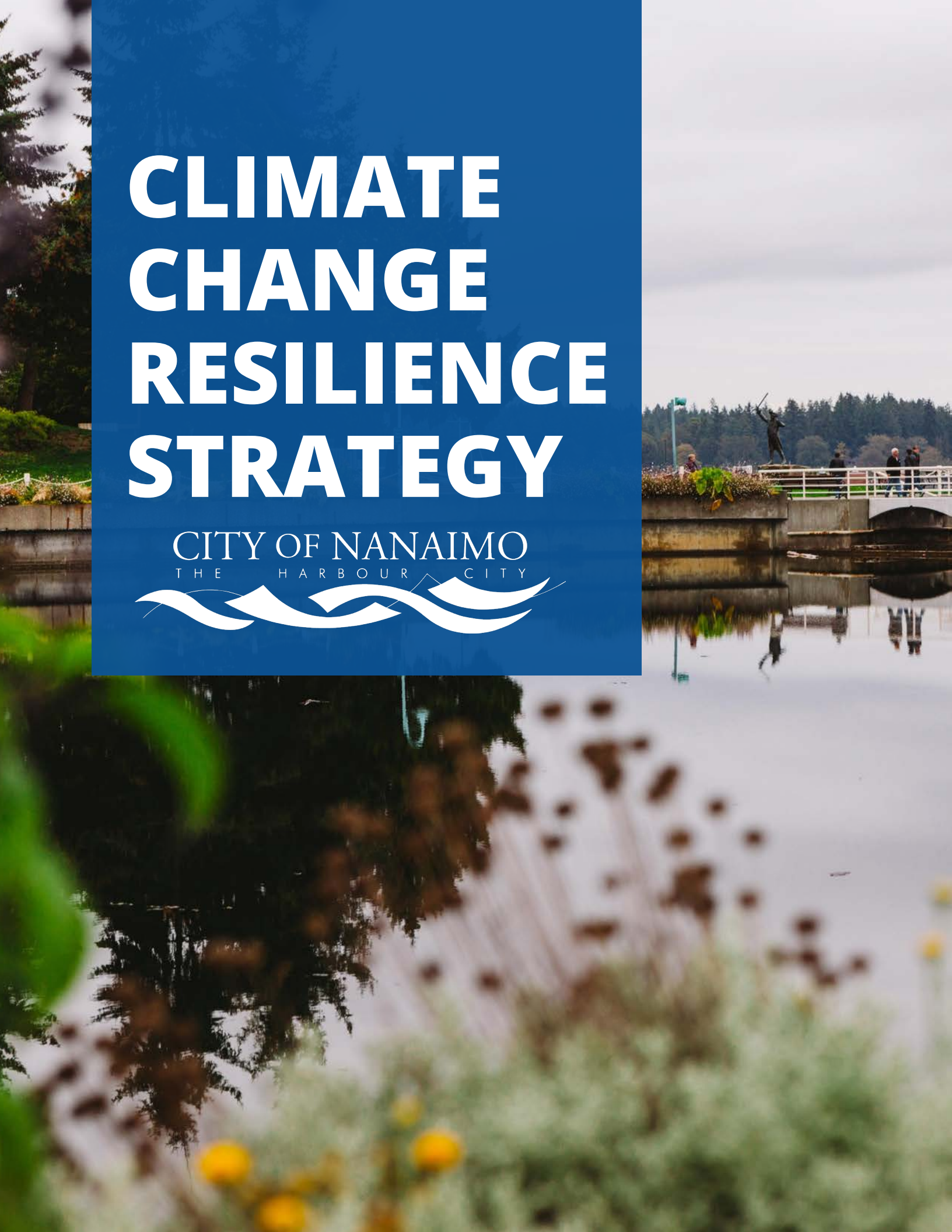

CLIMATE CHANGE RESILIENCE STRATEGY

CITY OF NANAIMO
THE HARBOUR CITY

Produced for:

CITY OF NANAIMO
THE HARBOUR CITY

Produced by:

INTEGRAL
with **Tamsin Mills Resilience Consulting**

and supported by:

Associated Engineering

DIAMOND HEAD

The preparation of this was carried out with assistance from the Government of Canada and the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them

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Executive Summary

Climate change will have profound and long-lasting implications on both ecosystems and our built environment, as well as serious consequences for our economies, food security, and health. Despite efforts to mitigate the greenhouse gas emissions that are causing climate change, there remains a need to adapt to the global warming that has already begun and will continue into the future. In response, the City of Nanaimo has developed this *Climate Change Resilience Strategy* to help the community prepare for and respond to the adverse effects of climate change, and to take advantage of opportunities.

Nanaimo is already feeling the effects of climate change. Mean annual temperatures have risen alongside an increase in the number of extreme weather events, and these are having serious consequences for our communities. As one example, the Nanaimo Lakes Fire (August 2018) burned more than 450 hectares, while a recent windstorm (December 2018) left over 150,000 people on Vancouver Island without power. The magnitude and seriousness of these climate-related events, as well as overall changes in climate, are projected to increase over time. By 2050, Nanaimo is projected to experience:

- An overall **increase in temperatures** across all seasons, which will have impacts on natural ecosystems, human health, the City's provision of services, and economic development;
- **More days of rainfall** in every season except summer, and **increased precipitation on rainy days**, causing challenges for Nanaimo's stormwater system and leading to local flooding;
- An increase in the frequency and severity of **extreme weather events**, including wildfires and associated wildfire smoke, which will compound with changing conditions; and
- Growing challenges from **sea level rise**, including coastal flooding and damage to public and private buildings and infrastructure, along with increased shoreline erosion.

Fortunately, many efforts that have already been completed or are underway in the areas of sustainability action, infrastructure design, asset management and emergency management already contribute to building Nanaimo's resilience (e.g. the *Community Sustainability Action Plan*, *Urban Forest Master Plan*, and *Water Supply Strategic Plan)*. This Strategy focuses on enhancing these initiatives where they already exist, and developing new actions where additional efforts are needed. Based on a series of workshops with a staff working group and key stakeholders, the Strategy presents over 60 action items spanning six thematic areas:

1. **Water Supply:** Actions to prepare for a more limited water supply over time and improve the resilience of existing water infrastructure.
2. **Flooding & Drainage:** Actions to minimize urban and overland flooding resulting from heavy rainfall, and to prepare for the impacts of sea level rise (e.g. shoreline erosion and coastal flooding).
3. **Environment, Parks & Recreation:** Actions to support Nanaimo's urban forests under a changing climate, and to help improve the resilience of Nanaimo's watercourse and marine ecosystems.
4. **Well-being & Preparedness:** Actions to help Nanaimo prepare for and respond to climate-related events, and to limit the health impacts of extreme weather on residents.
5. **Land Use & Buildings:** Actions to enhance resilience for new and existing buildings, including public facilities and homes, along with regulations to help limit risk.

6. **Corporate Governance & Mainstreaming:** Actions to help improve the City's agility in responding to and recovering from climate-related events, along with guidance on working with neighbouring jurisdictions on common goals.

The actions in this Strategy are accompanied by early implementation details and timelines. However, the success of the above actions will require further resourcing, along with the development of key performance metrics for each major action area to help the City track its progress. By taking bold first steps on these actions, the City of Nanaimo will show leadership on enhancing climate change resilience throughout the community.

Acknowledgements

The City of Nanaimo's *Climate Change Resilience Strategy* is the outcome of a year-long collaborative effort between a broad range of City staff and senior leadership, City Council, and external stakeholders. We wish to thank everyone involved for their time and contributions – their insights and expertise were invaluable in crafting this document.

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External Stakeholders

- Regional District of Nanaimo
- Island Health
- Nanaimo Port Authority
- BC Ferries
- BC Hydro
- Harmac Paper Products

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1. Introduction

The Climate Change Challenge

Climate change represents the greatest challenge facing the modern world. As the climate warms, increasingly negative impacts to ecosystems, human, and built systems are expected to occur as a result of warmer global temperatures, increases in the volume and intensity of precipitation, extreme weather events (e.g. forest fires, droughts) and sea level rise. These changes will have profound and long-lasting implications for communities, as well as serious consequences for economies, food security, and health.

The Climate Imperative

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) released a report outlining the need to limit global warming to 1.5° Celsius above pre-industrial levels in order to avoid the most severe impacts of climate change[1]. Municipalities around the world, including the City of Nanaimo, have responded by declaring a climate emergency, acknowledging the need to escalate climate actions to limit warming and avoid the most severe impacts of climate change.

These changes are especially important for Canada. Due to its northern latitude, Canada has already experienced a rate of warming approximately twice the global average – and this trend is expected to continue[2]. Since 1948 (the year Canadian temperature records became available), Canada has warmed by an average of 1.7° Celsius across the country, with northern regions warming by 2.3°C. In a future where global greenhouse gas (GHG) emissions are not substantially reduced, Canada is expected to warm by an estimated total of 6°C by 2100.

The effects of a warming Canadian climate are already becoming obvious. Over the last four years (2016-2019), some of the most serious and costly extreme climate-related events ever recorded have occurred, each resulting in substantial economic loses and even loss of life:

1. **2016 Fort McMurray wildfire:** Over 590,000 hectares of land burned, 2,400 homes and buildings lost, two indirect fatalities, and a cost over $9 billion[3];
2. **2017 Ottawa River flood:** This one-in-100-year flood caused $223 million in insurable damages and forced the evacuation of approximately 850 people[4,5];
3. **2018 Eastern Canada heat wave:** The humidex reached 48°C in Gatineau, Quebec, with 93 fatalities from heat-related complications in the province[6];

[1] United Nations Intergovernmental Panel of Climate Change (IPCC). (2018). *Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C Approved by Governments*.
[2] Environment and Climate Change Canada. (2019). *Canada's Changing Climate Report.*
[3] University of British Columbia. (n.d.) *Fort McMurray and the Fires of Climate Change.*
[4] Ottawa River Regulation Planning Board. (2017). *Summary of the 2017 Spring Flood.*
[5] Ottawa Business Journal. (2017). *Ottawa-area Flooding Caused $223M in Insurable Damages: Industry.*
[6] Environment and Climate Change Canada. (2019). *Canada's Top Ten Weather Stories of 2018.*

4. **2018 British Columbia wildfire season:** More than 1.3 million hectares of land burned with a cost over $615 million[7] and an unprecedented 22 days of air quality advisories in the Lower Mainland; and
5. **2019 Ottawa River flood:** Following several rounds of heavy rain, the Ottawa River reached levels even higher than in 2017, forcing more than 6,000 residents from their homes and leading to the death of two people[8].

The effects of a warming climate are also making themselves known on **Vancouver Island**. Mean annual temperatures have risen alongside an increase in the number of extreme weather events. In August of 2018, the Nanaimo Lakes Fire burned more than 450 hectares, prompting the Regional District of Nanaimo (RDN) to declare a State of Emergency[9]. That December, a windstorm affecting Vancouver Island left over 150,000 people without power, forced the cancellation of ferry service, damaged the City of Nanaimo's water treatment plant, and caused the death of one person[10].

These events, coupled with scientific evidence of increasing warming, shows us that despite efforts at curbing our GHG emissions, climate change is already here. Released in 2019, the IPCC's *Special Report for Policymakers*[11] noted that global average temperatures have already increased and will continue to rise for the next several decades[12]. The evidence is clear: countries, cities, and communities around the world must be prepared to respond to the needs and challenges of climate change.

Responding to Climate Change

Addressing the climate change challenge involves more than just preparing for the changes to come. Effective climate action requires both **mitigation**, or actions taken to reduce the emission of GHGs into the atmosphere, and **adaptation**, or actions designed to reduce the negative impacts of climate change and take advantage of opportunities. **This Climate Change Resilience Strategy focuses on adaptation: preparing Nanaimo for the current and future impacts of climate change.**

Resilience is a broad term that refers to the capacity of a system to absorb disturbances and recover well. More specifically, resilience to climate change includes climate change adaptation and the ability of systems to anticipate, prepare for, and respond to the adverse effects of climate change.

[7] BC Wildfire Service. (2018). *Wildfire Season Summary.*
[8] CBC News. (2019). *From floods to fires to weird Arctic weather, Environment Canada releases top 10 weather stories of 2019.*
[9] Nanaimo News Now. (2018). *The Nanaimo Lakes wildfire.*
[10] Times Colonist. (2018). *Storm aftermath: Thousands without power, Nanaimo water plant damaged, woman killed by tree.*
[11] IPCC. (2018). *Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C Approved by Governments.*
[12] NASA. (2019). *2018 Fourth Warmest Year in Continued Warming Trend, according to NASA, NOAA.*

However, some actions can achieve both mitigation and adaptation goals (see Figure 1 below), and the most effective response to climate change is one that integrates both mitigation and adaptation. Under this approach, resources are allocated to benefit both mitigation and adaptation objectives, simultaneously decreasing the *causes* of climate change while adapting to the *effects*. For example, increasing the number of trees planted in a city helps to mitigate climate change because trees absorb carbon dioxide (CO_2) and provide shade to nearby buildings, reducing indoor temperature and lessening demand for mechanical cooling. Urban forestry also contributes to adaptation by helping to absorb stormwater before it can lead to flooding, reducing local temperatures in the summer, and providing shady refuges.

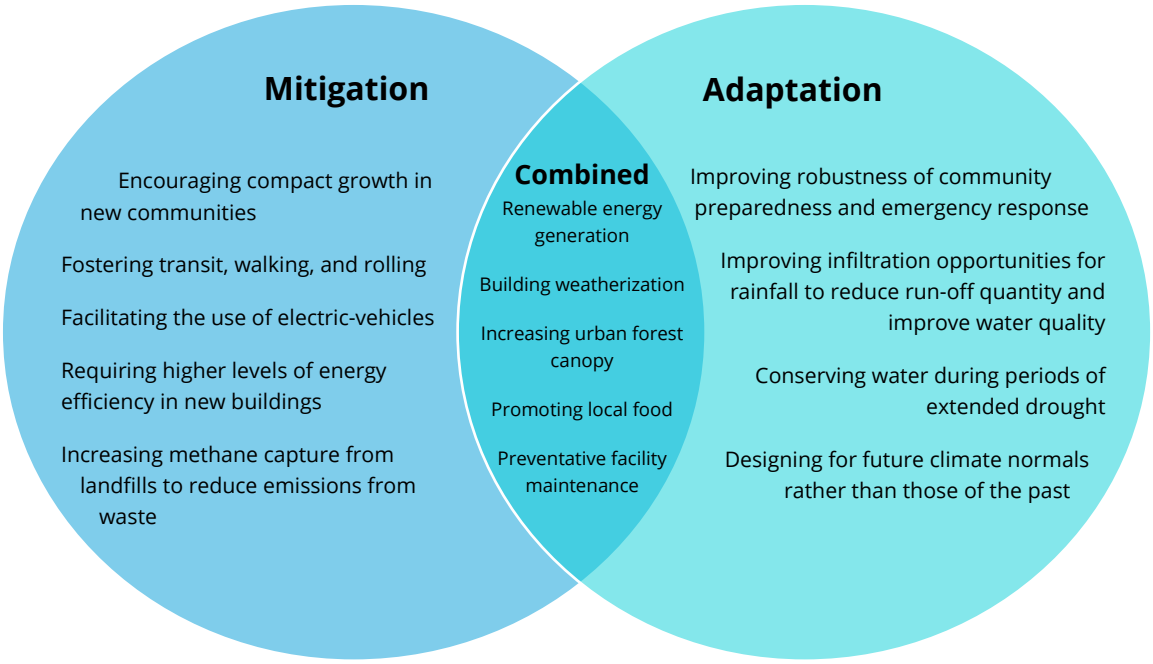


Figure 1: Examples of climate change mitigation and adaptation actions

Though the changing climate presents significant challenges for the Vancouver Island region, it also offers a number of opportunities. These include:

- Lower heating costs overall
- A longer growing season, more arable land, and the possibility of new agricultural crops
- Increased opportunities for active transportation (e.g. biking, walking, etc.), and
- The potential for increased tourism given Nanaimo's increasingly temperate climate.

In addition, climate action can often help support or advance other community goals and objectives (often called **co-benefits**), such as protecting and preserving green spaces and sensitive areas, increasing community and neighbourhood level preparedness and connection, and ensuring housing meets the needs of the whole community.

The Role of the City

The City of Nanaimo's role in building community-wide climate change resilience is one of both a leader and a partner.

As a **leader**, the City will demonstrate climate action in its own internal policies, programs, and facilities. It must continue to implement mitigation actions as well, and incorporate the newest scientific information and best practices into future decision making.

As a **partner**, the City will continue to build relationships with local businesses, community organizations, and other stakeholder groups, as well as other levels of government. These will help to ensure information and resources are shared, and goals and objectives are aligned, in turn maximizing the impact and effectiveness of resilience-building actions and strategies.

Stakeholders and partners involved in the development of this Strategy include:

- Regional District of Nanaimo
- Island Health
- Nanaimo Port Authority
- BC Ferries
- BC Hydro
- Harmac Paper Products

Other key stakeholders for future collaboration include:

- Snuneymuxw First Nation
- School District 68
- Vancouver Island University
- Nanaimo Chamber of Commerce
- Vancouver Island Homebuilders Association
- City Neighbourhood Association Network

The City will also act as a partner to its residents, as members of Nanaimo's communities have their own insights and experiences to share, and have a huge stake in the success of this Strategy. To this end, the City will educate and engage residents on relevant community issues, and incorporate their feedback and concerns into resilience planning. The City will also provide residents the tools and information they need to help increase their own resilience, both at home and across the community.

Report Contents

This report is a roadmap for improving climate change resilience in Nanaimo. It identifies climate-related risks specific to the local context and then outlines specific adaptation actions to address those risks. It also includes preliminary guidance on how to carry out those adaptation actions.

Section 1 provides background information on the climate change imperative, past and projected impacts, and responses to climate change.

Section 2 provides a review of Nanaimo's past and present plans, strategies, policies, and initiatives associated with climate change mitigation and adaptation.

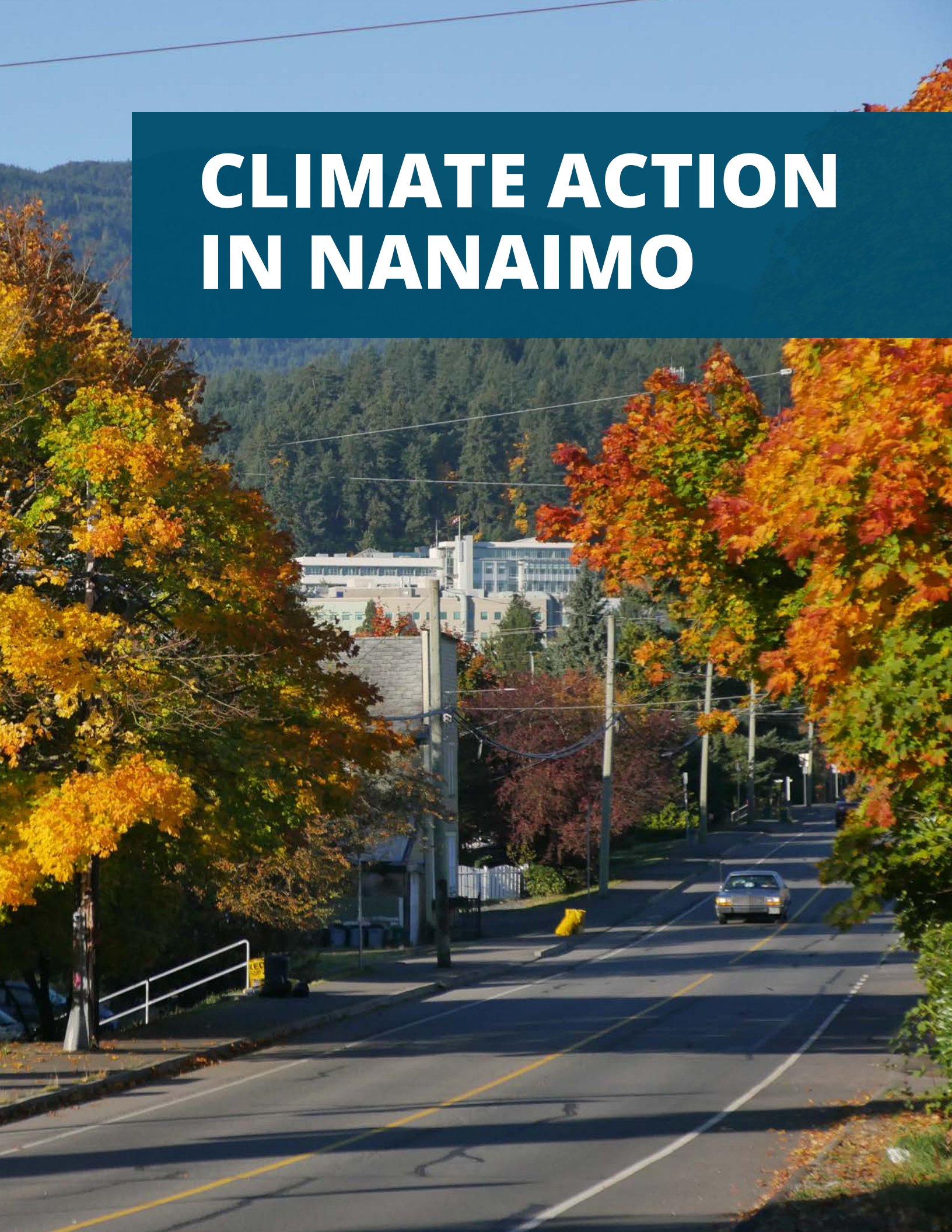
Section 3 provides a review of the climate science and projected impacts for Nanaimo, and identifies specific risks and vulnerabilities.

Section 4 sets out adaptation actions to improve resilience, including both "quick start"/immediate-priority actions and longer-term projects. It also introduces the many co-benefits of adaptation for the City and its community members.

Section 5 provides a guideline for carrying out the above adaptation actions, including guidance on implementation, with roles and responsibilities for different actors, as well as guidance on monitoring, including targets and metrics.

The *Climate Change Resilience Strategy* will be reviewed and updated at 5-year intervals to incorporate leading science and the changing needs of Nanaimo residents. Actions included in this Strategy include processes as well as outcomes, both of which can be updated as new information and practices become available.

CLIMATE ACTION IN NANAIMO



2. Climate Action in Nanaimo

The City of Nanaimo is not starting from scratch on climate change resilience. Nanaimo has long been a leader in environmental sustainability, using its municipal powers to develop and enforce a number of environmental policies and bylaws. Many efforts that have been completed or are underway in the areas of sustainability action, infrastructure design, asset management and emergency management already contribute to building the community's resilience. This Strategy focuses on building on and enhancing these actions, as well as identifying gaps for new action planning.

For example, policies such as the **Community Sustainability Action Plan** already set the stage for addressing climate change. As a signatory of the **BC Climate Action Charter**, the City has also committed to significant greenhouse gas emission reductions and the creation of a complete, compact, and more energy efficient community. **PlanNanaimo**, the City's *Official Community Plan* (OCP), establishes policies on energy and emissions management that align with the Charter. It also sets a goal of protecting and enhancing the environment through the preservation of sensitive areas and the promotion of urban forests and greenways. Finally, it includes policies to protect life and property from natural hazards such as steep slopes and flooding.

The City of Nanaimo has also completed initial work in a **Sea Level Rise Study**, in which maps were developed to show where new construction should be limited to remain above future flood levels along the coastline. The study identifies areas of higher erosion risk, potential impacts to storm and sanitary sewer infrastructure, and vulnerable areas of the City to explore in further depth.

Aside from those noted above, there are many other policies that are already underway that do not address climate change adaptation explicitly, but nevertheless improve the city's resilience to a changing climate:

- The City is a participant in the Federation of Canadian Municipalities' (FCM) **Leadership in Asset Management Program** and has explored the **Municipal Natural Asset Initiative**. The existing asset management program can incorporate a climate lens.
- The City has signed onto the Global Covenant of Mayors (GCoM) **Showcase Cities Program**, in order to share training opportunities and experiences among staff from 40 Canadian municipalities, working towards meeting ambitious climate adaptation and mitigation targets.
- The **Urban Forest Management Plan** explicitly recognizes climate change already and can be adapted to ensure ecosystem services are maintained under new climate "normals".
- The **Waterfront Walkway Implementation Plan** includes new sea level rise projections in planning.
- The City's **Manual of Engineering Standards and Specifications** used for infrastructure design and construction recognizes projected changes in rainfall and sea level with climate change.
- The **Water Supply Strategic Plan** was updated to include potential impacts from climate change.
- Nanaimo has several emergency response plans and recognizes major natural hazards through emergency management and planning.

Developing the Strategy

This Strategy was developed following the *BC Climate Risk Assessment Framework*[13] adapted for the context of local government adaptation planning (see Figure 2 below). Impacts, risks and vulnerabilities to the City and its community were identified in a series of workshops with a staff Working Group and key stakeholders. The methodology followed four general steps, outlined below, with further details on the process provided in **Appendix B**: Methodology.

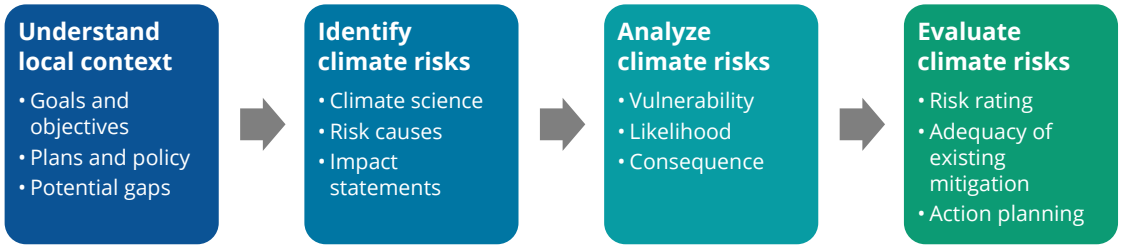


Figure 2: BC Climate Risk Assessment Framework (graphic adapted from the Province of BC)

Step 1

Step 1 involved developing an understanding Nanaimo's specific context, including local goals, objectives, and operating principles. To achieve this, the project team reviewed the City's existing policies, plans, programs, and projects that relate to climate change adaptation, and then identified potential gaps and opportunities to enhance resilience throughout the city.

Step 2

Step 2 included workshop participants using future climate projections to generate impact statements of how climate change might affect Nanaimo. These are meant to be clear and concise statements that identify the possible negative or positive effects of climate change that are expected locally. Important to note is that this considers both discrete events and ongoing changes. For example, intense rainfall events (discrete) are expected to cause local flooding that damages infrastructure and disrupts transportation. More positively, warmer winters (ongoing) will lead to longer growing seasons and possibly create new opportunities for agriculture.

[13] Government of BC. (2019). *Strategic Climate Risk Assessment Framework for British Columbia.*

Step 3

Step 3 saw the impact statements from Step 2 prioritized in order to focus future adaptation planning efforts on the areas of greatest need. This process followed the International Council for Local Environmental Initiatives (ICLEI) Canada's *Building Adaptative and Resilient Communities* (BARC)[14] approach to assess **vulnerability** by rating two factors: **sensitivity** and **adaptive capacity**. Sensitivity is the degree to which people or systems are impacted by changing climate conditions, either positively or negatively, whereas adaptative capacity refers to the ability to prepare for these impacts or respond to the consequences.

Step 3 also included a risk assessment. **Risk** was evaluated by considering the **likelihood** of an event and the **consequence** of that event should it occur. In other words: risk = likelihood x consequences**.** For the purposes of this project, likelihood was rated for both current risk and projected to 2050.

Step 4

Step 4 focused on adaptation action planning. By considering the impact statements that were generated in Step 2 and prioritized in Step 3, participants brainstormed specific adaptation actions to reduce risk and capitalize on opportunities. This was first done in a workshop setting and then followed up with several sets of review to determine how each action could be effectively implemented and monitored. The finalized adaptation actions were then categorized by themes and objectives, which are introduced in **Section 4**.

[14] ICLEI Canada. (2017). *BARC Program.*

3. The Impact of Climate Change in Nanaimo

Climate Science Projections

To understand how changes in climate will affect Nanaimo, it is important to first understand a few key terms.

- **Weather** refers to the atmospheric conditions at a specific location at a specific time – in other words, what is typically found in a weather report. These conditions generally occur over a short time period and change frequently.
- **Climate** refers to the longer-term trends in atmospheric conditions over years or decades.
- **Climate change** refers to changes in climate variables over long time periods that have been observed and are projected to occur in the future (30-year periods typically).

To identify how these factors will impact Nanaimo, specific (i.e. quantitative, statistical) regional climate data was used to representative more general climate measures. For example, to capture temperature changes, the project team considered statistics such as days below 0°C and extreme heat days above 25°C. For extreme wind events, statistics for frequency of 70+km/h wind gusts were analyzed, and so on. As no single comprehensive study of projected climate change measures exists for Nanaimo, multiple regional climate change projections were sourced from reputable organizations, such as the Pacific Climate Impacts Consortium (PCIC), Prairie Climate Centre, and Institute for Catastrophic Loss Reduction (ICLR).

All climate projections were based on the **Representative Concentration Pathway** 8.5 (RCP8.5) climate scenario[15] (**Figure 3**). This pathway assumes a 'business-as-usual' future in which little action is taken to reduce greenhouse gas emissions at a global scale, and is recommended by most

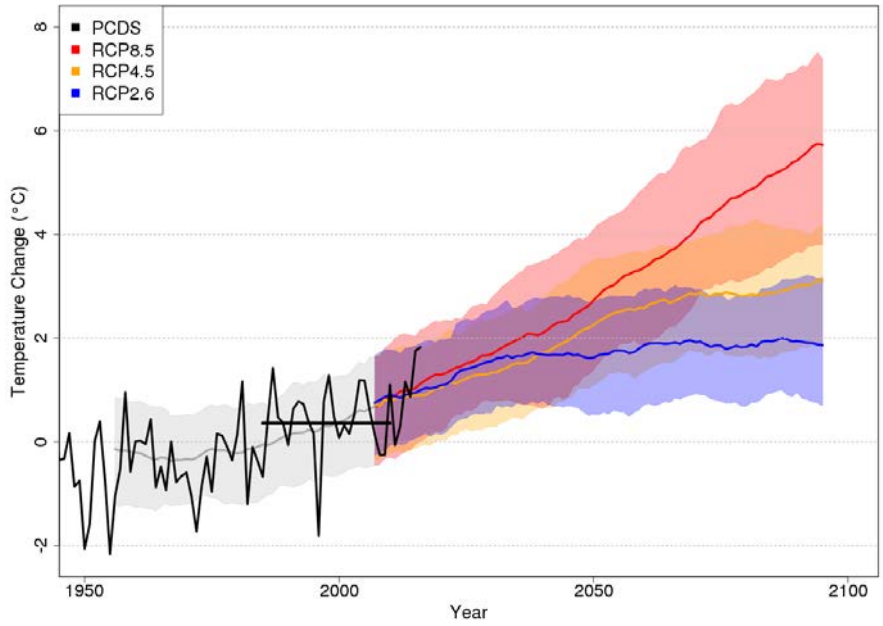


Figure 3: Representative Concentration Pathways (RCP) showing temperature change under different greenhouse gas concentration scenarios based on mitigation action (figure courtesy of PCIC)

[15] United Nations Intergovernmental Panel on Climate Change (IPCC). (2013). *Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis.*

institutions for climate change adaptation planning. This conservative approach is necessary to address any eventuality. While mitigation action is taking place both locally and globally, we are also already essentially "locked-in" to a certain degree of climate change regardless of what path we take, and will need to prepare accordingly.

The changes anticipated for Nanaimo under RCP8.5 to 2050 and beyond are summarized below in four general categories: changes in temperature, changes in precipitation, extreme events, and sea level rise. Detailed projections are available in **Appendix C**: Detailed Climate Projections for Nanaimo, with the full climate science review and historic baseline assumptions provided in **Appendix D**: Climate Science Review.

Changes in Temperature

Nanaimo can expect an overall increase in temperatures across all seasons, with an average increase of 1.6°C by the 2050s. Other projected changes are noted below:

- The hottest daytime temperature in the summer is going to be closer to 35°C by the 2050s, as compared to a baseline of 31°C (1971–2000).
- The number of days above 25°C in a year are projected to double by the 2050s.
- Cooling degree-days (a measure of demand for air-conditioning in a building) is going to almost double by the 2050s.
- Winter days and nights are going to get warmer, with frost-free days and growing season length both increasing significantly.
- Heating degree-days (a measure of demand for heating in a building) are going to decrease, reflecting a decrease in overall residential heating needs during the fall to spring months.

The impacts to *ecosystems* associated with increasing temperatures include changes to species' natural ranges, increased opportunities for invasive species, and added stress to natural systems as a result of prolonged heat and drought. *Human health* impacts from these changes include an increase in heat-related illness and smoke from wildfires are already increasing and water supply pressures during long dry, hot summers are a rising across Canada. Increasing temperatures and a longer growing season also provide *economic* opportunities such as new crops and/or increased productivity for agriculture, lower winter heating bills, and possibly new opportunities for summer tourism and recreation.

Changes in Precipitation

Nanaimo is expected to see more days of rainfall overall in every season except for summer, and the amount of precipitation on rainy days is projected to increase more than 1.25 times by 2050 compared to the historic baseline (1980–2007). Other precipitation changes for Nanaimo include:

- The maximum amount of rain over a consecutive five-day period is projected to increase from 177mm historically (1971–2000) to 218mm in the 2080s.
- Despite increases in the intensity and frequency of rain, the frequency and length of dry spells (or days without rain) in summer months will steadily increase.
- Snowfall during the winter and spring is projected to decrease 60% by 2050 and almost 80% by 2080.

Heavy rainfall will challenge Nanaimo's stormwater system, and can lead to localized flooding that damages buildings and infrastructure, especially when it continues over numerous days. Nanaimo

will also face increased river flood risk, especially when heavy rain and melting snow coincide. Furthermore, heavy rainfall will increase slope instability and the risk of landslides, and can also increase sedimentation that damages infrastructure and aquatic habitats.

Increase in Frequency & Severity of Extreme Events

Expecting the unexpected will become the norm in Nanaimo, with more extreme weather anticipated over time. Specifically:

- Increased temperatures and decreased summer precipitation are anticipated to see wildfire risk grow between 1.5–2 times by 2050, and up to 2.5 times by 2080 compared to the period from 1976 to 2005.
- Smoke from wildfires both locally and across the province are likely to engulf Nanaimo on a semi-regular basis.
- Greater amounts of energy in the atmosphere are projected to cause more frequent and intense wind events, as seen in the storm of December 2018.

These extreme events will interact with other climatic changes and likely become more challenging to deal with over time. For example, periods of drought will increase wildfire risk and make those fires more difficult to fight, and severe wind gusts will increase the possibility of coastal flooding through storm surge.

The impacts of extreme events can be wide-ranging and severe, from power outages and damage to trees and buildings from wind gusts, to significant physical and mental health hazards during extreme climate events, such as wildfire smoke, especially for vulnerable individuals. It is anticipated that emergency operations centres will need to be activated more frequently, and responding to these events will be costly and labour-intensive for the City and other organizations.

Sea Level Rise

Global average temperature increases are driving **sea level rise** (SLR) by causing glaciers and ice sheets to melt, releasing water that was previously held on land into the ocean. On top of this, the warming atmosphere is causing ocean temperatures to increase and sea water to expand, driving further sea level rise. As an oceanside city, Nanaimo is on the front lines of this change.

Figure 4: Recommended sea level rise allowances from present day to 2100 (figure adapted from the Province of BC)

In 2013, the Province published a guidance document for coastal flooding that recommended taking the following numbers into account for sea level rise: 0.18m to 2018, 0.5m for 2050 and 1m for 2100[16] (**Figure 4**). Note that the east coast of Vancouver Island is uplifting due to tectonic activity, and so a minor reduction to these numbers was applied through the development of this Strategy.

As highlighted in City of Nanaimo *Sea Level Rise Study*, our sea level rise estimates will continue to change as modelling techniques for geology and ice sheet movement improve over time. They will also evolve depending on climate mitigation efforts around the world, possibly accelerating further if drastic action is not taken. For this reason, planning for coastal flooding in Nanaimo will require a careful eye on sea level rise projections.

In considering how Nanaimo's coastline will be affected by sea level rise over time, it is important to look at the different components that contribute to overall water levels. Beyond sea level rise projections, these include:

- Tides, including exceptionally high **king tides**, which are gravity-driven and not a climate-related phenomenon;
- Storm surge, a local rising of the ocean driven by pressure changes in the atmosphere and strong wind gusts; and
- Wave height, which is related to winds strength and direction, along with shoreline characteristics.

Figure 5 summarizes these factors, showing current high tide conditions, current conditions during high tide and a storm, and future conditions at high tide during a storm, respectively. As base water levels continue to increase with sea level rise, it will no longer take a combination of coinciding events to cause coastal flooding at high tide.

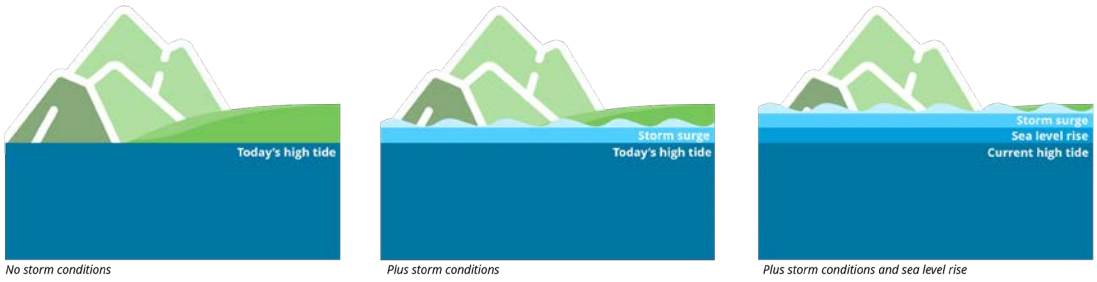


Figure 5: Components of sea level, including wind and waves, storm surge, and climate-related sea level rise

Potential impacts of sea level rise include coastal flooding with damage to public and private buildings and infrastructure, coupled with possible interruption of services, and storm and sanitary sewer backup. Sea level rise will also cause increased shoreline erosion in areas that are already vulnerable (e.g. in the north end between Departure Bay and Hammond Bay Roads and along the North Slope[17]), while initiating erosion in areas that were previously safe. As discussed in the **Sea**

[16] Province of BC. (2011). *Sea Level Rise Adaptation Primer.*

[17] City of Nanaimo. (2005). *Steep Slope Development Permit Area Guidelines.*

Level Rise Study, long-term sea level rise has the potential to cause the loss of low-lying waterside land, specifically in the areas of Departure Bay, Downtown, and Protection Island.

Impacts & Opportunities

The climate change projections presented above will present a wide range of consequences for the City of Nanaimo and the people who call it home. Climate change will also present a multitude of challenges for infrastructure, buildings, local economic development, and the provision of essential services. For City management and operations, climate change will also likely increase strain on contingency budgets and pose difficulties managing the renewal of infrastructure.

Participants involved in the planning process for the Strategy identified over 80 impacts for Nanaimo, many of which were challenges with a small number of potential opportunities (e.g. longer growing seasons). Through the risk and vulnerability assessment conducted with City staff and other stakeholders, these impacts were prioritized to address critical areas and make the most of Nanaimo's resources. below provides a brief summary of the key impacts identified through this process that were carried forward to adaptation action planning, categorized by general theme. Note that this is not a comprehensive list, but rather a representative snapshot of the type of impacts that were considered. The City has a record of all potential impacts discussed, which can be carried forward in future planning endeavours.

Table 1: Key climate-related impacts that were used to develop adaptation actions for Nanaimo

Projected Climate Trends	Water Supply / Flooding & Drainage	Environment, Parks & Recreation	Well-being & Preparedness	Land Use & Buildings	Economic Development & Corporate Governance
Hotter, drier summers	Strain on water supply	Greater risk of wildfire Added stress on local fish populations Added stress on local forests	Increased incidence of heat-related illness and stress, especially among vulnerable residents	Increased cooling demands with implications for energy cost and emissions	Challenges for the tourism industry and/or cancellation of events due to poor air quality
Warmer winters and overall temperature increases		Changes to tree species' range and increased incidences of tree mortality			Opportunities for agriculture with longer growing season
Increased intensity and frequency of precipitation	Increased flooding from overwhelmed stormwater drainage infrastructure, rivers and creeks	Degradation of riparian areas due to rainfall, high subsequent flow, erosion, etc. Increased landslide risk in areas that may damage public infrastructure		Increased erosion in steep slope areas Increased likelihood of landslide triggered by saturated soils	
Increase in extreme events	Increased demand on resources during times of recovery Damage to infrastructure causing service disruption	Potential damage and blocked access from fallen/dead trees, severe erosion and landslip	Increased stress and anxiety, especially for those most vulnerable Access challenges and safety risk for first responders		Increased demand on resources, including the City's contingency fund Long-term economic impacts given expense of continued response and recovery Disruption of transportation service and supply chains
Sea level rise	Further undermining of areas already vulnerable to shoreline erosion Impacts to storm and sewer infrastructure as sea levels and water tables rise	Loss of wildlife habitat in the estuary through coastal squeeze	Risks to public safety at the waterfront during high tide and storms over time	Risk to some low-lying and waterside areas Increased damage to public and private shoreline infrastructure (docks, marinas, etc.)	

4. Adaptation Actions

While many efforts are being made to mitigate climate change, some degree of climate change is inevitable. Nanaimo and its residents need to identify and implement a set of actions that will help them prepare for the impacts to come. This Strategy sets direction in six action areas, with economic considerations factored into each area:

1. Water Supply
2. Flooding and Drainage
3. Environment, Parks and Recreation
4. Well-being and Preparedness
5. Land Use and Buildings
6. Corporate Governance and Mainstreaming

The Strategy proposes between one and three objectives for each key area. Within each objective, both priority and additional supporting actions are listed. Technical details and implementation guidance for City staff are included in the companion document to this report.

WATER SUPPLY

Theme 1: Water Supply

The July 2019 *Preliminary Strategic Climate Risk Assessment for British Columbia*[18] rated seasonal water shortages as one of the high risks from climate change facing the province. Hotter, drier summers are projected to offset expected increases in annual rainfall, creating stresses on our water supply. Compounded by a significant decrease in snowpack by 2050, less water will be available for public, especially toward the end of hot summers. Significant population growth is also projected for both the province at large and for Nanaimo specifically, which will translate into an increase in the demand for water.

In addition to potential water supply issues, water infrastructure itself can also be at risk from climate change. In 2018, a storm in Nanaimo caused a chain of events resulting in the disruption of the water supply. Investing in resilient infrastructure and redundancies to cope with increased extreme events in the future is therefore key to overall resilience.

Objective 1: Prepare for more limited water supply over time and improve the resilience of the existing water supply infrastructure.

PRIORITY ACTIONS	
1.1.1.	Update the *Water Supply Strategic Plan* to account for climate change and population growth, and identify additional sources of drinking water
1.1.2.	Update the *Emergency Response Plan* for the water treatment plant and water supply infrastructure
Additional Actions	
1.1.3.	Continue and enhance water conservation and efficiency programs to avoid costly new infrastructure such as dams
1.1.4.	Establish a water governance committee or board to guide water sharing arrangements with neighbouring communities and First Nations groups
1.1.5.	Collaborate with the Province and local conservation partners to identify locations where water can be seasonally held and released during periods of low flow

FLOODING & DRAINAGE

Theme 2: Flooding & Drainage

Climate change will bring both more annual rainfall overall, as well as an increase in the intensity and frequency of rainfall when it does occur. Heavier rainfall on the wettest days or when it falls for several consecutive days can lead to localized flooding once soils are saturated, drainage infrastructure exceeds its capacity and rainfall flows over storm drains. At the same time, river flow patterns are set to change as snowpack declines over time and rainfall increases, changing floodplains making low areas at higher risk of flooding. Lastly, sea level rise is anticipated to continue for centuries, posing significant flood risk along the coastlines. Indeed, the 2011 provincial flood hazard guidelines now include a requirement for cities to plan for 0.5m of sea level rise by 2050, and 1m of sea level rise by 2100.

Responding to these anticipated changes includes the need to better understand current and future flood risks by including a climate lens on any infrastructure renewal projects, providing clear information to the public on what they can do to reduce their risk from any impacts, and reviewing associated regulations and policies.

Objective 1: Minimize urban and overland flooding resulting from heavy rainfall

PRIORITY ACTIONS	
2.1.1.	Identify, enhance and establish overland flow paths, drainage basins and protected right-of-ways on private property
2.1.2.	Prioritize and accelerate stormwater catchment master planning for local water basins
2.1.3.	Explore the potential for a stormwater utility rate to generate revenue as a sustainable funding source to mitigate impacts from climate change
2.1.4.	Complete floodplain modelling for major rivers
2.1.5.	Purchase a computerized maintenance management system (CMMS)
Additional Actions	
2.1.6.	Continue to update design requirements for on-site water retention and peak flow capacity to account for increased frequency and volume of rainfall
2.1.7.	Incorporate natural systems that help control stormwater flows (e.g. bioswales) into capital project planning

Objective 2: Prepare for the impacts of rising sea level and associated erosion and coastal flood risk

PRIORITY ACTIONS	
2.2.1.	Review minimum flood construction levels (FCL) and incorporate the results of the *Sea Level Rise FCL Study* for Nanaimo into the *Building and Zoning Bylaw*
2.2.2.	Develop a framework for an *Sea Level Rise Management Plan* that includes next steps and timelines
2.2.3.	Complete inundation modelling and mapping for areas identified as vulnerable during Phase 1 of the SLR Study (i.e. Departure Bay, Downtown, Duke Point and Protection Island)
2.2.4.	Review storm/sanitary manholes located in areas at risk of flooding, then outline steps for monitoring and preventative action as water levels rise
Additional Actions	
2.2.5.	Develop a green shores strategy to help protect waterfront properties from flooding risk, while also protecting and restoring habitats
2.2.6.	Develop and formalize a coastal erosion monitoring program

ENVIRONMENT, PARKS & RECREATION

Theme 3: Environment, Parks & Recreation

Warmer annual temperatures, fewer frost days, a longer growing season and other changes have significant implications for many species' ranges (including pests and diseases), as well as for ecosystems more generally. Increased disturbances from extreme events (e.g. extreme heat events, storms) are also expected to impact natural systems.

At the same time, natural areas such as forests, parks, and wetlands can help buffer the impacts of climate change. Urban forests improve stormwater management by absorbing and transpiring water, while also providing much-needed shade during hot summer days. Parks and natural areas help to filter and clean stormwater and are generally at low risk of flooding. Protecting and expanding these natural assets is key to improving Nanaimo's resilience.

Objective 1: Quantify and manage Nanaimo's urban forests to prepare for a changing climate

PRIORITY ACTIONS	
3.1.1.	Review and update City planting standards (for both City-led and private developments) to include climate-resilient tree species
3.1.2.	Reduce safety and access issues by improving tree resilience to storm and wind events along main transportation routes
3.1.3.	Develop and complete an urban forest inventory, and update the *Urban Forest Management Strategy* using a future climate lens
Additional Actions	
3.1.4.	Develop appropriate tree planting targets and schedules to replace trees lost during storm events and from overall climate warming
3.1.5.	Conduct park condition assessments in all City parks and develop adaptation measures to address climate impact risks (e.g. drought stress, heat events, wildfire smoke, storm damage, flooding)
3.1.6.	Continue to refer to and implement the City's *Community Wildfire Protection Plan* (CWPP)
3.1.7.	Identify and develop guidelines for fuel management zones within high-use parks

Objective 2: Assess and restore Nanaimo's watercourse and marine ecosystems to become biologically diverse and resilient

PRIORITY ACTIONS	
3.2.1.	Inventory City natural assets (e.g. Wexford Creek, Buttertubs Marsh, Park Avenue Wetland) and incorporate into the City's asset management program to protect and maintain their function
3.2.2.	Enhance watershed storage and impoundment to build resilience for urban streams within the Millstone River catchment area for fish habitat use during low summer flows
Additional Actions	
3.2.3.	Prioritize ecological restoration along riparian areas within the City to build resilience and protect habitat corridors, work with community stewardship groups and volunteers where possible
3.2.4.	Where feasible, design and install green infrastructure (e.g. bioswales, bioponds, retention tanks) that will improve water quality and potentially provide low summer flow into fish bearing streams
3.2.5.	Coordinate with the RDN to complete a detailed watercourse habitat health assessment for urban watercourses within the city, including diversity maintenance and invasive species control targets

WELL-BEING & PREPAREDNESS

Theme 4: Well-being & Preparedness

It is important to keep a focus on not only maintaining, but enhancing community well-being in the face of climate change impacts. Impacts to our health are growing as summers grow hotter and poor air quality advisories associated with province-wide wildfires increase in number. However, these risks can be reduced by improving neighbourhood-level resilience, as neighbours who are aware, prepared and connected to each other tend to do much better when faced with climate-related shocks or stresses.

In addition to supporting neighbourhood resilience, the City of Nanaimo will also work to enhance the city's general preparedness for changes in risks from extreme weather events. As risks of flooding are addressed specifically above, this includes addressing changes to wildfire and landslide risk and improving overall public awareness of extreme weather.

Objective 1: Work with community partners to minimize health impacts of extreme weather (higher heat days and poor air quality from wildfires) on residents

PRIORITY ACTIONS	
4.1.1.	Develop an *Extreme Heat Response Strategy* that includes information on cooling spaces that can serve community members during heat waves
4.1.2.	Work with Island Health and other stakeholders to deliver coordinated information on what the public can do during heat waves and poor air quality events
4.1.3.	Apply a climate change resilience lens when planning and designing public facilities, through considerations such as whether the facility can act as a cooling centre or clean air shelter
Additional Actions	
4.1.4.	Train outdoor staff (e.g. Bylaw, Parks, Public Works) to provide community members with information about options available to them during extreme events, such as public cooling centres
4.1.5.	Expand the *Blue Community* program to increase public water fountains and water bottle filling stations, and investigate the potential of mobile options

Objective 2: Improve knowledge, capacity and response plans to deal with increasing risk of landslides and wildfires

PRIORITY ACTIONS	
4.2.1.	Review and update the *North Slope Geotech Study* to incorporate climate change impacts and projections, and expand these lessons to other steep slope areas (e.g. Cilaire, Stephenson Point)
4.2.2.	Review procedures for servicing public infrastructure located on private property, including challenges accessing infrastructure
Additional Actions	
4.2.3.	Review and update engineering standards to better account for utility service elevations, retaining walls, and backyard easements
4.2.4.	Develop a proactive *Upper Nanaimo River Debris Management Plan* that accounts for climate change projections

Objective 3: Improve community capacity and resilience following events by increasing public awareness of climate change, its expected impacts and how the community can prepare

PRIORITY ACTIONS	
4.3.1.	Provide residents, neighbourhoods, and community organizations with opportunities learn more about climate change mitigation and adaptation efforts, and help facilitate resilience capacity building in the community
4.3.2.	Support neighbourhood-level organizations that help community members to prepare for climate emergencies
4.3.3.	Develop a community education program on park use fire safety and awareness
Additional Actions	
4.3.4.	Establish an outreach program to contact property owners with overland flow paths and provide education on how to maintain these paths while still enjoying their property
4.3.5.	Work with the Vancouver Island Real Estate Board and other stakeholders to develop a resilience awareness program for homeowners
4.3.6.	Educate current homeowners on requirements to maintain infrastructure to prevent damage (e.g. check and clean storm drains and private drainage infrastructure prior to rain events)
4.3.7.	Establish partnerships with landowners willing to use their property to showcase climate resilience actions to neighbouring residents

LAND USE & BUILDINGS

Theme 5: Land Use & Buildings

As noted above, climate change will have a significant impact on the magnitude and frequency of hazards such as wildfires and flooding events. Often in the way of these hazards are the buildings and facilities in which we live, work and recreate, which need to be protected to ensure both the health of occupants and the investment itself are safeguarded. This may require changes to the City's procurement strategy, but will also include updating performance standards, regulations or policies for new and existing buildings to ensure they are resilient to the shocks and stresses associated with climate change.

Objective 1: Incorporate resilience into new and existing facilities and support climate change resilience for homes

PRIORITY ACTIONS	
5.1.1.	Develop policy to require future climate considerations into new construction projects / rezoning applications (e.g. passive design, future climate modelling, appropriate shading)
5.1.2.	Include assessments for climate change impacts (e.g. wildfires, flooding, land-slip) into City-owned building facility assessments
Additional Actions	
5.1.3.	Remove regulatory restrictions on the placement of heat pumps, and provide education to homeowners on the benefits of heat pumps for improved energy efficiency and added cooling to stay comfortable in the summer months

Objective 2: Ensure development regulation and guidelines incorporate anticipated changes to climate-related natural hazards

PRIORITY ACTIONS	
5.2.1.	Identify forest interface wildfire risk areas adjacent to residential areas and City infrastructure, and establish a wildfire Development Permit Area (DPA) that includes FireSmart principles
5.2.2.	Update the *Hazard Land and Steep Slope Development Permit Area Guidelines* in the *Official Community Plan* (OCP) and other pertinent bylaws to require geotechnical reports for new construction in areas at high risk of flooding and landslides
Additional Actions	
5.2.3.	Develop a climate adaptation assessment checklist for rezoning and development permits
5.2.4.	Develop a sea level rise DPA with guidelines for new development/renovation and infrastructure placement in areas at risk of coastal flooding up to 2100
5.2.5.	Apply a climate adaptation lens to the natural hazard, steep slope and environmentally sensitive DPAs during the OCP refresh

Objective 3: Prioritize hazardous areas in the City's property acquisition strategy

PRIORITY ACTIONS	
5.3.1.	Identify hazardous lands and properties at risk from coastal flooding, sea level rise and landslide risk, and advocate to the Province for support in purchasing these lands as part of the City's long-term property management strategy
Additional Actions	
5.3.2.	Coordinate with other authorities/stakeholders/levels of government for property acquisition partnerships

CORPORATE GOVERNANCE & MAINSTREAMING

Theme 6: Corporate Governance & Mainstreaming

Improving our overall resilience means changing not just the things that we do, but how we do them: the way we approach a problem, our processes and procedures, and the way we make decisions. Incorporating a "climate lens" into the City's decision making and program development processes will exponentially improve the community's resilience by ensuring the impacts of a changing climate are considered before major investments are made or programs are developed. Corporate champions will be key to continuing the successful implementation of the Strategy and working with partners ensures resilience is built in partnership with key stakeholders.

Objective 1: Improve the City's agility in responding and recovering from climate-related hazard events

PRIORITY ACTIONS	
6.1.1.	Incorporate climate change resilience into the review and development of asset management plans
6.1.2.	Ensure contingency reserves contain an allowance for recovery from climate-related events
Additional Actions	
6.1.3.	Establish a *Family First Policy* to support City staff within the *Emergency Response Plan*
6.1.4.	Review large capital infrastructure investments using a Public Infrastructure Engineering Vulnerability Committee (PIEVC) (or similar) assessment method
6.1.5.	Review corporate business practices and plans to facilitate recovery (e.g. fast-tracking permitting processes during periods of recovery)
6.1.6.	Assess the potential economic benefits to the City as a result of climate change to help offset costs
6.1.7.	Explore partnership opportunities with School District 68 and other organizations having facilities that could support extreme weather shelters and/or backup recreational uses

Objective 2: Work with neighbouring jurisdictions to support climate change resilience and limit transfer of risk across jurisdictional boundaries

PRIORITY ACTIONS	
6.2.1.	Continue to work with Snuneymuxw First Nation (SFN) and other regional partners on the Nanaimo Estuary Management Committee and the Nanaimo River Watershed Roundtable to support climate adaptation initiatives that conserve and enhance habitat and protect property within the watershed
6.2.2.	Share information and collaborate with the Regional District of Nanaimo (RDN), neighbouring municipalities and SFN on implementation of sea level rise mapping and other resilience strategies
6.2.3.	Review existing servicing agreements between the City, SFN and District of Lantzville in light of climate projections and make appropriate adjustments to ensure consistent service and limit the transfer of risk across jurisdictional boundaries
6.2.4.	Partner with neighbouring jurisdictions and other municipalities to advocate for increased funding programs for climate change resilience

IMPLEMENTATION & MONITORING

5. Implementation & Monitoring

The actions presented in above have been accompanied by some early implementation details and timelines. However, more complex actions will first require the development of their own project and work plans as a first step. Some actions may require further investigation before they can be initiated, while others will be driven by the initiation of another process, such as a refresh of the City's OCP. Many actions will also rely on collaboration with community partners and residents, as enhancing overall community resilience depends on increasing awareness and supporting action by everyone.

The implementation of this Strategy will be coordinated through the Development Services department and overseen by the continued engagement of the City's Project Working Group. The Strategy will be reviewed at five-year intervals in order to assess impacts and actions against new climate science, incorporate new best practices and take advantage of new opportunities. Reviewing the Strategy in lock step with the IPCC's reporting cycle also helps to ensure a streamlined process as each new report triggers a new set of climate projections. The next IPCC synthesis report (AR6) is due in June 2022: allowing time for downscaled, local climate projections to be created, a review of Nanaimo's *Climate Change Resilience Strategy* could occur towards the end of 2022 or early 2023. A full refresh of the Strategy is recommended on a 10-year review, or in conjunction with OCP updates.

To maximize efficiency, the actions presented in this Strategy build on existing initiatives as much as possible. However, there are several actions that will require new funding and staffing resources for effective implementation. Now that the City has identified priority actions and timelines, the next step in implementation is to identify appropriate resourcing. Actions can either be separated into capital and operating needs and prioritized during upcoming budget cycles, or presented as emerging needs that require new resourcing as soon as possible. Fortunately, external funding for climate change adaptation is available and can be sought for specific projects (e.g. the *Disaster Mitigation and Adaptation Fund* available through Infrastructure Canada[19]).

The *Climate Change Resilience Strategy* should also itself be used as a basis for the review or development of other City plans and policies to ensure the integration of the actions into City planning processes. Integrating strategies and prioritizing adaptation actions that drive co-beneficial outcomes is key to improving overall climate change resilience. An important upcoming opportunity for the integration of the actions in this Strategy is the update to the *Official Community Plan*.

[19] Infrastructure Canada. (2019). *Disaster Mitigation and Adaptation Fund.*

Measuring Progress

Measuring adaptation to climate change is challenging for a number of reasons, especially considering the difficulty in defining success: is it an outcome that can be achieved, or an ongoing set of processes? The time horizons necessary to understand whether actions have successfully reduced risk can also be very long, such as with sea level rise, and baseline conditions can change during this time. Furthermore, estimates of outcomes that would have transpired without any adaptation action are difficult to measure and often inaccurate (e.g. the cost of implementing flood mitigation measures compared to the avoided cost of flood damage). Adaptation indicators are also frequently only proxy measures, as it is challenging to measure the true goal and identify when measures have negative unintended consequences[20].

Considering the factors above, good adaptation indicators are generally:

1. Linked to goals and objectives;
2. Allowing of adaptive and flexible planning;
3. Inclusive of both process (progress in implementing actions) and outcome (the change being made); and
4. Easy to measure and relatively accurate.

Indicators that will be explored to track Nanaimo's progress in improving resilience are presented in **Table 2** below. City staff will identify which of these indicators best fit with existing and anticipated monitoring plans and resourcing, and select appropriate targets based on local experience and expertise.

[20] Urban Sustainability Directors Network (USDN). (2016). *Climate Adaptation Framework and Indicator Evaluation.*

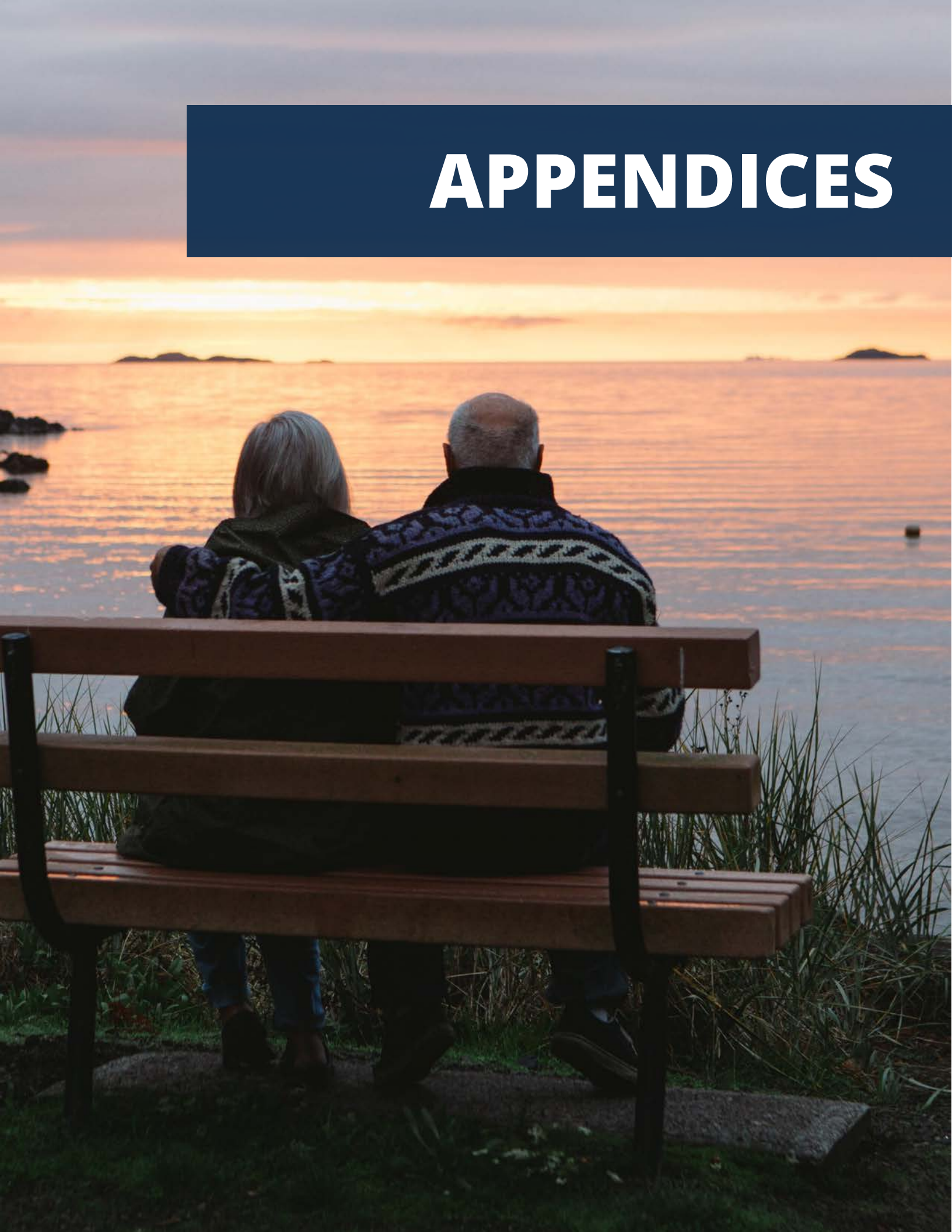
Table 2: Potential indicators for adaptation actions listed in this Strategy

Action Area	Indicator	Description
Water Supply	**Growth in volume of water stored (% from baseline)**	Choose a year as baseline and measure the growth in water stored and available for public use. Set a target to a certain year.
	Per capita water use	Litres of water used per capita. Develop a target reduction by a certain year.
Flooding and Drainage	**Number of complaints registered in Tempest CMMS**	Complaints made for flooding by the public. Set a target for a decrease in number or percentage by a certain year.
	Value of assets in unprotected future floodplain	Calculation of the value of assets in the floodplain for the year 2100. Target of what will be protected by a certain year by flood management planning.
Environment, Parks and Recreation	**Urban trees captured in a tree inventory (%)**	An annual or bi-annual target could be set until the inventory is complete
	Canopy cover	This is percentage of land covered by canopy. Requires a LiDAR or other study first to set the baseline and subsequent measurements
	Riparian restoration projects (#)	Set a target for a specific year
Well-being and Preparedness	***Heat Response Plan* complete and implemented**	This is a one-time progress indicator. Set a date to complete it by.
	Cooling centres available during extreme heat (#)	Set a number to achieve by a certain date.
Land Use and Buildings	**DPAs adopted and guidelines for areas at coastal risk completed (% or #)**	This is a one-time progress indicator. Set a date to complete it by.
	City owned facilities assessed for resilience (% or #)	Buildings audited for resilience criteria through a facilities conditions assessment. Set a target annually or monitor percentage of full portfolio annually.
Corporate Governance and Mainstreaming	**Asset management planning includes a well integrated climate lens**	By 2025. Success could be rated by what the Province has outlined for climate and asset management.
	Capital infrastructure projects assessed for climate risk (% annually)	Set a target of the percentage desired in 5 years, 10 years, etc.

6. Next Steps

Several changes in climate have been noted for the City of Nanaimo based on a range of reputable data sources. We recommend that further analyses and impact modelling build from this initial desktop review to better delineate local climate parameters and understand priority impacts. This could potentially include further analysis of climate parameters for the City of Nanaimo, or more detailed hydrological, groundwater and wildfire impact modelling to address specific climate impact risks. In addition, in light of rapidly improving climate data and information sources, we recommend maintaining a curated climate data guide for reference in evolving adaptation planning efforts.

APPENDICES



Appendix A: Acronyms & Glossary

Acronyms

BARC: Building Adaptive and Resilient Communities

CMMS: Computerized maintenance management system

CO_2: Carbon dioxide

CWPP: Community Wildfire Protection Plan

DPA: Development Permit Areas

FCL: Flood construction level

ICLEI: International Council for Local Environmental Initiatives

ICLR: Institute for Catastrophic Loss Reduction

IPCC: Intergovernmental Panel on Climate Change

HRVA: Hazard, Risk and Vulnerability Assessment

GCoM: Global Covenant of Mayors

GHG: Greenhouse gas

LiDAR: Light Detection and Ranging

OCP: Official Community Plan

PCIC: Pacific Climate Impacts Consortium

PIEVC: Public Infrastructure Engineering Vulnerability Committee

RCP: Representative Concentration Pathways

RDN: Regional District of Nanaimo

SFN: Snuneymuxw First Nation

VIU: Vancouver Island University

Glossary

Adaptation: Adjusting decisions, activities, and actions based on observed or expected climate conditions, with the goal of moderating the negative impacts of climate change and capitalizing on beneficial opportunities.

Adaptive capacity: The ability to prepare for these impacts or respond to the consequences.

Base year: A starting point for making comparisons, which can be used for factors such as GHG emissions, temperatures, and rainfall.

Climate: Longer-term trends in atmospheric conditions over years or decades.

Climate change: Variations in climate over long time periods that have been observed and are projected to occur in the future (30-year periods typically).

Co-benefits: Improvements to the community that occur alongside climate mitigation and adaptation actions, such as improved public greenspace or enhanced public transportation.

Consequence: The potential damage, disruption, or strain experienced should a climate-related event occur. Consequence can range from minor (inconvenience) to severe (e.g. loss of life).

Extreme weather: Unpredictable, unexpected, and severe weather for a given location, including occurrences such as heat waves, droughts, storms, and tornados.

Flood construction level (FCL): The minimum height that new development is required to build to in order to protect the it from risk of flooding.

Greenhouse gas (GHG): Gases that trap heat in the atmosphere and contribute to climate change by absorbing infrared radiation (e.g. carbon dioxide, chlorofluorocarbons, methane).

Green shores strategy: An approach to shoreline management that uses natural materials to dissipate wave energy, reduce storm surge and lessen flooding, while also protecting and restoring habitats.

Impact statement: A brief summary of potential climate-related impacts to a given climate projection, which should be specific and actionable.

Likelihood: The expected return period or probability of the hazard event or trend occurring.

Mitigation: Measures taken to limit GHG emissions and associated global warming.

Natural assets: Environmental features and ecosystems that provide people with vital services, such as aquifers, forests, streams, and riparian areas.

Resilience: The capacity of a social, environmental, or economic system to cope with a hazardous event, trend, or disturbance, by resisting or changing in a way that maintains an acceptable level of functioning and structure.

Risk: A function of likelihood that a climate-related event will take place, and the consequence of that event should it occur.

Sensitivity: The degree to which people or systems are impacted by changing climate conditions, either positively or negatively.

Storm surge: A local rising of the ocean driven by pressure changes in the atmosphere and strong wind gusts.

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.

Weather: The atmospheric conditions at a specific location at a specific time, which generally occur over a short time period and change frequently.

Appendix B: Methodology

The methodology used to develop this project aligns closely with the *BC Climate Risk Assessment Framework* that was published half-way through this project. In a broad sense it follows risk assessment steps as outlined by the International Standards Association and many others. It borrows from the currently under development modernization of the *Hazard, Risk and Vulnerability Assessment* (HRVA) process and the ICLEI (Local Governments for Sustainability) *Building Adaptive and Resilient Communities* (BARC) process tools.

Establishing Context

Several technical memos were developed as background material for the Strategy development process. These included a climate science memo and a baseline assessment memo. The former laid out climate projections anticipated to 2050 and 2080 based on the IPCC Representative Concentration Pathway 8.5 (RCP8.5) climate scenario. The Baseline Assessment summarized a comprehensive review of City of Nanaimo plans, policies, bylaws and standards for existing climate change resilience building efforts, gaps and opportunities. Both of these documents were used throughout the process (a summary of the projection memo was used at each workshop).

Impact Generation

In a workshop setting with staff and stakeholders, the concept of an impact statement was reviewed. An impact statement includes the climate-related shock or stress (i.e. heavier rainfall, increased frequency of heatwaves, coastal flooding) and the effect it may have (leads to property damage or illness or service disruption, etc.). Participants engaged through a world café style workshop to develop context-specific impact statements across climate projections. Scenarios for 2050 were used to initiate brainstorming and attempt to place participants in a different climate future. Through this process, participants generated a total of 85 impacts. Following the workshop, redundancies and overlaps were reconciled and clarifications made, bringing this number to 64 impacts. There was an opportunity to add impacts as they came up throughout the process.

Vulnerability Assessment

Again in workshop setting, staff completed a rating of vulnerability for all the impacts. Vulnerability was rated using ICLEI BARC proxies for sensitivity and adaptive capacity as detailed below. Staff worked in groups first individually rating impacts and then discussing ratings. A second group reviewed the ratings for any major differences in ratings. Following the workshop, staff reviewed the overall ratings of vulnerability and highlighted any to move up or down in rating.

Sensitivity Rating

If the impact occurs, will it affect functionality (the ability of the system / asset / group of people to serve its purpose or provide the use it is designed for)?

1	2	3	4	5
No:	**Unlikely:**	**Possibly:**	**Likely:**	**Yes:**
Functionality will stay the same	**Functionality will likely stay the same**	**Functionality is likely to get worse**	**Functionality will get worse**	**Functionality will become unmanageable**

Adaptive Capacity Rating

Can the system / asset / group of people adjust to the projected impact with minimal cost and disruption?

1	2	3	4	5
No:	**Unlikely:**	**Possibly:**	**Likely:**	**Yes:**
Will require substantial costs and intervention	**Will require significant costs and intervention**	**Will require some costs and intervention**	**But will require some slight costs and intervention**	**Little to no costs or intervention will be necessary**

	SENSITIVITY	No	Unlikely	Possibly	Likely	Yes
ADAPTIVE CAPACITY		S1	S2	S3	S4	S5
No	AC1			V4	V5	V5
Unlikely	AC2			V3	V4	V5
Possibly	AC3			V3	V4	V4
Likely	AC4				V3	V3
Yes	AC5				V3	V3

Risk Assessment

In workshop setting, staff risk rated only those impacts that received a V3 rating or higher. Nanaimo's HRVA risk scale was used for rating the impacts in order to help place anticipated future risk of these impacts relative to other non-climate related risks (train derailment, traffic accident etc.). The HRVA modernization effort currently underway was used, with likelihood rated for the future (2050) as well as current likelihood rated (based on past experience). The likelihood rating in Nanaimo's current HRVA for climate-related events (wildfire, extreme weather, etc.) was input for associated impacts as the "current likelihood" rating.

Consequence / Impact

Consequence score is based on the severity of the consequence to people, property and the environment. Rank consequences anticipated from the impact statement.

Score	Consequence / Impact on People, Property and Environment
4	**Catastrophic:** Multiple fatalities, municipal evacuation, widespread long-term environmental impact, no or minimal stakeholder confidence
3	**Severe:** Multiple serious injuries or one fatality or adverse long-term health impact, severe medium-term environmental impact, release requiring significant clean up, widespread reduction in stakeholder confidence
2	**Moderate:** Serious injury, minimal property damage, release with minimal short-term adverse effects on the environment, moderate reduction in stakeholder confidence
1	**Minor:** Minor injuries, minimal impact if any on public, equipment or property damage, environmental impacts confined locally, minimal or no reduction in stakeholder confidence

Likelihood

Likelihood score is based on the expected return period or probability of the hazard event or trend occurring in Nanaimo. We will rank likelihood based on past experience and events and the probability of them occurring in the future given climate change projections.

Score	Qualitative Description	Recurrent Impact	Single Event
4	**Frequent or almost certain:** Exposure will occur if not attended to and will result in repeated incidents	Monthly to 2 years	More likely than not - >50% chance
3	**Moderate or likely:** Exposure to hazard is common in the region and has happened infrequently in towns	3 to 10 years	As likely as not – 50/50 chance
2	**Unlikely or improbable:** Exposure to hazard is conceivable but unusual, unlikely in the region but heard of similar incidents	101 to 199 years	Unlikely but not negligible
1	**Highly unlikely or rare:** Exposure to the hazard is rare for this region	> 200 years	Negligible probability

Action Planning

Workshops were held with staff and stakeholders with specific expertise to generate the first round of action ideas to help prepare for these risks and minimize the associated impacts. Impacts rated high and medium for risk were the focus of action planning, but low risk impacts were reviewed for actions that were complementary or straightforward. Overall, 36 impacts were included for action planning, and evaluation was carried out looking at the benefit or impact to resilience, cost, and co-benefit potential. Several further rounds of review and an additional workshop were carried out to help finalize actions and add implementation details.

Appendix C: Detailed Climate Projections for Nanaimo

TEMPERATURE CHANGES	Baseline	2050	2080
Summer Extreme Temperature Hottest day time temperature averaged over a thirty-year period	31°C (*1971-2000*)	34.5°C	36.7°C
Freezing Conditions Number of degrees that a day's average temperature is below 0°C, summed over all the days in a year	92 degree days (*1981-2010*)	49 degree days	30 degree days
Growing Season Length The number of days per year between the first and last six-day periods with daily average temperatures above/below 5°C	262 days (*1971-2000*)	322 days	349 days
Extreme Heat Events Days per year above 25°C	23 days (*1971-2000*)	54 days	78 days
Cooling Degree Days Number of degrees that a day's average temperature is above 18°C, summed over all the days in a year, used as a metric of building cooling requirements	118 degree days (*1981-2010*)	323 degree days	537 degree days
Heating Degree Days The amount of energy that it takes to heat buildings to comfortable temperatures, calculated by multiplying the number of days that the average daily temperature is below 18°C by the number of degrees below that threshold	3489 days[21]	-547 degree days	-844 degree days

[21] Taken from the report: Climate Projections for Metro Vancouver as a proxy

PRECIPITATION CHANGES	Baseline	2050	2080
Extreme Short Duration Precipitation Maximum volume of rain that falls in one day for a 1 in 50-year return period	106 mm (*1980-2007*)	131 mm	143 mm
Extreme High Precipitation Over 5 Days Maximum amount of rain over a consecutive 5-day period on an annual basis	177 mm (*1971-2000*)	194 mm	218 mm
Dry Spells Longest continuous stretch with each day receiving less than 1mm of rain per day	22 days (*1971-2000*)	26 days	29 days
Snowfall Annual precipitation as snow	32 mm (*1976-2005*)	13 mm	7 mm
EXTREME EVENTS	**Baseline**	**2050**	**2080**
Wildfire Risk (Increase in Fire Spread Days) Fire spread days are a measure of days in which wildfire, once initiated, would expand	1x (*1976-2005*)	1.5-2x	2-2.5 x
High Winds Percent change in annual frequency of hourly 70 km/h wind gusts	0% (*1976-2005*)	20%	25%

Appendix D: Climate Science Review

INTRODUCTION

A clear understanding of expected future climate trends is a key aspect of developing a robust strategy to adapt to future climate impacts. To inform the City of Nanaimo's ongoing *Climate Change Resilience Strategy*, the consultant team completed a review of key regional sources of climate data and information. This review was targeted at information relevant to priority climate impacts for the City and developed from a variety of reputable sources, such as the Pacific Climate Impacts Consortium (PCIC). From these sources, we distilled city-relevant climate projection information.

Where directly relevant information was not available, or required additional analysis that was beyond the scope of the current project, the absence of this data has been noted to guide future refinement. In some cases, large uncertainty existed in the magnitude of future change due to current limitations of climate model projections. These cases are also noted as a way of providing context for any risk-based decision making that could rely on these estimates.

We focused on gaining an understanding of the changes to future conditions that are likely to present the most significant impacts on the City of Nanaimo's infrastructure, public land use, community health and well-being, and environment. Nanaimo climate change will be characterized by change that is consistent with broader regional patterns:

- Sea level will continue to rise despite ongoing land subsidence.
- Temperatures will increase across all seasons.
- Winter precipitation (including extreme precipitation) will tend to increase, while summer precipitation will tend to decrease.
- Simultaneous temperature and precipitation trends will cause notable increases to wildfire risk and decreases to precipitation as snow.

The details of this review, including sources of climate data and particular trends for each potential change in climate, are provided below.

SOURCES OF NANAIMO CLIMATE INFORMATION

As there is no single comprehensive study that presents projected climate change magnitudes across a consistent set of climate metrics for Nanaimo, multiple regional climate change information sources from a range of reputable providers have been used. This report uses information from data sources that were determined to be most recent and/or relevant to the City of Nanaimo:

- **Nanaimo Regional General Hospital (NRGH) Climate Change Vulnerability Assessment Report (RDH Building Science Inc.).** This provides an assessment of changes to a large number of climate variables developed in concert with climate scientists at PCIC.
- **City of Nanaimo Sea Level Rise Study (Associated Engineering).** This report provides an assessment of sea level flooding potential through to year 2100, including detailed modelling and analysis of storm surge and wave runup.
- **Geological Survey of Canada Open File 7737: Relative Sea-level Projections in Canada and the Adjacent Mainland United States.** This report provides an updated estimate of relative (net experienced) mean sea level changes, and also provides an estimate of upper-bound sea level rise associated with West Antarctic Ice Sheet collapse in the 21st century.
- **Wang et al. Projected changes in daily fire spread across Canada over the next century. Environmental Research Letters, 2017.** This peer reviewed scientific article projects change in daily wildfire spread metrics across Canada in response to climate change, for a series of standardized homogenous fire zones.
- **Chen et al. Possible Impacts of Climate Change on Wind Gusts under Downscaled Future Climate Conditions: Updated for Canada, Journal of Climate, 2014.** This peer-reviewed scientific article provides an estimate of changes to damaging wind gusts using downscaled climate model projections of Canada.
- **Climate Projections for the Cowichan Valley Regional District (Cowichan Valley Regional District).** This report provides projected change values for many climate metrics in the Cowichan Valley region, using data produced by PCIC.
- **IDF-CC V3.0 Tool (Institute for Catastrophic Loss Reduction/Western University).** This online tool provides estimates of future extreme precipitation changes by combining downscaled climate change information from PCIC with historical rainfall observations.
- **The Climate Atlas of Canada (Prairie Climate Centre).** This online tool provides evaluations of climate change based on aggregated downscaled climate information from PCIC for several key temperature and precipitation indices.
- **ClimateBC V5.60 Tool (UBC Centre for Forest Conservation Genetics).** This online tool provides estimates of changes to average climate conditions over British Columbia at high resolution, for a range of temperature and precipitation-dependent variables

New data and information sources will emerge in the future, including a more refined version of PCIC's Climate Explorer, which could be used to refine the analysis of future climate changes in Nanaimo. We recommend that the City of Nanaimo continuously engage with local and provincial climate scientists to maintain a curated database and current summary of all sources to aid in future decision making.

CLIMATE CHANGE PROJECTIONS

A set of high priority climate change metrics that are likely to impact the City of Nanaimo are summarized below. In all cases (except for sea level rise), future changes were based on the Representative Concentration Pathway 8.5 (RCP8.5) climate scenario[22]. This pathway assumes a "business-as-usual" future in which little action is taken to reduce greenhouse gas emissions at a global scale. It therefore represents a conservative (i.e. worst case) scenario and is recommended by most institutions to be used as a base level set of assumptions to ensure climate planning is robust.

We present information for high-priority climate change metrics below using consistent tables of information that summarize the source of the information, future projection values, and levels of confidence in projection direction and magnitude. Representative levels of change for both the mid-21st century ("mid-term", or 2050) and the end of the 21st century ('long-term", or 2080) have been provided in order to inform any resilience planning that may occur within these general timelines – for example, as determined by expected infrastructure useful lifetimes or long-term natural asset planning. For sea level rise, projected changes are based on an assumed 1.0m of sea level rise over the 21st century relative to the year 2000, as per official provincial guidance[23] (i.e. the British Columbia Ministry of Environment).

Information source	*This indicates the source of climate projection information*		
Information description	*This indicates what the information represents and how it was developed*		
Representative climate metric	*This indicates the specific measure/units of climate metric*		
Representative location	*This indicates the location/region of the projection information*		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	Average numbers for the recent past numbers	*Med-term projection estimate*	*Long-term projection estimate*
Projection direction confidence	*Level of confidence in qualitative "direction" of future trend (e.g. "hotter"/"wetter")*		
Projection magnitude confidence	*Level of confidence in quantitative projection values (e.g. "170 mm in 2050 period")*		

[22] United Nations Intergovernmental Panel on Climate Change (IPCC). (2013). Anthropogenic and Natural Radiative Forcing. In: *Climate Change 2013: The Physical Science Basis.*

[23] British Columbia Ministry of Environment. (2013). *Sea Level Rise Adaptation Primer.*

SEA LEVEL RISE

Potential impacts: Coastal flood damage and interruption of services, storm and sanitary sewer backup

It is nearly certain that relative sea level (as quantified in Flood Construction Level and other metrics) will increase, despite ongoing upward vertical land movement along eastern Vancouver Island. However, as highlighted in City of Nanaimo Sea Level Rise Study, updated sea level rise estimates from improved understanding (including tectonic, climate and ice sheet modelling) and evolving global carbon emission scenarios will drive changes to quantitative sea level rise estimates over time. The largest uncertainty in 21st century sea level projections stems from potential collapse of the West Antarctic Ice Sheet. In the scenario described in Geological Survey of Canada Open File 7737, this could potentially increase Nanaimo relative sea level rise values by an additional 0.65 m by year 2100. Continued monitoring of changing sea level projections is recommended.

Information source	City of Nanaimo Sea Level Rise Study		
Information description	Flood Construction Level heights resulting from 1-in-200-year peak annual wind speeds were developed via an assessment of all components of the local sea level budget, from global sea level rise to local storm surge effects		
Representative climate metric	Flood Construction Level (meters, referenced to CDVD2013 datum)		
Representative location	Study Transect 22 (Departure Bay)		
Baseline/projected change	**Baseline**	**2050s**	**2100s**
	6.68 m	7.00 m	8.10 m
Projection direction confidence	HIGH		
Projection magnitude confidence	MEDIUM		

SUMMER EXTREME HEAT

Potential impacts: Wildfire risk, heat stress, health impacts, infrastructure stress

Extreme warm temperature metrics were taken from the recent Cowichan District report despite its southern location. We are confident that equivalent temperature increases in Nanaimo are likely to be similar. Conversely, other available Nanaimo-focussed reports were unclear in their calculation of summer heat metrics (NRGH Climate Change Vulnerability Assessment Report), provided only mid-century projections (NRGH Climate Change Vulnerability Assessment Report), and/or were overly spatially coarse and therefore likely included the effect cooler interior highland temperatures (Climate Atlas of Canada).

Information source	Climate Projections for the Cowichan District		
Information description	Downscaled climate model projections of the Cowichan region, south of Nanaimo, were used to estimate changes to daily summer temperature maximum increases		
Representative climate metric	30-year average hottest daytime high temperature change for RCP8.5 scenario		
Representative location	Cowichan District “Developed Areas” (low elevation, coastal) sub-region		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	31 °C (1971-2000)	34.5 °C	36.7 °C
Projection direction confidence	HIGH		
Projection magnitude confidence	HIGH		

WILDFIRE RISK

Potential impacts: interface zone damage, air quality impacts

We are confident that increased temperatures and decreased summer precipitation (Climate Atlas of Canada) will drive increased local wildfire risk, leading to high direction confidence. Because increased risk holds for the province as a whole, we also have high confidence that increases in smoky conditions in the City of Nanaimo related to fires elsewhere will also occur. However, complex interplay between temperature and precipitation, influence of additional non-climatic factors, and assessment of average spread over large Pacific zone leads to a low magnitude confidence for local Nanaimo region fire risk changes. We recommend further local-scale desktop review and analyses to refine the estimate provided here.

Information source	Wang et al., 2017		
Information description	Data from climate model projections, weather observations and the national fire database of Canada are combined to estimate future wildfire conditions		
Representative climate metric	Realized fire spread days are a ratio of increasing days relative to present, for RCP8.5 scenario; Realized fire spread days are a measure of days in which wildfire, once initiated would expand. When projected into the future, this provides a proxy for risk of dangerous interface fire growth		
Representative location	Pacific zone		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	1 (1976-2005)	1.5-2x	2-2.5x
Projection direction confidence	HIGH		
Projection magnitude confidence	LOW		

EXTREME SHORT-DURATION PRECIPITATION

Potential impacts: erosion, riverine flooding, water quality degradation, property damage, risks to public

The IDF-CC Tool was used to estimate historical and future annual maximum 1-day precipitation changes at the Nanaimo City Yard Environment and Climate Change Canada weather station. Future change is represented as a mean of an ensemble of downscaled and bias-corrected PCIC climate output. The increase in annual maximum 1-day precipitation by the 2050s is consistent with a similar but independent finding within the NRGH Climate Change Vulnerability Assessment Report, providing validation of both results and allowing IDF-CC to extend NRGH Climate Change Vulnerability Assessment Report trends to the 2080s. We attach high direction confidence to projections of increased extreme short-duration precipitation. This direction confidence also holds for hour-scale annual maximum precipitation trends. However, medium/low magnitude confidence in daily/hourly annual maximum precipitation trends reflects inherent difficulty in quantifying the exact magnitude of short-duration local precipitation in climate model simulations.

Information source	IDF-CC Tool, NRGH Climate Change Vulnerability Assessment Report		
Information description	Data derived from observations, climate models and statistical extreme precipitation tools are combined to estimate extreme precipitation trends		
Representative climate metric	1-in-50 year 1-day annual maximum rainfall (mm) for RCP8.5 scenario; This is the maximum volume of rain that falls in one day on a 1 in 50-year return interval (e.g. a 2% annual chance of an equivalent event occurring in a given year)		
Representative location	Nanaimo Regional General Hospital		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	106 mm (1980-2007)	131 mm	143 mm
Projection direction confidence	HIGH		
Projection magnitude confidence	MEDIUM		

EXTREME PERSISTENT HIGH PRECIPITATION

Potential impacts: erosion, increased landslide risk, property damage, riverine flooding, water quality degradation, risks to public

Extreme persistent high precipitation metrics were taken from the recent Cowichan District report despite its southern location, as we are confident that equivalent increases in Nanaimo are likely to be similar. We attach a high level of direction confidence to projections of increased persistent heavy precipitation. However, a medium level of confidence in the magnitude reflects inherent difficulty in quantifying the exact magnitude of local multi-day persistent precipitation event increases in future climate simulations.

Information source	Climate Projections for the Cowichan District		
Information description	Downscaled climate model projections of the Cowichan region, south of Nanaimo, were used to estimate changes in multi-day rain event magnitude		
Representative climate metric	5-day maximum precipitation for RCP8.5 scenario; This measures the maximum amount of rain over a consecutive 5-day period on an annual basis.		
Representative location	Cowichan District "Developed Areas" (low elevation, coastal) sub-region		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	177 mm (1971-2000)	194 mm	218 mm
Projection direction confidence	HIGH		
Projection magnitude confidence	MEDIUM		

EXTREME PERSISTENT LOW PRECIPITATION

Potential impacts: Drought, water shortages, agricultural productivity loss

Extreme persistent low precipitation metrics were taken from the recent Cowichan District report despite its southern location. We are confident that equivalent decreases in Nanaimo are likely to be similar, as both regions follow similar regional trends. We include the entire Cowichan District in our analysis as a proxy for similar regions upland of Nanaimo that provide important water catchment watersheds. We attach a high level of direction confidence to projections of future increased dry spell durations but medium projection magnitude confidence, in light of the difficulty in accurately simulating the length of specific drought-causing atmospheric conditions (e.g. individual high-pressure blocking systems) in future climate model predictions.

Information source	Climate Projections for the Cowichan District		
Information description	Downscaled climate model projections of the Cowichan region south of Nanaimo were used to estimate changes in persistent dry spell conditions		
Representative climate metric	Dry spell duration (days) for RCP8.5 scenario; This measure refers to the longest continuous stretch with each day receiving less than 1mm of rain per day		
Representative location	Cowichan District (entire district)		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	22 days (1971-2000)	26 days	29 days
Projection direction confidence	HIGH		
Projection magnitude confidence	MEDIUM		

SNOWFALL

Potential impacts: Spring freshet changes, water shortages

We used precipitation as snow over the annual period (with a natural weighting towards the winter season) as a proxy for the presence of persistent snow occurrence in the Nanaimo region. In practice, snow does not typically linger in Nanaimo proper, although higher elevation inland mountainous areas do accumulate significant snowpack. Changes to this snowpack can potentially cause significant implications for spring freshet and summer water supply. We attach high direction and magnitude confidence to a prediction of strongly decreasing snow presence. More detailed snowpack analysis would better constrain complex elevation impacts on the hydrological response to inland snow melt.

Information source	ClimateBC V5.60		
Information description	ClimateBC uses a combination of high-resolution provincial temperature and precipitation climatologies and global climate model simulations to provide an estimate of changes to the fraction of precipitation that falls specifically as snow		
Representative climate metric	Annual precipitation as snow (mm) for RCP8.5 scenario		
Representative location	City of Nanaimo Centre		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	32 mm (1976-2005)	13 mm	7 mm
Projection direction confidence	HIGH		
Projection magnitude confidence	HIGH		

WIND GUSTS

Potential impacts: Storm surge, tree/vertical infrastructure fall-induced damage or damaged to neighbouring structures

We recommend caution when applying the projected wind gust change projections due to medium/low direction/magnitude confidence. Our suggestion for caution stems from large uncertainties in future wind projections related to difficulty in capturing atmospheric and land-atmosphere interaction dynamics and local wind microclimates. Nonetheless, an assessment of increased wind gust activity is consistent with a general expectation of higher energy atmospheric circulation in response to future warming. We recommend that the City monitor the ongoing emergence of high-resolution atmospheric model frameworks, for potential application to improved City-specific wind gust projections.

Information source	Chen et al., 2014		
Information description	Downscaled climate model projections were analyzed to assess changes to extreme wind conditions		
Representative climate metric	% change in annual frequency of hourly 70 km/h wind gusts for RCP8.5 scenario		
Representative location	Pacific Coastal Region		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	0%	20%	25%
Projection direction confidence	MEDIUM		
Projection magnitude confidence	LOW		

FREEZING CONDITIONS

Potential impacts: Agricultural activity, building heating requirements, transportation infrastructure and safety

High projection direction and magnitude confidence is given to a projection of less freezing degree days. Note that this metric is highly elevation-dependent, such that higher elevation City of Nanaimo areas could experience significantly different magnitudes than lower elevation areas. Nonetheless, the direction of change, towards fewer freezing degree days, will be the same in both cases.

Information source	ClimateBC V5.60		
Information description	ClimateBC uses a combination of high-resolution provincial temperature and precipitation climatologies and global climate model simulations to provide an estimate of changes to cold winter conditions		
Representative climate metric	Freezing degree days, the number of degrees that a day's average temperature is below 0 °C, summed over all the days in a year		
Representative location	City of Nanaimo Centre		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	92 degree days (1981-2010)	49 degree days	30 degree days
Projection direction confidence	HIGH		
Projection magnitude confidence	HIGH		

GROWING SEASON LENGTH

Potential impacts: Agricultural productivity

High projection direction and magnitude confidence is given to increasing growing season length, which is already relatively extensive in Nanaimo due to its low elevation maritime location. Note that this metric is highly elevation-dependent, such that higher elevation City of Nanaimo areas could experience significantly different growing season lengths than lower elevation areas. Nonetheless, the direction of change towards fewer frost days will be the same in both cases.

Information source	Climate Projections for the Cowichan District		
Information description	Downscaled climate model projections of the Cowichan region, south of Nanaimo, were used to assess changes to the length of the full growing season		
Representative climate metric	Growing season length, the number of days per year between the first and last six-day periods with daily average temperatures above/below 5 °C		
Representative location	Cowichan District "Developed Areas" (low elevation, coastal) sub-region		
Baseline/projected change	**Baseline**	**2050**	**2100**
	262 (1971-2000)	322	349
Projection direction confidence	HIGH		
Projection magnitude confidence	HIGH		

EXTREME HEAT EVENTS

Potential impacts: Heat stress, health impacts, infrastructure resilience, water quality

High projection direction and magnitude confidence is given to increasing number of days above 25 °C. Note that this metric is highly elevation-dependent, such that higher elevation City of Nanaimo areas could experience significantly different numbers of days above 25 °C than lower elevation areas. Nonetheless, the direction of change, towards increasing warm summer days, will be the same in both cases.

Information source	Climate Projections for the Cowichan District		
Information description	Downscaled climate model projections of the Cowichan region, south of Nanaimo, were used to assess the number of particularly warm summer days		
Representative climate metric	Days per year above 25 °C		
Representative location	Not listed		
Baseline/projected change	**Baseline**	**2050s**	**2080s**
	23 (1971-2000)	54	78
Projection direction confidence	HIGH		
Projection magnitude confidence	HIGH		

SUMMER WARMTH

Potential impacts: Building cooling requirements, agricultural productivity

High projection direction and magnitude confidence is given to a projection of increasing cooling degree days, which provide an integrated measure of summer warmth that relates closely to building air conditioning energy requirements. Note that this metric is highly elevation-dependent, such that higher elevation City of Nanaimo areas could experience significantly different magnitudes than lower elevation areas. Nonetheless, the direction of change towards greater numbers of cooling degree days will be the same in both cases.

Information source	ClimateBC V5.60		
Information description	ClimateBC uses a combination of high-resolution provincial temperature and precipitation climatologies and global climate model simulations to provide an estimate of changes to the number and intensity of warm summer days that typically require building cooling		
Representative climate metric	Number of degrees that a day's average temperature is above 18 °C, summed over all the days in a year, used as a metric of building cooling requirements.		
Representative location	City of Nanaimo Centre		
Baseline/projected change	**Baseline**	**2050**	**2100**
	118 degree days (1981-2010)	323 degree days	537 degree days
Projection direction confidence	HIGH		
Projection magnitude confidence	HIGH		