Chapter 5

Risks from Extreme Events

Ull nwi7s kuc melkwentes re7 sna7a’s tyegweten re7 Syegwyu'gwt ell me7yecwmen ell westen re timicw

We'll take care of our spirit powers’ secureness with strength and then look after Mother Earth with high respect.

We need to take care of all our relations which includes all living things on Mother Earth. She keeps all our relations balanced and alive.

If we fault with any responsibilities, we unbalance the cycles around us. It changes the natural system of all our relations—living cycles that keeps things in rotation. This includes the seasons' weather changes.

Secwépemc translation provided by Julianna Alexander and Bart Thomas

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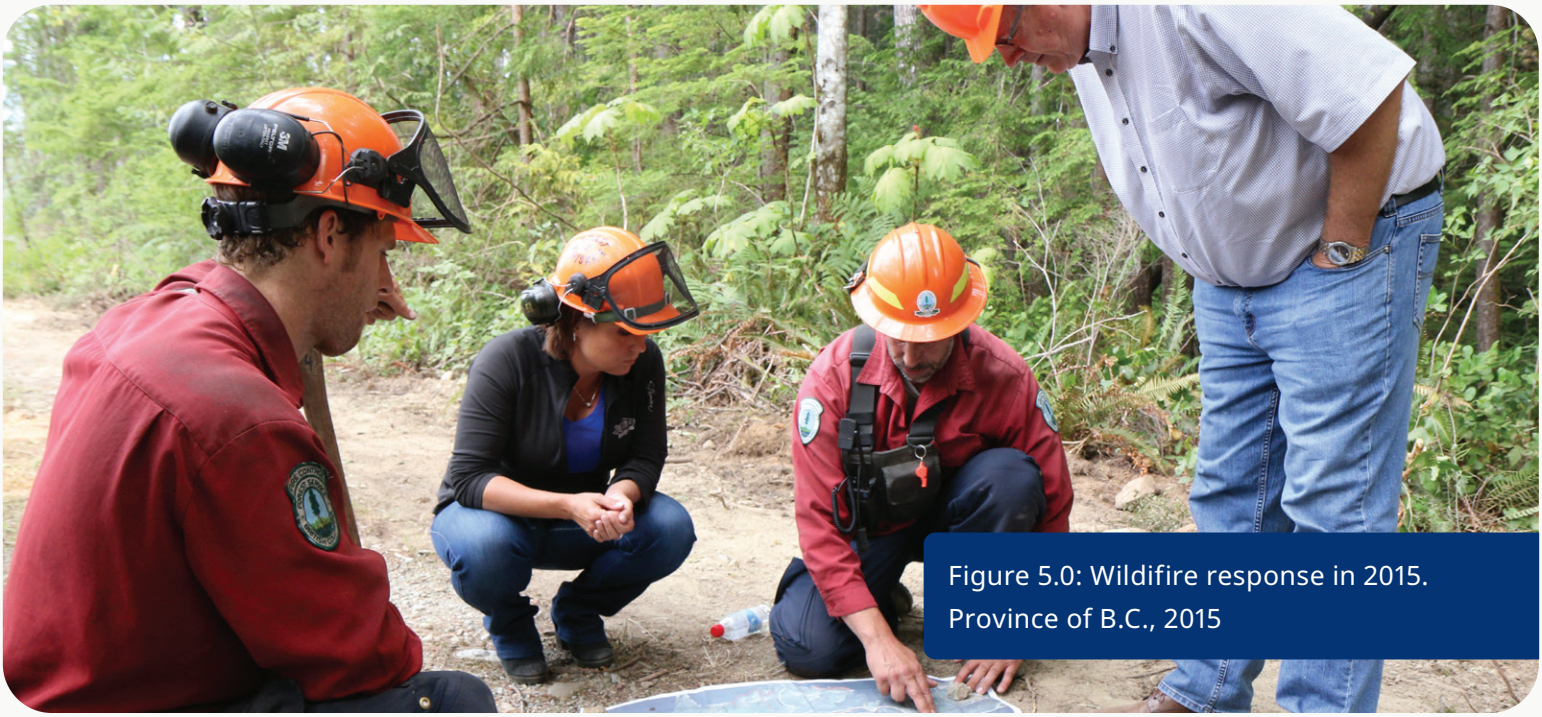


Figure 5.0: Wildifire response in 2015.
Province of B.C., 2015

5.0 Risks from extreme events

Scenarios

Scenarios provide details around potential risks and describe how the future might evolve due to a specific hazard(s). They are intended to facilitate understanding, discussion and learnings about hazard events. This includes what or who is exposed (assets, services, conditions and populations), vulnerabilities, strengths and impacts. In the context of disaster and climate risk, scenarios also provide a tool to manage uncertainty, especially in the case of complex and interdependent risks that are not well understood or cannot be quantified or even identified through observations of past events.

The Provincial Disaster and Climate Risk and Resilience Assessment (DCRRA) uses disaster and climate event scenarios to explore interdependencies and drivers of risks. This methodical approach examines how complex and diverse risks may impact the value areas and resilience of the systems to potential impacts. Doing this can reveal potential vulnerabilities, strengths, opportunities and challenges related to bigger picture risk planning and management that might be overlooked in more traditional methods of risk assessment.

Exploring several different scenarios allows actors to learn from diverse hazard event characteristics, climate change influences, and unique assets, services, conditions and populations exposed. This process highlights the differences across events, from a major event in a large

urban zone resulting in significant but recoverable consequences, to a relatively minor but more frequent event in a small rural community with catastrophic results.

When evaluating scenarios for different hazards, it is crucial to consider the variables and factors that significantly influence the outcomes.[1] It is best to use a range of circumstances that allow for exploring pivotal areas relevant to each hazard type, such as geographical location, intensity, duration, seasonality, infrastructure vulnerability, population density and potential cascading effects.

Scenarios support creative thinking about plausible futures, rather than attempting to predict specific outcomes. Presenting these scenarios in a storytelling format enables those who will use this document to visualize and communicate the possible outcomes, making them more relatable and understandable to a wider audience. This work is intended to be scrutinized and debated to advance the learning among knowledge holders, decision makers and partners.

About the extreme events selected for the Provincial DCRRA

For the Provincial DCRRA, a library of diverse critical events was developed for each priority hazard (see section 5.8). One extreme plausible event was selected for each hazard to develop the scenario, which is then used to evaluate the consequences and interdependencies for various value areas. The extreme plausible event scenarios are found in sections 5.1 to 5.7.

Events were selected using the following criteria:

- The event affects a large part of B.C.; this should include secondary hazards, and direct and indirect consequences, with the understanding that the implications of an event might extend beyond the geographical location in which it occurred
- The event creates significant consequences in most of the value areas:
    - **Natural environment:** Damage to key natural assets
    - **Built environment:** Damage to buildings, and damage and disruption to critical infrastructure
    - **Society, cultures and relationality:** Loss of social cohesion; loss of cultural values
    - **Health and wellbeing:** Loss of life, morbidity, injury, disease, hospitalization and psychological impacts

    - **Economy:** Direct economic loss; loss of productivity
    - **Governance:** Surpassing of provincial response capacity; disruption to government services
- The event's impact is beyond the capacity of the local and regional governments and would require provincial government resources
- Conditions suggest that the event is plausible (for example, it might occur tomorrow)
- The event has similarities to recent historical events in B.C., which makes it relatable to audiences and allows for the use of historical data and observations

The information provided for the extreme events is based on observations of past events in B.C., across the country or internationally. In addition, insights from quantitative models were used whenever possible. At an in-person workshop, technical advisors and ministry hosts of the Hazard Working Groups and Value Area Working Groups discussed and exchanged insights on the consequences of the identified events to each value area.

Climate change influence on likelihood of extreme events

The extreme event scenarios are defined by magnitude and likelihood, at present. To understand how the frequency of such a significant event is affected by climate change, the workshop participants evaluated the likelihood of the event in present conditions and for climate conditions at two Global Warming Levels (2.5°C and 4.0°C). The extreme event scenarios include information about the approach for assessing future likelihood.

Labels and definitions for five levels of likelihood, which are used in the library of critical events and the extreme event scenarios, are as follows:

- **Frequent:** Annual chance ≥ 50% (return period < 2 years)
- **High:** Annual chance ≥ 10% to < 50% (return period between 3 and 10 years)
- **Moderate:** Annual chance ≥ 2% to < 10% (return period between 11 and 50 years)
- **Low:** Annual chance ≥ 1% to < 2% (return period between 51 and 100 years)
- **Remote:** Annual chance < 1% (return period > 100 years)

Managing uncertainty

Significant levels of uncertainty are commonly found in disaster and climate risk assessments, stemming from various sources. The main sources of uncertainty are the inherent complexity of interactions within the natural systems on Earth and of the hazard events with assets, services, conditions and populations. An additional source of uncertainty comes from the limitations in data availability and quality, including incomplete historical records, scientific understanding and limitations in modelling tools.[2] Human knowledge gaps and varying risk perceptions add more layers of ambiguity. Consequently, these challenges in the information produced by risk assessments must be managed through decision-making processes to implement robust risk mitigation strategies and adaptation measures in the face of these dynamic realities.

For the extreme plausible scenarios developed in the Provincial DCRRA, confidence scores were used to communicate the uncertainty in likelihood levels and evaluation of the consequences. The confidence scores are defined based on the strength of the knowledge base and evidence used for the analysis as well as the sensitivity of the analysis results to changes in the assumptions. Sensitivity is considered based on whether small changes in some of the assumptions cause significant changes in the analysis results.

Confidence categories, based on the strength of evidence, are defined as follows:

- **Very high:** Multiple sources of information with general agreement between the studies and/or experts, or based on robust methodology and high-quality data, published relatively recently
- **High:** Several sources of information with general agreement between the studies and/or experts, or based on acceptable methodology and moderate-quality data, published relatively recently
- **Medium:** Few sources with a general understanding of the matter, or from structured "expert opinion" where very little or no specific information is available
- **Low:** No or very few sources of information and/or little agreement between the studies and/or experts; also considered is poor methodology or quality of data, published a long time ago (more than 15 years)

5.1 Severe spring riverine flood in the Fraser River watershed

Course of the event

A major flood starts in late May in the Fraser River watershed following a period of cooler temperatures through the early spring that sustained an above-average snowpack in the mountainous regions of the upper watershed.

Rapid melting of the ripe snowpack commences during seven days of unseasonably warm temperatures, causing this 200-year riverine flood event (roughly 15 percent chance of occurring in a 30-year period). This unseasonable warming is followed by a widespread 80-millimetre rainfall event across the central interior region, further exacerbating the flooding or conditions for flooding. Runoff from snowmelt (accelerated by rain on snow) and extensive rainfall exceed the capacity of small streams and rivers.

Given the fast-flowing conditions of the Fraser River, floodwaters overtop the banks of the rivers over a few days, breaching existing flood protection structures, such as dikes or natural barriers. Interior communities located in valley bottoms and floodplains (for example, Quesnel, Tŝilhqot'in, Kamloops) experience widespread flooding first, within the first two days of the event. McBride is the first community to experience flooding, followed by Lheidli T'enneh Fort George 2 Reserve, Quesnel, Tŝilhqot'in and Kamloops. Communities in the lower portion of the Fraser River watershed—in the Fraser Valley and Coast Salish territories—are flooded within the first few days.

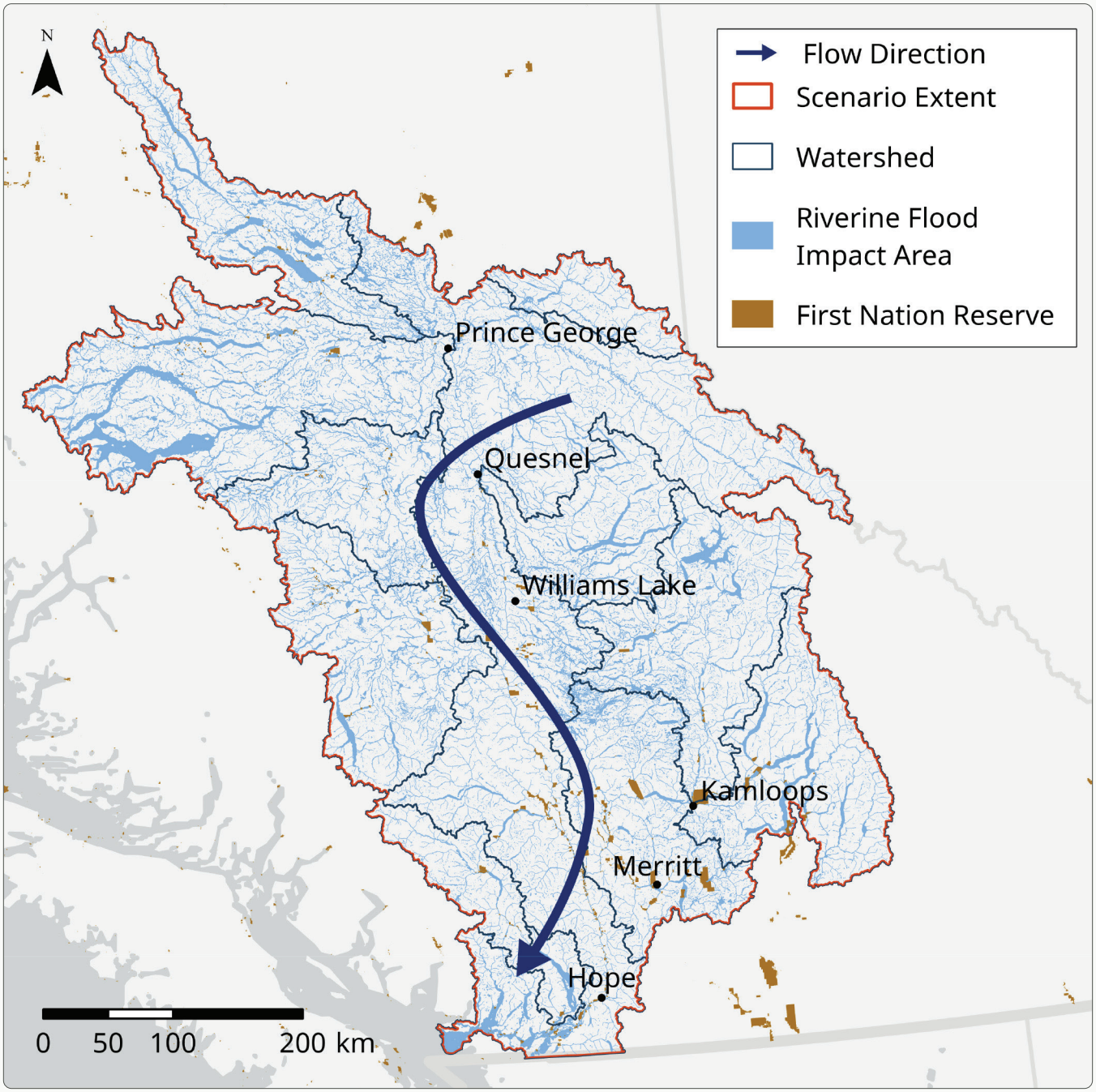
This scenario was selected by the hazard working group to illustrate an extreme, plausible riverine flood event for several reasons. The geographic extent of the Fraser River flood incorporates a wide range of communities and ecosystems, from larger population centres in the Lower Mainland to rural and First Nations communities along the mid and upper Fraser. In addition, this flood mechanism has led to significant riverine floods in B.C. history, including the 1894 and 1948 Fraser River floods and the 2018 Grand Forks flood. The impacts from this flood scenario could significantly exceed those from the 2021 Atmospheric River flooding. Also, this scenario has been close to unfolding in several recent freshet seasons. Higher-than-normal snowpack with delayed snowmelt, followed by periods of warm temperatures, have occurred in recent years. Significant flooding has been avoided because the third ingredient in this scenario, widespread rainfall in the upper Fraser watershed, did not materialize.

Scenario parameters

Location

- The flood event starts in the upper watershed of the Fraser River and impacts interior communities located in valley bottoms and floodplains first, followed by communities in the lower watershed
- The Fraser River watershed covers 240,000 km^2

Figure 5.1.1: Area impacted by the riverine flood (created by GeoBC).



Time

- Multiple, consecutive days in May

Duration

- Peak flood is reached within 24 hours from the start of the event and water levels remain high for multiple days before the floodwaters start to recede

Intensity

- Flood depths > 3 m in some areas of the floodplain
- High streamflow velocities

Seasonal and weather conditions

- Higher-than-average spring snowpack, followed by a period of rapid snowmelt due to increased air temperatures
- Coincident rainfall causes rain-on-snow event, in addition to direct runoff from rainfall

Comparable events

- 1894 Flood of Record on the Fraser River (> 500-year event)
- 1948 Fraser River flooding (200-year event)
- 1972 Fraser River flooding (50-year event)

Correlated or cascading events

- Landslides
- Steep creek flood events (debris flood or debris flow)
- Geomorphic events (bank erosion, scour, deposition and channel abandonment)

Likelihood of extreme event

- Annual likelihood: Remote (< 1%)
- Likelihood in the span of 10 years in current conditions: Moderate (2% to < 10%)
- Confidence in likelihood: High

Climate change influence

- Annual likelihood at 2.5°C global warming level: Moderate (2% to < 10%)
- Annual likelihood at 4°C global warming level: Moderate (2% to < 10%)
- Confidence in likelihood with climate change influence: Medium

Due to the differences across B.C.'s complex watersheds, a single likelihood estimate for a specific riverine flood event is not representative of the province-wide hazard. With the large area of the province, the likelihood of experiencing a 200-year event somewhere in the province in any given year is higher. Spring floods, as described in this

document, will continue to impact the region and are significantly influenced by climate change. Existing research based on hydrological models of the Fraser River basin suggests that, in the worst case (increasing precipitation with slower snowpack loss under a moderate emissions scenario), a 200-year freshet peak flow event could become a 50-year event by the mid-21st century and a 30-year event by the end of the century. This is equivalent to a change in annual likelihood from Remote to at least Moderate for Global Warming Levels (GWL) of 2.5°C and 4.0°C.

Assessment of consequences

Natural environment

The unseasonably warm temperatures in May accelerate the growth of grass, shrubs, wetland plants and other vegetation in the central interior region and stimulate the growth in agroecosystems within the Fraser River basin floodplains. During the flood, agricultural lands— particularly those used for crops and livestock—are more significantly impacted than undisturbed natural ecosystems, with inundation leading to crop loss, livestock stress and soil degradation. Conversely, undisturbed forests and wetlands, with their natural resilience, are able to mitigate the impact of extreme precipitation and high temperatures, although localized effects may still occur. For instance, these disruptions reduce food availability and habitat for wildlife in the area, such as mule deer, which can result in cascading impacts across food chains.

Elevated and fast-moving floodwaters damage and destroy altered or modified riparian vegetation that lack root structure, relative to undisturbed riparian areas adjacent to the Fraser River and major tributaries. This increases vulnerability to future flood and erosion hazards since these ecosystems help to regulate the amount of precipitation reaching the ground and stabilize soils.

Floodwaters have the ability to reach and inundate wetlands and other lower-lying habitats as well. However, large, healthy wetlands can absorb significant amounts of floodwater and are able to withstand moderate impacts of flooding. Short-term changes in habitat, habitat loss and diminished food availability displace wildlife from their territories and disrupt predator-prey dynamics. Severe flooding can significantly impact waterfowl and other waterbirds by temporarily displacing them from feeding and nesting areas, impacting annual life cycle processes such as migration, breeding and molting.[3] Changes to wetland, riparian and aquatic species composition

only become apparent once floodwaters recede, and likely not until years later. The central interior already harbours invasive plant and freshwater fish species, with counts that will rise due to the spread of invasive species by floodwaters.

Soil erosion from high floodwaters cutting into banks and from slopes impacted by recent large wildfires and mobilized by floodwaters increases turbidity and sedimentation of aquatic ecosystems. This embeds and smothers substrate, impacting the habitat of fish and aquatic invertebrates. Soil and sediment are not the only materials mobilized; pollutants and contaminants found in waterways and transported downstream include things like pharmaceuticals, fecal coliform bacteria, pesticides, hydrocarbons and metals. The mobilization of pollutants, sediments and other contaminants by floodwaters impairs water quality in rivers, streams and lakes, which affects the provision of water for drinking and non-drinking purposes. Rivers and streams are critical habitats for freshwater fishes (for example, bull trout, mountain and lake whitefish) and anadromous fishes (for example, Chinook salmon, sockeye salmon, Pacific lamprey) that occur in this region. The biophysical and chemical changes to waterways and their substrates caused by the severe flood reduce suitable habitat for aquatic species, affecting species' growth and reproduction and hampering fisheries production.

Built environment

Floodwater inundates communities located in low-lying areas adjacent to the Fraser River and major tributaries, leading to property damage and disruption of critical infrastructure.

Buildings

In low-lying communities adjacent to rivers, the inundation of floodplains, overtopping of flood control structures, and elevated groundwater levels lead to flooding of buildings and streets, requiring evacuation from residential and commercial areas. Thousands of homes are damaged or destroyed, up to 10,000 residents will be displaced, and insured damages could be in the order of hundreds of millions of dollars. Key government services located in the floodplain, such as hospitals and community centres, also require evacuation if flood defences are insufficient or water pumps do not have the capacity to remove the water. It takes many weeks to reestablish key services associated with these buildings. Floods also impact boats and boating infrastructure, particularly in First Nations fishing communities.

Additionally, floodwaters often carry mud, debris and pollutants that infiltrate buildings, causing extensive damage to interiors and creating health hazards from mould and contaminants.

Transportation

Major highways that connect communities and facilitate the movement of people and goods across the region are subject to short-term disruptions due to flooding. They are also susceptible to key connections being severed due to undermining and erosion of the road surface or damage to key bridges and culverts. Similarly, many smaller roads that service remote communities or resource extraction areas become impassible, stranding people and goods from key services and supply chains.

The mainline railways in the region are susceptible to loss of track or key bridges and culverts, leading to multi-day interruptions of service across the region, in turn leading to impacts to regional and local economies. The ability of rail operators to bring these main lines back into service depends on site access for people and equipment, so any disruptions of the road network further exacerbate rail delays.

Water infrastructure and waste infrastructure

Potable water and wastewater treatment facilities located within the floodplain sustain damage. And there is the potential of mixing with floodwaters, leading to contamination of the potable water supply in low-lying areas, the spread of disease, and a scarcity of safe water. When wastewater treatment facilities located in low-lying areas are impacted, more people must be evacuated because of the impacts to wastewater and drinking water services.

Flooding disrupts landfill sites and other waste disposal areas, releasing contaminants into the environment. It also damages roads and other infrastructure necessary for waste collection and management, disrupting service. The cleanup following a flood generates substantial amounts of debris and waste, including damaged furnishings, building materials and hazardous substances, which overwhelms existing waste management systems.

Energy

If hydroelectric generation reservoirs have insufficient capacity to accommodate additional flows, spillways must be opened, leading to impacts on downstream communities and fish habitat. Power generation and distribution infrastructure (such as substations and power lines) are damaged, leading to widespread and prolonged power outages.

Energy pipeline operators with infrastructure located along rivers are on alert to monitor the progress of flows in relation to key pipeline crossings. Pipeline flow is shut off as a precaution to prevent potential exposure or rupture, leading to short-term disruptions to the flow of petroleum or natural gas to communities and ports.

Information and communication

Key communication infrastructure facilities in low-lying areas are inundated and inaccessible for staff, leading to local or regional disruptions in communications. Backup systems limit disruptions in larger centres, but more isolated communities experience longer disruptions.

Society, cultures and relationality

Flooding can result in week(s)- to month(s)-long evacuations, prolonged displacements for those living in the most flood-prone areas, and potential fatalities either during or after the flood event. Connections to land, food, culture, medicine and ceremony are disrupted, and these effects will be felt through successive seasons.

During this time, communication networks and access to community-based emergency response resources are disrupted. Community members may struggle to share and receive information from social service providers, emergency first responders, family members and friends. Some people are socially and geographically isolated from their support systems and family members. This can lead to worry, concern, stress and anxiety, which can, in turn, have negative impacts on community resilience, cooperation, the giving and receiving of informal care, and resource sharing—from food and medical supplies to equipment, skills and knowledge—needed to respond to the flood and its aftermath.

The evacuations reduce social cohesion and connectedness. Long-term displacement and the relocation of community members due to damaged housing and community infrastructure significantly impact the resilience of social support networks, disrupt family routines, and weaken neighbourhood relationships. Given the nature of riverine flooding, some communities have previously experienced flood events; this current event increases the resource burdens faced by those affected. It further erodes community wellbeing; adds additional stressors to previously impacted infrastructure; and exacerbates existing social, health and economic inequities, particularly for systematically marginalized populations that are disproportionately impacted by flood events.

Some Indigenous communities are able to facilitate community evacuations—by

effectively deploying local infrastructure and coordinating with first responders—while simultaneously caring for Elders and children. However, they are also in urgent need of food, fuel and medicine, and must seek additional supplies and resources from nearby regional administration centres and local governments.

Closure of essential roads limits access to Indigenous ceremonial sites and sacred spaces, low-lying sites experience ground erosion, and shell middens are damaged. Disrupted access to important rivers interrupts Indigenous traditional practices and food accessibility, as the river is often a source of food as well as a site for ceremony, cultural gathering and intergenerational teaching. In Indigenous worldviews, the river is a living relative that will need healing.

Evacuation, displacement and relocation disrupt the delivery of education and traditional teaching, which exacerbates social disconnection. Separating youth and children from their support networks will have disproportionate impacts for at-risk youth. Relocation, whether temporary or longer term, can also overexpose community members to experiences of interpersonal and structural racism and programming that is culturally insensitive and not trauma informed.

Affected businesses shut down either temporarily or permanently, and job loss contributes to social and economic issues. Unemployment and stress contribute to a rise in gender-based violence—particularly toward women, children and members of the 2SLGBTQIA+ community—at the same time that access to supports, services and safe spaces may be impeded.

Ranches and farms near rivers and in low-lying areas are unable to evacuate their livestock, which impacts human–animal social connectedness and livelihoods and can impact a way of life that has been maintained for multiple generations. Ripple effects include the risk to food security—a significant social threat in communities—and the increase of biohazard risk in flooded areas and downstream.

Health and wellbeing

People suffer from injuries due to landslides, debris flows or being swept away by fast-moving waters. Search and rescue teams respond to incidents involving people trapped in vehicles or on rooftops. People's health will be affected by infectious diseases due to exposure to contaminated water. In some rural communities relying on well water, water contamination results in outbreaks of illnesses such as gastrointestinal diseases. People with chronic conditions like diabetes or heart disease may find it difficult to manage their health during a

flood due to a lack of access to medication, clean water or healthcare facilities.

Food and water insecurity result from water shortages, flood-induced damage to water and food supply chains and treatment systems, and decreased availability of local and traditional foods due to flood-induced damage and disruptions to food systems and infrastructure.

During flood recovery, the use of portable generators in enclosed spaces can lead to carbon monoxide poisoning. This is a potential hazard during prolonged power outages after flood events, where residents may attempt to reoccupy their homes prior to the restoration of services and attempt to use a portable generator in or near the building.[4]

After the waters recede, damp conditions lead to mould growth inside buildings, which can cause respiratory problems, especially in those with pre-existing conditions like asthma. In the longer term, more health impacts emerge, such as allergic and hypersensitivity reactions due to living in homes with moisture or mould buildup.

Beyond physical health, this event results in significant psychosocial impacts among those directly affected, such as insomnia, anxiety, emotional distress, depression, post-traumatic stress disorder (PTSD), substance abuse and suicidal ideation. Additionally, vicarious trauma and other emotional health effects, such as ecological grief and anxiety, can arise from witnessing the devastation caused by a flood and its effects on others.

Psychosocial health and cultural identity are greatly impacted by damage to property, experiences of displacement, and loss of livelihoods. For example, flood-induced displacement and migration lead to increased social isolation and a decreased sense of social support. Familial and financial stressors also increase due to crowded and unstable housing situations resulting from displacement. In the longer term, flood-induced loss of land and ecosystems negatively affects spiritual wellbeing and cultural identity among Indigenous communities as a result of reduced opportunities for sharing Indigenous Knowledge and participating in traditional activities.

The flood event impacts the health workforce, services and operations. The emergency response effort is hindered due to the reduced availability of the healthcare workforce who have themselves been affected (for example, by being evacuated). Medical services, including mental health services, are disrupted or delayed due to damage to essential infrastructure and restrictions on travel, leading to poorer health outcomes. Flooding can cut off access to pharmacies, leaving people unable to get essential medications, and some people

face difficulty refilling prescriptions due to supply chain disruptions. Medical equipment and supplies are depleted in response to a significant increase in demand and supply chain delays.

The event inequitably affects the physical and psychosocial health of various groups, with disproportionate risks for women, rural and remote communities, and individuals whose livelihoods and traditions depend on the land and the environment including farmers, fishers and Indigenous communities.

Economy

The flood event has widespread consequences for the economy, affecting jobs, businesses, infrastructure and communities as a result of significant damage to infrastructure and disruption to transportation and supply chains. Roads and highways are washed out, impacting the movement of goods and people. Rail line damage further complicates transport, with implications for many industries. Smaller ports, such as the Fraser River port, have less capacity or fewer resources and recover more slowly than larger ports like the Port of Vancouver. The high cost of the upgrades essential to mitigate flood risks often exceeds what local governments can afford, increasing vulnerability to aging and undersized infrastructure, which are damaged by floodwaters.

Securing funding for flood recovery is another challenge. It is more difficult for those living in remote and rural areas, where internet and telecommunications infrastructure is less reliable and takes more time to repair. This creates obstacles for rebuilding and developing preventive measures to reduce future flood risks.

This event has insured losses of around $500–$800 million—primarily from business claims, as flood insurance does not cover many residential properties in high-risk flood areas. The total economic cost to the province is $10-$15 billion. This figure includes the direct costs of repairing infrastructure, homes and businesses, as well as broader economic impacts, such as lost income, productivity shortfalls due to business closure, and damage to critical industries like agriculture.

Flooding causes immediate job loss by stopping operations in the affected industries of agriculture, manufacturing and services due to infrastructure damage and safety concerns; this has disproportionate effects for some groups (for example, in the service industry where the workforce is primarily women or in manufacturing where the workforce is mostly men). Over the coming weeks or months, prolonged

disruptions in supply chains, damaged facilities and lost productivity in the tourism, transportation and construction sectors lead to layoffs or business closures, especially for small businesses.

Employment opportunities diminish as businesses shut down or reduce their staff levels because of flood damage. During the rebuilding process, trades like construction and carpentry—typically male-dominated jobs—see increased demand, intensifying gender income inequity. Some small businesses—often the backbone of local economies—cannot afford the cost of rebuilding, leading to permanent closures and job loss. This has a ripple effect on low-income households already struggling to recover without the safety net of insurance or savings.

Tourism, a key industry in B.C., may suffer as visitors cancel trips to areas facing flood-related issues. With evacuations underway and disruption to critical transportation infrastructure, locals and out-of-province tourists, planning to enjoy outdoor recreation and cultural and commercial sites throughout the area, see these plans cancelled. Such a reduction in tourism affects businesses and communities that rely on visitor income. Hotel availability for tourism during the rebuilding phase may be limited because that accommodation may be used to house those who lost their homes, along with trades and temporary workers seeking accommodation in impacted communities.

Insurance challenges

Consumers with inadequate insurance coverage due to costly premiums or inaccessibility in high-risk areas are vulnerable to potentially significant financial losses. While overland flood insurance provides added security to homeowners in flood-prone areas, this relatively new product's affordability, availability and long-term consistency are a concern. Though the federal government has sought to address this risk through the creation of a National Flood Insurance Program that would ensure that all Canadians have access to affordable flood coverage, it is not yet in effect.

Governance

The Flood Watch advisory is issued by B.C.'s River Forecast Centre (RFC) and quickly elevates to Flood Warning status, communicating that river levels have exceeded bankfull or will exceed bankfull imminently, causing flooding. The warning is communicated to the public through EmergencyInfoBC Alert and other alert portals used by local authorities in the affected regions. This warning provides crucial time for people to act quickly, prepare their necessities, and begin to evacuate where possible.

The Province declares a State of Provincial Emergency (SOPE), enacting emergency powers for response activities, as necessary. The Provincial Regional Emergency Operations Centres (PREOC) in Southwest, Central and Northeast regions are activated. First Nations and local governments in the affected area assess the situation. Where applicable, they activate emergency response systems and plans, including local emergency operations centres (EOCs) and communications systems like Voyent Alert! for communities that have these systems set up. Initial response is focused on the safe evacuation of people and animals. With the flood reaching peak levels within 24 hours, communications, resourcing and priority evacuations are initially delayed for the safety of the responders because of the flooding impact on facilities and unsafe mobility.

The Province responds to requests for additional support from First Nations and local governments, getting involved in emergency response coordination. This includes supporting evacuations, deploying staff from outside the region, identifying response needs, and prioritizing and coordinating response activities.

Smaller and rural communities face significant challenges as a result of limited emergency response staff and little to no staff redundancy. Where those staff cannot reach their workplaces due to the flooding, these communities find themselves with even less capacity to respond. Local volunteers, also affected by the flooding, struggle to support the response efforts because they are dealing with their emergencies or are not in a position to obtain resources, coordinate efforts, or make decisions on where and how limited resources should be allocated.

As floodwaters rise and begin to inundate several communities in the Fraser River watershed, including cities, smaller communities and First Nations communities, local residents and organizations spring into action alongside provincial and local authorities' formal emergency response systems. Volunteers and community-based organizations that provide emergency response and recovery services find their resources stretched thin, and their reduced capacity leaves many services unfulfilled. Communities, neighbourhoods and individuals try to fill the gaps, developing ad hoc support systems.

Tens of thousands of people are forced to evacuate their homes. Evacuees need to be supported in neighbouring communities, which soon reach their limits regarding accommodations and available resources. The distribution of aid and support is challenged, straining relationships between organizations, residents and government. Communications to, from and within First Nations communities with multiple

overlapping jurisdictions around evacuation options and processes is challenging. This leads to departure delays and increased risks for those left behind. Displaced members of First Nations communities face the additional burden of losing critical community support systems.

The Province, local authorities and First Nations experience direct and immediate financial costs associated with the response efforts of rescue, relocation, temporary food and shelter services, and more. In some jurisdictions, these costs extend beyond the emergency response budgets and financial reserves available.

Early recovery phase decision-making might be constrained, as qualified professionals fear liability concerns and avoid advising on recovery and rebuilding, especially in regions lacking risk-based land-use plans or limited or outdated hazard and risk assessment information. Early recovery phase decisions, made under time pressure, may lack sufficient consultation with First Nations and community members. Trust between First Nations communities, local authorities and the Province is challenged both in the short and medium term. This necessitates revisiting and updating of emergency management policies and processes in a way that reflects the changes required to facilitate relationship-building and dialogue, which are the foundation for the restoration of trust between all levels of government.

5.2 Winter storm and high-tide flood on southwest coast

The course of the event

During an evening in late December, an intense winter storm makes landfall along the southern coast of B.C. and Vancouver Island. The storm is characterized by extremely strong winds, heavy rainfall, large waves and storm surge. The storm surge arrives during a period of seasonal extreme high tides, resulting in higher-than-normal water levels along the coastline. The combination of storm surge and very high tides results in a greater than 200-year return period event (0.5 percent annual exceedance probability) that causes significant impacts to buildings and infrastructure in communities in low-lying areas on eastern Vancouver Island and the Lower Mainland.

The storm's intensity causes floodwaters to breach or overtop existing coastal flood protection structures such as dikes, sea walls and natural barriers. This contributes to localized flooding in low-lying areas of the Lower Mainland surrounding the Fraser River, including Vancouver, Richmond, Delta, Surrey and Squamish to the north of Metro Vancouver. Intense wave action, storm surge and heavy rainfall trigger erosion and landslides along steep coastal cliffs, resulting in further damage to communities. Swells and waves carry debris that causes further damage to coastal infrastructure.

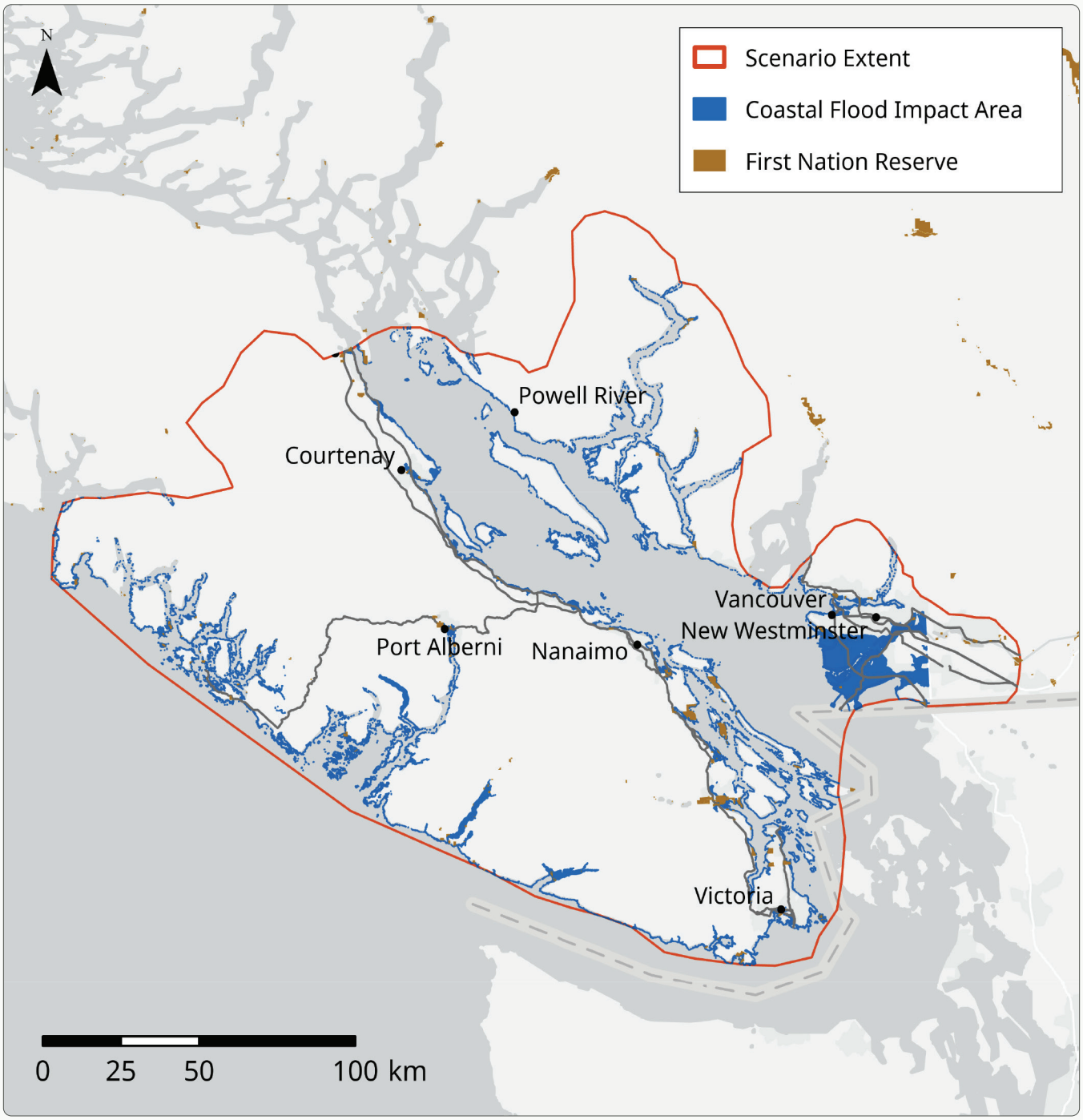
The hazard working group selected this scenario as it reflects the recent experiences with coastal flooding from winter storm events in the Lower Mainland, which will become more severe with relative sea level rise. Although coastal flooding will also have increasingly severe impacts to small and remote communities along less-populated areas of coastal B.C., the exposure and vulnerability to flooding on the southwest coast is significant.

Scenario parameters

Location

- Eastern Vancouver Island (including Cowichan Bay, Qualicum Beach and Campbell River) and the Lower Mainland of B.C. (including Richmond, Delta, Squamish, Surrey and Vancouver's Fraser River area)
- A 30,000 km^2 area of the southern coast of B.C.

Figure 5.2.1: Regional coastal flood risk map. The scenario presents an area with higher impact along eastern Vancouver Island and the Lower Mainland of B.C. (created by GeoBC).



Time

- Nighttime in December

Duration

- 24-hour storm event

Intensity

- Flood depths 1–3 m above highest tide level
- High wind speeds and high-velocity sea currents
- Nearshore waves; significant wave heights that make landfall and impact the shoreline

Seasonal and weather conditions

- 60–100 mm of rainfall during the event
- Cold temperatures (below 5°C) during the event
- Saturated ground conditions due to previous smaller events before the storm
- Very strong winds, with gusts in exposed coastal areas reaching hurricane-force levels

Comparable events

- 2007 Great Coastal Gale
- 2012 winter storm and seasonal high tide

Correlated or cascading events

- Dike breaches/damage to existing flood protection structures or seawalls
- Coastal erosion
- Landslides on steep coastal slopes

Likelihood of extreme event

- Annual likelihood: Remote (< 1%)
- Likelihood in the span of 10 years in current conditions: Moderate (2% to < 10%)
- Confidence in likelihood: High

Climate change influence

- Annual likelihood at 2.5°C global warming level: High (10% to 20%)
- Annual likelihood at 4°C global warming level: Frequent (< 50%)
- Confidence in likelihood with climate change influence: Medium

A coastal flooding event combining the effects of storm surge, high tide and sea level rise can be related to extreme sea levels discussed in Chapter 2, section 2.3. While that analysis focused on a specific area located near the mouth of the Fraser River, the results are also relevant for the region-wide scenario described above. A 1-in-200-year extreme sea level event (“Remote” likelihood) is expected to occur once every five to ten years (“High” likelihood) under all three emissions scenarios by the 2050s, or for a Global Warming Level (GWL) of around 2.5°C. By the end of the century (a GWL of around 4.0°C), this event is projected to occur every one to two years under a medium or high emissions scenario (“Frequent”).

Assessment of consequences

Natural environment

Two of B.C.'s most biodiverse ecoprovinces[i] are affected, threatening 12 out of 25 of the province's Key Biodiversity Areas[ii] of global and national significance that provide refuge to threatened species, species with highly localized distributions, and habitat for wintering. Fast-moving coastal floodwaters—along with the debris they entrain and deposit—destroy or degrade intertidal and marine coastal habitats through erosion, scouring and altered sediment patterns. These impacts affect coastal forests, estuaries, shallow rocky reefs, tidal saltmarshes, seagrass meadows and coastal sand habitats. Strong winds magnify damage through windthrow, impacting vulnerable habitats, such as seabird nesting habitats. Together, these disturbances threaten essential ecosystem services, such as shoreline stabilization and water filtration, and diverse flora and fauna. The impairment of these habitats and localized losses increases future vulnerability to erosion, storm damage and loss of biodiversity.

Suitable habitat for many species is lost or degraded, including spawning habitat, fish nurseries and food sources for larger fishes and birds. The Pacific sand lance is reliant on intertidal habitat and is an important food source for juvenile Chinook salmon, mature salmon, tufted puffins, common murres and rhinoceros auklets. Losses in suitable habitat reverberate through food chains, including disruptions to fisheries, with cascading cultural, social and economic implications. For example, declines in juvenile Chinook salmon populations (due to degraded nurseries or food availability) can lead to diminished populations over time. This can have cascading effects on Indigenous food security and disruptions to Indigenous cultural practices, weakening relational ties within communities and between people and the land. Furthermore, declines in salmon can also impact commercial fisheries, not only in terms of the number of fishing vessels that are employed to catch salmon, but also in terms of support facilities and auxiliary industries, such as docks, vessel repair shops, processing plants and more, that rely on the species for economic gain.[5]

Severe coastal flooding disrupts natural regulatory processes—primarily sediment transport, nutrient cycling and water flow patterns. Changes in the distribution of sediment and nutrients hamper habitat

i. Coast and Mountains Ecoprovince and the Georgian Depression Ecoprovince.

ii. Key Biodiversity Areas are sites of global importance to the planet's overall health and the persistence of biodiversity (https://www.keybiodiversityareas.org/).

suitability for marine and coastal species. Human communities reliant on coastal aquifers see shortfalls in the quality of water supplies, as coastal inundation leads to the salinization of soils for agriculture and groundwater, leading to gradual long-term salinization of shallow aquifers, which can have implications for flora and fauna.[6] Coastal floodwaters mobilize pollutants and contaminants from across the coastline, which then flow with currents. Densely populated sections of the region in the south with urban, industrial and agricultural land uses, along with localized development corridors in the north, are major sources; runoff from these areas creates pollution hotspots in nearshore areas.

Biophysical and chemical alterations to seagrass meadows and tidal marshes threaten the release of stored carbon back into the atmosphere, contributing to climate change. These habitats are important "blue" carbon sinks, sequestering carbon dioxide from the atmosphere and storing it in vegetation and sediments. They are also important habitats for keystone fish species, particularly for juveniles, including Pacific Salmon and Pacific Herring[7,8] and migratory bird species.

Built environment

A major coastal storm and flood have both shorter- and longer-term impacts on the built environment and the services that it supports.

Buildings

In communities in low-lying areas, including parts of Greater Vancouver and Victoria as well as smaller towns on Vancouver Island and in the Lower Mainland, the elevated water levels breach flood defence structures. This leads to widespread inundation of residential, commercial and industrial areas, damaging or destroying these buildings and causing the evacuation of residents and visitors, as well as outages for businesses that provide key services and support the local economy. Tens of thousands of buildings are impacted by the floods and may be rendered inoperable for months to years.

King tide events are usually paired with large storms that result in the destruction of buildings, such as house roofs being damaged or destroyed.

Transportation

Inundation and damage lead to severe interruptions to crucial transportation infrastructure that connects ports, airports, intermodal facilities and other key supply chain nodes to the rest of B.C. and Canada. Ferry services between Vancouver Island and the mainland are interrupted.

The dike system at Vancouver International Airport is breached, leading to operational disruptions (due to runway closures) and potential damage to infrastructure that may require extensive repairs and that impacts the airport's ability to function. Critical infrastructure to coastal First Nations communities, including docks, marinas and shoreline highways, are at risk. Major highways, bridges and access roads sustain damage that renders them inaccessible for a period of days to weeks until access is restored, with an associated length of interruption to the regional and national supply chain. Significant flooding could also severely impact marine traffic (shipping and ferries) in terms of damage to ports and docks, which would lead to lingering disruptions in the loading/unloading of goods and passengers, navigation hazards from debris that may cause damage to vessels, and operational disruptions due to high water levels and strong currents.

Water infrastructure and waste infrastructure

Salt water intrusion into surface water bodies and aquifers and contamination of the potable water supply by waste products located within the flood zone decrease the amount of clean potable water.

Facilities like waste treatment plants, particularly those in low-lying areas, experience equipment damage and disruption of waste processing and sewage treatment services. Sewage systems overflow and mix with floodwaters, leading to widespread environmental contamination. Floodwaters infiltrating landfill sites cause leachate to escape into the environment and contaminate surrounding land and water bodies.

Energy

Energy infrastructure, such as substations, transformers and power lines, are physically damaged by floodwaters, disrupting the distribution and transmission of electricity and severing it completely in isolated communities with singular transmission lines. Due to high winds, fallen trees physically damage power lines and lead to regional power outages. Extended power outages disrupt fuels production, including key jet fuel imports that are barged in from Washington State. Coastal erosion threatens the stability of these structures over the longer term.

Information and communication

Communications facilities are inundated and linear infrastructure destroyed, leading to the disruption of key communications systems during response. Isolated communities with singular linear connections suffer from loss of communication due to high-wind damage to above-ground transmission infrastructure.

Society, cultures and relationality

Coastal flooding impacts the large urban centres located on the south coast and the more remote settler and Indigenous communities differently, but the impacts to community infrastructure, ways of life and the natural world occur everywhere. Significant disruptions necessitate the evacuation of populations for days or weeks. This has implications for social cohesion and connectedness and limits access to local resources, services and ways of social, cultural and economic life, which has an effect on both displaced populations and host communities.

The Lower Mainland is one of the province's "bread baskets" and sources of potable water, with a high density of residents. Given that evacuations require smaller inland and less-resourced communities to host large numbers of evacuees, the temporary increase in population density, diversity, and service and care needs could overwhelm host communities, exhaust existing social and built infrastructure, and reduce access to food. The Lower Mainland is also a major transportation corridor, and disruptions could affect livelihoods, businesses, family connectedness and the flow of goods and services, intensifying competition for basic resources and amplifying political, social and cultural tensions.

Disruption to communication channels and access to community and emergency responses isolates community members from their support networks. It disrupts access to enabling services, such as translation, and can lead to secondary stressors, such as lack of access to culturally sensitive, trauma-informed and life-stage-appropriate care. Overall, these challenges increase stress and anxiety, which negatively impacts individual and community resilience and can erode goodwill in relationships that may take a long time to heal.

During the event, businesses shut down and locations for community convening and resource distribution do not reopen or are repurposed as evacuation centres. Long-term displacement and relocation of community members post-event due to damaged housing and built infrastructure has significant impacts on the structure and functioning of informal and formal social support networks, such as family structures and neighbourhood relationships, schools, religious and cultural communities, and access to nature.

Evacuation, displacement and relocation have an impact on housing security. Housing stock is degraded during the event and leads to the short- or long-term displacement of local residents (for example, those living in basement suites or on the waterfront). Housing shortages are also intensified when evacuees are placed, short term, in housing that would have otherwise been available to the long-

term rental market. School-aged children experience impacts on education and social connections, which may have long-term development and social implications for them, particularly in relation to the development of peer cohorts located in unaffected locations. Family and social supports and food security programs are also interrupted, increasing the risk for already marginalized youth. The flood event has disproportionate impacts on rural, remote, island and Indigenous communities, which were already experiencing rural-urban education gaps with many youths and children needing to leave their home communities to attend school.

For First Nations located in coastal and island communities, coastal flooding also impacts homes and intergenerational family cohesion; dislodges cultural artifacts, such as totem poles, and sacred sites, such as burial grounds. It also impacts cultural restoration and traditional food security projects, such as aquacultural revitalization efforts.

Health and wellbeing

Effects on physical health are broad, spanning injuries and fatalities, due to many types of hazard impacts:

- Flood-induced landslides or debris flows
- Infectious disease (due to exposure to contaminated water, overcrowded shelters and temporary living conditions resulting from displacement)
- Food and water insecurity due to water shortages
- Flood-induced damage to water and food supply chains and treatment systems
- Decreased availability of local and traditional foods as a result of flood-induced damage and disruptions to food systems and infrastructure

In the longer term, additional health challenges emerge. These include allergic and hypersensitivity reactions, due to living in homes with moisture or mould buildup from flooding.

Beyond physical health, this event leads to significant psychosocial health issues among those directly exposed, such as insomnia, anxiety, emotional distress, depression, post-traumatic stress disorder, substance use and abuse, and suicide and suicidal ideation. Further, experiences of vicarious trauma and other emotional health impacts (for example, ecological grief and anxiety) stem from witnessing the impact of a flood event on others. Psychosocial health and cultural identity are significantly impacted by damage to property, experiences of displacement, and loss of livelihoods. For

example, flood-induced displacement and migration leads to increased social isolation. Familial and financial stressors also grow due to crowded and unstable housing situations. In the longer term, flood-induced loss of land and ecosystems negatively affects spiritual wellbeing and cultural identity among Indigenous Peoples due to reduced opportunities for sharing Indigenous Knowledge and participating in traditional activities.

The flood event affects health services and operations. The emergency response effort is hindered due to the reduced availability of the healthcare workforce, who have been impacted (for example, if they have been evacuated). Disrupted or delayed medical services, as a result of damage to essential infrastructure and restrictions on travel, lead to poorer health outcomes. Due to a large increase in demand and delays to supply chains, medical equipment and supplies are depleted.

This coastal flood event inequitably affects the physical and psychosocial health of various groups, with disproportionate risks for Indigenous Peoples, materially disadvantaged and low-income populations, and those who are underhoused. Underhoused and materially disadvantaged populations face greater vulnerability to coastal flooding due to their lack of necessary resources to prepare for and respond to coastal flooding events adequately. Many low-income communities are located in areas prone to coastal flooding because of housing affordability constraints. Indigenous communities bear a disproportionate share of coastal flood impacts, as seawater inundation leads to the loss of land and ecosystems, disrupting the transmission of Indigenous Knowledge and engagement in traditional practices.

Economy

Ports and harbours, marine-based assets such as boats, docks and barges, as well as land-based infrastructure along the coasts of the Salish Sea are impacted by waves, inundation, fast currents and debris, resulting in direct economic loss.

The impact on Vancouver's busy port, a key hub for international trade, is severe. Flooding halts or disrupts shipping operations, damages port infrastructure, and results in substantial losses for the trade and logistics industries. Smaller ports, such as the Fraser River Port, have less capacity or resources and recover less quickly than larger ports like the Port of Vancouver.

Similarly, the economic impact on Vancouver International Airport (YVR) a key aviation hub for the movement of goods and people, is significant. Airport

operations are blocked (for a period of days or weeks) as a result of flooded runways, inaccessible terminals and overwhelmed drainage systems. When essential airport operations resume, the cost of processing previously blocked and delayed movement of goods and services is high.

Agriculture in the fertile Fraser River Delta suffers as floodwaters inundate farmland and cause saltwater intrusion, degrading soil quality. This leads to reduced crop production and long-term economic harm for farmers. Fisheries, both wild and aquaculture, are at risk as disrupted ecosystems damage a vital industry in the Salish Sea. For people who live in B.C. and farmers who are affected by the flood, disaster financial assistance is available for uninsurable losses.

The tourism sector, another key economic driver, faces a downturn as flooding damages beaches, marinas and recreational infrastructure, reducing the number of visitors and causing losses for hotels, resorts and related businesses. Ocean tours and cruise ship tourism may suffer as visitors cancel trips due to infrastructure and site damage. Reduction in tourism affects businesses and communities that rely on visitors for income.

Flooding leads to local job loss in tourism, fisheries, agriculture and transport services, which are key sectors in many coastal and remote coastal communities. This job loss is temporary; however, these labour pools begin to search for work in other geographic areas or seek out reskilling/retraining opportunities.

Increased insurance claims from property damage drive up premiums, and for those without adequate coverage, recovery is costly and dependent on access to financial assistance. Real estate values in coastal areas may be impacted due to heightened flood risks, affecting investments and the property market. The displacement of residents and business interruptions exacerbate the economic strain, as people lose homes and livelihoods, and small businesses face closure without sufficient support.

Environmental damage from flood-related pollution, such as chemical runoff and sewage spills, requires costly cleanup efforts. First Nations communities along the coast, reliant on natural resources and cultural practices tied to the land and sea, are particularly affected, necessitating focused recovery initiatives.

Emergency response efforts, including search and rescue, temporary housing and healthcare services, further strain public resources.

Governance

Environment and Climate Change Canada's Coastal Flooding Prediction and Alerting Program issues an early warning and an alert about this event.[9] This provides valuable time for local authorities and the Province to begin emergency response preparations, such as evacuation planning and establishing flood protective barriers. However, Vancouver Island and the Lower Mainland—the most populated centres of British Columbia and the hub of economic and government activity—are significantly affected by the flooding. Many local governments and First Nations initially take the lead role in local flood response and declare a state of local emergency (SOLE). For some communities, their capacity is quickly exceeded, necessitating more direct support from the provincial and federal governments.

Provincial regional emergency operations centres (PREOC) are activated in the Vancouver Island Coastal and Southwest regions. A supporting provincial emergency coordination centre (PECC) is opened in Victoria to help coordinate resources and communications, and to liaise with other provinces and the federal government for support.

The Provincial response is initially constrained, as flooding impacts Victoria and surrounding areas where many government employees are based. Efforts to move government staff between the Island and the Lower Mainland to support response and recovery are hampered by airport flooding in Richmond and damage to seaplane and ferry docks.

Outside of the urban centres, in many rural and small towns, evacuation communications are hampered by access challenges and poor coordination with smaller remote communities that have vulnerable connectivity. In areas with multiple overlapping jurisdictions, conflicting evacuation communications cause confusion and delays. Communication breakdowns lead to uncoordinated approaches with First Nations, limiting the delivery of culturally appropriate and timely support. Disparities become evident as well-resourced waterfront property owners leave the affected area, while others are moved to community evacuation centres.

Communities and neighbourhoods develop personalized and adaptive strategies, such as informal networks for shelter and supply distribution. In some areas, limited local government capacity results in increased community and private sector participation in flood response. Conversely, strong local government capacity in other areas fosters effective synergies between community actions and government response.

Extreme pressure mounts for a quick recovery and financial relief for property and business owners. Moreover, having lost territory to erosion during the event, First Nations communities seek answers and support for expanding reserves and territory inland or in other areas. For communities that had pre-event recovery and "build back wiser" plans or approved long-term coastal adaptation strategies, residents return from evacuations quicker and with higher confidence in the financial supports than communities that were less prepared or resourced. In the sensitive and stressed context of recovery, the discrepancy in preparedness and capacity within communities builds pressure on provincial agencies to quickly understand and supplement these gaps in recovery, while simultaneously navigating their own operational challenges.

5.3 Summer heatwave in Pacific Southwest B.C.

Course of the event

After a cooler-than-average spring, temperatures in the Southwest British Columbia region climb during the last week of June. A high-pressure system stalls over a large portion of the Pacific Northwest, including almost all of British Columbia. From June 16 to 23, temperatures ramp up day over day. By June 24, based on forecasts, a heat warning is issued by Environment and Climate Change Canada. On June 25, forecasts call for substantive day-over-day increases until June 29, peaking at 34°C during the daytime and dropping to only 19°C overnight. Given the expected continued increase in temperatures, the BC HEAT Committee issues an alert in line with the most extreme criteria outlined in the BC Heat Alert Response System. Following these spikes in daytime and nighttime temperatures, a progressive return to seasonal temperature norms occurs over a seven-day period, starting on June 30.

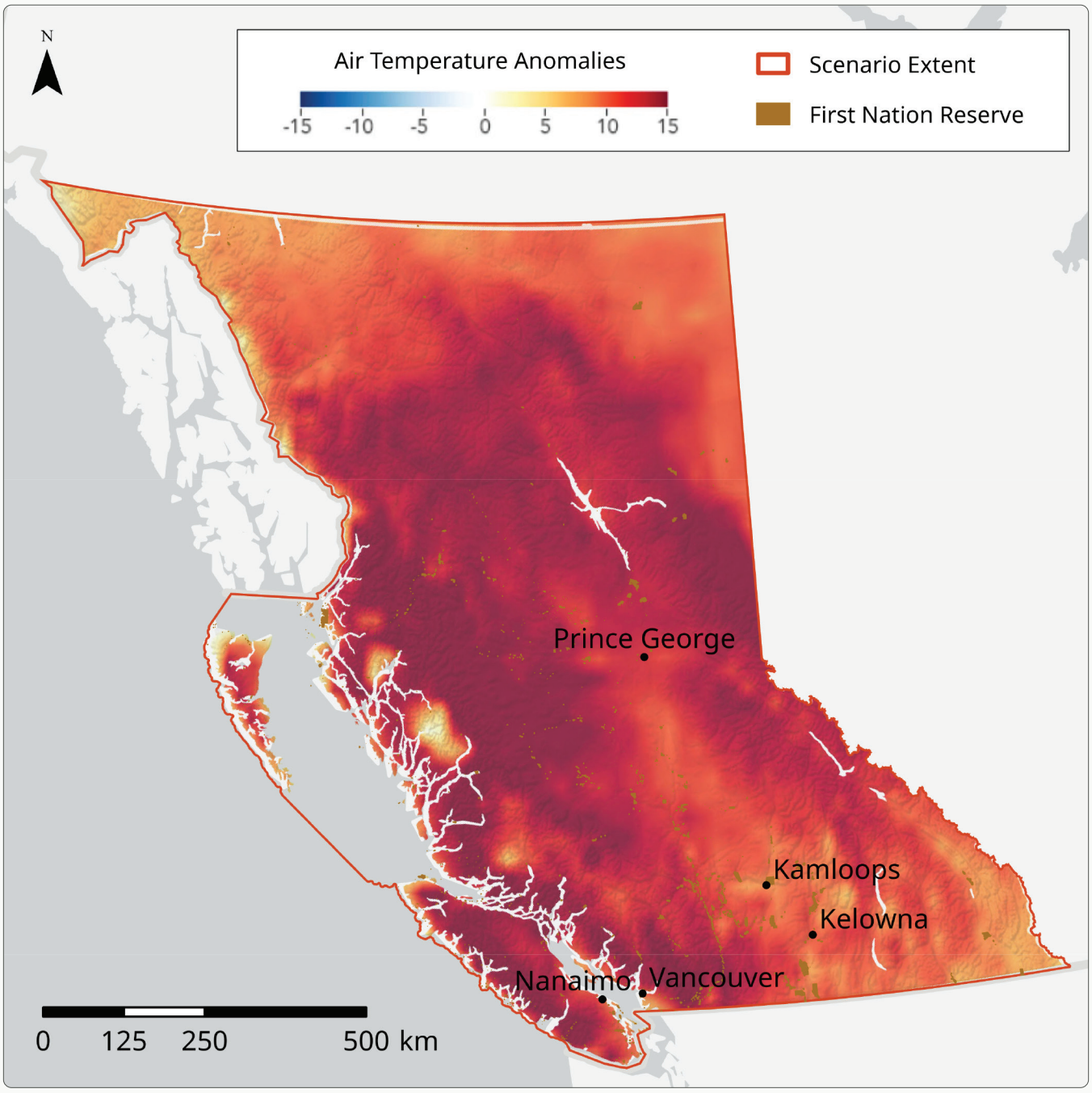
This scenario was selected to illustrate an impactful yet plausible extreme heat event when people are not yet acclimatized to the heat, resulting in reduced coping capacities. The scenario used the 2021 Pacific Northwest heatwave as a foundation, with key changes of slightly earlier timing and slightly lower temperatures, compared to the 2021 event. The potential province-wide impacts include a large number of preventable deaths and health impacts in addition to wildfires, flooding (from snowmelt), decreased air quality, thunderstorms, water scarcity and power outages, which will stretch or exceed existing response and recovery capacities. Finally, while this type of heatwave is currently of Low or Remote likelihood, it is projected to become at least a Moderate-likelihood event by mid-century.

Scenario parameters

Location

The high-pressure system impacts the whole of British Columbia, although the most intense and enduring temperatures affect the southwestern part of the province. The specifics provided below are for Metro Vancouver and Fraser Valley.

Figure 5.3.1: Areas of B.C. impacted by the extreme heatwave of late June 2021. The map, created by GeoBC from a larger version produced by the Goddard Earth Observing System (GEOS) model, shows air temperature anomalies (2 m height). Darker areas are where air temperatures climbed more than 15°C higher than the 2014–2020 average for the same day https://earthobservatory.nasa.gov/images/148506/exceptional-heat-hits-pacific-northwest.



Time

- Last week of June

Duration

- One week of temperatures that increase beyond an extreme heat warning, followed by five days and four nights of an extreme heat emergency (temperatures significantly above seasonal average), and then seven days of slow cooling to seasonal norms

Intensity

- High daytime temperatures, with insufficient overnight recovery
- Daytime temperatures around 34°C
- Nighttime temperatures ≥ 19°C

Seasonal and weather conditions

- Cool spring temperatures followed by a sudden shift to the first heatwave of the year
- High-pressure system for five days
- Low surface-wind speeds

Comparable event

- The 2021 Pacific Northwest heatwave was used as a foundation for this scenario. In 2021, and in this extreme event, the heatwave is the first local exposure to hot temperatures, increasing the vulnerabilities of the population, as people are not seasonally acclimatized. In other words, they have reduced coping capacities.

Correlated or cascading events

- Poor air quality due to increased ground-level ozone generation (smog), stagnation of the air, and increased likelihood of wildfires and wildfire smoke
- Thunderstorms due to increased water evaporation near large bodies of water

Likelihood of extreme event

With few analogues of this type of event in the past, there is currently little consensus on its likelihood, other than to say that it is rare, with a return period ranging from 235 to 1000 years (see Chapter 2).

- Annual likelihood: Remote (< 1%)
- Likelihood in the span of 10 years in current conditions: Moderate (2% to < 10%)
- Confidence in likelihood: Low

Climate change influence

- Annual likelihood of a three-day extreme heat event: Remote (< 1%)
- Annual likelihood at 2.5°C global warming level: Moderate (2% to 10%)
- Annual likelihood at 4°C global warming level: High (10% to 50%)
- Confidence in likelihood with climate change influence: Medium

Given the rarity of this extreme five-day event, for the purposes of this project, a comparable likelihood analysis of a three-day mean temperature of 26.5°C is used to determine the influence of climate change on likelihood (see Chapter 2.4 for details). While this type of heatwave would be described as a Low- or Remote-likelihood event in the historical climate, it is projected to become at least a Moderate-likelihood event, and in selected areas, High- or Frequent-likelihood at a mid-century global warming of 2.5°C. By 4.0°C of global warming (approximately the 2080s; see also Appendix B, Figure 11), these frequency trends spread to a much larger area of B.C. The entire northeast, interior plateau and most areas at low elevation in the southern half of the province are projected to experience such heatwaves at least once every 10 years (High likelihood).

The likelihood of this heat scenario, located in southern B.C., was Remote in the historical climate. It is projected to become at least Moderate in large parts of the region by mid-century, and High over the entire region by the end of the century.

Assessment of consequences

Natural environment

The hottest days of the heatwave coincide with significant low tides, leading to extensive mortality of intertidal species, including barnacles, clams, oysters, crabs and sea stars. During low tide, temperatures in some intertidal pools exceed 50°C and significantly surpass the tolerance limits of several plants and animals found in that habitat. Mortality of species unable to move to find refuge, such as barnacles and mussels, is especially high. All told, billions of marine invertebrates in the Salish Sea die from the extreme heat. The display of dead species and lingering smell cause a toll on concerned citizens and residents, but the extent of ecological damage is not yet apparent. While the low tide exacerbated these extreme mortality rates, significant losses would have still occurred due to the extreme heat alone, as it elevated temperatures in the intertidal zone well beyond normal survival thresholds, even when some tidal cover was present.

Nearshore waters get significantly warmer, creating an unsuitable habitat for forage fish species, like the Pacific sand lance, as even half a degree change in water temperature can have a significant negative impact on very sensitive marine flora and fauna. Heat stress and disruptions in food availability affect the growth and survival of many marine species, including seabirds.

Terrestrial species also suffer from heat stress. In particular, ectotherms (such as

amphibians and reptiles) are anticipated to be exposed to extreme thermal events beyond their historical levels.[10] Their vulnerability is increased by drought conditions in recent years and the fact that coastal forests are not adapted to temperatures this high. Many saplings and seedlings die, leaves on hardwood trees scorch, and some coniferous species lose their needles. Urban forests and street trees are also affected, causing mortality and physiological stress. Tree losses in densely populated areas afflicted by urban heat islands diminish the provision of ecosystem services, including local climate regulation and air quality.

Glaciers and snowpacks melt rapidly, raising stream flows in many basins. In basins lacking substantial glacier coverage, water managers expect lower-than-normal flows throughout the summer. This melting also significantly affects the quality and quantity of freshwater assets, reducing their availability for human consumption, agriculture and ecosystems.

The heatwave exacerbates smog pollution and dries vegetation in urban and rural settings, impairing the cooling effect of vegetative cover.

Extreme heat puts food production at risk. Growers estimate losses of field crops and fruit crops of up to 30 percent, with livestock also affected by heat stress. In addition to reduced yields, heat stress significantly impacts the quality of the crops that do survive. Prolonged temperatures above 28°C cause many plants to stop growing, compromising their health and making them more vulnerable to pests and diseases. For instance, heat-stressed plants may experience reduced nutrient uptake, leading to lower nutritional value and poorer market quality. Livestock are also affected by heat stress, leading to decreased productivity and increased mortality in severe cases.[11,12] These combined effects magnify the impacts of food insecurity and economic losses for farmers. Heat stress also impacts small-scale community production, such as in rural and remote First Nations communities. Heat stress reduces available water for greenhouses and gardens, impacting local food security.

Built environment

The extreme heat event leads to different impacts and interdependencies on components of the built environment.

Overall, structures operating outside of design conditions experience increased wear and tear and increased failure.

Buildings

Older buildings that are not constructed to shed heat amplify the heat intensity. In addition, buildings without air conditioning systems experience indoor temperatures ranging between 30°C and 40°C, which is unsafe for occupants, leading to the potential for fatalities and/or the requirement for inhabitants to evacuate to community cooling centres.

Key public, commercial and industrial facilities that lose the ability to sufficiently regulate temperature lead to unsafe working conditions and disruption of services required to support society and the economy.

Transportation

Some elements of the transportation system experience minor impacts that require maintenance repairs, such as rail tracks or road surfaces. Vehicles that overheat lead to mechanical failure. Vehicle occupants who become stranded in elevated heat conditions without the ability to cool themselves experience health impacts.

Water infrastructure and waste infrastructure

Higher temperatures lead to an increased use of water to support cooling, causing further strain on the water supply. Water scarcity and water quality impact First Nations, particularly remote communities with drinking water advisories, as well as rural and remote communities more broadly.

The efficiency of waste collection is compromised because the heat affects workers' health and safety, leading to delays in service or the need to reschedule work to cooler parts of the day. Furthermore, higher temperatures increase the rate at which waste decomposes, leading to more intense odours and a higher risk of disease from contaminants or pathogens.

Energy

For buildings and facilities that have been built to modern standards, the increased reliance on mechanical cooling leads to increased strain on the electrical grid. At the same time, the extreme heat causes key transmission lines to sag, making it necessary to reduce loads and potentially take critical structures offline. This increased demand and reduced supply requires utilities to purchase electrical capacity from neighbouring jurisdictions. However, neighbouring jurisdictions are also affected by the heat and have their own capacity challenged; there may not be sufficient supply available for purchase, leading to rolling power outages. For remote communities and First Nations that are serviced by a single radial line, the reduction or loss of transmission forces them to rely on generator power, if available.

Information and communication

Buildings critical to the operation of Information and Communication Technology (ICT) infrastructure become overheated and unsafe for habitation, impacting services. Specific elements that require efficient cooling to operate reliably, such as data centres, are affected. Extreme heat overtaxes cooling systems, leading to higher energy consumption and system failures when cooling is inadequate.

Society, cultures and relationality

People living in poverty are at increased risk of illness and death during extreme heat events. This correlation underscores the importance of addressing the links between social inequities, disproportionate risk, and interventions that build social wellbeing and resilience. For example, populations disproportionately impacted by the 2021 heatwave in B.C. were isolated older adults, people with disabilities, and those with pre-existing mental and physical health conditions. Other factors that increased risk included previous experiences of extreme heat events, a lack of access to adequate resources, knowledge, social relationships and interventions to mitigate against the cumulative impacts of extreme heat exposure.

The heat event interrupts community services, shelter and home support, and community care services, impacting social connections. This has specific consequences for structurally marginalized populations. Prolonged exposure to extreme heat can lead to physical, psychosocial and emotional distress, increased interpersonal conflict and competition, and can cumulatively cause social fracturing. Some people with financial means and/or social connections may be able to temporarily leave communities such as urban cores or low-lying valleys for cooler regions, which may impact the social cohesion of the host communities and leave others (without similar means) to shelter in place.

When a whole region is impacted by a heatwave, some may be under- or un-served by publicly offered interventions, such as those with weaker ties to social connections and cultural practices or those who are harder to reach and connect with. For example, for many people, cooling centres can be beneficial physically, socially and culturally and can help build community resilience and support physiological wellbeing. However, some people experience barriers to accessing or remaining safely in these centres. Where cooling facilities, for example, are not wheelchair accessible, do not have private facilities to provide

for individuals with complex care needs, are not on public transportation routes, or cannot accommodate people with differing abilities, these spaces are not accessible to these populations. People with specific cultural or religious needs may find it difficult or even unsafe to engage in certain practices, such as prayer or ceremony. People who are fleeing abuse may not want to enter a place where they could encounter their abuser(s). If staff and volunteers have not received training in culturally appropriate and trauma-informed service provision, experiences in the facility could be harmful.

Inequities in communities may be exacerbated for others, such as pregnant people, young children and older adults, as well as people with mental health conditions and individuals with disabilities. People who are economically vulnerable, such as those who work outdoors, who are subjected to unsafe and unfair working conditions, and who face a range of consequences if they do not work—from loss of income to deportation—are also overexposed to risks. People with little access to social, legal or healthcare services may also face increased risks and vulnerabilities.

The protective factors of a sense of belonging to a place and a sense of wellbeing in a place can be eroded, both during acute heat events and over the long term (for example, when rivers dry up). Extreme heat affects the integrity of crops and harvesting practices, the survival of traditional foods, integrity of waterways, fishing practices and ceremony. Time spent on the land is reduced and opportunities for Elder-to-child interactions are limited due to the disproportionate impacts of extreme heat on these age groups. Long-term heat-induced changes to land and ecosystems negatively affect spiritual wellbeing and cultural identity among Indigenous Peoples due to reduced opportunities for sharing Indigenous Knowledge; participating in traditional activities; sustainably stewarding medical plants, wild animals and traditional food sources; and monitoring the ecological integrity of the land and waters. Intergenerational, placebased teaching is also impacted, changing children's relationships with the natural world.

Health and wellbeing

Health risks are particularly concerning due to the early onset of this heatwave, allowing little to no time for seasonal acclimatization. Many people will experience heat-related impacts on their physical health. Some will experience milder conditions, such as heat edema or heat rash, while others will face severe illnesses, such as dehydration, heat exhaustion, heat stroke and hyperthermia. Heat-related mortality is expected to rise, potentially leading to hundreds of deaths during this extreme heat event. Beyond heat-related illnesses, this event may cause heat-related interactions with medications or exacerbate other existing chronic conditions. For example, extreme heat can degrade air quality, worsening respiratory and cardiovascular conditions such as coronary heart disease. Warmer water temperatures may increase cases of vibriosis, an illness caused by certain species of Vibrio bacteria, often contracted by eating raw or undercooked shellfish or from exposure to contaminated waters (such as during recreational activities).

The extreme heat will also affect psychosocial health and exacerbate existing mental health conditions. This may include decreased mood, sleep difficulties, anxiety and depression. Mental health-related mortality may increase, with potential rises in deaths due to substance-related mental disorders, organic mental disorders and suicides. Concerns about dangerously high indoor temperatures may lead communities to cancel events and close schools, increasing social isolation and diminishing community support.

This extreme heat event inequitably affects the physical and psychosocial health of various groups. For example, it may disproportionately impact young children and older adults, individuals with pre-existing health conditions, those who are materially disadvantaged and underhoused, and Indigenous Peoples. Urban areas, which have high exposure to extreme heat, are also home to populations that are less able to adapt due to factors such as age, income and newcomer status (for example, these areas have a higher proportion of low-income older adults). People who are unsheltered or have inadequate housing face heightened risks to health and wellbeing during heat events, especially if they face prolonged sun or wildfire smoke exposure and if they do not have access to basic amenities, such as water, food and sanitation. Further, people who are underhoused face amplified health risks due to poor housing conditions, such as living in older buildings without air conditioning, and may have limited mobility or opportunity to access cooling centres. People who are underhoused also face

systemic barriers to accessing cooling centres, such as stigma and policies that prohibit bringing their belongings with them. Extreme heat impacts First Nations health and wellbeing by reducing access to traditional foods, berries and medicines. In extreme heat, game and fish cannot be processed due to risk of spoiling. Communities must change their practices, access resources such as ice and coolers if possible, or identify other ways to safely preserve food.

The extreme heat will greatly impact health services and operations. Hundreds of people with severe cases of heat-related illness will seek treatment, placing increasing demands on the healthcare system. Consequently, there will be a rise in 911 calls, corresponding ambulance dispatches, and increased hospital and emergency department visits. Healthcare providers may experience challenges from patient surges, including mental health concerns such as burnout, increased workload, and other health risks from working in facilities with elevated temperatures. Increased temperature in health facilities may strain cooling systems, leading to equipment overheating and failure, and ultimately disrupting or delaying medical services (for example, cancelled surgeries).

The anticipation of summer and additional extreme heat events, following the spring extreme heat events, can cause psychological impacts, such as anxiety and stress. People may also endure unexpected anxiety and stress from continuous intense heatwaves, impacting a sense of safety, comfort, health and social isolation.

Economy

The extreme heat event significantly impacts the economy, with repercussions that ripple through various sectors and communities. One of the immediate consequences is a decrease in labour availability, as workers face health risks due to intense temperatures. This reduction in workforce productivity places added economic pressure on businesses and services.

Women and women-owned businesses face greater economic implications because they typically shoulder a larger share of caregiving responsibilities for children and the elderly. They also typically have lower earnings than men, adding to their financial and time burdens during heat emergencies.

Small businesses struggle with the capacity to apply for financial assistance. Unlike larger corporations, which typically have dedicated resources for such tasks, small businesses find the process of applying for aid daunting and complex.

During heatwaves, coping costs surge. The use of air conditioning increases, along with a significant rise in the consumption of water and other resources aimed at cooling. For people already facing challenges with housing and food affordability, the need for cooling is an issue of equity. The financial burden of purchasing and running air conditioning units is particularly challenging during periods of high daytime and nighttime temperatures.

Productivity suffers a tangible decline: at 32°C, productivity drops by 25 percent, and at 38°C, it plummets by 70 percent. Workers are compelled to move slower, take more frequent breaks, end their workdays earlier and require more time off. This leads to diminishing quality of work, and increased mistakes and workplace accidents. Many workers cannot afford to take time away from work, despite its health impacts.

The aftermath of extreme heat extends beyond the immediate crisis. Increased morbidity rates can persist for months, affecting the availability and productivity of the workforce. This creates a sustained demand for caregivers and medical attention, further straining economic resources.

Many sectors are adversely impacted by extreme heat. Crop production declines due to the heat stress on plants, disrupting the food supply chain and inflating food prices. Agricultural operations lost close to $25 million in revenue from production declines.[13] Transportation networks and power transmission are vulnerable to disruption due to the heat, which can deform infrastructure materials and overload systems, creating supply chain disruption, preventing workers from getting to workplaces, and requiring time and money to repair. Healthcare facilities encounter increased operational costs and face a rising demand for their services, stretching resources thin and potentially affecting the quality of care. The built environment—buildings and all types of infrastructure—experiences greater wear and tear, reducing structural and performance lifespans and therefore requires replacement sooner.

Total economic costs of a similar event, the 2021 heatwave, were estimated to be between $247 and $426 million.[14]

While communities are aware of their needs to mitigate risk and manage response and recovery, existing gaps in maintaining relationships with various levels of government, which work to provide funding and coordinate activities, hinder their ability to fully understand the nuances of individual communities' needs.

Governance

B.C. communities, learning from the recent experience of the 2021 heatwave, have made strides in preparedness with support of the increased funding of heat response planning from the provincial government. Many communities have bolstered their capacity and understanding of local vulnerabilities to extreme heat, such as differences in land-based surface temperatures, building conditions and socio-demographic factors. Communities that received funding for planning have identified actionable measures to mitigate future heat risks, potentially reducing their vulnerability compared to those without such resources. However, significant gaps persist in funding for implementing both short-term and long-term mitigation strategies, leaving many community plans unrealized.

As this extreme heat event unfolds, the provincial Heat Alert and Response System (HARS) is activated to alert the public through EmergencyInfoBC and other alerting platforms. Local governments and First Nations swiftly activate their Emergency Operations Centres (EOCs), leveraging recent response planning efforts. Cooling centres are activated, distributing cooling equipment and conducting heat check-ins to ensure that those vulnerable to extreme heat, including those without stable housing, are protected during extreme heat events.

Leading up to the event, coordination between agencies improved community readiness and response capabilities, fostering stronger inter-organizational relationships. As a result, communications during the event provide consistent messaging, translated across languages and communication channels, resulting in widespread understanding and compliance across diverse communities. The private sector also contributes by disseminating information and providing essential resources like water and cooling spaces.

Efforts to support neighbourhood heat champions yield mixed results: some neighbourhoods implement effective check-in campaigns and mutual aid networks, while others rely more heavily on local government responses.

Despite improved coordination efforts, gaps persist in support for heat-vulnerable individuals and groups, as no single agency assumes responsibility for their comprehensive care. The surge in calls for British Columbia Emergency Health Services overwhelms health services, causing significant delays as fire and rescue personnel await patient transportation. Healthcare

providers, however, manage the influx effectively due to earlier preparations.

For frontline public sector workers, such as police and firefighters, workplace safety and productivity are at risk. Government operations and processes for these workforces adjust to implement heat safety protocols, adapt working hours, and—where necessary— temporarily close operations. This has a ripple effect, reducing the responsivity of these workers to the immediate safety and security of people who reside in B.C., particularly in cases where these workforces are responsible for health and wellness checks.

In urban areas with reduced natural vegetation and tree cover urban heat island effects are exacerbated. This intensifies temperatures in already hot environments, particularly impacting exposed and vulnerable individuals.

Since the last event, home cooling incentives have had high uptake by well-resourced households, though for many, energy poverty continues to pose a significant barrier to cooling. As a result, low-income households and renters are particularly at risk during this event, as they have more limited financial means and/or rights to install cooling systems in their homes. Province-wide funding to install free portable air conditioning in low-income households that need them most reduces the impacts for those who have been able to access this program. Rental and strata legislation and regulation continue to create barriers. Building regulation ensures that new buildings have active and passive cooling measures. However, retrofitting existing buildings continues to be a gap, and lower-income individuals tend to live in older buildings that have not been upgraded.

Following the event, renewed scrutiny highlights inequities in thermal safety between homeowners and renters, and among occupants of older versus newer buildings.

5.4 Multi-year drought across B.C.

The course of the event

B.C. enters fall, after a summer of average temperatures and precipitation. Instead of receiving the typical fall rain and snow, there is an extreme lack of precipitation. This is the beginning of a five-year period of extremely low warm-season precipitation and well-above-average year-round air temperatures across the province. Snowfall and snowpack across the province consistently remain well below the historical average over this period. In addition, average air temperatures for the five-year period consistently remain above the historical 80th percentile for each region.

This scenario was selected by the hazard working group to illustrate an extreme, plausible drought event for several reasons. The recent trends of provincial drought conditions in B.C. indicate that the intensity and frequency of drought is becoming more common. Climate data and climate change models already indicate a warming trend and potential for winters that consistently present lower snowpack levels as precipitation falls as rain more frequently.

Dendrochronological records suggest that a five-year snow drought has occurred in parts of the province in the last 400 years. Glacial studies indicate that B.C.'s glaciers are melting rapidly and may be mostly lost by the end of this century, creating significant loss of surface water and groundwater recharge during the warmer months. All of these stressors, combined with a growing population and demand for water consumption, suggest that the extreme drought conditions, as proposed, are plausible.

Scenario parameters

Location

- The entire province of British Columbia: 944,735 km^2

Duration

- Five years

Intensity

- Most regions in B.C. experience drought levels 3 and above throughout the five-year period
- Low warm-season precipitation (consistently below the 20th percentile of the historical average), below-average wet-season precipitation, and year-round high-average temperatures (consistently above the 80th percentile of the historical average) for each region of the province
- Snowfall and snowpack across the province consistently remain below the historical average over this entire period because increasing amounts of wet-season precipitation falls as rain instead of snow

Seasonal and weather conditions

- Year-round, starting in the fall
- Precipitation consistently remains below average, with warm-season rainfall below the 20th percentile of the historical record for each region of the province
- Average air temperatures consistently remain above the 80th percentile of the historical record for each region of the province

Comparable event

- No record of this type of event in the past 100 years
- Dendrochronological records suggest that a five-year snow drought has occurred in parts of the province in the last 400 years
- The drought that started in 2023 and continued in 2024 represents a comparable event that persisted for more than one year

Correlated or cascading events

- Increased wildfire activity because of dry conditions
- Increased floods, debris flows and landslides following extended periods of drought and wildfire

Likelihood of extreme event

- This is a slow-onset event, defined as a five-year drought. The likelihood of such an event occurring in B.C. is presently estimated as Remote.
- Confidence in likelihood: High

Climate change influence

- Confidence in likelihood with climate change influence: Medium

Drought is likely the most complex of the climatic hazards considered in this report (see Chapter 2, section 2.5). The multi-year period of below-normal precipitation coupled with above-normal temperature specified in this scenario would lead to a multi-year hydrological

drought. This would likely occur even in snow-dominated basins, due to the depletion of mountain snowpacks, which operate as a buffer against short-term deficits in precipitation and/or extensive snowmelt (due to high temperatures). The resulting consistently below-average snowpack ("snow drought") is what would allow a drought to continue, even in the presence of natural variability in precipitation and temperature over such an extended period.

By definition, annual snow drought occurs in years with snowpack amounts below the 33rd percentile of historical levels. Under 2.5°C and 4°C of global warming, the frequency of annual snow drought increases by a factor of 2.5 and 3, respectively, with associated changes in likelihood:

Annual snow drought in southern basins

- Annual likelihood: High (33%)
- Annual likelihood at 2.5°C global warming level: Frequent (~80%)
- Annual likelihood at 4°C global warming level: Frequent (≳90%)

Consecutive snow drought (three years, southern B.C.)

- Annual likelihood: Moderate (2% to 10%)
- Annual likelihood at 2.5°C global warming level: Moderate (2% to 10%)
- Annual likelihood at 4°C global warming level: Moderate to High (9% to 20%)

The likelihood of three consecutive snow drought years estimated above assumes that snow drought probability is independent across years: this is a simplification necessitated by a lack of projections data for multi-year snow drought. Despite the common occurrence of annual snow drought in a single southern B.C. basin today (33 percent, by definition), the independence assumption gives a likelihood of consecutive (three-year) snow drought of $(0.33)^3$ = 4 percent or Moderate (1–10 percent). Applying the factors derived for each GWL gives a Frequent future likelihood of annual snow drought in individual basins (≥50 percent), and likelihoods of multi-year snow droughts under different climate projections that are somewhat larger than at present (~9 percent for a GWL of 2.5°C and ~11 percent for a GWL of 4.0°C; lower limits). Nevertheless, we can anticipate that should the occurrence of consecutive snow droughts increase in the southern basins of B.C., so would the likelihood of consecutive summers of hydrological drought. In addition, hydrological drought could be exacerbated in the future by higher temperatures that increase atmospheric demand for water, combined with increasing human consumption.

Assessment of consequences

Water cannot sustainably meet system demands. Drought can lead to water scarcity, which can be worsened by land-use policies and practices, as well as water supply infrastructure that affects water storage and supply.

Natural environment

With very low flows in large rivers, dry creeks, higher stream temperatures and reduced oxygen levels in water bodies, instream flows are insufficient to meet aquatic species' environmental needs. Drought conditions dramatically reduce the availability of fish spawning and rearing habitat, food resources and instream refugia across multiple watersheds in the province. As a result, aquatic species, including Pacific salmon and other aquatic species at risk, face habitat fragmentation, strandings, delayed migration, increased susceptibility to disease, predation and mortality. Above-average temperature conditions cause shifts in the growing season, resulting in some species thriving from prolonged heat, while others are negatively impacted. With impacts on reproduction, growth rates and the odds of survival, localized and regional significant biodiversity losses are inescapable. Human communities in the province have strong cultural ties to salmon, with species losses marking a significant shift in identity.

Ephemeral ponds and wetlands dry out, leading to a shift in their associated populations of insects, amphibians, plants, birds and semi-aquatic rodents. Facing dry conditions and reduced food resources, beavers leave the water's edge and become exposed to predation by large carnivores. Wetland functions suffer, including their ability to slow and store water, with implications for flood regulation during intense rainfall events. Drying wetlands alter carbon sequestration rates with mitigation potential being lost as peatlands and other wetlands become less productive.

Prolonged dry periods result in a buildup of roadway contaminants. During rainfall events, roadway contaminants enter fish-bearing watercourses through stormwater. Evidence shows that without stormwater treatment, these occurrences result in significant mortality events of Coho salmon and possibly other fish species.[15,16]

Water quality and quantity decrease. With persistent, record-low flows, the dilution capacity of receiving surface waters decreases. Pollutants entering waterways concentrate and cross thresholds required to sustain life, to be safe for human uses, or to be prudent for commercial withdrawals. Little to no groundwater recharge occurs across the province. Aquifers in high-demand areas are mined for their groundwater,

resulting in compaction and a permanent reduction in aquifer productivity. Reservoirs supplying drinking water to residents and visitors across the province are slow to replenish, even in healthy watersheds, with strict water restrictions in place almost everywhere in B.C. to ensure the supply of drinking water.

The higher temperatures increase evaporative demand and force farmers to increase irrigation. Despite reduced soil moisture on farmland, surrounding unirrigated landscapes are even drier, attracting pests. Agroecosystems across the province face unprecedented insect infestations, decimating crop harvests.

Drought inhibits tree growth and increases blowdowns from weaker trunks, reducing forest health overall and increasing erosion from hillslopes due to a lack of root strength. The understory of forested areas also dries out, impairing soil quality and the overall health of other vegetation. Dry, hot conditions result in the drying of fuels in the forests and grasslands, and the fire season starts earlier and earlier each year because of the cumulative effect of continued drought—and holdover fires become more common. Following droughts and wildfire, the ability of the land to absorb rainfall is diminished and the risk of flooding is enhanced. The province ends up managing two or three disasters at the same time or consecutively, in a particular area/watershed.

Built environment

Although water scarcity may cause relatively localized damage to infrastructure, the primary impacts are on limiting the effectiveness of water supply systems and increasing the costs of the services that the human-built infrastructure can provide.

Buildings

Buildings need sufficient water for basic operations, such as sanitation, fire suppression systems and HVAC cooling processes that rely on water, but obtaining enough water during drought conditions can be a challenge.

In addition, in areas with poor water quality due to increased salinity or contamination, accelerated corrosion and damage to plumbing systems affects long-term infrastructure integrity and increases maintenance costs.

Lower water levels in hydroelectric reservoirs leads to a strain on the electricity grid and the requirement to import electricity, if possible, to sustain HVAC systems in buildings. When insufficient electricity is available, systems that regulate temperature cannot operate and some buildings become temporarily uninhabitable.

Transportation

Sustained lack of water leads to lower flows in streams and rivers. In communities or industries that use waterways to transport people or goods, these lower levels lead to increased navigation risks in some areas, requiring alternate transportation methods. Drought conditions impact road operations—particularly dust control services, which are important not just for road safety for all users, but also for people with respiratory ailments.

Water infrastructure and waste infrastructure

In agricultural areas, crops suffer due to less available surface and groundwater resources that support irrigation infrastructure. That is, irrigation systems are seldom designed with a multi-year drought in mind. This water scarcity leads to lower crop yields and therefore a lack of supply and increased prices for consumers for high-demand items and food imports. The need for water for irrigation must be balanced with other needs such as aquatic life, domestic use and industry. For industries where water is required to support processing, water scarcity can result in reduced production or increased costs.

Lower surface water and groundwater levels reduce the availability of water for water suppliers. It is anticipated that small water suppliers will have greater difficulty providing water to users during a multi-year drought event. For drought-resilient communities, some access remains for water for drinking and to support the movement and treatment of sewage, but non-essential uses of water are severely rationed, leading to the lack of ability to water vegetation, which increases fire danger. Communities with preexisting supply issues may lose access to basic services such as fire prevention, waste management and delivery of drinking water, leading to population displacement.

Limited water supply and rising demand continue to put a strain on ongoing water rights conflicts, often between the oil and gas industry and First Nations. First Nations inherent rights and title, in relation to water on their territories, is recognized in the UN Declaration on the Rights of Indigenous Peoples and B.C.'s Declaration on the Rights of Indigenous Peoples Act.

Many waste management processes, including sewage treatment, rely on adequate water supply. Reduced water availability compromises the efficiency of these processes, leading to pollution and public health issues, such as water-borne diseases and water contamination. The long-term drought conditions increase the amount of solid waste, such as dead plants and failed crops, which can strain waste management systems and lead to increased fire risks in landfills and waste disposal sites.

Energy

At hydroelectric power generating stations in the province, the lower water levels limit the ability of the utility to generate sufficient electricity to support provincial demand. This requires rebalancing hydroelectric capacity and demands across the province (and possibly scheduled "brownouts") and purchasing additional capacity from neighbouring jurisdictions, leading to associated economic impacts on rate payers. Increasing the demand for electricity produced by other jurisdictions using fossil fuels leads to increased production of greenhouse gas emissions. Lower reservoir and outflow levels impact the ecosystems in close proximity to the reservoirs as well as downstream watercourses.

Information and communication

Data centres and network operation centres, which require significant cooling, struggle to maintain optimal temperatures due to limited water availability and/or electricity for cooling systems, leading to overheating and reduced reliability of services. Moreover, the impacts on hydroelectric power generation cause disruptions in the operations of information and communications technology (ICT) infrastructure in terms of providing a reliable power supply for operation and cooling.

Society, cultures and relationality

Water is important socially, culturally, spiritually, economically and politically, as well as physiologically and environmentally. Droughts and water scarcity can cause significant ecological and social disruptions to community life. Directly, water scarcity impacts households by limiting daily activities, including bathing and cooking, leisure and sport activities, religious observances, and ceremonial practices. Over time, indirect impacts emerge, as widespread limits to water access can lead to social inequities, financial strain, conflict over water governance, and tensions around the exercising of rights between water user groups, which include family units, small and large businesses, hospitals and schools, farmers and food producers, government and service providers.

Many rural and remote communities rely on intensive water-use sectors. Farmers and ranchers experience crop and livestock failures during times of drought and imposed water shortages, which can compound economic hardship, loss of livestock, livelihood and identity. This leads to disruptions in human-animal connections and increases in novel human-animal encounters that can lead to newly emerging injury and

disease. It disturbs traditional food gathering and cultural continuity for many Indigenous communities, leads to price increases for many items essential to daily life, and indirectly deepens and intensifies pre-existing social and health inequities, including food security.

Urban and municipal water infrastructure is sustained by large-scale water systems with advanced emergency protocols, robust financing and clear intergovernmental agreements, but for many First Nations communities, the impacts of a drought amplify pre-existing water scarcity issues, such as the ongoing boil water advisories, and thus illuminate the social and political factors that make access to water an ongoing rights-based issue in Canada. Daily life is disrupted by water scarcity, and wellbeing is eroded by the industrial contamination of sources of water found in the natural environment. During droughts, without seasonal rains, dry rivers have a catastrophic impact on salmon runs, while forests and traditional foods and medicines can weaken or die. This, in turn, means that wild foods cannot be harvested, ceremonies cannot be practised, and cultural knowledge cannot be transmitted within ecologically intact landscapes.

Downstream, water scarcity disrupts the production of hydroelectricity, and water conservation requires lifestyle changes that many people oppose or struggle to comply with. Rapid water-use policy changes can increase tensions in households by way of financial and resource hardships. This can lead to friction between citizens and government agencies in communities.

Communities with strong economic reliance on the tourism industry can struggle to both attract and host visitors. For example, mountain communities impacted by reduced snowfall and coastal communities affected by low water levels may experience low visitor turnout. Farmers reliant on water-intensive harvests, such as stone fruit, may lose entire annual yields, as well as the plants and trees themselves. All of these sectors stand to lose seasonal revenue. If experienced year after year, this could force communities to shutter businesses and lead to individual or whole community relocations, which includes leaving behind multi-generational legacies and properties. Similar experiences may arise in rural and remote communities with resource extraction-based economies. For Indigenous communities with relationships to territory that spans millennia, the challenges of staying—and healing water, land, culture and community—generate another set of social, political, economic and legal issues. These must be addressed alongside the imperative to heal the waterways and steward the health and wellbeing of the human and more-than-human communities for whom water is life.

Health and wellbeing

The long-term drought limits access to sufficient potable water. Drought results in turbid water of lower quality due to the absence of freshets to flush out rivers and lakes. People are exposed to and experience:

- Respiratory illness due to increased fine particulate matter and dust concentration
- Infectious disease due to decreased water quality resulting from water stagnation and increased concentration of pathogens
- Increased toxins and chemical contaminants (for example, Arsenic) as a result of dust storms
- Food and water insecurity due to water shortages
- Decreased availability of local and traditional foods as a result of drought-induced damage and disruptions to infrastructure

After these direct impacts, significant secondary, or downstream, health impacts arise from the initial health concerns. For example, food insecurity and undernutrition lead to weight loss, adverse birth outcomes, child development issues, exacerbation of chronic disease and increased healthcare burdens. Beyond physical health, drought leads some to experience significant psychosocial impacts, such as emotional distress, anxiety, depression, substance use and abuse, suicide and suicidal ideation.

Stress over a lack of water, damage to property, experiences of displacement, and loss of livelihoods will greatly impact psychosocial health. Drought-induced displacement and migration increase social isolation and decrease the sense of community and social support.

Drought impacts healthcare services and operations. The reduced availability of healthcare workers (for example, because some have been displaced or migrated, or are experiencing their own health impacts) disrupts or delays medical services and leads to an increase in poorer health outcomes. Some medical equipment and supplies are depleted due to a significant increase in demand and delays to supply chains.

Water scarcity inequitably affects the physical and psychosocial health of various groups, primarily rural and remote communities and those individuals whose livelihoods depend on the land and the environment, such as farmers, fishers and Indigenous Peoples. The physical and psychosocial health risks stemming from drought in rural and remote communities, among specific occupations and First Nations, may be amplified by additional intersecting determinants of health, such as lower socioeconomic status or limited access to culturally relevant healthcare.

Economy

This period of water scarcity has widespread effects on various aspects of the province's economy, both directly and indirectly. Water scarcity directly affects the economy by reducing agricultural productivity, increasing costs for water-dependent industries and limiting access to clean water for households, leading to lower incomes and higher poverty levels. Additionally, forest health is compromised, leading to increased susceptibility to pest outbreaks and reduced forestry-related activity. The environmental stakes are high, as water deficits contribute to tree mortality and increase the risk of wildfires, which are affected by ongoing weather conditions. Indirectly, water scarcity strains public resources, diverting funds from other economic development priorities.

Communities are making difficult decisions about water use. Crops under higher thermal stress require significantly more water due to the increased evaporation rate, leading to a heightened need for irrigation and further straining water resources. The water shortage impacts food security with crop failures—including reduced amounts of feed and water for livestock and range animals—and job losses. Agricultural disparities become more evident, with some of the larger operations capable of managing the financial burdens associated with water shortages, such as by investing in water storage, while smaller farms struggle due to limited access to resources and capital.

Lower water levels impact transportation along the Fraser River, an important commercial waterway, hampering the movement of goods and affecting trade.

Low water levels challenge energy sectors to produce enough energy to meet demand, leading to higher costs. Where reduced water availability limits hydroelectric power generation, an increasing reliance on more expensive and less efficient energy sources can raise costs.

Some communities have to prioritize the water needs of certain sectors, such as healthcare and education, over the water-related needs within their tourism sector. The impacts extend into recreational sectors like sport fisheries and winter sports, where water levels and snowfall are critical. Economically, livelihoods related to the tourism sector are affected, becoming more intermittent or significantly reduced for a period of time.

Governance

The provincial drought-response governance structure involves First Nations, local, provincial and federal agencies. There are several working groups and committees.[17]

With the responsibility of monitoring and formalizing drought levels on a regional and watershed scale, a Provincial Technical Drought Working Group starts to meet on a bi-weekly basis. The provincial working group monitors and adjusts drought levels based on indicator thresholds. Information about the provincial drought levels, watershed conditions and drought monitoring data are shared at the Drought Information Portal. Measures associated with the drought threshold levels outlined in the B.C. Drought and Water Scarcity Response Plan are activated. As the drought levels increase from 0 to 5, communication efforts progressively escalate, along with updates to partners, assessments of water supply vulnerability, local government water restrictions, and planning for or procuring temporary or alternate water supplies. At the highest drought level (5) voluntary measures and water restriction measures may be augmented with responses from the provincial government under the Water Sustainability Act.

With reduced snowpack and reduced aquifer levels, all regions face increasing pressures to regulate and prioritize water use across the province, with some regions more heavily impacted depending on local drought conditions, water supply availability, storage capacity of local water infrastructure, and other community supply and demand factors.[18]

Many local authorities declare a State of Local Emergency (SOLE), allowing authorities (provincial and local) to exercise emergency response powers under the Emergency and Disaster Management Act (EDMA). This includes restricting non-essential water use, ordering evacuations in certain areas, prohibiting travel, and entering private property that may present risks to people, property, or objects or sites of heritage value.

Industries, commercial operations and agricultural producers—all of whom rely heavily on water for their business viability and are now subject to water use restrictions—become more vocal about their challenges and needs as the drought progresses. Residential and recreational water users also voice their concerns and experiences regarding the water restrictions. Local authorities respond by enhancing communication and consultation opportunities on regulatory processes, decisions and the information used to support those decisions. Social-political tension increases, nonetheless.

Restrictions that came into effect with the SOLE and that were initially identified as temporary must be extended or intensified, which escalates stress between water users and governments. Conflicts arise between different groups with competing water-use priorities, increasing distrust in government and potentially leading to social unrest, protests and heightened community tensions. Businesses impacted by water use limitations may pursue litigation, citing inadequate government measures to conserve water resources.

Regionally, local governments and First Nations grapple with severe water shortages in existing water systems, lacking alternative sources that could take years or even decades to develop. Insufficient monitoring and climate change adaptation planning leave some communities highly vulnerable to prolonged drought conditions, both in terms of quantity and quality of water. Communities relying on smaller aquifers or snowpacks for their water face extreme drought scenarios, leading to severe restrictions and the necessity to purchase and truck in water just to meet basic needs. In the face of these immediate concerns, local authorities and First Nations governments may be forced to revise or abandon long-term water management plans.

The reduced water availability hampers firefighting efforts, a critical concern as wildfire risks rise due to the drought. Small communities off the integrated grid that depend on small hydropower face potential power brownouts or blackouts, severely impacting their ability to govern and meet basic community needs.

5.5 Wildland urban interface fire

The course of the event

A combination of a low-snowpack year, a continued multi-year drought, negligible spring precipitation, and above-average temperatures across British Columbia result in an exceptionally active and continuous fire season, starting in early May.

During the last week of July, a heat wave brings record-breaking temperatures as a dry cold front passes over most of the province. The cold front produces several thousand lightning strikes and very little rain. This results in over 300 new aggressively burning wildfire ignitions throughout the province, stretching wildfire response resources.

On August 1st, a new fire-start in a heavily forested drainage area is initially estimated as a 30 ha fire displaying aggressive fire behaviour. The wildfire (wildfire A) is declared "Out of Control" and "Beyond the Initial Attack" capabilities of the current available resources.

The high-pressure weather pattern persists throughout the week, resulting in sustained record temperatures in the high 30s to low 40s, only slightly subsiding through the nights, with no precipitation and only light southwesterly winds. The wildfire grows substantially, contributed to by drought-stressed fuels, record dry conditions, competing priorities across the province, and steep and largely inaccessible topography that limits safe firefighting activities. By day five, it is the largest fire in the region (3,393 ha).

On August 7th, a second dry cold front arrives, producing sustained winds of 50–60 km/h with gusts to 80 km/h. Hundreds of lightning strikes are recorded locally. The eastern flank of wildfire A turns into the head of the fire, pushing a 12 km-wide flaming front to the southeast. Despite the suppression response and installation of structure protection resources, the fire reaches the properties of a medium-sized community within four hours.

A new lightning-caused fire starts to the east (wildfire B) and almost immediately spreads into a small community. A second lightning strike starts a wildfire (wildfire C) to the north and spreads into a large community. Driven by the strong winds, embers are carried 500 metres or farther ahead of the fire front, producing multiple spot fires and causing the simultaneous ignition of hundreds of structures. Fire begins to spread from structure to structure in higher density neighbourhoods, and fire spread rates are intensified on slopes. Fire suppression resources are almost immediately overwhelmed by the erratic

fire behaviour and are forced to withdraw to Safety Zones. Tactical evacuations of nearly 40,000 people take place. Pushed by strong winds, the fires continue to burn. By late summer, all three fires are officially declared under control. Winter precipitation and multiple spring aerial infrared flights confirm extinguishment.

This scenario was selected to illustrate a complex, impactful yet plausible extreme event, which focuses on the regional scale but is set in a context of a provincial-wide, exceptionally active and continuous fire season. While a specific location was considered by the working groups in the development of this scenario, the event described here is more generic, as this type of event could happen in many locations across B.C., with similar parameters and consequences, and learnings that are relevant province-wide. This event is expected to cause multiple impacts on values at risk, including public safety and human health, environmental values and large financial impacts at local and regional scales. The occurrence of such an event will become more likely in the future, as climate change induces more extreme weather conditions.

Scenario parameters

Location

- Wildfire A (medium community): 10,354 ha
- Wildfire B (small community): 692 ha
- Wildfire C (large community): 1,336 ha

This scenario represents an area of up to 100 km along a transportation corridor, populated with several rural hamlets, homesteads, as well as small, medium and large communities. It is representative of settlement patterns throughout the province and could be replicated in all regions.

Time

- The first two weeks of August

Duration

- 6 weeks
    - Ignitions occur on August 1st and August 10th, with a dry cold front passage arriving on August 1st
    - Fire travels into communities on August 7th; arrival of a second dry cold front passage
    - Fire is “Being Held” as of August 25th and is “Under Control” as of September 15th

- All three fires are officially declared extinguished late summer; winter precipitation and multiple spring aerial infrared flights confirm extinguishment

Intensity

- Aggressive crown fire with rapid spread during high winds persists for almost 24 hours as the strong cold front passes over
- Multiple spot fires and structure ignitions; fire spreads from structure to structure

Seasonal and weather conditions

- Seasonal influence: midst of ongoing, multi-year drought
- Weather conditions in June/July: hot and dry (see stats from 2023)
- Weather conditions in early August: heatwave, dry lightning storm
- Weather conditions leading to wildfire ignition: sustained high pressure with high temperatures and low relative humidity
- Weather conditions during wildfire complex: strong cold front resulting in a sudden breakdown of the stable high-pressure system, high winds and lightning, with very little precipitation

Comparable events

- Grouse Complex (2023)
- Bush Creek Complex (2023)
- White Rock Lake wildfire (2021)
- Tremont Creek wildfire (2021)
- Elephant Hill wildfire (2017)
- Williams Lake (2017)
- Telegraph Creek (2018)
- Okanagan Mountain Park wildfire (2003)

Concurrent or cascading events

Concurrent events include:

- A multi-year drought
- Heatwave weather event
- Multiple wildfire ignitions
- Multiple wildfires burning across the province

Cascading events that could occur include:

- Changes to soil and vegetation
- A subsequent rainfall event in the burn scars that leads to mudslides, debris flows and runoff into the lake

Likelihood of extreme event

- Annual likelihood: Moderate (2% to 10%)

- Likelihood in the span of 10 years in current conditions: High to Frequent (18% to 65%)
- Confidence in likelihood: High

Climate change influence

- Annual likelihood at 2.5°C global warming level: High (10% to 30%)
- Annual likelihood at 4°C global warming level: High (10% to 40%)
- Confidence in likelihood with climate change influence: Medium

Historically, damaging interface fires, such as the one described in this extreme event scenario, were made more likely by extreme weather conditions. More recently, longer term, year-round increasing trends in air temperature, in concert with precipitation deficits in successive seasons, lead to more persistent drying of forest fuels. While most climate models do not contain explicitly simulated wildfires, they can be used to derive "fire weather" variables that encapsulate the non-ignition component of fire risk (Fire Weather Index).

The scenario described has a Fire Weather Index (FWI) well in excess of historical FWI x 95 values (exceeding the 95th percentile of the FWI). For example, in areas such as Southern B.C., there are around 11 such days per fire season (May to September), or about a seven to eight percent likelihood, putting them in the category of "Moderate" events.

Climate models indicate that such extreme FWI days are projected to occur about 60 percent more frequently at a GWL of 2.5°C (mid-century), and about 2.5 times as often at a GWL of 4.0°C (end of century), compared to the 1980s. In other words, this would turn a Moderate likelihood wildfire event with current likelihood of <10 percent into a High likelihood event by the end of the century (10 to 50 percent likelihood). This assessment does not address potential changes in ignition likelihood, which includes human-induced and lightning-induced contributions, or realized fire intensity or extent.

Additional insights on climate change trends and influence on the wildfires can be found in sections 2.1 and 2.6. More detailed information is available in Appendix B: B.C. Provincial Climate Overview.

Assessment of consequences

The wildfires result in a myriad of impacts to neighbourhoods, businesses, natural areas and many other areas. The three fires cause direct, specific changes that affect multiple aspects of the communities. The combination of impacts before, during and after the wildfire complex affects numerous sectors and has significant long-term consequences on the economy, social and cultural fabric, and the natural environment of the region.

Natural environment

The extended drought has increased the susceptibility of ecosystems to negative impacts of fire. Although some of the highest elevations in the areas affected by these fires were shaped by low-frequency, high-intensity fires, many of the ecosystems in most burn areas were shaped by frequent low- to moderate-intensity fires. Extended drought has decreased the live fuel moisture content of otherwise fire-adapted plants, making them less likely to survive a future wildfire.

A lack of low-intensity fire frequency increases the fuel load and, therefore, the intensity (heat) of the fire. The increased vegetation density and soil moisture conditions increase the fire's severity, resulting in the complete or near-complete consumption of all organic materials, including seed banks. This leaves a lack of fertile areas and significantly impacts the ability of plants to reproduce and grow. It also creates a favourable environment for many invasive plants to dominate. These changes to soil properties and vegetation lead to secondary hazards such as erosion, mudslides/debris flows following rainfall, and runoff into the lake/contamination of water supplies. In addition, the chemical runoff from the mass burning of human-built structures and the resulting water runoff from firefighter efforts contaminate soils and domestic water supplies, leading to costly and difficult cleanup projects for years to come.

Built environment

Buildings

As the wildfires approach, winds push embers well ahead of the fire and into communities, igniting roofs, decks, wooden fences, shrubs, mulch, scraps of wood and more. Some spot fires begin to spread and burn more landscaping, sheds and homes nearby. As flames consume structures, more embers are produced and propagate as they fly into more neighbourhoods. In the higher-density areas, adjacent homes also ignite from

the intense heat and flames from these burning structures, resulting in structure-to-structure ignition, creating urban blazes. Tens to hundreds of structures burn in multiple neighbourhoods.

Upon conclusion of the event, over 1,200 homes, outbuildings (sheds, garages, barns) and businesses are damaged or destroyed by the wildfires. Damage to residential neighbourhoods is extensive and hundreds of families must rebuild, rent or move elsewhere. Commercial and light industrial areas suffer structural damage and losses, and a major industrial site is burned to the ground.

Following the immediate evacuation, residents who decide to return face a long (months to years) process to reestablish their homes. Some businesses destroyed by the fire have not been reconstructed. Industrial and agricultural facilities located in the area need many months to years to reestablish. Not all rebuilding efforts can meet higher fire protection standards due to limitations of insurance policies, current codes, development policies and the expense to rebuild. Archaeological sensitivities and permit requirements for rebuilding further complicate construction efforts. Limited availability of building materials due to increased demand also slows rebuilding. It is expected that the reconstruction of homes and businesses may not be complete within five years of the fire, leading to long-term displacement of large portions of the population.

Transportation

As the wildfire complex escalates, the fire threat forces road closures on arterial highways, essentially cutting off impacted communities and limiting options for evacuated residents to travel. An existing highway construction project limits traffic to single lane, resulting in a mass evacuation of vehicles stuck in bumper-to-bumper traffic, with limited visibility due to heavy smoke. While generally orderly, a few vehicles become panicked, leading to a traffic incident and minor injuries. This further reduces traffic flow and slows the evacuation process.

Due to wildfire smoke, many important services are suspended, including closing air space to commercial flights or other non-essential air traffic. This impacts visitors and locals trying to arrive or depart from the two regional airports and delays delivery of parcels and other goods.

Direct fire damage to highway infrastructure is minimal and does not generally cause significant impacts to operations, but wooden bridge structures along smaller roads are damaged or destroyed, leading to weeks or months where key access points for remote communities are inaccessible. Repair of critical infrastructure along highways prolongs recovery and disrupts transport of goods in and out of the area. Rail

operations in the area are suspended during the wildfire and disrupt provincial rail logistics. Other bridges and roads are subsequently impacted by secondary hazards, including debris flows and flooding. The high severity of the wildfire leaves steep slopes along the highway corridor and in critical water supply areas vulnerable to landslides, erosion and debris flows, threatening the safety of the highway and impacting numerous other resources for years to come.

Water infrastructure and waste infrastructure

During the course of the event, water supply and treatment are compromised due to energy outages.

After the event, more erosion and mudslides/debris flows following rainfall increase runoff into the lake and risk blocked intakes and gathering sediment. In addition, the chemical runoff from the mass burning of human-built structures and the resulting water runoff from firefighter efforts contaminates soils and domestic water supplies, leading to costly and difficult cleanup projects for years to come.

The destruction of vegetation and the presence of hydrophobic soils increase the amount of surface runoff during the next rainfall. The runoff carries sediments, ash and other pollutants into water bodies and reservoirs, compromising water quality. Water pipes burned in structure fires may introduce contaminants throughout the remaining water distribution infrastructure. Moreover, the water supply systems, such as pipelines and treatment facilities located in or near the fire zone, are damaged directly by the fire or indirectly by subsequent soil erosion or debris flows, disrupting service and requiring costly repairs. Water supplies of First Nations and small communities are affected.

Energy

Impacts begin even before the fires burn into the area. Utility providers de-energize several major transmission lines to reduce the risk of the high winds knocking down a power line and starting another ignition. This results in several residential and commercial areas being left without power in the middle of August. Local hospitals and other critical facilities have backup generators; however, many small businesses and homes do not. This leaves some without power for various needs, such as personal medical equipment, communications devices, refrigeration of foods, air conditioning, processing credit card transactions and more.

As the wildfires progress, additional assets are damaged or destroyed. This includes a major transmission line and several power lines, leading to more power outages in multiple neighbourhoods. Natural gas distribution is suspended during the wildfires,

affecting some residents and businesses. Overhead power lines, poles and other electrical infrastructure are also damaged. Fire-induced power outages are widespread and prolonged, affecting not just the immediate area but also regional networks. The power outages complicate the operation of other critical infrastructure, including water supply and treatment, communications and emergency response services. Energy infrastructure affected by fire, smoke or heat requires extensive maintenance or replacement, increasing operational costs; restoration takes weeks to months.

Information and communication

During the event, cellular communications become overloaded due to the high volume of local calls, texts and data transmissions. This affects all cellular carriers and temporarily disrupts service, leading to additional confusion and miscommunication among residents in receiving accurate evacuation information. Communications lines and facilities are damaged, making some services unavailable during and for weeks after the event.

Society, cultures and relationality

Before the fires burn into the area, local governments and responders initiate Evacuation Alerts, Evacuation Orders and Tactical Evacuations for multiple neighbourhoods located on the edge of communities closest to the fires, and eventually through the entirety of the threatened communities. This immediately displaces several hundred people who need to find temporary shelter for several days, if not longer. Some residents go to emergency shelters while others stay with family or friends. There are a few available hotel rooms due to last-minute cancellations from tourists concerned about poor air quality from widespread wildfire smoke. However, hotel options are extremely limited due to a large tourist presence during the August long weekend as well as displaced residents across the region from other active wildfires. Further, these options are costly for many families and cannot always accommodate pets, populations with access or functional needs, or other unique considerations.

Many wildfire survivors face displacement for months or years. The associated potential challenges include financial hardship; uncertainty of the future; grieving the loss of personal history and items; adjusting to a new living situation; relocating to a new school system; and being separated or removed from family, place and cultural ties. As businesses take time to reestablish, some residents are unable to find new employment in the area and conversely, some businesses are unable to find skilled staff. For some,

the increased stress and trauma can lead to higher instances of domestic violence, post-traumatic stress disorder, suicide or thoughts of suicide, and other conditions. This is further exacerbated by local closures or restrictions on regional/ provincial roadways due to hazardous conditions. Many residents feel disconnected from the land, have reduced ability to enjoy the outdoors, and mourn the loss of their local neighbourhood and community vitality. In some cases, parcels of land may remain vacant due to delays in rebuilding or are abandoned by residents who do not return to the area.

The sheer enormity of mass hazardous debris removal requires an extensive mobilization of heavy machinery, trucks and specialized environmental remediation personnel and equipment and the debris is beyond the local landfill capabilities The clean-up effort also requires a massive workforce which puts additional strain on already limited local accommodations and services, compounding the struggles of some displaced residents seeking housing. This activity, along with the other incidents across the province, diverts workforce personnel away from rebuilding homes. Builders of new homes are further paralyzed by the ongoing province-wide labour shortage, contributing to the affordable housing shortage.

Health and wellbeing

As wildfires approach and enter several communities, the overall sense of fear increases among many residents, visitors and business owners. Wildfire smoke deteriorates air quality, and many people across the region are forced to stay indoors and cancel outdoor plans or activities. Pollutants from burning homes and other structures are particularly detrimental to air quality and impacts on health as toxins are released. Emergency room visits spike as vulnerable populations, including the elderly, children and those with underlying health conditions, experience respiratory problems or other health impacts from the smoke.

Within the confusion of the mass tactical evacuation, the lives of two individuals were lost.

Maintaining physical and mental wellness can disproportionately affect some groups. This includes emergency responders who experienced multiple disasters or lengthy fire seasons, residents who have been evacuated multiple times, residents who lost their homes, business owners who lost their businesses or revenues, employees who no longer have jobs due to business closures, care professionals supporting recovery, and Indigenous Peoples

and other residents whose cultural resources were damaged or destroyed.

Many people who experienced the wildfires—residents, evacuees, visitors and emergency responders—struggle with adverse mental health issues, such as depression, anxiety, post-traumatic stress, sleep disturbance and burnout. For those who lost a family member or friend, emotional recovery may take years, if not longer. Even those who were not directly affected by the fires but witnessed the damage or served in response and recovery support roles are vulnerable to the effects of secondary traumatic stress.

In addition to mental and emotional trauma, some populations must also cope with long-term consequences on their physical health. This includes vulnerable populations, such as those with underlying health conditions that were exacerbated by prolonged exposure to poor air quality, emergency responders with chronic exposure to wildfire smoke and those who were physically injured during the wildfire event. Short- and long-term moves impact vulnerable populations such as the frail and elderly, who can experience rapid health decreases from disruptions to their diet and day-to-day life. Other groups may be disproportionately affected, including visible minorities and those in specific occupations such as farmers and ranchers. Other public health concerns stem from long-term contaminants in drinking water due to the release of hazardous materials throughout the urban burned areas. Road closures resulting from ongoing post-wildfire infrastructure repairs and maintenance may limit access to medical facilities for some residents.

Economy

In the first 12–24 hours of the wildfires burning, some supplies at local grocery stores become limited as more residents are panicked at the uncertainty of the growing disaster, while other businesses close early so employees can go home and wait for potential news on evacuation notices. As air quality further deteriorates, many across the region are forced to stay indoors and cancel outdoor plans or activities.

A commercial and light industrial area suffers structural damage and losses, with fires destroying multiple businesses, including an auto dealership, a convenience store, several restaurants, a drug store, and retail shops. A local industrial site—a major long-term local employer—burned to the ground, along with all of its inventory and equipment.

Several prominent economic sectors experience declining revenues from the numerous impacts of the wildfire

complex. One of the most affected is the tourism industry, including hotels, restaurants, shops, recreational facilities, events and associated local vendors, and other tourist-dependent uses, which face challenges from both immediate cancellations and longer-term concerns.

Some businesses and restaurants that lost inventory during the power outage are still recovering from these losses. Many would-be tourists have become wary about booking future vacations in the area during the summer months for fear of experiencing evacuations, disruptions, and smoke, heat or other wildfire-related impacts. Without being able to rely on the peak summer season for income, the tourism industry must make additional investments in marketing and search for alternative strategies to boost revenues.

Another industry facing long-term challenges is local agriculture. Due to losses of crops damaged from smoke, extreme heat or flames, the region will lose produce during peak growing season. This reduces farmers' ability to sell goods regionally and at the local markets. In addition, many crops were tainted by the smoke and will see a lower yield, further stressing bottom lines and decreasing future supply. Several other businesses—including the local local industrial site that burned—temporarily or permanently close, leaving several hundred residents without employment. While some of these businesses intend to rebuild, previous employees are uncertain as to how long that will take and whether some businesses will ever recover.

An additional economic consequence results from home losses. Damaged and destroyed homes strain budgets for hundreds of families and renters while they face the decision of whether to rebuild, rent or move elsewhere. Many homeowners are underinsured and struggle with the cost of rebuilding, which exceeds their personal savings and insurance coverage. Property owners who relied on rental income and lost their properties are also considering their options. Renters face limited options, as housing affordability and availability across the region is not favourable for finding new housing. All of this is compounded by the difficulty of finding builders and contractors who can build new homes quickly, increasing the likelihood that displacements will be long-term and costly.

The economic consequences of home losses extend to other homeowners not directly affected by the wildfire through an increase in insurance premiums for all residents in fire hazard areas. In addition, long-term displacement of residents leads to a crunch on local housing supply due to increased demand for rentals and new homes. The vacation market stagnates as prospective buyers

reconsider investing in the region due to the rising cost of insurance and the threat of future wildfires.

Energy infrastructure affected by fire, smoke or heat requires extensive maintenance or replacement, increasing operational costs and customers' monthly energy bills. Restoration sometimes takes weeks to months and leads to continued service interruptions for affected residential and commercial properties.

Property tax revenue drops due to the decreased assessed value of properties, either because neighbourhoods and individual properties are less desirable or because owners delay or choose not to rebuild on properties.

Governance

Due to an exceptionally active and continuous fire season, all six fire centres in B.C. are at their highest preparedness levels. Other Canadian provinces and western U.S. states are also experiencing active fire seasons, leading to wildfire response resource shortages at regional, national and global scales.

Day 1 (August 1st)

During the initial stages of the event, as the local fire centre receives reports of multiple wildfires in the region, air tankers are tasked with other priority fires and cannot offer immediate response assistance.

The wildfire is declared "Out of Control" and "Beyond the Initial Attack" capabilities of the current available resources. Additional situational factors include:

- The relatively remote location
- A low number of structures immediately threatened
- The fire growth prediction to continue north and west and away from the larger concentrations of populations
- A short-term weather forecast for a stable high-pressure ridge, with no immediate wind concerns

Considering that the fire growth is initially away from urbanized areas, the Wildfire Coordination Officer and the onsite Incident Commander determine that the first priority is to undertake tactical evacuations of the residents of the two immediately threatened properties and then focus on protecting them. The local authority activates their Emergency Operations Centre and issues several Evacuation Alerts and Evacuation Orders.

Days 2 – 4 (August 2nd – 4th)

Crews and resources continue to respond to the fire, when it's safe to do so—but with the terrain and

fire behaviour, there are limited areas that can be safely actioned.

Day 5 (August 5th)

Wildfire A becomes the largest fire in the region (3,393 ha). However, suppression resources continue to be challenged by other significant incidents in the region. The BC Wildfire Service establishes a Ministry Zone Operations Centre (MZOC) to manage this fire and potential new starts for increased efficiency in operations and resource coordination.

Many residents heed the Evacuation Orders. A few attempt to return to their homes for items but are turned away at the roadblock. In addition, some residents are evacuating or corralling horses and other livestock to safety and protecting other assets on their property. These activities divert critical resources from emergency response to coordinate with residents who refuse to leave or require additional assistance.

Day 6 (August 6th)

The weather forecast reveals that a strong low-pressure weather system on the following day will extend further over the province than originally expected. This system will result in unstable atmospheric conditions, including strong and erratic winds and lightning. Fire Behaviour Advisories are issued for wildfire A. Suppression resources are reorganized, with some resources focused on protecting properties on the western side of the medium-sized community and remaining resources staying mobile for initial response to newly lightning fires. An Evacuation Order is issued for the entire medium-sized community and the surrounding area.

Day 7 (August 7th)

A dry cold front arrives, producing sustained winds of 50–60 km/h from the northwest, with gusts to 80 km/h. Hundreds of lightning strikes are recorded locally. With the frontal passage, the eastern flank of wildfire A turns into the head of the fire, pushing a 12 km-wide flaming front to the southeast. The fire almost immediately enters rural properties and reaches the western properties of a medium-sized community within four hours.

A new lightning-caused fire starts to the east (wildfire B) and almost immediately spreads into a small community. A second lightning strike starts a wildfire (wildfire C) to the north and spreads east into a large community. Driven by the strong winds, embers are carried 500 metres or farther ahead of the fire front and produce multiple spot fires and the simultaneous ignition of hundreds of structures. Fire begins to spread from structure to structure in higher density neighbourhoods, and fire spread rates are intensified on slopes. Fire suppression resources are almost

immediately overwhelmed by the erratic fire behaviour and are forced to withdraw to Safety Zones. Tactical evacuations of nearly 40,000 people take place.

In advance of approaching flames, winds push embers well ahead of the fire and into communities. Spread is quick, and firefighters can't keep pace in responding to all of the fires. Additional areas are placed on Evacuation Alerts and Evacuation Orders due to the rapidly spreading fires. This includes residential neighbourhoods, businesses, primary care and long-term care facilities, in addition to several other facilities with special needs or vulnerable populations. Many residents heed the Evacuation Orders, but some are hesitant to leave. A few attempt to return to their homes for items but are turned away at the roadblock. In addition, some residents are evacuating or corralling horses and other livestock to safety and protecting other assets on their property. These activities divert critical resources from emergency response to coordinate with residents who refuse to leave or require additional assistance.

Pushed by strong winds, the fires continue to burn through the night and into the morning of August 8th. In total, 12,382 ha are burned and many significant natural, cultural and other assets are damaged or destroyed.

The response and recovery effort relies on community service organizations and volunteers to fill gaps and to best understand the needs of their clientele. Volunteers suffer mental and emotional stress and become unavailable to respond to other non-climate/disaster issues that require community support.

Recovery following the event is complex, exposing challenges in accessing financing and insurance coverage to rebuild—particularly in strata properties and other multiple-ownership models. In some situations, decisions around rebuilding are rushed, without due care for gathering input, knowledge and evidence to inform the balanced allocation of resources. Significant effort and resources are needed to rebuild trust and relationships, diverting from recovery efforts, mitigation and the preparation for future hazard events.

5.6 Cascadia Megathrust M9.0 Earthquake during wildfire season

The course of the event

On a morning in August, during wildfire season and a heatwave, megathrust (subduction interface) a magnitude 9.0 (M9.0) earthquake occurs offshore of Vancouver Island. Minutes of strong shaking are felt across the region—on Vancouver Island and the Lower Mainland—and as far south as northern California. Intense and long-duration ground shaking causes damage in communities on Vancouver Island, the Lower Mainland and the Sunshine Coast. The shaking is expected to cause complete damage of approximately 18,000 buildings, more than 10,000 injuries (noncritical and critical hospital injuries) and 3,400 fatalities.[i] Early Earthquake Warning alerts guide people to take immediate action—"drop, cover and hold"—before the damaging shaking occurs. After the shaking, coastal communities are alerted of an imminent tsunami and are asked to move to high ground.

A tsunami follows the earthquake, hitting the west coast of Vancouver Island 10–20 minutes after the shaking.[ii] The tsunami's trough hits first, making it look like the ocean is unexpectedly receding. The crest follows, impacting the outer coast most heavily, but reaching the east coast of Vancouver Island and the Lower Mainland 30–60 minutes later. Local amplification of the tsunami in ocean inlets impacts some communities farther north along the coast.

Currents along the west coast and into Victoria's Inner Harbour are very strong and cause damage to coastal infrastructure and communities. Landslides are triggered on the steep slopes of Vancouver's North Shore and Sea to Sky Highway. Widespread liquefaction is observed in areas of soft and loose sediments (such as False Creek in Vancouver) and natural sandy soil deposit environments (such as parts of the Fraser River Delta). Meanwhile, urban fires have broken out across the region. Wildfires that started earlier in the season continue to burn as regional and provincial response capacity is impacted by the earthquake. Aftershocks hamper rescue and recovery

i. These estimates include only direct mainshock damage without account of secondary hazards like landslides, liquefaction, tsunami, fires and more. These estimates are informed by NRCan RiskProfiler.

ii. Tsunami arrival estimates vary based on model assumptions and data resolution.

efforts from the outset and continue for months following the earthquake.

An intense aftershock sequence follows immediately after the mainshock. Some of the early aftershocks reach or exceed M7.0. Some of these aftershocks are large magnitude earthquakes and are closer to Vancouver, causing stronger shaking and damage in Vancouver and the east coast of Vancouver Island than that caused by the main earthquake. One of the major aftershocks is a 60-kilometre-deep M7.1 earthquake under Sidney, which happens in late September, at 11 pm, as an atmospheric river is passing by southwest B.C. The aftershock causes significant additional damage from Victoria to Nanaimo, including southeastern Vancouver Island and the Gulf Islands, and in the southern municipalities of Metro Vancouver, requiring, once again, post-earthquake search and rescue and damage assessments. Aftershock frequency and intensity diminish over the next year.

The Cascadia Megathrust M9.0 Earthquake was selected as a scenario as it is currently one of the more likely earthquake scenarios in B.C., it complements existing scenarios, and it highlights important and less understood insights into the risks and impacts of this unique and inevitable earthquake. Unlike other earthquakes, a megathrust M9.0 earthquake will induce a tsunami, major aftershocks, widespread landslides, liquefaction damage, fires and floods with a direct impact on infrastructure, food and supply chains, and priority value areas of British Columbians throughout the province.

Scenario parameters

Location

- The heaviest damage occurs on Vancouver Island and a roughly 20-kilometre band along the mainland coast, from the U.S. border to the Sunshine Coast[i]
- The area affected by the most severe impacts is roughly 45,000 km^2 (lesser impacts are felt across a much larger area)[ii]

i. The 20-kilometre band corresponds to 20%g in NRCan RiskProfiler. More sporadic damage will occur farther inland due to local shaking amplification, secondary hazards and vulnerable structures.

ii. Aftershocks may occur on other faults and broaden the impact zone and may interact with other climatic hazards.

Figure 5.6.1: Number of completely damaged buildings in the area affected by the earthquake (created by GeoBC).

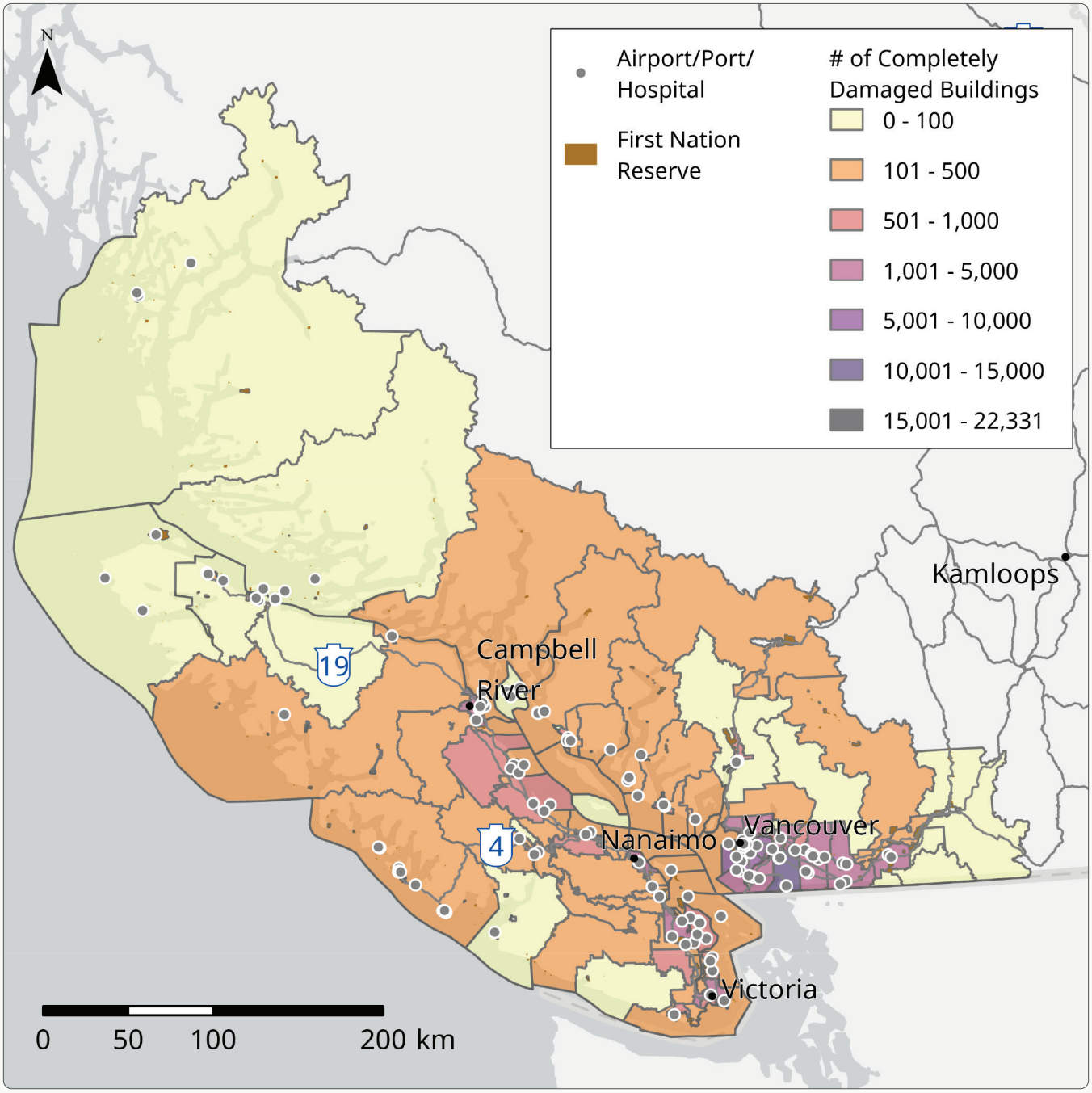
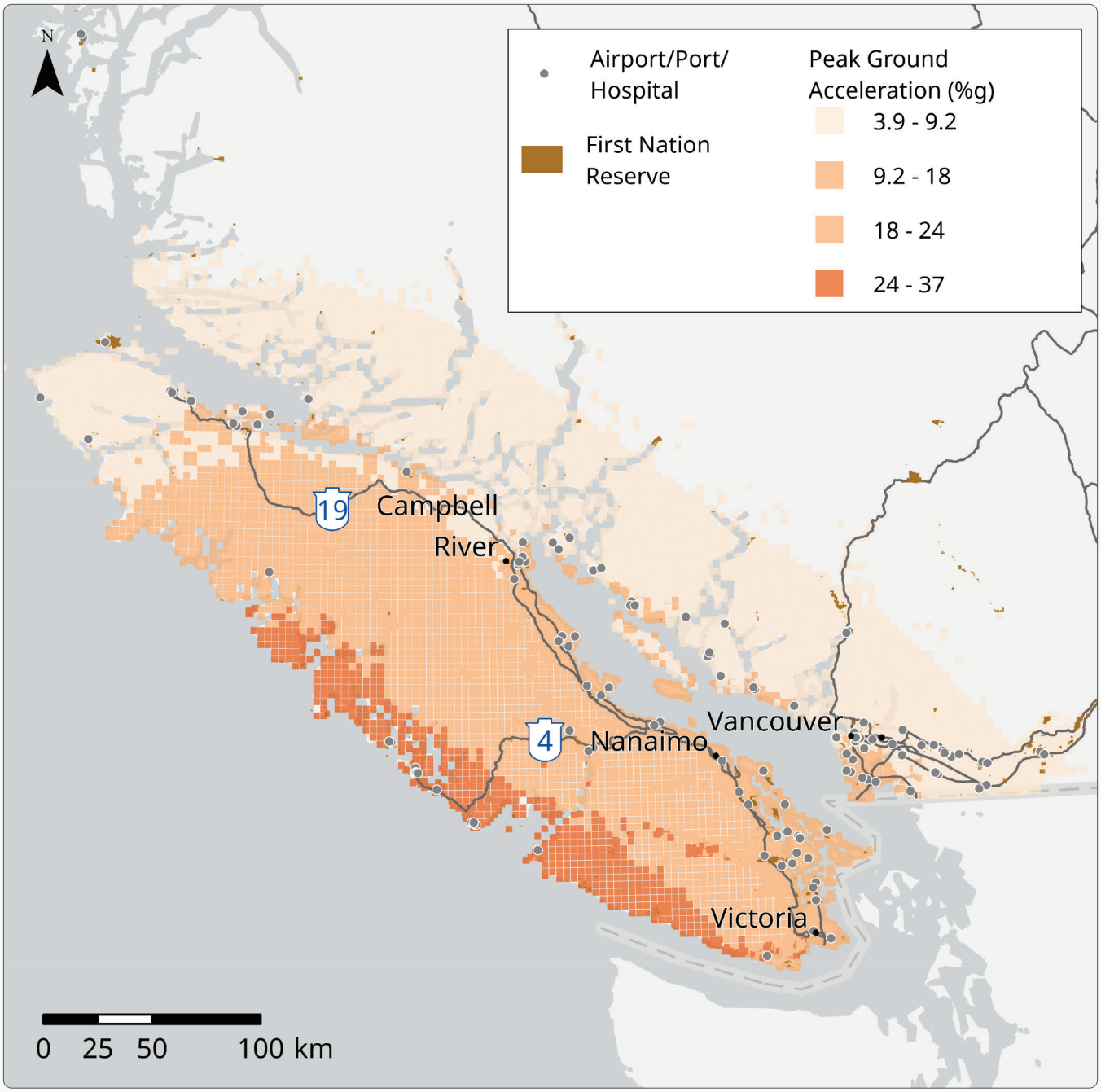


Figure 5.6.2: Peak Ground Acceleration (%g) and the location of airports, hospitals and ports in the area affected by the earthquake (created by GeoBC).



Time

- Earthquake (mainshock): Daytime in August; 10 am
- Aftershock of interest: Nighttime in September; 11 pm

Duration

- Earthquake (mainshock) shaking duration: Three minutes
- Tsunami (multiple waves) duration: Several hours
- Aftershock: While many aftershocks follow the mainshock, one notable aftershock occurs about a month later and has a shaking duration of 20 seconds

Intensity

- M9.0 rupture extends for about 1,000 km from mid-Vancouver Island to northern California
- M7.1 aftershock occurs 60 km deep under Sidney

Seasonal and weather conditions

- Earthquake (mainshock): Summer; ongoing heatwave (30°C–40°C) and smoke from wildfires
- Aftershock: Fall; atmospheric river

Comparable events

- 1700 Cascadia subduction earthquake, comparable in terms of its magnitude, impact area and tsunami generation; however, the impact area in B.C. now hosts a lot more people and infrastructure
- 2004 M9.1 Sumatra earthquake, comparable in terms of its tectonic setting, length of rupture and tsunami generation

Correlated or cascading events

- Tsunami
- Urban fires
- Liquefaction
- Landslides, rockfalls and avalanches
- Floods and seiches (sloshing of water in lakes, ponds and other enclosed water bodies)
- Aftershocks
- About 1 m of subsidence on the west coast of Vancouver Island

Likelihood of extreme event

- Annual likelihood: Remote (< 1%)
- Likelihood in the span of 10 years in current conditions: Moderate (2% to < 10%)
- Likelihood in the span of 30 years in current conditions: Moderate (2% to < 10%)
- Likelihood in the span of 50 years in current conditions: High (10% to 20%)
- Confidence in likelihood: High

Though a 10,000-year paleoseismic record of Cascadia subduction zone earthquakes is available, it remains a challenge to identify the magnitude of past ruptures and, therefore, the actual probabilities of M9+ earthquakes are dependent on the assumptions made in these calculations.

The return period for this earthquake is 400–500 years on average. This estimate is obtained from the paleoseismic record from about 10,000 years ago and indicates a return period of anywhere from 200 years to 1,000 years in past events. The annual likelihood of this event, based on this evidence, is less than one percent. As of 2024, it has been 324 years since the last subduction interface earthquake, which occurred in January of 1700 (shown by various lines of evidence, but most precisely by written tsunami records in Japan). Accordingly, the likelihood of an event occurring in the next 10 years is about three percent, and about nine percent in the next 30 years.

Since stress accumulates on the subduction interface, the likelihood of the next such event increases over time. For example, 50 years from now, the likelihood in the span of 10 years and 30 years will increase to 5 percent (Moderate) and 14 percent (High), respectively.

Assessment of consequences

Natural environment

The tsunami quickly inundates coastal areas, leading to severe erosion, salinization of soils, and destruction of coastal ecosystems such as estuaries, marshes and tidal flats. These ecosystems support many species of birds, fish and other wildlife. The physical impact of the tsunami damages and destroys nearshore marine habitats, including kelp forests and eelgrass beds, which serve as important nurseries for marine life. Additionally, the incursion of saltwater inland is devastating to forests, creating ecological damage that will take years—likely decades—to remediate. The tsunami also brings debris that impacts marine life, coastal communities and navigation.

The intense ground shaking causes widespread landslides, particularly in the mountainous and forested areas of Vancouver Island and the adjacent mainland. These landslides alter habitats and bury riverbeds and coastal areas. The earthquake and landslides alter river courses, affecting hydrology and aquatic habitats, including impairments to fish populations, particularly salmon, which are crucial ecologically, culturally and economically.

The earthquake and related tsunami, liquefaction and landslides uproot trees over vast forested areas, resulting in losses in habitat and other ecosystem services. Disturbances to forests, other vegetation and soils alter carbon sequestration dynamics and increase the risk of forest fires in the aftermath. The release of significant amounts of stored carbon dioxide takes place, contributing to global climate change.

The tsunami, landslides, liquefaction and erosion increase sediment and contaminant loads in water bodies, negatively impacting water quality and fish habitats along waterways. Fish populations decline. Other flora and fauna are affected in coastal environments and in inland water bodies experiencing extremely large waves (seiches) triggered by the earthquake. The provision of water from rivers, lakes and reservoirs for drinking water is disrupted, with poor water quality creating restrictions on water supply and the need for enhanced testing efforts.

Designated areas are needed to dump the large amount of earthquake zone impact debris, some of which is toxic, but such dumping damages and destroys important habitats, with long-term ecological health effects. Other toxic and hazardous materials that were previously secured are finding their way into water sources and soils, complicating recovery efforts and posing long-term health risks.

The cumulative effect of these disturbances leads to biodiversity losses in B.C., as the magnitude of the impact will be devastating. Species, including species at risk, either perish in the immediate aftermath or fail to adjust to the dramatically altered environments. Since the affected area hosts a disproportionately high number of species at risk and endemic species, biodiversity losses are significant. Additionally, with predator-prey relationships and plant-pollinator interactions disrupted, long-term changes in ecosystem structure and function are expected. Ecosystem recovery in and around the earthquake damage zone takes decades, although some impacts, such as the extirpation of localized species populations, are permanent.

Built environment

A megathrust earthquake and its aftershocks, along with many concurrent and cascading events, severely impact the built environment.

Buildings

The ground shaking from the mainshock causes complete damage to about 18,000 buildings; in addition, about 10,000 buildings will experience extensive damage.[19] The damage is worse on the southern half of Vancouver Island. Still, significant damage is also observed in older neighbourhoods of cities across southwestern B.C., including Vancouver, where there are seismically vulnerable unreinforced masonry buildings, pre-1990s concrete buildings, and older wooden apartment buildings with tuck-under parking (parking openings at the ground, typically found at the back half of the building and supported by wood or steel posts (see Figure 5.6.3; see also text box on seismic building code levels in Canada).

Urban areas with tall buildings on deep, soft sediments (for example, parts of Richmond) that resonate with the long-period seismic waves generated by the subduction interface earthquake also suffer significant damage (see Appendix C). Many pre-1970s homes that are not bolted to their foundations fall off or are swept off their foundations as the tsunami inundates low-lying areas.

Figure 5.6.3: Apartment buildings with tuck-under parking are especially vulnerable to ground shaking and ground failure.

Seismic building code levels in Canada

The terms Pre-Code, Low Code, Moderate Code and High Code, in the context of seismic building codes in Canada, are related to the era and requirements of construction, reflecting how well buildings are designed to withstand earthquakes. These levels apply to the vast majority of existing building stock in B.C., which falls under the Normal Importance Category,[20] for which the performance goal is to prevent loss of life through collapse prevention. Existing buildings are only required to consider seismic retrofitting in the case of significant alterations to the building.

- **Pre-Code:** Refers to buildings constructed before any seismic design codes were in place, typically before the 1970s. These buildings are not designed with earthquake resilience in mind and are considered highly vulnerable.
- **Low Code:** Applies to buildings constructed under early seismic design regulations, often between the 1970s and early 1980s. These codes introduced basic seismic provisions, but they were less stringent, compared to modern standards.
- **Moderate Code:** Refers to buildings constructed under seismic codes developed in the late 1980s to early 2000s. These codes provided more comprehensive requirements for earthquake resistance but may not meet today's higher resilience standards.
- **High Code:** Refers to buildings constructed according to the most recent and stringent seismic codes, such as the 2015 and 2020 National Building Code of Canada, which incorporate advanced knowledge of seismic hazards and structural performance.

The direct economic loss from building damage due to mainshock ground shaking is around $38 billion.[21] Shaking damage to infrastructure, along with damage to buildings and infrastructure as a result of secondary hazards such as liquefaction, landslides, tsunamis and fires following the earthquake, increase the economic losses. Many of the fatalities and severe injuries occur in damaged, unreinforced masonry buildings and older concrete buildings designed before the development of current seismic requirements in building codes.

The ground shaking causes fires, particularly in dense urban zones, in the two days that follow the earthquake. Almost 50 percent of the earthquake-induced ignitions occur in the Metro Vancouver area, while only about 10 percent of the ignitions occur in the Victoria area. A handful of ignitions are concentrated in the central business district of Vancouver, where ignition risk is increased due to overhead power lines near mid- and high-rise buildings. Other ignitions are scattered throughout the affected area in small communities, which are less likely to see simultaneous ignitions. Still, a fire that ignites may involve several buildings on a block or even consume the entire block. Urban fires require quick response before they can spread, but damage to water distribution lines and hindered access make this particularly difficult. Communities that have the ability to use seawater for fighting fires fare better. Fires break out for various reasons, including damaged gas lines, live electrical wires from toppled electrical poles and towers, and damage to ports and industrial facilities housing flammable materials.

Transportation

Access for evacuation and response is severely hampered by damage to transportation infrastructure, especially major transportation corridors in the immediate aftermath of the earthquake. Damage to many other secondary roads and bridges hinders access to communities for search and rescue as well as access to resources for the community. Key bridge structures, roads and rail lines are damaged by ground shaking and are subsequently inundated by the tsunami, limiting the ability to access key locations.

Disruption in road transportation is caused by debris from earthquake damage to buildings and other structures blocking roads. Downed power lines on roads pose an extra layer of difficulty, as the crews need confirmation that the lines are not “live” before they can remove them. The ability to restore critical services depends on how quickly the transportation network is up and running again. Remote communities with a single access route are impacted disproportionately as a result of being completely cut off and the repair crews getting to those routes more slowly.

Water infrastructure and waste infrastructure

The ground shaking, soil liquefaction and landslides damage water treatment facilities, pipelines, dams and reservoirs, leading to significant disruptions in drinking water supply. Breaks in waste and wastewater transport lines and damage to facilities lead to contamination of the remaining water supply, posing serious health risks. Water and pipe

breakages and the fear of contamination cause drinking water shortages.

The tsunami introduces saltwater and contaminants into some freshwater sources, further complicating access to potable water. These contaminants are released from damaged marine and aviation fuel docks, fuel tanks, fuel lines and facilities that house toxic chemicals. The tsunami carries these pollutants inland with the tsunami waters.

Many older dikes in the region have little or no seismic resistance and are damaged, with some failing. These dikes need to be repaired quickly to protect communities from flood risk. Aftershocks occurring during fall and winter storms enhance the risk of flood due to damaged dams and dikes, and shaking-induced landslides.

Sewer pipe breakages and damage to wastewater facilities cause an urgent need for significant alternative waste treatment facilities. Urban waste management services are damaged or not accessible due to damage to key transportation routes, leading to accumulations of waste that could spread disease. Damage to industrial and hazardous waste management facilities could release contaminants into the air or water supply, further exacerbating the impacts of the event on human health.

About 20–25 million tonnes of debris are generated just from the structures damaged and collapsed due to the earthquake shaking. The debris must be broken down and removed from streets to allow for traffic flow to support response and facilitate recovery efforts. The tsunami, landslides, aftershocks and liquefaction add to debris generation.

Energy

The initial earthquake and ongoing aftershocks cause extensive damage to power plants, transmission lines and substations, leading to prolonged power outages across the region. Damage is also likely to impact major fuel processing and storage locations and LNG refining sites, which are coastal based. These include two Indigenous-led LNG projects (Ksi Lisims and Cedar—Nisga'a and Haisla). Damaged roads and disrupted transportation modes delay the repair and restoration of energy infrastructure, exacerbating the outage duration. Damage and disruptions to fuel and gas distribution create shortages that affect many individuals, industries and commercial activities, as well as first-response activities.

Information and communication

The communication grid is significantly impacted due to both damage to and increased load on this system, leading to loss of communications for the general public. This hampers evacuation and response activities and causes anxiety in individuals who cannot confirm that families and friends are

safe. Mobile communication antennas are deployed in large urban centres, but many communities have to wait until facilities and antennas are repaired. Disruptions in communications continue for days to weeks. Some key wireless links are maintained and access to emergency personnel is prioritized, leading to a prolonged lack of access to communications for the general population. Disruption in communications makes it difficult for coordination teams to quickly assess needs, such as search and rescue, hospital functionality and utility restoration. This can delay getting the right resources to the areas that need them most.

Society, cultures and relationality

While most people shelter in place during the initial earthquake, many are on the streets, especially with ongoing aftershock activity or lack of a safe place to shelter. There is a widespread and immediate demand for rapid damage assessment of all structures, particularly residential buildings, since people want to know whether they can re-enter their homes.

People need shelter until their buildings are assessed, and even then, some are too scared to re-enter their buildings even if they are not tagged red, as ongoing aftershock activity is a constant reminder of the risk. Shelter needs are further exacerbated by the fact that an ongoing heatwave requires the shelters to have adequate ventilation and cooling. Some public buildings used for shelter are unsafe and social services infrastructure, particularly for systematically marginalized populations, is unavailable. This includes medical centres, safe injection sites, religious and cultural centres of ceremony and worship, schools, universities and workplaces. People in search of safety, supplies and services may migrate further from the epicentre of the earthquake or take shelter in newly erected temporary facilities.

People are thirsty within 24 hours, and it is unclear whether the water is potable and where it can be accessed. There is also a need to ensure that places of shelter are safe, and authorities and emergency service providers do what they can to address the fear and anger and the "opportunity crimes" that increase in the aftermath of the earthquake. Food and medical supply shortages follow, leading to the start of resource hoarding in some communities and the need for greater security and novel ways of distributing these goods and services.

Buildings with seismic upgrades (such as schools) are repurposed, disrupting children's educational continuity, connection to other children, and support from teachers with whom they

have formed positive bonds. Remote communities are cut off from government assistance for extended periods as a result of the extent of damage to transportation infrastructure and the focus on opening priority routes. This keeps numerous small communities across B.C. isolated, particularly because the tsunami impacted ports, docks and rail infrastructure.

During aftershocks, structures that have been damaged are at risk of collapse. Aftershocks continue for months, and weather conditions shift with the approaching winter and usher in extreme winter events, such as an atmospheric river and potential floods, ice storms or snowstorms, which compound pre-existing hazards. The power that was re-established after the initial event is out again in a large area, making it hard for people to evacuate their buildings in the dark and in the rain. People who still require permanent shelter after the main event now grapple with cold temperatures and flooding in their temporary shelters. Food insecurity grows and food safety is compromised due to lack of refrigeration and contamination by insects and rodents, leading to illness.

Given the magnitude of the event and severity of the impact on infrastructure, many people choose to move out of high-damage zones, breaking up communities and weakening family and neighbourhood bonds. Internal migration of people causes significant shifts in community demographics across the province. Staff, frontline workers and volunteers, who are supporting communities while also contending with the impacts of the earthquake themselves, experience severe mental health impacts and physical exhaustion, which has negative effects on family connections and their capacity to continue to provide services. Concern grows about a diminishing workforce in this time of crisis.

Infrastructure damage affects religious and sacred sites, disrupting community convening efforts post-earthquake and making it difficult to bring people together to grieve loss, build strength and make meaning within the devastation—which is what people need to rebuild and return to a new normal of daily life.

Without receiving guidance from the local authorities or the Province, particularly while governments address gaps in their trained workforces, community members and organizations self-organize to address immediate societal needs. Neighbours help each other, individuals volunteer within communities, and communities assist other communities. In the immediate aftermath, places where people are closely connected do better than areas where residents do not have these established relationships. Through their intimate knowledge and interconnectedness with the land, isolated First Nations maintain their cultural

teachings, ceremonies and practices following the event, enhancing their resilience. Some communities seek support from those outside of impact areas, connecting through social and informal networks to provide leadership, resources and renewed hope.

Disproportionate social impacts from earthquakes

Individuals of lower socioeconomic status are often housed in seismically more vulnerable building stock, such as older (pre-1990s) and unreinforced masonry buildings. This population is also less likely to have means for structural mitigation strategies and comprehensive insurance policies and, at the same time, tends to have more people living in single-family homes. Immigrant and migrant populations and tourists sometimes lack the language capabilities to follow government announcements about disaster mitigation, aid and support. Because of this, if they are separated during post-earthquake relocation efforts, their reconnection to each other and to the community can take longer.

Health and wellbeing

People trapped under partially or fully collapsed buildings need immediate help. However, in the initial chaos, it takes time to determine where assistance is needed. Search and rescue teams are deployed, but due to damaged and debris-filled roads and transportation corridors, it is difficult to access people who need help.

The mainshock alone results in thousands of people being killed,[22,23,24] more than a thousand people with critical injuries, and more than 10,000 people with noncritical injuries requiring hospitalization.[25] This overwhelms the already stressed healthcare system. Staff shortages and difficult working conditions are caused by damage to some hospitals, power and service outages, too few beds for a large influx of people, difficult commutes to healthcare facilities, and personal responsibilities (see Appendix C, case study 4). Patient triage stations are overwhelmed and are much slower than usual, adding to the initial death toll. Hospital operations are hindered by thousands of uninjured, distraught people overwhelming the hospitals—looking for loved ones and seeking shelter.

After the earthquake, thousands more are killed or injured by triggered hazards, such as the tsunami, aftershocks and fires. People dependent on healthcare equipment cannot get the care they need due to facility damage, power disruption, and the depletion of medical equipment and supplies due to a large increase in demand and delays in the supply chain.

Impacts to acute and chronic health issues increase: respiratory disease due

to toxic smoke from fires in ports and industrial facilities; infectious disease caused by exposure to contaminated water, damage to supply chains and treatment systems, and overcrowded shelters and temporary living conditions resulting from displacement; food and water insecurity due to water shortages, damage to water and food supply chains and treatment systems, and decreased availability of local and traditional foods as a result of damage and disruptions to food systems and infrastructure; and in the longer term, allergic and hypersensitivity reactions from living in homes with moisture or mould buildup resulting from flooding. Significant secondary, or downstream, health impacts arise from these initial health concerns. For example, food insecurity and undernutrition lead to weight loss, adverse birth outcomes, child development issues, exacerbation of chronic disease, and increased healthcare burden.

Beyond physical health, the earthquake and its many concurrent and cascading events lead to significant psychosocial health risks among those directly exposed, such as emotional distress, anxiety, insomnia, depression, post-traumatic stress disorder, substance use and abuse, and suicide and suicidal ideation. Further, experiences of vicarious trauma and other emotional health impacts, such as ecological grief and anxiety, stem from witnessing the impact of this extreme event on others. Psychosocial health is greatly impacted by property damage, the destruction of sites of significance, displacement, and the loss of valued lands and ecosystems. All of these impacts undermine livelihoods and reduce opportunities for engaging in important spiritual and cultural activities. Displacement and migration increase social isolation and decrease people's sense of social support. Familial and financial stressors increase due to crowded and unstable housing situations resulting from displacement.

Economy

Two to three million people experience immediate disruption of their jobs when offices, stores and other workplaces close down temporarily or, in the case of severe damage, permanently. Businesses in facilities that remain standing and safe enough to occupy are not able to fully reopen until all services (transportation, power, water, sewer, communications, heating, etc.) are restored. Grocery stores lose goods that require refrigeration as the loss of power leads to spoilage, and gas stations, if they can operate, have limited fuel supplies, hindering personal and commercial transportation and disrupting supply chains.

There is significant economic disruption as many people, particularly those working for small businesses, are without an income until the business is restored to a semi-normal operational state. People who live paycheque to paycheque or with low financial security experience greater impacts due to the loss or interruption to revenue or employment. The situation is exacerbated by the fact that banks in the region stay closed until basic services are restored, and even ATMs are disrupted by power and communication outages and difficulties in transportation to service them. Businesses that can stay open struggle with a lack of staff, as people cannot come back to work due to health reasons (injuries to themselves or their families), transportation disruptions and critical responsibilities. Some workers find the trauma of the big earthquake and the ongoing aftershock activity too stressful and leave southwestern B.C entirely.

Remote communities are particularly vulnerable, as without direct communication, their situation remains unknown until they can be reached by air. In the interim, some communities rely on an informal economy—bartering goods and services and using any available cash—while official systems of trade and finance are disrupted. The coastal areas, especially the west coast of Vancouver Island, experience changes in land elevation, necessitating new safe zones for tsunamis and strategies for food distribution to scattered populations that are suddenly disconnected from typical supply chains. Many coastal communities economically depend on fisheries and are further impacted by the earthquake and tsunami damage to coastal systems of fauna and flora.

The impact on the insurance industry will be significant, as insured losses exceeding $42 billion trigger the systemic failure of Canada's property and casualty (P&C) insurance industry.[26] Claims for damages soar, challenging the industry's capacity to respond quickly enough for businesses and households to get back on their feet. The industry has to address not only the direct damages to properties but also the additional living expenses for displaced residents and business interruption payouts. The time taken to gain access to the damaged areas for repairs and reconstruction further delays the process, increasing the pressure on the insurance industry to meet the surge in claims for both residential and commercial properties. Governments and other entities have trouble accessing material and resources to start repairing and rebuilding. The amount of reconstruction happening all at once causes shortages in labour and materials, driving the construction costs up.

Damage to Vancouver International Airport, the Port of Vancouver, and key road and rail access leads to long-term disruptions to the flow of goods and people in and out of the

province, disrupting the movement of food and supplies to the general population and greatly affecting provincial and national economies.

Tourism, a vital component of B.C.'s economy, suffers a sharp and immediate break. Downtown Victoria's high concentration of seismically vulnerable heritage buildings is strongly impacted. The downtown core remains closed for months to years due to the extent of the damage, affecting provincial government operations, the many businesses based there, and the tourism industry. Older parts of Vancouver, such as Gastown and Yaletown, are similarly impacted. The fear of aftershocks and ongoing risks deters visitors, leading to an extended period of reduced tourist activity. The time required for recovery and rebuilding further extends this period, affecting all businesses and services tied to the tourism sector. The loss of confidence requires careful management to aid in the economic recovery of the region.

The total economic losses are valued at about $128 billion, with economic growth reduced to half in the aftermath of the earthquake, leading to a cumulative GDP loss of nearly $100 billion and 43,700 jobs lost over the next 10 years.[27]

Governance

The Early Earthquake Warning (EEW) system is triggered, providing crucial time for people to act, thereby reducing injuries and deaths. In the future, the EEW system will be significantly enhanced through the implementation of automated response devices and applications that will be triggered by EEW messages. Such future automated responses have the potential to slow down trains and stop traffic from driving onto bridges and tunnels, etc. While these automated actions are not yet enabled, they could greatly reduce damage and related injuries, allowing people to focus on their own protection. The EEW system provides a case for investing in risk management to save lives and reduce impacts.[28]

The Province declares a State of Provincial Emergency (SOPE) to enable the use of emergency powers needed for response activities. Ministerial Orders are issued under the Emergency Management Act and other legislation to address specific issues, as needed. First Nations and local authorities on Vancouver Island and the Lower Mainland are anticipated to issue a local Band Council Resolution (BCR) or to declare a State of Local Emergency (SOLE).[29] The Provincial Regional Emergency Operations Centre (PREOC) in the Vancouver Island Coastal and South East regions are activated, as well as the Provincial Emergency Coordination Centre

(PECC). However, the functionality of the PREOC and the PECC are compromised due to damage to facilities and impacts on staff. The PREOC and the PECC require operating at alternate locations. First Nations and local authorities are prepared to varying degrees.[30]

Due to the magnitude of the event, the formal response capacity of First Nations and local authorities within the impact area is overwhelmed, resulting in limited and delayed local response activities. Immediate support from the provincial and federal governments and other organizations is required. Some of the local emergency operations centres (EOCs) are delayed in activating due to the impact on staff and facilities.

The provincial government, one of the largest employers in the Victoria region, is significantly impacted by the earthquake, with disruptions to key services and infrastructure. Buildings, including the legislature, suffer damage, and critical infrastructure such as power and communications are affected. Transportation routes are severely hindered, preventing government employees from reporting to work. This creates gaps in the Provincial response and other essential services. As a result, response efforts rely heavily on staff from outside the region to coordinate across numerous agencies including provincial and federal ministries, First Nations, local authorities and critical infrastructure operators.

Damage to transportation routes and the prioritization of essential personnel and supplies make mass evacuation impossible, and the public is directed to shelter in place. Many schools, retrofitted under the B.C. schools program, can be used as temporary shelters after safety assessments. However, challenges arise in other areas—local search and rescue teams are overwhelmed, and resources from other parts of B.C., other provinces and the U.S. are delayed due to widespread transportation and communication disruptions.

Within 24 hours, access to safe drinking water becomes limited, and distributing bulk potable water across the affected region remains challenging for the first four to five days. Food shortages follow, leading to panic and looting in some areas, which escalates the strain on government resources. Concurrent events overwhelm local capacity, and the Emergency Support Services model, while active, struggles to manage the scale of the disaster. Staff and volunteers, already limited in number, must prioritize immediate rescue efforts and basic safety needs.

Fatalities from the earthquake, tsunami and related impacts are estimated to be in the thousands, requiring additional government resources

for body identification and handling. Meanwhile, the government faces pressure to conduct post-earthquake building assessments as aftershocks continue. Damage assessment teams are overwhelmed, with buildings tagged red (do not enter), yellow (restricted access) or green (safe), leaving about two million people in need of alternate housing.

The response demands the involvement of many levels of government, including collaboration across all levels and sectors. However, a lack of redundancy in key positions and limited geographically diverse leadership hinders decision-making, further complicating the understanding of the situation and the ability to communicate effectively with partners and communities.

As decision makers prioritize rebuilding efforts, they face ongoing mental health challenges and staffing strain. The gaps in government action during the recovery phase lead to a loss of trust and reputation among residents.

The recovery will come at a significant cost to all levels of government, adding about $122 billion in net new debt to government.[31]

This major earthquake has lasting effects on the governance of the region. The immediate aftermath exposes weaknesses in existing disaster response mechanisms, infrastructure resilience and resource allocation, prompting a comprehensive review and overhaul of governance structures. In the long term, this can lead to significant policy changes, including stricter building codes, improved urban planning and enhanced emergency management protocols. The disaster may also shift political priorities, with increased focus and funding directed toward risk reduction, climate adaptation and infrastructure modernization. Additionally, the recovery process can reshape relationships between different levels of government.

This event provides evidence of the value of past investments in earthquake risk management measures, such as the seismic retrofits of schools,[32] the newly established Early Earthquake Warning system,[33] funding programs including the Disaster Risk Reduction-Climate Adaptation fund, and the Disaster Resilience and Innovation Funding program.

Despite all efforts, the public's trust in institutions is significantly impacted due to the shortcomings of the response and recovery efforts. This can result in changes to leadership, institutional reforms, and new approaches to community engagement and participatory governance. Furthermore, the earthquake's socioeconomic impacts may necessitate long-term changes in

fiscal policies, social welfare programs and economic development strategies, fundamentally altering the governance landscape of the affected region for years or even decades to come.

5.7 Multi-hazard event including drought, heat, wildfire, floods and a moderate earthquake

Context

British Columbia's diverse landscapes create conditions for many natural hazards. This includes from the coast, where flooding and tsunamis can occur; inland waterways that can also flood; steep mountains that create conditions for landslides; volcanoes that can erupt; and forests that can burn. All of these hazards pose risks on their own, but it is also important to consider how they overlap in time and space, and how they interrelate to and with each other, often amplifying and exacerbating the hazard severity and resultant consequences. To add complexity, multiple hazards can occur in chains, as one hazard triggers or creates conditions for another hazard.

The type of wildfire, atmospheric rivers and flood events chosen for this scenario have occurred in this combination before and are highly probable to occur again (see Chapter 2, Table 2.8.1). This multi-hazard event also includes a moderately sized earthquake which, although this has not occurred recently, is a known hazard with an increasing likelihood of occurrence. As climate-related events become more frequent, the probability of an earthquake occurring in combination with an unrelated event increases and is therefore explored in this scenario.

Course of the event

Drought and heat events – Following a two-year drought, a large heat event occurs across the province in July, with particularly intense heat in the interior of B.C.

Wildfire event – The drought and heat events set conditions for a wildfire in late July. This occurs adjacent to Highway 3, about halfway between Manning Park and Princeton. This wildfire remains uncontrolled throughout August and impacts the local area when mostly recreational communities and some resource sites are evacuated. There is some damage to rural properties and transmission lines. The region and province, more broadly, are affected by the closure of Highway 3, which creates disruption to the movement of people and goods between the Lower Mainland and the Interior. The wildfire is extinguished in late September.

Atmospheric storm/floods/debris flows – As the wildfire season across the province comes to a close in the fall, the southern part of the province experiences a series of atmospheric river events that result in significant rainfall across the region. In mid-November, the Similkameen River floods the town of Princeton, as well as a number of rural homes in the region. The wildfires of the previous summer have damaged the ecosystem and created hydrophobic soils, exacerbating the severity of the flood events. Water is not absorbed into the landscape and flows off quickly, creating steep creek hazards.

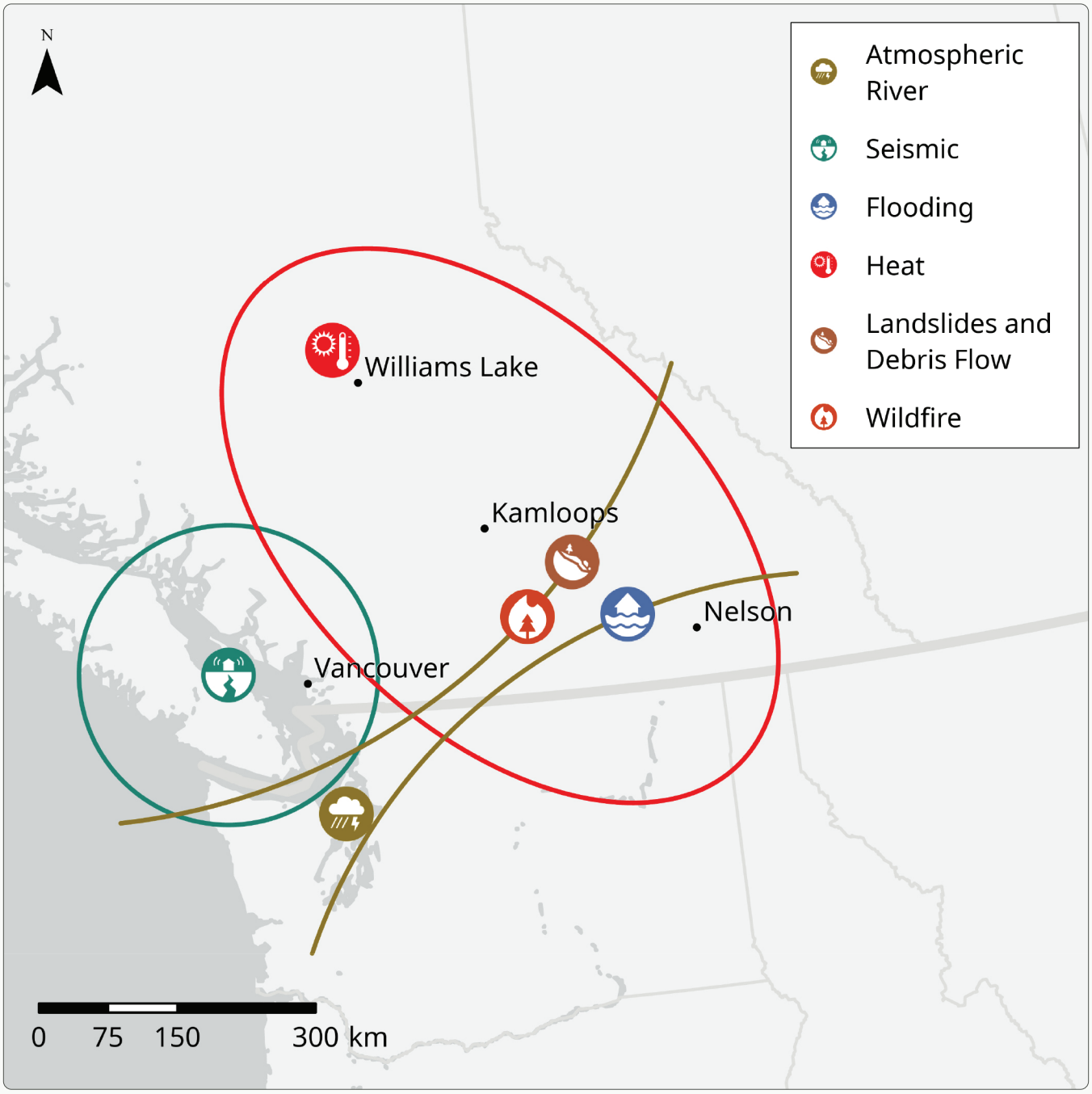
Earthquake event – In late November, just as the southern Interior begins to dry out post-flood, but before permanent repairs to flood- and landslide-damaged structures and infrastructure are completed, the Lower Mainland suffers a magnitude 6 earthquake in the Strait of Georgia. This causes light to moderate damage across the Lower Mainland and the east coast of Vancouver Island, with breakdowns in transportation networks and critical services including hospitals. There are widespread power outages and spot fires across the region.

Scenario parameters

Location

- Southern B.C., with nodes in and around Princeton, as well as the Lower Mainland

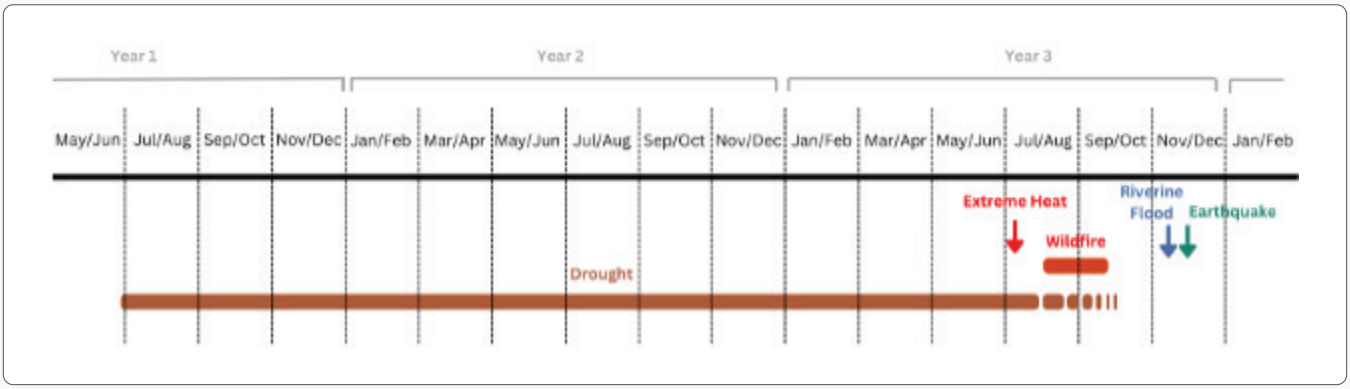
Figure 5.7.1: Area impacted by multi-hazard event (created by GeoBC).



Duration

- Days for the earthquake, weeks for the flooding, months for the fires, years for the drought
- The whole cascade occurs over a period of 2.5 years, with key events occurring between July and November within a single year; there is minimal overlap in the hazard events, but significant overlap in recovery periods

Figure 5.7.2 Timeline of multi-hazard event.



Intensity

- Each event is of moderate intensity on its own

Seasonal and weather conditions

- Multi-year, with most hazards occurring in summer through fall
- Weather is varied

Comparable events

- Drought and Heat: Present and 2021
- Wildfire: 2021 Garrison Lake Wildfire
- Atmospheric River: November 2021
- Floods and Landslides/Debris Flows: November 2021

Likelihood of extreme event

- Annual likelihood: Remote (<1%)
- Likelihood in the span of 10 years in current conditions: Low (1% to <2%)
- Confidence in likelihood: High

The annual likelihood of the first three hazard events occurring as a cascade is Moderate (2 to <10 percent), but the addition of the earthquake hazard as part of the multi-event scenario reduces the likelihood to Remote. In 30 years, the likelihood increases to Low for the full suite of hazards due to the probability of earthquake increasing.

Assessment of consequences

Natural environment

Continued drought has the cumulative effect of drying fuels in the forest and grasslands. The heat event after this drought leads to a highly flammable landscape, resulting in a wildfire burning forests and vegetation. The destruction of essential habitats and mortality of wildlife that cannot outpace the fire threaten the biodiversity of plant and animal species in the affected areas. Wildfire smoke and ash severely affect air quality, with immediate adverse effects on wildlife health and long-term impacts on plant life. The intense heat from the fire burns organic matter in soils, which degrades soil quality and nutrient availability and increases the susceptibility to erosion.

Wildfires release carbon stored in vegetation and soils into the atmosphere, contributing to climate change. These hazard events disrupt the carbon cycle, affecting carbon sequestration rates in terrestrial and aquatic ecosystems, but in not entirely predictable ways.

When the fall rains arrive, the burned and drought-stricken landscape struggles to absorb water, leading to rapid runoff and increased flooding. Floodwaters carry large amounts of ash, charred debris and loosened sediment from the wildfire-affected areas into rivers and streams. Water quality degrades, harming aquatic life by reducing oxygen levels, clogging fish gills, and covering fish spawning grounds with sediment. The increased sediment loads also disrupt the natural flow of rivers and streams, altering habitats and the protective services they provide, and exacerbating flood risk downstream.

The combination of floods and steep creek hazards alter streambeds and affect aquatic habitats, with fish populations suffering from poor water quality and substrate. On land, flooding destroys plant life and displaces wildlife, threatening biodiversity.

In the wake of the wildfire and floods, the moderate earthquake in the Georgia Strait triggers landslides and exacerbates soil instability, especially in areas near the Georgia Strait where fires cleared vegetation. The loss of root structures that typically stabilize the soil leads to increased erosion and sediment deposition in rivers and streams. The earthquake also physically changes habitats. Fallen trees, rockslides and ground deformation change the landscape, disrupt ecosystems and affect the natural flow of waterways, further stressing aquatic and terrestrial species in these habitats.

Ecosystem recovery is prolonged and complex. Forests and vegetation take years to regrow, and during this time,

the soil remains vulnerable to erosion and to future extreme events. Wildlife populations adapt to the changed landscapes and waterscapes, but local extinctions occur due to habitat loss or impairment and changing availabilities of resources to support life requirements.

Built environment

Buildings

The large regional heat event impacts the use and functionality of many types of buildings. In many cases, older residential dwellings in smaller and remote communities are not sufficiently designed to manage heat, which leads to dangerous conditions. Where residents do not have access to safe shelter, regional community buildings are utilized as cooling shelters. Many commercial, industrial and institutional buildings are not able to regulate heat and are temporarily closed to ensure the safety of workers, leading to disruptions in community services. As the heat limits power transmission, this reduced load and increased demand for electricity leads to reduced reliability of the electrical system, particularly for remote communities with backup systems.

When the subsequent wildfires impact these communities, additional evacuations are required, and homes and buildings that support regional services are destroyed, leading to longer term displacement of residents and requiring evaluation as to which structures may be rebuilt and which services may be reestablished.

The atmospheric rivers further exacerbate the impacts on the smaller communities. Key community services and homes in the Princeton area are flooded, leading to additional evacuations from areas in the flood hazard region. Based on requirements to support recovery in the Lower Mainland, there is not sufficient capacity, in terms of expertise, to assist with recovery operations following the flood, and buildings that provide key services remain uninhabitable for weeks.

When the earthquake event occurs, there is significant damage to a range of buildings across the Lower Mainland, especially those that have not been retrofitted to current seismic standards. As many residential, commercial, industrial and institutional buildings are no longer safe to utilize, large portions of the population are displaced for months and many essential services are offline for weeks. Densely populated areas in Vancouver are particularly affected by building damage and displacement from ground shaking, while parts of Delta and Richmond, which are built on the Fraser Delta, are affected by liquefaction-related damage. While this earthquake does not have a direct impact

on the areas in the Interior affected by wildfires, provincial resources are tied up in response and recovery in the Lower Mainland and away from the Interior.

Transportation

Localized disruptions of both road and rail traffic during the wildfire event limit movement of people and goods for days to weeks, primarily due to inspection and repairs to wooden railway trestles in impacted areas.

The atmospheric rivers contribute to damage to road/rail lines and structures along and across rivers and many locations. Debris flows and overland flooding, triggered in areas impacted by the wildfire from the summer, lead to blocked culverts and further severing of services for many days to weeks in some areas. Critical supply chain routes are prioritized for repair, but access to move people and supplies to local communities is impacted for weeks to months.

The subsequent earthquake event leads to some damage to road surfaces and critical structures, such as bridges and overpasses, and creates challenges for movement of people and goods during the initial response and recovery operations. In addition, unstable slopes along the Sea to Sky Highway corridor, already weakened by the prior events, loosen and collapse onto the highway and railway, leading to closures and a fatality. Critical national supply chain road, rail, air and marine infrastructure requires many weeks to reestablish regular operations, which leads to a lack of access to supplies in southwestern B.C. and also to supply chain disruptions across the region and Canada.

Water infrastructure and waste infrastructure

Following multiple years of drought conditions, water supply from both surface and groundwater are impacted and there are regional restrictions on water use for non-essential services. This leads to competition for water resources among communities, industry and recreational users.

When the wildfire occurs, there are additional impacts on the quality of water, based on impacts from ash and fire retardant entering surface water bodies. In smaller communities, the water treatment facilities are insufficient to address these water quality issues and residents need to import water from neighbouring communities. This further taxes the water supply and increases restrictions and competition for water.

The flooding associated with the atmospheric rivers impacts water and waste treatment infrastructure located in the flood hazard area, leading to contamination of the water supply and the requirement for potable water to be imported or boiled prior to use. In the Lower Mainland and the Interior,

the failure of flood protection systems during the subsequent atmospheric rivers causes flooding, leading to inundation of both water treatment and waste management facilities, and contamination of the potable water supply.

Earthquake-induced damage to water supply pipelines and treatment facilities leads to shortages of potable water to support the affected population. Water supplies already compromised by the regional flooding event cannot be reestablished, and regional shortages of potable water persist.

During the extended heat event in the Interior, concerns for worker safety and the ability to run equipment lead to a reduction in waste collection services. This causes a buildup of both residential and industrial waste, increasing the spread of disease.

The atmospheric rivers lead to flooding, which inundates waste management sites and contaminates water supplies, leading to lack of access to potable water for impacted regions.

In southwestern B.C., road closures and damage from the earthquake obstruct access to disposal sites, complicating efforts to manage and dispose of waste safely. The destruction of structures and the earthquake's aftermath generate large volumes of debris, including hazardous materials from burnt structures and damaged chemical storage facilities. Improperly managed waste, especially hazardous materials, leads to further environmental and public health risks, particularly as waste infiltrates waterways or leaches into the soil.

Electrical Energy

In the B.C. Interior, the primary impacts of the drought and extreme heat are on the electrical generation and transmission system. Lower reservoir levels lead to reduced generation capacity for hydroelectric facilities, and heat impacts on transmission lines lead to the requirement to reduce loads. The reduced electrical generation capacity resulting from lower reservoir levels amplifies the difficulty of meeting the increased electrical demand (which is often also stressed by increased air conditioner use during heat events), leading to potential grid failures or rolling blackouts. These failures worsen the societal and economic consequences of the heatwave. These impacts are particularly significant to remote communities serviced by radial lines that do not have the same system redundancy as the larger centres.

The subsequent wildfires will intensify these impacts by requiring further load reductions on transmission lines to avoid electrical arcing. In addition, the potential evacuation of facilities due to safety concerns leads to decreased generation capacity.

In the southern portion of the province, the primary impacts of the atmospheric rivers on the electrical system are: temporary disruption of service, resulting from the loss of power poles/ structures undermined by river erosion; overcapacity reservoirs that require increased spilling; and associated increased river flows that exacerbate flooding in downstream communities.

While the regional earthquake event does not directly impact the Interior, disruptions to the generation capacity of hydroelectric facilities in the Lower Mainland and Vancouver Island strain the provincial system and affect all areas of B.C.

In the Lower Mainland and on Vancouver Island, earthquake-related damage sustained to electrical distribution infrastructure leads to outages of electrical supply to areas over days to weeks, until safe distribution can be reestablished. Operating capacity is reduced at many of the generating stations in the region to assess the impacts of ground shaking on structures. The additional high flow levels associated with the previous atmospheric rivers complicate assessments and prolong periods of reduced operational capacity.

Petroleum

Overall, the drought, extreme heat and wildfire events have minimal impacts on the petroleum transmission pipelines and infrastructure in the Interior. While the heat impacts both people and equipment, it does not lead to significant reductions in service.

The subsequent flooding associated with the atmospheric rivers impacts pipelines due to sections being undermined or exposed by flooding, which leads to short-term operational disruption in the scale of days to weeks to receive approval to restart systems. Oil storage facilities located in the Lower Mainland are not damaged, but key transportation routes to these facilities are, leading to short-term operational impacts.

When the earthquake strikes the Lower Mainland and Vancouver Island, the ground shaking, liquefaction and co-seismic landslides impact pipelines and transmission facilities. While none of these impacts lead to long-term disruptions, damage to transportation networks and impacts on staff lead to extended timelines to inspect and repair damage, in order to resume operations. System outages of days to weeks occur, cutting off the Lower Mainland and Vancouver Island from the supply of oil and natural gas from the north and the east.

Information and communications

During the extreme heat events in the Interior, key data centres have greater energy demand for cooling and therefore draw more power from an electrical grid that is itself compromised by the heat. Reduced capacity of the electrical grid disrupts communications infrastructure and service.

The wildfire events impact microwave transmission due to thick smoke in the area. These outages impact response operations, especially for remote communities with outdated infrastructure.

In the Lower Mainland and the Interior, the atmospheric rivers flood low-lying areas. In some communities, data centres and locations of key services are inundated, leading to the loss of regional data and communications services, which impedes regional response, recovery and reconstruction operations.

The earthquake damages key communication and electrical lines, interrupting service and further impacting response and recovery operations. In some cases, infrastructure damaged by the earthquake is in a vulnerable state, impacting the ability to bring systems back up to an operational state.

Key technical personnel are directly impacted by the hazards, reducing their capacity to assess damage and bring vital services back online during a time of extremely high work volume. Additional resources are imported from other jurisdictions.

Society, cultures and relationality

Ecosystem impacts (such as dry rivers and continued water restrictions) lead to associated psychological impacts (such as anxiety and stress) on communities, resulting from the prolonged two-year drought event. Water and food security is affected by the prolonged drought, leading to tension in communities with insufficient water resources.

The extreme heat event in July leads to disproportionate impacts on communities experiencing inequities, as they are unable to invest in mitigation measures. Low-income, unhoused and elderly populations are particularly impacted by the extreme heat. Cooling centres are initiated in urban and rural communities in local convening spaces.

The wildfire event leads to long-term displacement and relocation of the affected communities along Highway 3 due to damaged housing, impacting the structure and functioning of informal and formal social support networks, such as family structures and neighbourhood relationships. The disruption of the

movement of people and goods between the Lower Mainland and the Interior leads to supply chain disruptions and higher prices for essential goods. This compounds the anxiety and stress for communities affected by drought, heat and wildfire in the summer months. Relocations of evacuees occur in the Interior, putting stresses on community convening spaces to provide Emergency Social Services and accommodation for those displaced by the fire, leading to significant work in host communities to receive and integrate newcomers.

The atmospheric rivers in mid-November lead to alert and trauma fatigue as the communities along Highway 3 are again impacted. Coping capabilities and resilience of communities along Highway 3 are stressed from having to adapt to ongoing events. Princeton, which hosted evacuees during the summer and continues to house long-term displaced evacuees, now faces its own evacuation, and the evacuees from the summer are displaced again to other communities in the Interior. The demand for access to social services and institutional supports is overwhelming, as both existing and newly displaced populations from the Interior are now seeking assistance.

Education is disrupted as a result of the atmospheric rivers, affecting social connections for both children and adults, safety reporting, healthy lunch programming, and learning continuity for youth and children. Food security is impacted by the compounding drought, heat, wildfire and atmospheric river events, affecting the availability of affordable and nutritionally appropriate foods, as well as access to traditional and cultural foods. Continued displacement from the wildfire and floods will create barriers to continued care for animals and will make it difficult for evacuees to feel connected to their landscapes and homes.

Following these events in the Interior, the earthquake shifts resources and emergency response efforts toward the Lower Mainland and Vancouver Island. Power outages lead to stressors on community convening sites that are now being used as heating centres, as it is cold in late November and power outages are prolonged due to the widespread impacts across both rural and urban areas. Demand for social services increases, and social support services are impacted as the infrastructure they operate out of is damaged, and the staff is affected. Supply chains are deeply impacted, as transportation out of the Lower Mainland to the Interior and to Vancouver Island is inhibited. This has implications for food security and the affordability of nutritious food across the region. Education is impacted as retrofitted schools and community centres convert to Emergency Operations Centres through Emergency Social Services. Neighbourly and familial networks are essential to support evacuees and the long-term rebuilding

and resilience of communities. There is a growing need for social, cultural and spiritual supports as communities seek to adapt to their current situations, gather resources to build resilience and make meaning in the midst of cascading climate events, and as they attempt to build and maintain resilience and hope.

Health and wellbeing

Heat-related mortality and morbidity rise, and water shortages lead to increased food and water insecurity. Although everyone exposed to these hazards is at risk, certain populations are inequitably affected. Young children, older adults, individuals with pre-existing health conditions, and those who are materially disadvantaged and underhoused face inequitable health risks from extreme heat, whereas water scarcity disproportionately affects rural and remote communities and individuals whose livelihoods depend on the land and the environment (for example, Indigenous Peoples, farmers and fishers). Physical and psychosocial health risks in these groups are exacerbated by intersecting determinants of health, such as lower socioeconomic conditions or limited access to culturally relevant healthcare. These heightened health challenges increase the burden on the healthcare system. Additionally, higher temperatures in healthcare facilities cause medical equipment to overheat, disrupting or delaying medical services (for example, cancelled surgeries) and leading to poorer health outcomes.

The wildfires cause cascading health risks due to direct exposure to the fire and the spread of wildfire smoke, which worsens air quality across the province. Populations already inequitably impacted by heat and drought face additional health challenges. For example, respiratory illnesses become a major concern during periods of poor air quality caused by wildfire smoke, particularly for children and older adults. First responders, such as firefighters, are disproportionately affected due to their exposure to toxic chemicals and long shifts in hazardous and stressful conditions. The emergency response effort will be further hindered by the reduced availability of healthcare workers who have been personally affected by the wildfire, such as those evacuated from their communities.

Flooding introduces new health risks and compounds existing challenges from previous events. For example, it causes further displacement, overwhelming the capacity to provide adequate shelter and services for those affected. This exacerbates social isolation and decreases the sense of social support among those initially impacted by the fire. Familial

and financial stressors increase due to crowded and unstable housing situations resulting from displacement. Disrupted or delayed medical services, caused by damage to essential infrastructure and travel restrictions, leads to poorer health outcomes, particularly in rural and remote locations. For example, road closures caused by flooding and debris flows disrupt the delivery of critical medical supplies, affecting individuals who rely on home dialysis, among others. Medical equipment and supplies, including vaccines, medications and other essential treatment and supplies, are depleted due to increased demand and supply chain delays.

Damage from the earthquake adds pressure to the already stressed healthcare system. Local power outages and breakdowns in transportation networks and critical services are particularly challenging. For example, there is an inadequate number of beds to respond to the large influx of patients. Doctors and nurses have difficulty commuting to healthcare facilities due to blocked roads or are unable to work because of personal obligations to their own families and friends. This prolonged emergency causes a shortage of staff and challenging working conditions. This creates a need for medical support from out of province. Patient triage is overwhelmed and is much slower than usual. People dependent on healthcare equipment struggle to get the care they need because of facility damage, power disruptions and the depletion of medical supplies as a result of high demand and supply chain delays.

Economy

The seasonal workforce, heavily relied upon in various industries, shrinks as the region deals with the intense heatwaves. This reduction in labour results in decreased productivity, particularly in outdoor occupations and those without adequate heat protection measures.

In the tourism sector, visitors stay away, deterred by the hazardous conditions, which leads to revenue losses for businesses dependent on tourist dollars. The agriculture sector, which often carries its own insurance against such events, faces severe financial strain. While provincial and federal agricultural relief programs exist, many crops fail either directly due to the heat or indirectly due to subsequent disasters, with ensuing financial impacts to farmers.

The earthquake adds another layer of complexity, inflicting local damage to public buildings and infrastructure and intensifying the impacts of local wildfires and floods. The capacity and resources of emergency response services are stretched to their limits,

leading to fatigue among responders and a slowdown in emergency operations in the earthquake-affected area, as well as the recovery process in the flooding- and fire-affected areas.

In many municipalities, some buildings and infrastructure are uninsured, which makes recovery slower and more costly because responsibility for repair and rebuild is unclear, and unforeseen costs manifest. Further, critical transportation hubs, including airports and ports, are now closed, disrupting the flow of goods and people—and by extension, the economy at large. With insufficient cash available due to damaged or depleted ATMs and intermittent internet services, a barter system has sprung up.

The behaviour of individuals and households shifts markedly with the earthquake event, as fatigue from multiple hazard events sets in. Earlier in the year, people had a largely communal spirit and empathy toward those more severely impacted; the earthquake brings more individualistic attitudes and behaviours.

The impact on the province's GDP is significant, with different sectors affected to varying degrees and responding differently over time. Some industries are on track to disappear altogether, with a critical mass of businesses in the value chain choosing to relocate or reinvent, rather than rebuild. Others are evolving as the business landscape adapts to new needs and opportunities arise from an increasingly uncertain future. Such shifts lead to the emergence of new markets, or the adaptation of existing ones, to meet the changing conditions and needs of the population.

Governance

Through this series of compounding and cascading events, the systems of governance in British Columbia are pushed to their limits—both at the province-wide scale and at the local scale—in the areas most affected. The following critical challenges and risks arise with each unfolding event.

The B.C. River Forecast Centre has been monitoring and issuing drought advisories over the past two years. Alerts are communicated through the B.C. Drought Information Portal, local governments and media outlets. As temperatures rise in July, the BC Centre for Disease Control (BCCDC) and Environment and Climate Change Canada issue heat warnings and heat advisories. Emergency services and public health authorities activate their extreme heat response plans, ensuring that cooling centres are available and accessible to unsheltered and at-risk communities.

Public messaging is amplified through media, social media and local governments. The BC Wildfire Service, which monitors conditions, issues fire danger ratings of High or Extreme in at-risk areas. By late July, as a wildfire ignites near Highway 3 between Manning Park and Princeton, the BC Wildfire Service, in conjunction with local emergency authorities, issues Evacuation Alerts and Evacuation Orders for affected areas.

Communications are deployed via mobile alerts, local radio, television and social media, advising residents of evacuation routes and safety protocols. Already strained water resource allocation and planning are further strained by increased needs for firefighting purposes. With the wildfire and flooding, First Nations and local authorities issue Band Council Resolutions (BCRs) and declare a State of Local Emergency (SOLE) in the affected areas. Local Emergency Operation Centres (EOC) are activated. Provincial Regional Emergency Operations Centres (PREOC) are activated in the central and southeastern parts of the province.

Emergency support services are activated to provide temporary shelter and supplies to evacuees. Evacuations strain trust in government. Vulnerable populations already affected by the heatwave need additional support during evacuation, but this is lacking. The closure of Highway 3 disrupts the movement of people and goods, straining supply chains and hampering economic activities needed to support and provide for evacuees and their host communities.

In mid-November, a series of atmospheric river events flood the town of Princeton and several rural homes. The B.C. River Forecast Centre issues flood watches and flood warnings, particularly in areas with compromised soil and weakened hydrological systems due to drought. Alerts are disseminated through the B.C. emergency alert system, including real-time updates via radio, TV and text-message alerts.

Residents in flood-prone areas are warned to evacuate or shelter in place, depending on the severity of the situation. Emergency response teams and community-based organizations in the region, still recovering from the summer events, are fatigued and struggle to keep up with the rapid onset of this new crisis. Volunteers are overburdened, with many unable to fully contribute to this event response due to burnout. Additional resources from the provincial government and neighbouring communities are needed to support evacuations, responses and recovery. Decisions are increasingly made in haste, and without proper consultation and input from affected people, as the strain of multiple events sets in. Community trust in government is further eroded. Inadequate business continuity plans challenge response and recovery plans.

In late November, a magnitude 6 earthquake strikes the Lower Mainland. A few seconds before the earthquake, an alert is sent out through the Earthquake Early Warning system. With the earthquake, the Province declares a State of Provincial Emergency (SOPE) to enable the use of emergency powers needed for response activities. First Nations and local authorities issue Band Council Resolutions (BCRs) and declare a State of Local Emergency (SOLE) on the east coast of Vancouver Island and in the Lower Mainland. The Provincial Regional Emergency Operations Centre (PREOC) in Vancouver Island Coastal and Southeast regions are activated, as well as the Provincial Emergency Coordination Centre (PECC).

This event strains provincial resources and communication systems, exposing limitations in capacity and backup in key response positions, due to staff being directly affected by the earthquake. Resources directed toward the Princeton flooding are pulled back to support the Lower Mainland response, significantly delaying recovery in those communities. Emergency services are stretched thin by responding to immediate earthquake impacts while still attempting to support ongoing recovery from previous disasters. The risk of not following due process for decision-making is heightened and further erodes trust in government, as well as trust in relationships between organizations that are critical to effective response and recovery systems.

This scenario underscores the need for a comprehensive, multi-agency response plan that can adapt to the overlapping and compounding effects of simultaneous disasters, ensuring that the public is informed, prepared and supported throughout. In such a scenario, the systems of governance in British Columbia are pushed to their limits—both at the provincial and local levels—in the areas most affected.

Overarching challenges and risks for governance in the face of multi-hazard events

The following describes overarching and critical challenges and risks related to any cascade of events:

Challenges to interagency coordination and resource allocation: Government agencies often operate in silos, which can lead to delays and inefficiencies in planning and response. Historically, extreme events have been treated as isolated incidents that require a specific response. There is now a better understanding of the interconnections and dependencies between extreme events. Despite this, there are still significant gaps in effectively linking specialized government agencies, emergency response teams, and private critical infrastructure owners and operators for coordinated action, which leads to inefficient and less-effective risk management efforts. For instance, during the 2017 Haida Gwaii earthquake, multiple levels of government found it challenging to coordinate, leading to unfavourable impacts on infrastructure, as well as hurried decisions made without proper consultation.

Challenges from outdated policy: Many policies are currently not designed to manage the complexity of cascading extreme events. While multi-hazard planning is being integrated in a current update of EMCR's All-Hazard Plan, other disaster management frameworks are still inadequate for multiple extreme events and their interdependencies and cascading effects.

Challenges from compounding strain on resources: As cascading events unfold, they place significant strain on government, community and private sector resources, which may have already been allocated to previous events. For instance, in 2021, B.C. experienced a series of cascading extreme events, including a heatwave, drought, wildfires and flooding. Each of these events placed significant strain on emergency services, funding and emergency budgets, and led to compounding effects, such as volunteer fatigue, poorer mental health outcomes and business continuity challenges, which cause issues for the successful implementation of emergency response plans.

Challenges to prioritizing response efforts with competing issues: When extreme events occur simultaneously, there may be competing demands for shared resources, such as labour, equipment or funds. During a combined drought and wildfire season, water restrictions or reallocations may be needed to prioritize access for firefighters,

for example. There can also be challenges related to jurisdictional overlaps and a lack of centralized command, leading to an ineffective or inequitable response. During the 2021 heatwave the unsheltered and elderly populations, for example, were severely impacted by heat-related illnesses and death due to poor access to, and a lack of, cooling resources, warnings and information. Without equitable policies and response measures that prioritize vulnerable groups, there is a risk of similar negative outcomes, particularly when dealing with cascading events.

Challenges to proactivity and inclusion: When extreme events cascade into one another, there is little time for proactive planning or consultation between events. This leads to agencies and organizations responding reactively, rather than proactively. It can also lead to responses that lack the inclusion and involvement of local people, and such responses may not be culturally appropriate, especially in Indigenous communities. This can lead to significant communication and coordination challenges between government agencies, and can decrease the likelihood of adherence and cooperation from local people. During the 2023 Shuswap wildfires, emergency response teams and authorities faced challenges related to Evacuation Order defiance. Residents refused to leave their homes, largely due to a lack of trust in government directives, which complicated emergency response. This highlights a need for proactive communication and trust-building measures with communities.

Challenges to recovery: When extreme events cascade into one another, government agencies and organizations must prioritize resources for response to the next event, rather than response to the previous one. For instance, during 2021, the atmospheric river severely impacted the Princeton and the Similkameen areas, which were still struggling to recover from the summer heatwave, wildfires and drought. The floods exacerbated the strain on First Nations, local governments and community volunteers, who were already overwhelmed and lacked resources to effectively manage the events in the prior season. The immediate needs of responding to the floods led to a lack of resources and capacity to attend to recovery efforts, such as the restoration of natural systems, which are essential to long-term resilience. This highlights a need for disaster plans that simultaneously anticipate cascading effects and plan for effective recovery and response.

5.8 Library of critical events

For the Provincial DCRRA, a library of diverse critical events was developed for each priority hazard. A multitude of variables and factors have been considered in developing the diverse set of events—including likelihood, intensity, geographical context and human settlement. The critical events descriptions and likelihood evaluations are based on current conditions, without accounting for future climate change influence.

Riverine floods

Riverine floods can be categorized into various types based on the dominant climate driver, severity and duration of the event. There are several different types of floods across B.C. Understanding the drivers and characteristics of different types of floods can help to clarify the risks associated with each flood type and develop appropriate mitigation and response strategies to minimize the risks and impacts associated with each type. Table 5.8.1 outlines different events with different likelihoods and locations. The mixed-process flood (snowmelt and rainfall) was selected for the extreme plausible event scenario for the Provincial DCRRA. The evaluation of the consequences of such an event is presented in section 5.1.

Table 5.8.1: Riverine flood event types.

Event type	Description	Regions possibly affected	Likelihood
Rainfall-dominated flood (pluvial) – long duration	Floods generated from a significant, longer duration (for example, multi-day) rainfall event, including atmospheric rivers. Rainfall events can trigger other secondary hazards such as steep creek hazards (debris flood and debris flow), groundwater flooding from excessive saturation of the soil, or dam failures.	All of B.C.	Frequent
More information: Multi-day rainfall events occur annually in B.C. and, depending on the rainfall intensity and antecedent condition of the soil, can cause widespread flooding that impacts any community or infrastructure located in floodplains. A narrow band of heavy precipitation from the Pacific, known as an atmospheric river, typically occurs in the fall and winter months and can trigger flooding in the southern portion of B.C., such as the case during the November 2021 flood emergency.			
Rainfall-dominated flood (pluvial) – short duration	Floods generated rapidly due to an intense, localized rainfall event that occurs over a shorter period and over a smaller geographical area (sometimes referred to as "flash" floods). Localized flooding can trigger other impacts such as steep creek hazards (debris flood and debris flow) and landslides or landslide-triggered floods.	All of B.C.	Frequent
More information: This flood type can occur anywhere in B.C., but impacts are often localized to individual sub-watersheds. However, these types of events can occur quickly and can trigger steep creek hazards that transport water and debris such as rocks, sediment and large wood. An inventory of steep creeks and landslide sites can help communities to prepare for this type of flood hazard.			

Event type	Description	Regions possibly affected	Likelihood
Snowmelt-dominated flood (nival)	Floods generated from spring melt of a deep snowpack, such as the Grand Forks 2017 flood. The magnitude of the event depends on the depth of the snowpack accumulated over winter.	All of B.C.	Frequent

More information: This flood type occurs annually during the spring freshet and can result in flooding over the majority of B.C., though snowmelt floods typically impact northern and central interior communities. A period of unseasonally high temperatures in the spring can result in rapid snowmelt and associated flooding.

Snowmelt in the upper Fraser River watershed can result in flood impacts to the Lower Mainland, depending on the amount of snowmelt that accumulates over the winter months and how quickly the snowpack melts in the spring. Snowmelt floods on Vancouver Island and in smaller watersheds along the B.C. coast are generally less frequent, as fall and winter pluvial events generate the highest annual stream flows.

Mixed-process flood (rainfall and snowmelt)	Floods generated from a combination of snowmelt and rainfall events or rain-on-snow events. The combination of snowmelt and rainfall can result in catastrophic flooding and cascading hazards, such as geomorphic channel changes, landslides and steep creek hazards.	All of B.C.	Low to moderate

More information: This flood type can impact most of B.C. During the November 2021 flood event, an atmospheric river occurred during a period of the year when there was an early snowpack, resulting in greater impacts to communities in the Lower Mainland and the Interior from the combination of rainfall and snowmelt.

Event type	Description	Regions possibly affected	Likelihood
Ice-jam floods	Floods occur when river ice accumulates and forms a dam, obstructing the flow of water and causing it to spill over the banks. Ice-jam flooding can result in other hazards such as bank erosion or channel avulsions.	Northern B.C. and Rocky Mountains	Low
More information: This flood type is generally specific to northern rivers (for example, Skeena River and Nechako River) and the Rocky Mountains (for example, Kicking Horse River at Golden), but historical examples of ice-jam flooding in the Interior also exist (for example, Nicola River). These types of floods can cause secondary impacts such as damage from bank erosion.			
Groundwater flood	High groundwater table due to higher-than-normal inflows or precipitation results in flooding. This can occur in areas behind dikes or in other low-lying floodplains with limited surface drainage or infiltration.	All of B.C.	Moderate to high
More information: Floods are often localized in extent, such as the 2017 flooding that affected several First Nations communities due to the impacts of high groundwater levels to septic fields. A high groundwater table can result in secondary impacts such as septic tank backups in isolated communities.			

Coastal floods

Coastal floods are influenced by several factors. Some of these are predictable, such as annual cycles in tides, while other components are less so, such as storm surges driven by atmospheric conditions. Identifying the drivers and characteristics of different types of coastal floods can help us to understand the risks associated with each flood type and develop appropriate mitigation and response strategies to minimize the risks and impacts. Table 5.8.2 outlines different types of events with different likelihoods, locations and capacities of the communities affected. All types of coastal floods can trigger slope instability due to the wave surge, which can cause damage to buildings and infrastructure. This is a main concern in some coastal areas where infrastructure such as liquid waste and sewage lines are buried underground close to the shore. A combination of coastal flood types that includes storm surge, high tide, wind and wave action, and sea level rise was selected for the extreme plausible event scenario for the Provincial DCRRA. The evaluation of consequences from such an event is presented in section 5.2.

Table 5.8.2: Coastal flood event types.

Event type	Description	Regions possibly affected	Likelihood
Storm surge, wind and wave action	Floods generated from a temporary increase in ocean water level due to an atmospheric event such as a storm with wind and a low-pressure system. Wind and waves during such events have additional energy that can trigger slope instabilities and cause erosion and damage of natural barriers such as beaches, dunes and wetlands. They can also cause saltwater intrusions in both surface water and groundwater.	All of B.C.'s coastline	Frequent
More information: This flood type impacts most of B.C.'s coastline, generally on an annual basis during the winter months. These types of storms can impact isolated communities located on the Gulf Islands and cause extensive damage.			
Storm and king tides	Floods caused by the rise of water level during a storm due to the combination of storm surge and the astronomical tide. Extreme high tides, known as king tides, occur in response to the gravitational pull of the moon. Extreme high tides that coincide with storm surges or high winds can lead to localized coastal flooding and erosion.	All of B.C.'s coastline	Frequent
More information: King tides happen twice a year in B.C. but are typically more intense during the winter months. King tides are predictable and on their own generally do not cause flooding, but can if they coincide with a storm surge or high winds.			

Event type	Description	Regions possibly affected	Likelihood
Tsunami	Giant or long-period waves triggered by seismic events such as underwater earthquakes or landslides.	Sections of B.C.'s coastline: west coast of Vancouver Island, Haida Gwaii and the mainland	Remote
More information: Tsunami warning systems are used to provide advance warning of tsunami events for communities such as those located along the west coast of Vancouver Island. These events can occur quickly (over hours) or over days, depending on the magnitude of the earthquake and distance of the epicentre from the shore.			
Sea level rise	Flooding due to the gradual increase in ocean water levels in response to climate change.	All of B.C.'s coastline	Low
More information: Rising sea levels pose a significant threat to coastal areas across B.C. This rise, even if gradual, can exacerbate coastal flooding during storm surges and high tides. Communities in low-lying areas along B.C.'s coastline are susceptible to the effects of sea level rise, as flood protection structures such as dikes were not designed to account for sea level changes.			

Extreme heat

Extreme heat events are categorized in terms of intensity of temperature, humidity and duration (days). Table 5.8.3 outlines different types of heat events on a scale of low intensity and low duration to high intensity and high duration. Heat Warning criteria and Extreme Heat Emergency criteria from the BC Provincial Heat Alert and Response System[34] are used in defining these events. The extreme heat emergency type was selected for the extreme plausible event scenario for the Provincial DCRRA. The evaluation of consequences from such an event is presented in section 5.3.

Table 5.8.3: Extreme Heat event types.

Event type	Description	Regions possibly affected	Likelihood
Low-and-slow heatwave	These are low-intensity, long-duration events with high temperatures at the upper end or just exceeding seasonal norms for six or more days. Events can result in wildfires, decreased air quality and thunderstorms.	All of B.C.	High

More information: The relatively high frequency of this event, combined with an increased number of people who may be affected, make this type of event high risk. Sensitive individuals in vulnerable populations, such as elderly people, those with chronic diseases and those with physical disabilities, may be impacted on a regular basis by this type of event. Additionally, such events may result in widespread triggered, amplified and compounded hazards, including wildfires, decreased air quality, thunderstorms and more.

Event type	Description	Regions possibly affected	Likelihood
Short-duration heat warning	These are mid-intensity, low-duration events with temperatures that meet heat warning criteria and last three to five days. Events can result in wildfires, decreased air quality, thunderstorms and power outages.	All of B.C.	Moderate
More information: In addition to all of the above considerations, heat criteria thresholds are known to be associated with a 5% increase in mortality. In addition to mortality, there can be less severe health impacts and decreases in workforce participation. Events can exacerbate existing vulnerabilities like underlying health conditions, economic inequity, social isolation and access to transportation. There is a slight chance that the additional strain on the power grid, combined with decreased transmission capacity, may result in power disruptions.			
Long(er)-duration heat warning	These are mid-intensity, high-duration events with temperatures that meet heat warning criteria and last for six or more days. Events can result in wildfires, decreased air quality, thunderstorms, water scarcity and power outages.	All of B.C.	Low
More information: In addition to all of the above considerations, the longer the event meets heat warning criteria, the larger the impacts will be. Events can impact the built environment that is operating beyond its design parameters, such as buildings and roadways. Power grids will be taxed by increased demand and reduced power transmission capacity, and outages are possible. This would be a good scenario to test existing capacities while remaining in a mid-intensity range.			

Event type	Description	Regions possibly affected	Likelihood
Hot-and-fast heatwave	These are high-intensity, low-duration events with localized heatwave well above seasonal norms for two days or less. Events can result in wildfires, flooding (from snowmelt), decreased air quality, thunderstorms and power outages.	All of B.C.	Low
More information: While events are relatively short, the consequences can be great. Hot-and-fast heatwaves are particularly dangerous early in the season, when acclimatization has not occurred. This type of event requires rapid response and mobilization. This type of event is more likely than a high-intensity, high-duration event.			
Extreme heat emergency	These are high-intensity, high-duration events with a heatwave of regional or provincial extent, well above seasonal norms, for a period of three days or more. Events can result in wildfires, flooding (from snowmelt), decreased air quality, thunderstorms, water scarcity and power outages.	All of B.C.	Remote
More information: Without preparation, events create the potential for a relatively large number of preventable deaths. In addition to all of the above considerations, these events can impact power transmission and supply (decreased transmission efficiency and increased electrical demand) and can impact the built environment that is operating beyond its design parameters, such as buildings and roadways. This type of event will stretch existing response and recovery capacities and will exceed existing capacities in some instances.			

Drought and water scarcity

Drought severity is influenced by factors such as precipitation deficits, temperature, wind, soil moisture and the water demands of human activities and ecosystems. In B.C., there is a pronounced seasonality to precipitation, as most of it (over much of the province) occurs during the fall and winter months. This means meteorological drought can be initiated by a combination of reduced snowpacks, high temperatures that accelerate snowmelt, increased evaporative demand because of high air temperatures, and reduced summertime precipitation.[35] If sufficiently long, meteorological drought causes agricultural drought, hydrological drought, ecological drought and societal drought. The severity and location of water scarcity events vary in length and in their meteorological drivers (for example, precipitation changes and air temperature changes). Table 5.8.4 outlines several types of events with different drivers and likelihoods. The multi-year period of very low precipitation and above-average temperatures was selected for the extreme plausible event scenario for the Provincial DCRRA. The evaluation of the consequences from such an event is presented in section 5.4.

Table 5.8.4: Drought and water scarcity event types.

Event type	Description	Regions possibly affected	Likelihood
Multi-year period of very low precipitation and above-average temperatures	Five-year period of very low precipitation across the entire province. Snowfall and rainfall consistently remain below the 20th percentile of the provincial historical average. Average temperatures consistently remain above the 80th percentile of the provincial historical average. Such a drought increases wildfire and flooding hazards.	All of B.C.	Remote
More information: In the instrumented record (post-1940s), this type of event is considered remote. Dendrological records suggest that an approximately five-year snow drought occurred in southwestern B.C. in the early 1700s. Climate change may increase the probability of such an event. During this type of event, regions will need to find alternative water supplies and implement water restrictions. Large scale water transfers will not be possible. All aspects of society will be affected and will identify where additional planning is needed.			
Shorter-duration multi-year period of low precipitation	Two-year period of very low precipitation across most of the province. Such a drought increases wildfire and flooding hazards.	All of B.C.	Moderate
More information: This event is becoming more probable and happened in 2023–2024. It is an appropriate event to use in regional planning, as this may become a commonplace event.			

Event type	Description	Regions possibly affected	Likelihood
One year of very high spring and summer temperatures	A very hot summer, with temperatures above the 90th percentile and a very early spring melt. High temperatures across most of the province are coupled with little rainfall during the spring and summer months. Such a drought increases wildfire and flooding hazards.	All of B.C.	High

More information: The past few years indicate that provincial temperatures will continue to rise. The occurrence of the 2021 heatwave and the continuing rise in global temperatures make this scenario highly probable.

All regions should be ready for this type of event, because it will become increasingly common.

Low snowpacks and minimal spring precipitation in a region with high population and/or high agricultural activity	This event can happen in any high population centre, such as the Lower Mainland and Vancouver Island, or in areas of high water demand from agriculture, such as communities in the Interior. The region experiences low snowpacks below the 10th percentile, coupled with minimal spring rainfall. Such a drought increases wildfire and flooding hazards.	Lower Mainland (high population density and presence of agriculture in the Fraser Valley) and the Interior (high irrigation demand)	High

More information: 2015 is a good example year for this type of event. This is an important event to consider for investigating the impact on municipal water supplies, hydroelectric power generation and lack of irrigation water for agriculture.

Event type	Description	Regions possibly affected	Likelihood
Loss of glacier water in the system	Climate change is projected to eliminate many of the glaciers in B.C. within the next 50 to 100 years. Glaciers provide a substantial proportion of the water in the late summer and early fall in watersheds where greater than 1% of the area is covered by glaciers. Presently, the melting glaciers are supplementing the river discharge. Some rivers may experience a 20% to 40% decline in summer and fall discharge in the coming decades.	Watersheds with greater than 1% of their area covered by glaciers	High

More information: Over the next 50 years, it is nearly certain that the glacier loss in B.C. will be extreme. There is no emission scenario that will likely avoid the loss of many of the glaciers in B.C. [36, 37] Forecasting river discharge in glacier-fed streams will allow regions to better prepare for a decline in water availability. This impact needs to be embedded in all scenarios in regions with glaciers.

Event type	Description	Regions possibly affected	Likelihood
Multi-year hydrological drought	Five-year period with annual peak snowpack consistently below the provincial historical average. In addition, low precipitation and high temperatures during the warm seasons result in very low streamflow across most of the province. Such a drought increases wildfire and flooding hazards.	Nearly All of B.C.	Low to remote

More information: Snow droughts of five to seven years have occurred in specific basins (Stikine, Vancouver Island) over recent decades, but not province-wide. The historical likelihood of the latter is probably less than 2%. This event is becoming more probable, as temperatures continue to increase because of climate change.

Across the province, precipitation will increasingly fall as rain instead of snow, and rain-on-snow events will deplete snowpacks earlier in the season. Years with high temperatures and lower-than-normal precipitation may become increasingly more common.

Wildfires

The level of impact from wildfires, as well as the response and recovery process, can vary depending on the location, duration and how familiar the affected communities are with wildfires. Table 5.8.5 outlines different types of wildfire events with different likelihoods, locations, scales and capacities of the communities to respond and recover. The events are realistic, and most have occurred within the most recent fire history of B.C. One important consideration is that not all wildfires are bad, and many have restorative effects that benefit ecosystem services. While all of these events describe the negative impacts of wildfire, it is important that wildfire comes back to the landscape within a controlled and restorative framework of prescribed fire. A single, large, wildland urban interface fire that threatens rural First Nations communities and urban areas was selected for the extreme plausible event scenario for the Provincial DCRRA. The evaluation of the consequences from such an event is presented in section 5.5.

Table 5.8.5: Wildfire event types.

Event type	Description	Regions possibly affected	Likelihood
Single, large wildfire away from human settlements	Affects the natural environment but has minimal impacts on people and the built environment.	All of B.C.	High
More information: Events can cause human health impacts from smoke and travel disruption. This type of event can be left to burn to benefit ecosystems.			
Single, large, wildland urban interface wildfire	Poses significant threats to all value areas.	All of B.C.	High
More information: Events can have multiple impacts on values at risk, including on public safety and human health and environmental values, with large financial impacts at local and regional scales.			

Event type	Description	Regions possibly affected	Likelihood
Wildfire that threatens rural First Nations	Poses significant risk to life and property, heritage and cultural values. The event leads to cascading hazards, including landslides, debris flows, erosion and flooding.	All of B.C.	High
More information: Events can cause significant impacts on human health and wellbeing, built-up areas can be destroyed, and loss of cultural and heritage values.			
Single, large, regional-scale wildfire that impacts multiple interface communities	Has a wide range of impacts, including community impacts, and may lead to multiple cascading hazards. An example is the White Rock Lake wildfire. Such an event can trigger secondary events such as the burning of a large municipal watershed or damage to critical infrastructure like electrical utility systems.	All of B.C.	High
More information: Such a large event can lead to numerous management issues and control difficulty and can be associated with a period of "spread event days" attributed to high winds. The event can impact a significant local or regional population because of interruption to delivery of high-quality drinking water.			

Event type	Description	Regions possibly affected	Likelihood
Multiple events affecting a large regional wildfire burst – more than 150 lightning ignitions	Multiple areas with threats to human health and safety, and impacts on values areas. Regional-scale impacts include reduced quality of water and drinking water, debris flow and landslides, human safety and health hazards.	Specific regions of B.C. such as Cariboo, Kootenays and northeastern or northwestern portions of the province	High
More information: The event can cause multiple impacts on values at risk, including on public safety and human health and environmental values, with large financial impacts at local and regional scales.			
Provincial-scale wildfire event	Impacts every region of the province—multiple communities, infrastructure and landscape values at risk are impacted. Potential for entrapment and loss of life. The conditions that enable a provincial-scale wildfire are widespread drought similar to the conditions in 2023 that covered large areas of western North America, or extended periods of extreme fire weather and heatwaves as was experienced in 2021 in B.C.	All of B.C.	Moderate to high
More information: Provincial-scale impacts can create numerous environmental and safety hazards that impact a large portion of the population through evacuations, loss of homes and infrastructure, long delays in recovery, and initiation of services lost. Events can have large financial impacts at local and regional scales.			

Earthquakes

There are, broadly, three types of earthquakes that can happen in southwestern B.C., where the Cascadia Subduction Zone dominates the earthquake hazard: 1) subduction interface earthquakes; 2) deeper in-slab earthquakes in the oceanic Juan de Fuca Plate; and 3) crustal earthquakes in the overriding North America Plate, some of which occur on known active faults. North of the Cascadia Subduction Zone, there are other major active faults, such as Queen Charlotte Fault and Haida Gwaii Thrust. Elsewhere in B.C., crustal earthquakes can occur anywhere, though with lower activity rates in the interior and eastern portions of B.C. Table 5.8.6 outlines several types of impactful earthquake events with various magnitude and likelihood. The subduction interface earthquake was selected for the extreme plausible event scenario for the Provincial DCRRA. The evaluation of the consequences from such an event is presented in section 5.6.

Table 5.8.6: Earthquake event types.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Cascadia subduction interface earthquake	The expected magnitude of this event is 9.0. Strong shaking will be several minutes long and will have an impact on all coastal communities. Tall buildings and bridges in areas of deep soft sediments, such as the Fraser River Delta, will be shaken particularly hard. Major impacts to older buildings and infrastructure is expected.	Major tsunamis, fires following the earthquake, liquefaction, landslides, rockfalls, avalanches, seiches (sloshing of water in lakes and other water bodies) and intense aftershock activity. The west coast of Vancouver Island is expected to experience about 1 m subsidence.	All coastal communities from Vancouver Island to the Canada–U.S. border and down to California in the U.S.	Remote: The return period is roughly 450 years based on paleoseismic records from the last 10,000 years. The last event was 300 years ago.

More information: The event has a higher likelihood of having an impact on coastal communities than a shallow crustal earthquake. It will have an impact on a much larger area and a more severe aftershock sequence than any other type of earthquake. It has the potential to cause a tsunami similar to the Indian Ocean tsunami caused by the 2004 Sumatra earthquake.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Deeper earthquake in the subducting slab	These events are damaging when they reach M6.5 to M7.0. They are the most frequent type of earthquake that occurs in southwestern B.C. While the latest examples (1949 Olympia, 1965 Puget Sound, 2001 Nisqually) all happened south of the U.S. border, they are as likely to happen anywhere from Vancouver Island to the coastal parts of Metro Vancouver. They are typically felt over a large area, but due to their depth (50–70 km) are not as damaging as shallow crustal earthquakes.	Possible tsunami (though likely not as severe as the Cascadia subduction interface earthquake), liquefaction, landslides.	Vancouver Island, Georgia Strait, coastal Metro Vancouver, down to the Canada–U.S. border.	Moderate: On average, M6.5 and larger events of this type have occurred in southwestern B.C. and northwestern Washington every 20 to 40 years in the instrumental era.

More information: They are the most frequently occurring type of earthquake that can cause damage in south-western B.C.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Shallow earthquake on known active coastal fault	There are only a few known active faults in B.C., including the Queen Charlotte Fault, Haida Gwaii Thrust and the Leech River Valley Fault. Research is ongoing to identify more (for example, Elk Lake Fault and Beaufort Range Fault). The Queen Charlotte Fault caused Canada's largest recorded earthquake (M8.1) in 1949. Haida Gwaii Thrust caused an M7.8 earthquake in 2012.	Liquefaction, landslides, fires following the earthquake, fault displacement, aftershocks.	Most of the damaged area is expected to be within approximately 50 to 100 km of the ruptured portion of the known active fault, though this depends on the magnitude of the earthquake and the soil conditions in the communities nearby.	Moderate: The overall probability of a shallow earthquake on any of the known active faults on the coast is higher than any individual fault. Each fault has its own return period.

More information: Since the locations of listed faults are known (as are their return periods, generally), an estimate of damage and risk can be made for communities on or near these faults. However, there are likely many other unidentified crustal faults in western B.C.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Other shallow coastal earthquakes in western B.C.	Shallow earthquakes of large magnitude (M7 or greater) have occurred in coastal areas of B.C. on previously unknown faults or areas of no known faults (such as the 1949 M7.3 mid-Vancouver Island earthquake that caused damage in Courtenay, Comox and Port Alberni). They generally cause intense shaking within 50 km of the epicentre, causing significant damage if there is an urban area in the vicinity.	Liquefaction, landslides, fires following the earthquake, fault displacement, aftershocks.	Most of the damaged area is expected to be within ~50 to 100 km of the earthquake, though this depends on the magnitude of the earthquake and the soil conditions in the communities nearby.	Remote: The likelihood of these earthquakes of M7 or greater is higher than in inland B.C. but lower than deep earthquakes in the subducting slab.

More information: It is hard to estimate where (and when) the next major earthquake in coastal B.C. will be, but given that they can cause intense damage in urban areas that are close to them, it is important to consider them.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Shallow inland earthquakes	While rare, shallow damaging earthquakes have occurred in the past in inland areas of B.C., and there is potential for more of them to occur in the future.	Liquefaction, landslides, fires following the earthquake, fault displacement, aftershocks.	Most of the damaged area is expected to be within ~50 to 100 km of the earthquake, though this depends on the magnitude of the earthquake and the soil conditions in the communities nearby.	Remote: Compared to other regions in B.C., large-magnitude events are least likely inland, but still possible.

More information: Since inland areas of B.C. have generally lower seismic risk, the building code requirements are also lower. Therefore, if a major earthquake occurs inland, it has the potential to cause more damage here than in coastal areas if all conditions are the same (for example, same magnitude, size of city, soil conditions, etc.).

Multi-hazard events

There are almost a hundred potential pairs of hazards and even more cascading chains of three or more hazards that might occur in the province. Several primary hazards will trigger or amplify large numbers of secondary hazards. A sample of these highly prolific primary hazards is described in Table 5.8.7. The event containing water scarcity, wildfire, flood and debris flow, followed by a moderate earthquake, was selected for the extreme plausible event scenario for the Provincial DCRRA. The evaluation of the consequences from such an event is presented in section 5.7.

Table 5.8.7: Multi-hazard event types.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Coastal subduction zone (CSZ) earthquake and triggered tsunami	A CSZ megathrust event occurs off the west coast of Vancouver Island, triggering a fast-moving tsunami wave that grows to as high as 20m as it reaches the shoreline.	Liquefaction of soft soils, landslides, coastal erosion.	Coastal areas adjacent to the CSZ (the west coast of Vancouver Island and portions of the mid-coast).	Remote: While the annual likelihood of the CSZ earthquake is remote, it is inevitable and is certain to trigger a tsunami.

More information: There is limited current understanding of the fragility of structures that are first damaged in an earthquake and are then hit by a tsunami wave. Further, constructing stiff structures to withstand an earthquake may increase vulnerability and result in more damage than a tsunami.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Earthquake coincident with Fraser River freshet flood	Earthquake events ranging from moderate to extreme are anticipated to cause severe or extreme damage to Lower Mainland diking infrastructure, which, if followed by even a mod-erately high-flow event, will mean widespread flooding in the areas behind the dikes if they breach. A 475-yr return period event is expected to cause severe or ex-treme damage to 48% of dike segments in the region. A 2475-yr return period event is expected to cause severe or extreme damage to 89% of dike segments in the region. [38]	Liquefaction of soft soils, landslides, coastal and riverine erosion.	Limited to the southwestern portion of the province where earthquake hazard exists.	Remote: The likelihood of such a joint event is in the order of 0.15% chance of exceedance annually. Flooding with failed dikes occurs approximately once every 20 years on the Lower Fraser River.[39,40]

More information: In the Lower Mainland, the current flood risk reduction strategy is tied to dike infrastructure, which is predominantly earthen dikes that would likely be damaged and potentially fail in an earthquake. These would take multiple years to rebuild. A flood, even of moderate magnitude, that followed an earthquake would have extensive impacts.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Volcanic eruption in Garibaldi volcanic belt triggering rapid snow and ice melt and flood	Mount Meager erupts, creating localized impacts from overland lava flows and regional impacts from the volcanic plume. Lava flows over glaciers and snowpack cause rapid snowmelt and localized extensive flooding.	Air quality is poor across the region, and the flooding will likely cause erosion and avulsions and may trigger landslides along the valley walls.	Throughout the western portions of the province, from Yukon to the U.S. border. There are also glaciers and mountains with snowpacks, and therefore potential for flooding, across this same region.	Unknown: last occurred 2400 years ago.

More information: This type of event has occurred historically and created extensive and abrupt flooding along the Lillooet River Valley, which is now well populated. Sudden and extreme flooding of this scale is not well studied or understood—and given the sudden onset of this type of event, would result in significant impacts.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Repetitive riverine floods causing erosion and avulsions	Many of the coastal river systems on the mainland and Vancouver Island have frequent, repetitive, low-severity flooding. With repetitive flooding, especially when it occurs within a short time period on previously saturated and damaged soils, river banks become prone to further failures.	Debris from the avulsions and erosion can move downstream and create additional blockages and damages.	Along all river systems.	Frequent

More information: Fluvial geohazards resulting from flooding, especially with consideration of downstream effects, are not well studied or mapped. With climate change, this event type will occur more frequently. Because of their short onset, avulsions and related fluvial geohazards have the potential to impact life and safety.

Event type	Description	Possible cascading hazards	Regions possibly affected	Likelihood
Water scarcity, wildfire, flood cycles	A large regional heat event happens across the province, which occurs on the heels of two years of drought. Heat and drought set conditions for an interior wildfire that remains uncontrolled for many summer weeks. Atmospheric river events begin in the fall months, followed by a late-fall earthquake in the Strait of Georgia.	Water scarcity and drought change land cover conditions so that they amplify the likelihood of wildfire and, potentially, flooding.	All of B.C.	Frequent

More information: This is an increasing concern with climate change. The event is included in the Provincial DCRRA extreme hazard scenario, but other geographic and severity combinations are required to fully understand the linkages. The combined impacts of this type of event cascade would affect large populations as well as economic sectors throughout the province.

Chapter 5 Endnotes

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