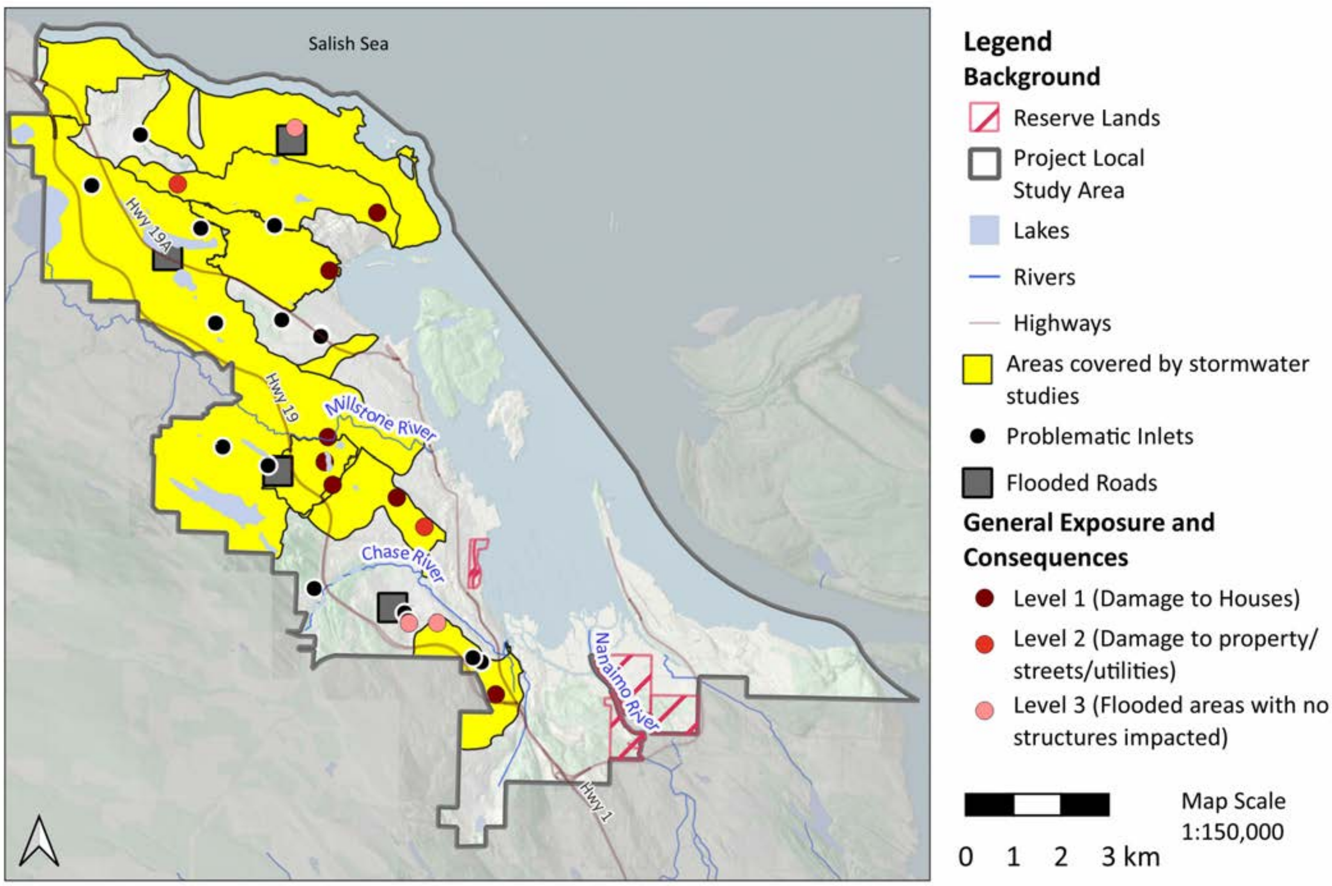
- Approximately 55% of the LSA has been assessed using stormwater models, drainage studies and master plans.
- The majority of the identified areas of concern (AOCs), which consist of problematic inlets, flooded roads and other linear segments, and general exposure and consequence, occur within the areas that have been studied using stormwater models.
- The majority of the AOCs are located within 100 m of a stream or lake, which means that they could be influenced by riverine flood hazard (see the relevant mapping results in the riverine flood hazard section).

Future Trends

The following results provide a sense of how the hazard could change in future:

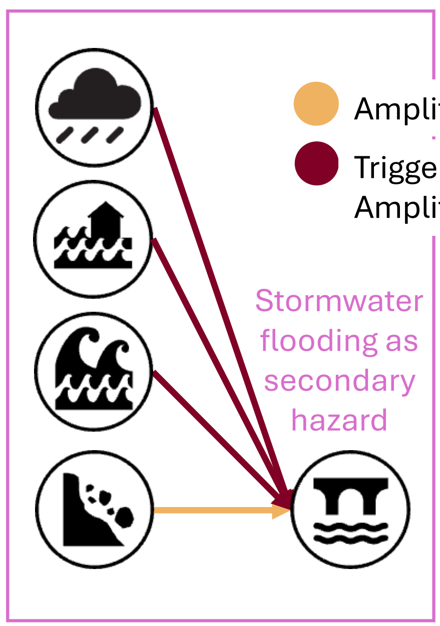
- Extreme rainfall events are becoming more intense and the projected changes are greater for events of longer duration and larger magnitude. Based on the projections for the Nanaimo City Yard station, the 1-day rainfall event is likely to increase in intensity by more than 20% in the future compared to the recent past.
- Recent stormwater modelling studies have accounted for climate change projections, which should help the City adapt systems to the projected increases in rainfall.
- As the City builds out, the impervious area could increase from the current 65% to 80% in 2046. This condition could exacerbate the hazard substantially if stormwater management systems are not properly planned and maintained to convey more intense rainfall.

In the next 5-10 years, the precipitation projections are likely to apply, meaning that this hazard is trending toward getting worse. However, issues of stormwater management systems and impervious surfaces may be adapted to offset increases in rainfall. Based on the limited information we reviewed, this is currently uncertain.



Interactions with Other Hazards

Stormwater flooding is primarily triggered, amplified, and coincided by extreme rainfall and by backwater effects from riverine or coastal flooding. Mass movements can also amplify and coincide with stormwater flooding (by blocking drains). The first stormwater flood of the rainy season, called the "first flush," can follow drought periods. Periods of stormwater flooding may be succeeded by extreme heat.



Emergency Management Considerations

- Higher annual precipitation amounts are linked to La Niña events, whose forecasting can be used to track upcoming hazard potential (see Provincial resource discussed in Section 9 Recommendations)[28].
- Follow weather alerts, local forecasts, and websites to monitor rainfall accumulations.
- Continue to monitor areas of concern.

28 The ENSO index is based on long-term average conditions, and it does not mean that an extreme precipitation event cannot occur during an El Niño phase.

Drought

Occurs when there is a deficiency of precipitation over an extended period, resulting in a water shortage.

EXTENTS	CONSEQUENCE
REGIONAL	HIGH

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
CHRONIC	MONTHS-DECADES	MAINLY SUMMER	MONTHS-YEARS	ALMOST CERTAIN

About the Hazard

Water is essential for life and is needed for human consumption, industry and agriculture, recreation, and the environment. Preventing water shortages is linked to understanding drivers and modulators and managing drinking water systems, and supply and demand. Droughts are primarily **driven** by a persistent deficit in local precipitation and/or high air temperatures from the local hydroclimate. The likelihood and severity of these conditions are often influenced by large-scale climate patterns and persistent high atmospheric pressure systems. The progression and severity of droughts are **modulated** by watershed physical characteristics (especially soil water holding capacity and geology influencing groundwater), land use and changes (affecting evapotranspiration and infiltration), and infrastructure and extractive modifications (such as water extraction from reservoirs or groundwater).

What We Assessed

We analysed **components of the drought context in terms of water supply processes** (e.g., meteorological, soil moisture, and hydrological drought) and the **water management system** (e.g., human-environment drought). For the former, we reviewed regional drought patterns, temperature and precipitation projections under climate change, and considered the amount of available water in the watershed. For the latter, we considered future human demand and the drinking water system capacity.

Recent Past	Current	Future	Far Future

Challenges

- Drought is subject to complex physical relationships related to the water cycle, and human decisions involved with managing water supply and demand.
- Provincial drought levels recorded in the region over the last decade are not consistent.
- A much more detailed analysis would be required to more fully understand the nuances of drought (e.g., projecting the net effects of seasonal temperature and precipitation changes).

Results

While we mapped certain components of the drought hazard context (e.g. climate projections for temperature and precipitation), a map summarizing drought hazard was not deemed useful based on the available data. However, key findings from our analyses are as follows:

- The water management system is dependent on a predominantly rain-fed system in the Upper Nanaimo River watershed.
- Drought levels in the last decade have potentially shifted toward the late summer and may be increasing in duration.
- Future water supply is dependent on changes in temperature and precipitation (see Climate Change Trends).
- The drinking water system infrastructure is robust and human demand management instruments are in place.

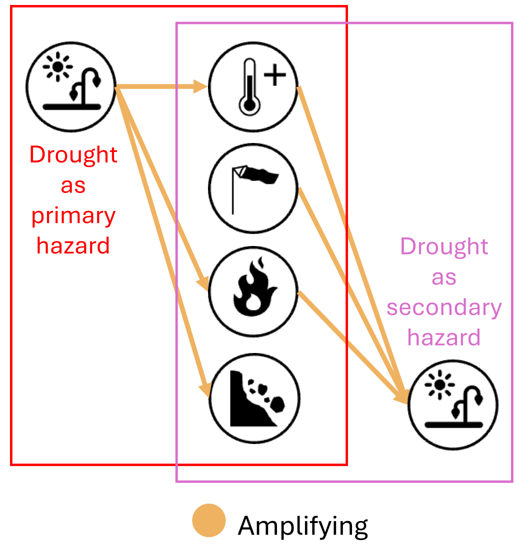
Future Trends

- The RSA is likely to experience increasing temperature, and reduced rainfall in summer in the 2050s. However, increases in rainfall during spring, fall, and winter could offset the declines in summer.
- More knowledge about impacts to the hydrologic cycle (e.g. evapotranspiration, infiltration) are required to understand the net effects of the climatic changes.
- The Jump Lake Dam (see Figure 2-1) stores the majority of the region's drinking water, and its supply and capacity is projected to meet demands to the year 2061.

In the next 5-10 years, it is difficult to determine a trend based on the uncertainties outlined above and the related human decisions that will be made. For this reason, the hazard should continue to be monitored and understood.

Interactions with Other Hazards

Drought strongly amplifies and coincides with extreme heat and wildfire hazards. It can coincide with extreme cold. Drought is often succeeded by extreme precipitation, and subsequently by associated riverine, coastal, or stormwater flooding. This has implications for reservoir management. Drought amplifies the susceptibility of future mass movement geohazards by drying soils and stressing vegetation. As a secondary hazard, drought is amplified by and coincides with extreme heat and wildfires. Windstorms can amplify drought effects (e.g., increasing evaporation) and coincide with dry conditions (creating dustbowls).



Emergency Management Considerations

- Due to its linkages with temperature and precipitation, drought hazard could potentially increase during El Niño events, whose forecasting can be used to track upcoming hazard (see Provincial resource discussed in Section 9 Recommendations)[29].
- Related to the above, track the BC drought information portal.
- Work with drinking water system personnel to periodically assess the risk of drinking water infrastructure.

29 The ENSO index is based on long-term average conditions, and it does not mean that extreme heat and extreme precipitation events cannot occur during a La Niña phase.

Windstorm

Wind gusts and high wind speed, that is often associated with heavy rain.

EXTENTS	CONSEQUENCE
REGIONAL	MODERATE

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
SHOCK	HOURS-DAYS	FALL-WINTER	DAYS	VERY LIKELY

About the Hazard

Windstorms can damage trees, powerlines and other critical linear infrastructure, with impacts that are far-reaching. Wind patterns are complex and variable. They are primarily **driven** by strong atmospheric pressure gradients caused by temperature differences on land and ocean surfaces (sometimes causing cyclones and thunderstorms). The localized intensity of the wind is **modulated** by watershed physical characteristics (topography causing funneling or shelter) and land use and changes that affect surface roughness (surface winds behave differently in a forest compared to an urban area, or coastal shoreline).

What We Assessed

We analysed wind data from three weather stations located within the RSA, and one that was within the Salish Sea (Entrance Island station). For a subset of these stations, we reviewed extreme wind data, including extreme winds and wind gusts (see the relevant technical study for details) that was reliable.

We also analysed shoreline wind fetch (the length of water over which wind can blow without obstruction).

Recent Past | Current | Future | Far Future

Challenges

- Wind patterns are complex, variable, and difficult to simulate. Wind data has high uncertainty and low spatial resolution.
- There are not enough observation records from weather stations to capture the highly variable spatial patterns of local winds.
- Current modelling results are usually focused on large-scale estimates of average conditions. These models are not suitable for understanding local-scale extreme events.

Mapping Results

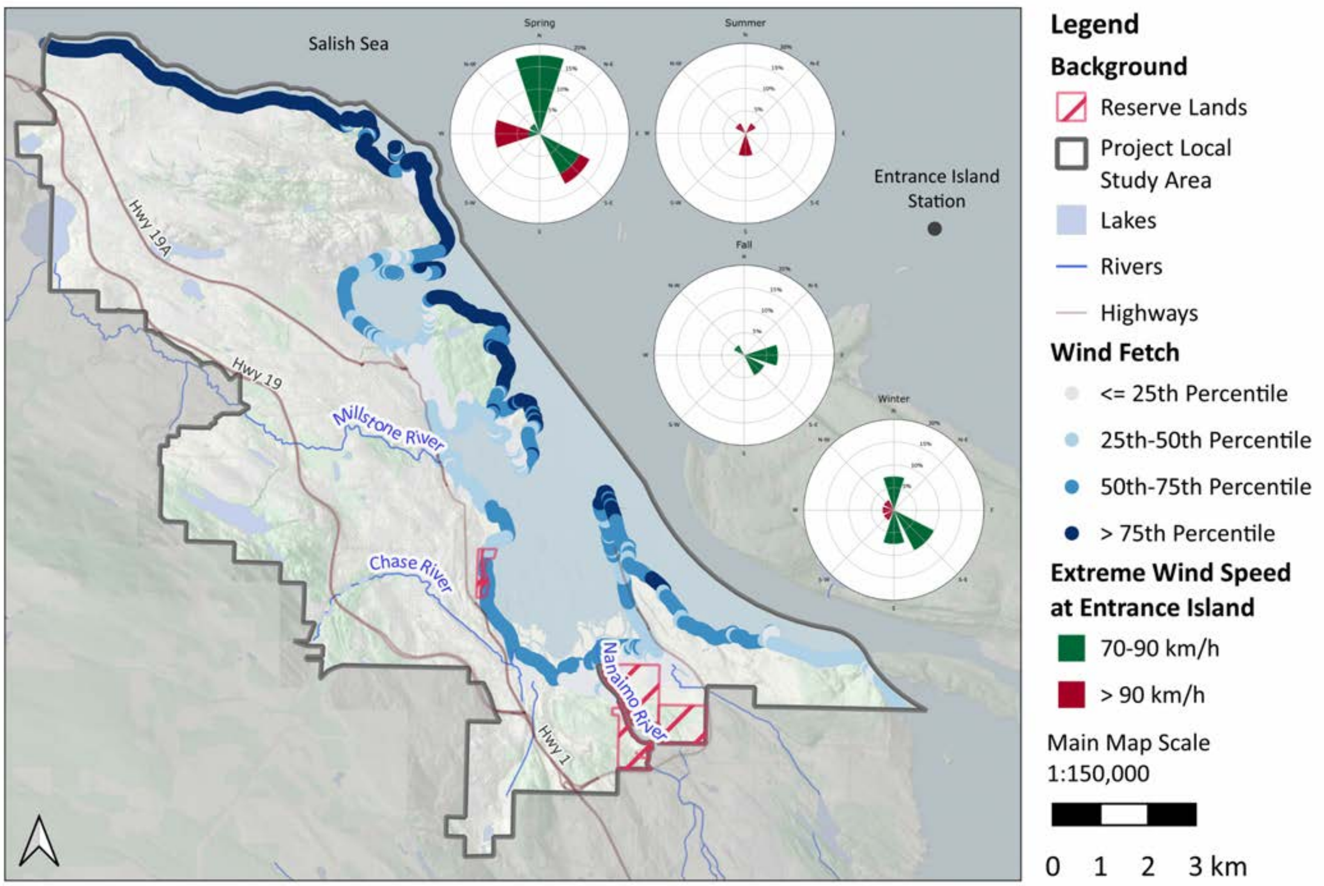
Our findings include the following for wind speed:

- In general, these are higher in areas closer to the coast, and in the Salish Sea. However, there is a very large variability in extreme wind events among the stations analysed; extreme wind directions also change seasonally.
- In the Salish Sea, extreme winds occur mostly in winter and spring, and are northerly (from the north), southeasterly, southerly, and westerly.
- A relatively small proportion of wind speeds recorded at Entrance Island were above warning thresholds (i.e. 70 km/h and 90 km/h).
- Extreme wind events have occurred sporadically in the past with notable events occurring in 2013 and 2014.
- Many coastal areas are relatively sheltered from offshore features such as Gabriola Island, Saysutshun Island, and Duke Point. However, areas with larger fetch and that are exposed to the dominant southeasterly or northwesterly wind patterns, are likely to experience higher winds. This includes the North Slope (see dark blue area at the top of the map).

Climate Change Trends

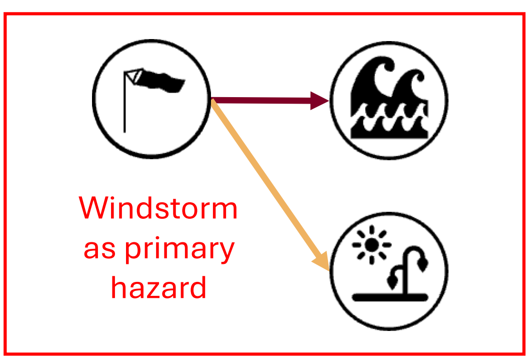
It is difficult to assess climate change influences on extreme winds in the project area due to the limited available data. Based on an analysis of wind data at Entrance Island, winds have become stronger on average; whereas the likelihood of unusually high or low winds relative to the average wind speed has remained almost constant. Therefore, it is possible that extreme winds have increased in the project area. Our confidence in this trend is low, but it is consistent with some research literature (e.g. (Cheng et al., 2014).

In the next 5-10 years, we can reasonably assume that the trend outlined above will continue.



Interactions with Other Hazards

Windstorms frequently coincide with extreme cold, extreme precipitation, and associated riverine or stormwater flooding (as part of the same storm system). Windstorms trigger, amplify, and coincide with coastal flooding (storm surge). When they occur in warmer periods, windstorms amplify and coincide with drought conditions by increasing evaporation and mobilizing dust. They can coincide with wildfires, significantly influencing their behavior.



Amplifying Triggering + Amplifying

Emergency Management Considerations

- Advocate for the collection of extreme wind speed data at more locations to obtain more representative records.
- Given the challenges associated with understanding extreme winds based on available data, focus efforts on reducing risk and increasing resilience to windstorm hazard across the project area where practicable.

Wildfire

Unplanned fires occurring on forest or range lands, which burn forest vegetation, brush, etc. and can spread to developed areas.

EXTENTS: LOCAL-REGIONAL

CONSEQUENCE: HIGH

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
SHOCK	DAYS-WEEKS	SUMMER	HOURS-DAYS	LIKELY

About the Hazard

Wildfires can damage property and infrastructure, wildlife habitat and ecosystems, and human health. Wildfires are primarily driven by an ignition source (human activity or lightning) occurring in a receptive fuel bed conditioned by local hydroclimate factors (lack of precipitation, high air temperatures, low humidity). Large-scale climate patterns influence these conditioning periods. Fire behavior is modulated by land use and changes (fuel type, load, continuity – heavily altered by logging, insect infestations, or previous fires), watershed physical characteristics (topography, especially slope), and fire suppression efforts.

What We Assessed

Blackwell and Associates Ltd. conducted a detailed analysis based on historical climate and wildfire data, terrain, and fuel type. The latter was ground-truthed and filled an important knowledge gap. A 2-km buffer around the LSA was mapped to understand how conditions outside of the boundary could affect wildfires inside the LSA. Head fire intensity, rate of spread, and ignition potential were modelled and combined to understand suppression difficulty. These two were then combined to map wildfire hazard. Several simulations were conducted to understand wildfire spread based on scenarios that considered different ignition source locations and wind patterns.

Recent Past | Current | Future | Far Future

Challenges

- The Provincial fuel type classification applied is based on a forest resource inventory database algorithm. The data reliability is based on the age and quality of the inventory, changes related to human disturbance, and the time since last update. While the inventory provides the best available data on fuel type there are inherent errors that cannot be adjusted for in this type of project.
- The map shows fewer or no hazards in many urban areas, but this is a limitation of modelling related to transportation of embers. These areas are still susceptible to embers generated as far away as two kilometers from the interface.
- Fire growth simulation is critical to emergency management and fire preparedness.

Mapping Results

Approximately 50% of the land base in the study area is classified as either high (23 km²) or moderate (67 km²) wildfire hazard. Winds during the fire season are predominantly northwestern or southeastern.

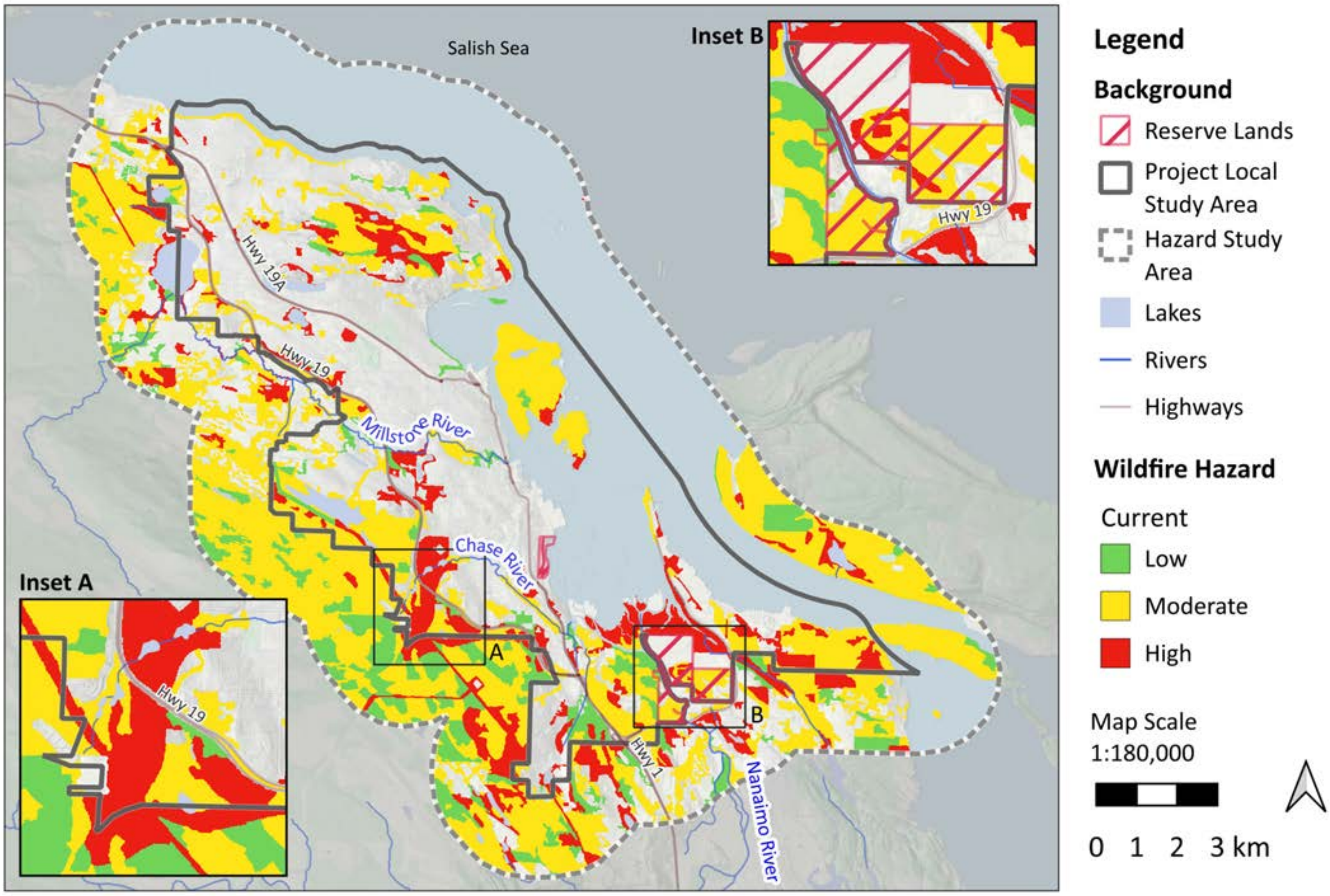
There is a continuous extent of forested land, classified as moderate hazard, along the western boundary of the City. Ignition and spread simulations from this area produced the most significant fire behavior observed in the modelling. If left unsuppressed, a wildfire ignited along the western boundary could spread along the community's edge within a 24-hour burn period (see the yellow areas on the left hand side of the map).

Climate Change Trends

Wildfire hazard is projected to increase along with extreme heat and, potentially, drought in the project area. Other trends include:

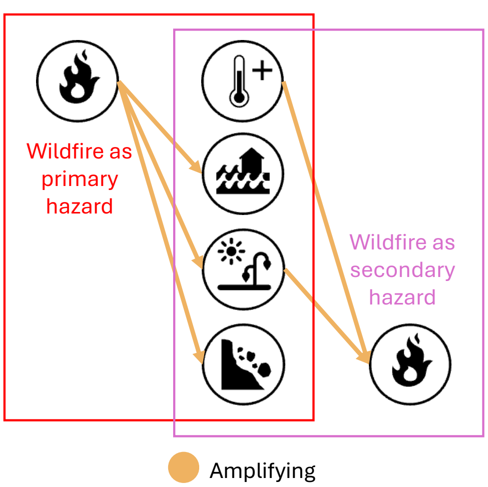
- The conditions causing wildfires will increase in frequency due to extended periods of high and extreme danger class days.
- The total area burned on an annual and decadal basis is expected to increase.

In the next 5-10 years, this hazard is trending toward getting worse.



Interactions with Other Hazards

Wildfires interact with five other priority hazards. They intrinsically coincide with extreme heat and drought conditions, which create fuel flammability. They also can coincide with windstorms, which drive their spread. Post-wildfire conditions significantly amplify the risk of subsequent riverine flooding, stormwater flooding, and mass movement geohazards. It is noted that extreme precipitation works against wildfires by partially or fully extinguishing them.



Emergency Management Considerations

- Due to its linkages with temperature and dryness, wildfire hazard could potentially increase during El Niño events, whose forecasting can be used to track upcoming hazard potential (see Provincial resource discussed in Section 9 Recommendations)[30].
- During a severe drought, lack of water supply can complicate firefighting efforts.
- Education and prevention should be emphasized, where wildfire preparedness should be properly planned and organized.
- A tactical suppression plan can contain and limit wildfires within the project area under difficult wildfire conditions.

30 The ENSO index is based on long-term average conditions, and it does not mean that an extreme heat event, and dry conditions, cannot occur during a La Niña phase.

Mass Movement Geohazards

Occurs when material such as rock, debris, and soil moves downslope.

EXTENTS
LOCAL-REGIONAL
CONSEQUENCE
MODERATE-HIGH

TYPE	DURATION	SEASONALITY	WARNING TIME	LIKELIHOOD
SHOCK	MINUTES-MONTHS	FALL-SPRING	DAYS	LIKELY

About the Hazard

These are powerful events that can occur suddenly and without warning, damaging a range of assets including buildings, roads, and utility infrastructure. Mass movement geohazards occur on a spectrum based on how quickly material is transported, the size of material, and the water content of the mass movement. Mass movement geohazards are primarily driven by local hydroclimate processes (intense or prolonged rainfall, rapid snowmelt, freeze-thaw cycles) or geophysical events (earthquakes). The likelihood of triggering rainfall patterns is influenced by large-scale climate conditions. The susceptibility of a slope failure is modulated by watershed physical characteristics (slope steepness, geology, soil properties), land use and changes (especially deforestation or post-wildfire conditions), and infrastructure and extractive modifications (like access roads or mine pits).

What We Assessed

In the study area, SLR Consulting identified and assessed hazards related to unstable slopes. Four hazard areas (HAs) were delineated, which represent similar conditions within a geographic area and include a buffer zone beyond the observed areas of instability. The four HAs were: **rockfall, rock-topple, coastal slides** a**nd slope instabilities within drainage networks**. Each HA was delineated using specific modelling and analysis techniques, which were used as the basis to understand areas of terrain stability concern.

Areas of stability change due to climate change were assessed based on professional judgement and understanding of interactions with projected climate (e.g., increased extreme precipitation and temperatures).

Recent Past | Current | Future | Far Future

Challenges

- The desktop analysis was not ground-truthed; therefore, maps should be considered approximate only.
- The hazard areas shown are not likely to occur simultaneously, nor do they represent secondary or tertiary effects from geohazard initiation.
- Geohazards are influenced by natural climate variability, which can obscure the effects of long-term climate change, as well as human-caused effects that may alter the natural state of stability.

Mapping Results

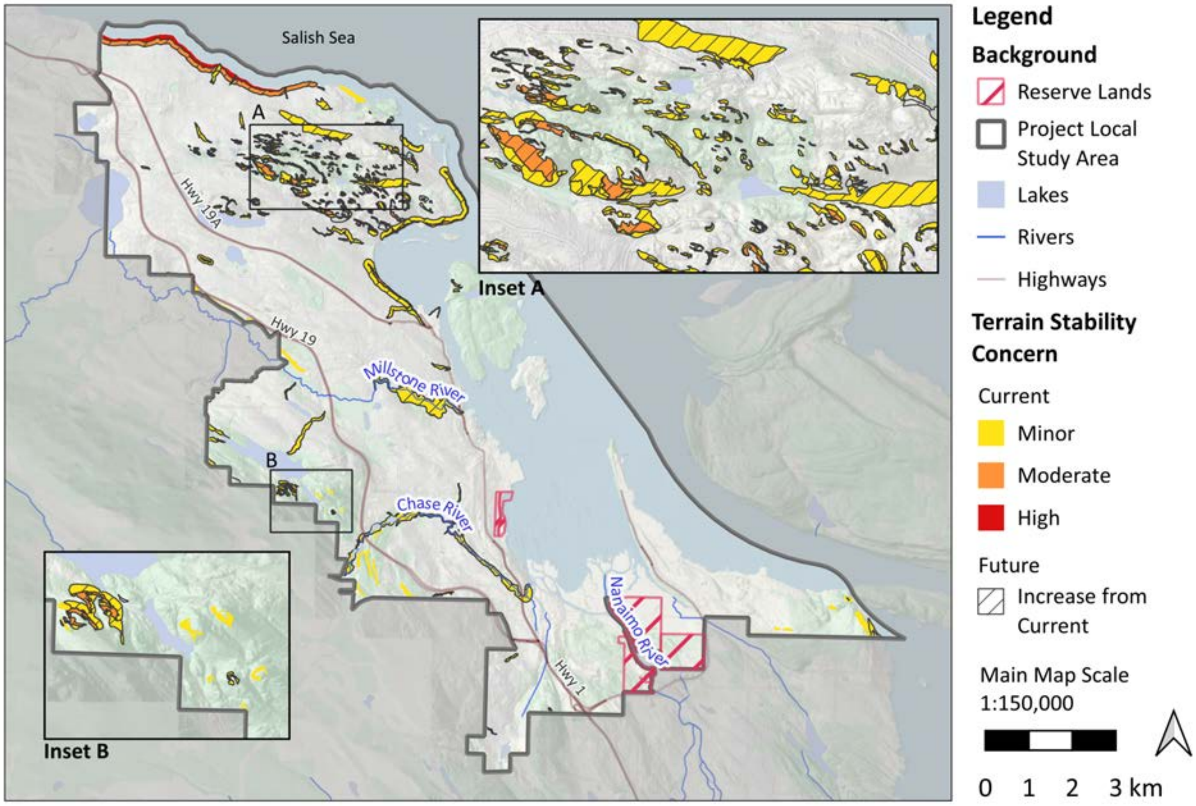
The map shows areas of minor, moderate, and high likelihood of mass movement initiation (stability concern) based on the 5-class terrain stability classification system in BC. For the recent past conditions, 453 ha were of minor likelihood. These areas may require specific management practices to reduce the likelihood of instability initiation. There was 102 ha of area with moderate likelihood, which require detailed assessment and management. Insets A and B provide more details on a couple of minor and moderate stability areas of concern.

Along the north coastal area, a 32 ha stretch of area was associated with a high likelihood of instability, due to coastal slides that include ongoing retrogressive landsliding (see top portion of the map). These areas are unsuitable for development without further site-specific analysis and mitigation measures.

Climate Change Trends (2050s)

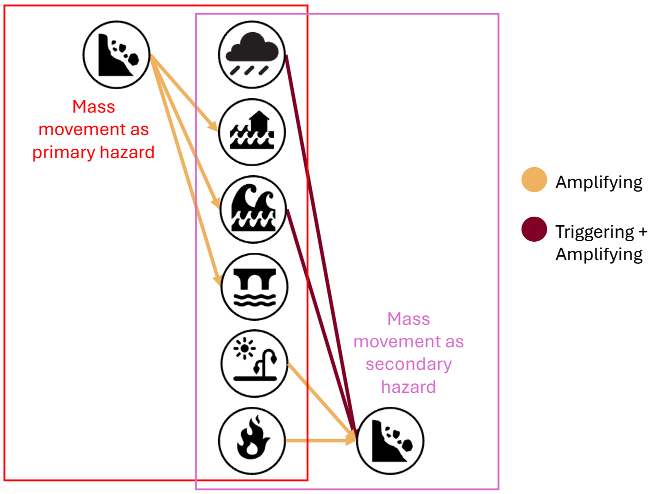
- Areas where the stability concern is likely to increase are shown with hatching in the above map.
- All four HAs are affected by climate change due to a combination of increasing precipitation, temperature, wind (potentially), and sea levels in the project area.
- Debris slides and retrogressive earth flows are likely to increase in areas already prone to this geohazard, and potentially in a small amount of new areas.
- Debris slides in coastal areas are even more sensitive to climate change due to the additional effects of sea level rise.
- Slope instabilities in drainage networks (e.g., along the banks of the Millstone and Chase Rivers) are likely to increase, leading to more slope failures during extreme precipitation events.

In the next 5-10 years, the above trends are likely to apply, meaning that this hazard is trending toward increased frequency of events occurring.



Interactions with Other Hazards

Mass movement geohazards amplify and coincide with riverine flooding (e.g., by damming rivers or adding sediment), coastal flooding (e.g., through coastal erosion from sea level rise and storm surges, and by triggering local tsunamis), and stormwater flooding (e.g., by blocking drainage). Mass movement geohazards are primarily triggered, amplified, and coincided by extreme precipitation. Coastal flooding (wave erosion) and riverine flooding (bank erosion) can also trigger and coincide with mass movements. Wildfire and drought amplify the susceptibility to future mass movement geohazards.



Emergency Management Considerations

- Due to its strong linkages with precipitation, mass movement geohazard potential could potentially increase during La Niña events, whose forecasting can be used to track upcoming hazard potential (see Provincial resource discussed in Section 9 Recommendations)[31].
- Emergency managers should prepare for an early and rapid response (e.g., evacuation) to imminent or active mass movement failures.
- Emergency preparedness planning may necessitate establishment of more widespread real-time monitoring networks and development of weather-related thresholds (e.g., rates and/or totals of rainfall) above which mass movements are likely.

31 The ENSO index is based on long-term average conditions, and it does not mean that an extreme precipitation event cannot occur during an El Niño phase.

Snuneymuxw First Nation Statement – Water is Life

Snuneymuxw tsun "I am Snuneymuxw"

***himuth*, Elder Jerry Brown, March 2025**

Thank you for this opportunity to talk about our sacred tumux, When I am asked about the land and the current hazards I think about my parents and grandparents and the way they were with the land and how they were with each other. Especially the teachings that they have left related to the land… As it was told to me, the greatest teaching that we have is love and respect. This teaching stems from their direct and sacred relationship with the land. Sadly, this teaching has been lost, we no longer love or respect the land, instead we cause harm at every turn, as you might say "climate hazards".

From our Elders, as it has been told to us, land is known and honored as the birthplace of our knowledge system, culture, and language. The Snuneymuxw landscape in all its beauty is the essence of the Snuneymuxw people.

They continually reminded us, the earth is alive, and its energies come together in the most amazing ways to provide supports and opportunities for the betterment of all.

It is well understood and practiced by our people: "We are all related." Based on our way of being, this idea of relationality extends beyond humans. Members of our community include all of us, seen and unseen that live and breathe on Mother Earth. The air we breathe, our shared breath, connects us in the most amazing way.

This is the way of our lands:

Qwam Qwum Qa—these sacred waters, the lifeblood of Snuneymuxw territory—run through our veins. This profound oneness can never be broken.

Teytuxtun has always been known as a place of significant spiritual power. It is truly one of the precious gifts from the Creator.

I have spent much time on the mountain, praying and using the pristine waters to cleanse my body and soul. There, I have found medicines, healing like the water itself, helping me grow and learn spiritually, while building a strong heart, mind, and soul. In the stillness of the mountain, I found time for quiet reflection and prayer. This ritual has forever taught respect and kindness.

It is through our timeless practices that we have come to know our lands and become one with their spirit. This is the way of the Elders, preparing us to live in a good way despite the challenges of the modern world.

Honouring Cedar. Cedar holds immense significance, we know cedar to be "the tree of life". The cedar tree, is the closest thing to a human being, she continually absorbs and reflects the emotions of those around her. But regardless of all the harm caused to her, she continually stands with her hands raised in the air showing gratitude.

Honouring the Salmon. We know the Salmon to be beings who lived like people—our true relatives who lived in the sea world. Each year, they returned in the form of fish to give their flesh to humans. In return, we treated them with the utmost respect and ensured that their home remained unharmed.

Riparian zones Jack Point, have a deep knitted relationship with snuneymuxw mustimuxw, they play a primary role to our cultural and ecological well-being. Jacks point riparian zone was altered in the 1980s where dredging and filling in areas including the land connecting Jack Point to Duke Point. This alteration has left snuneymuxw mustimuxw without essential resources such as our foods. I remember as a young boy we would harvest crabs, clams, oysters, and ducks. Salmon used to utilize the eelgrass as their shelter and spawning before moving upriver.

One of my fondest memories as a young man was traveling to Campbell River on my father's fishing boat. He sang for the entire journey. Looking back, I now understand how sacred the time on the water was to him. It inspired songs of gratitude, love, and healing.

Since the beginning of time, these lands have been critical to the survival of our people. Without a doubt, these lands have been our most honored relatives, esteemed teachers; with great kindness, they have provided all the essentials—teachings, food, shelter, medicine, and a gateway to a deeply spiritual way of life. This is our way of being.

The reality today is that climate and environmental changes are affecting us all.

Because of the harm we have caused, we now find ourselves at a point where we must rethink our approach. We now need to give more than we take. We must allow Earth the opportunity to heal and catch her breath.

We seek to restore deep respect for the land and all living things—a responsibility that has always been ours.

The Elders referred to this responsibility as the Sacred Trust. It is about developing a relationship with and responsibility for the environment, taking adaptive actions through a relational lens, and fostering connections with other communities and the more-than-human world. It means learning to share our gifts so that knowledge can take root in the minds and hearts of others.

Snuneymuxw has a deeply intertwined relationship with riparian zones.

As we have been told, Mother Earth will give until she has nothing left to give—until her last breath.

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