Climate Change Adaptation Strategies for the City of Colwood

A preliminary stakeholder informed guiding document

2020
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- School District 62
- Island Health
- Westshore Chamber of Commerce
- Royal Roads University
- Capital Regional District

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Our Vision

Colwood is prepared to adapt to a changing world by building resilience and integrating multi-faceted approaches to climate change.
1.0 Introduction

Climate change poses the greatest environmental challenge of our time. The impacts of climate change and severe weather events are being experienced throughout the Capital Region and beyond, with local events increasing in frequency and magnitude over the past several years (Capital Regional District [CRD], 2017). An overwhelming 97 percent of scientists agree that climate change poses unprecedented risks to society and the ecosystems upon which we all depend for survival (Cook et al., 2016). This risk is further complicated by the time lag associated with climate change. For example, the world’s oceans store the greatest amount of heat energy; however, this stored heat has not yet impacted air temperature or climate-related conditions on land. This time lag means that even if society takes immediate steps to curb all greenhouse gas emissions (GHGs) we would still be committed to approximately 1.3 °C of warming (International Panel on Climate Change [IPCC], 2014; Richardson et al., 2012).

Climate change will have varied impacts on Colwood’s social, natural, and built systems, with the biggest climate hazards being increased average temperatures, seasonal variability in precipitation and temperature, extreme weather events, and sea level rise (CRD, 2017; Lemmen et al., 2008). Although the overall risk to coastal flooding is low in Colwood, low-lying areas are susceptible to the impacts of coastal storm flooding with the greatest potential impacts expected to occur to the ecosystems and cultural heritage at the Esquimalt Lagoon (CRD, 2020). Hotter, drier summers are predicted to become the norm, causing a myriad of impacts from increased wildfire risks, to stress on City trees and ecosystems, to human health impacts from extreme heat and air quality events. A particularly memorable event in recent history were the wildfires in the summer of 2017 and 2018; the impacts of wildfire smoke rippled throughout the region during these events that occurred across the province. All of these climatic impacts undermine the integrity of the built, natural, and socio-economic systems within the City.

The need to proactively plan for climatic impacts is a priority within the City, and options for developing a climate change strategy moving forward have been laid out in this Climate Change Adaptation Strategies document. This document will be a component of Colwood’s development of a comprehensive plan for climate action that addresses climate mitigation and adaptation, through the lens of low carbon resilience (LCR).
1.1 Together for Climate Project
ICLEI Canada’s Together for Climate project facilitated Colwood’s climate adaptation planning process. Together for Climate was a two-year initiative that engaged eight communities across Vancouver Island to develop climate adaptation strategies. This project builds local capacity within each community to engage with local stakeholders, while also providing the opportunity to receive input from a wide range of experts. The Together for Climate project also provided these communities with the opportunity to come together at three provincial workshops to share their challenges and successes, while connecting them to a broader network of practitioners working on climate adaptation across the province and country.

ICLEI Canada’s Building Adaptive and Resilient Communities (BARC) program guided each Together for Climate participant through Milestones 1 to 3 of a 5-milestone planning framework that supports municipal climate change adaptation planning. The process involved identifying local climate impacts, a community risk and vulnerability assessment, and a participatory approach to action planning to reduce vulnerability and increase resilience to the projected climatic changes. An iterative approach was taken to the process; whereby, each phase of the project built on the previous, resulting in a robust community-informed and supported adaptation planning document. The output has the potential to be scaled up or down, depending on the local needs and context, meaning that it can be an implementation-ready adaptation plan or a stakeholder informed guiding document that is intended to be used at a later stage to further inform future adaptation planning processes.

A crucial aspect of this planning process is the involvement of external partners; this multi-stakeholder engagement model allows for climate impacts, risk and vulnerability, and solutions to be articulated and developed from the communities most impacted by climate change. More information about ICLEI’s BARC program and the methodology for used in this planning process can be found in the ‘Our Process’ section.
1.2 City of Colwood and Together for Climate
The City of Colwood’s Official Community Plan (OCP) recognizes that community well-being is fully dependent upon the well-being of the ecosphere. Climate change is one of humanity’s greatest challenges, and City policies provide direction for both climate change adaptation and mitigation (through GHG emission reductions). The City of Colwood is undertaking several corporate initiatives to demonstrate leadership in climate action, including this Together for Climate project.

In addition to Together for Climate, the City of Colwood has partnered with Simon Fraser University to take part in the Integrated Climate Action for BC Communities Initiative (ICABCCI). This project aims to assist local governments in achieving strategic integration of climate change adaptation and mitigation, by using an approach called “low carbon resilience” (LCR). LCR is a climate action approach that coordinates and mainstreams adaptation and mitigation strategies, while also advancing co-benefits to achieve ‘win-win’ outcomes. It requires that the City’s climate data – the climate risk and vulnerability assessment (here in the form of this Together for Climate document) and energy and emissions inventory and forecast – be co-evaluated in order to identify synergistic climate action strategies that reduce vulnerability and emissions, and advance other community priorities such as health, equity, biodiversity, and economic development.

1.3 Adaptation, Mitigation, and Low Carbon Resilience
The effects of climate change are wide ranging and will require a diversity of responses. While adaptation measures are urgently needed to address climate change impacts that are already happening, preparing now for increased frequency of impacts over time needs to be reflected in long-term investment, community planning, and development decisions. Mitigation targets and strategies play a primary role in the long-term impacts of global warming. Both adaptation (reducing risk and vulnerability) and mitigation (reducing emissions) have the same goal: to minimize the effects of climate change impacts over time.

Climate change adaptation refers to initiatives and actions taken to adjust ecological, social, and economic systems in response to actual or expected climatic change and the resulting local impacts. In the municipal context, adaptation efforts may focus on increasing education and awareness to influence individual behaviour, updating municipal bylaws and policies, upgrading physical infrastructure, and protecting critical ecosystem services through the preservation of biodiversity and natural areas. Climate change mitigation refers to the efforts to minimize or prevent GHG concentrations in the atmosphere. Mitigation actions include clean air bylaws, building retrofits to conserve energy, economic approaches and instruments (e.g., price incentive to cut emissions), and transitioning to low-carbon energy sources. Simply put, mitigation involves avoiding the unmanageable, while adaptation involves managing the unavoidable.

Low carbon resilience (LCR) is an approach to municipal planning, decision-making and implementation that supports community’s advancement towards a resilient future by breaking down the siloes between adaptation, mitigation, and other municipal priorities. Climate action has traditionally separated adaptation and mitigation, which can lead to contradictory or maladaptive results (see Figure 1). The goal is to minimize adaptation actions that increase emissions (Adaptive Emissions in the upper left corner), such as turning on gas-powered air conditioning during heat events, or mitigation actions that increase risk and vulnerability to climate impacts over time (New Vulnerabilities in lower right corner), such as building critical infrastructure in a floodplain. Applying an LCR lens across all local government policy and decision-making supports continued efforts in enhancing the fiduciary goals of
local government and protecting the safety and well-being of citizens and ecosystems over time (ACT, 2019). It builds the coordinated and collaborative approach to help organizations transition toward their sustainable development goals.

For the City of Colwood, this document represents the adaptation component in the development of a comprehensive LCR plan. As noted above, an LCR plan coordinates climate adaptation and mitigation planning, strategically linking climate action with other community priorities, in order to develop comprehensive, cross-departmental solutions that are embedded and monitored across the organization.
1.4 Policy Direction on Adaptation

International, federal, and provincial governing bodies can set standards, provide strategic focus, and offer potential funding streams for adaptation. The federal government acts as the overarching voice on climate leadership in Canada and a strong commitment to climate action at this level is more likely to lead to climate leadership within local governments. While top-down leadership is important in setting the stage for climate adaptation, it is up to local governments become leaders in inspiring local change.

1.41 Federal Policy Direction on Adaptation

Canada was one of 195 countries to sign the Paris Agreement in December 2015. The Agreement aims to keep the global temperature to well below two degrees Celsius, and to drive efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels. In terms of adaptation, the Agreement aims to enhance local adaptive capacity and resilience while reducing vulnerability to global climate change in ways that align with a country’s own national objectives (Government of Canada, 2016; UNFCCC, 2020).

The Government of Canada has also produced several policy documents that support and guide the country’s position on climate change adaptation. For example, in 2016 the Government of Canada released its Pan Canadian Framework on Clean Growth and Climate Change, which includes adaptation considerations and actions to improve climate resiliency (Government of Canada, 2019). Major focus areas include building climate resilience through infrastructure, protecting and improving human health and well-being, and reducing climate-related hazards and disaster risks. The framework recognizes the important role that Canadian municipalities will play in implementing climate solutions locally.

1.42 Provincial Policy Direction on Climate Adaptation

In 2019, the Province of British Columbia (BC) completed a Preliminary Strategic Climate Risk Assessment for BC as a first step in better understanding climate-related risks in BC and to help the government develop appropriate measures to address those risks.

The assessment is being used to inform a provincial climate preparedness and adaptation strategy to help protect people, communities, and businesses from the impacts of climate change (set to be released in late 2020). While the risk assessment is not intended to be used as a prediction of future events, it can act as a tool to evaluate the likelihood and potential consequences of each event happening in the future to understand the degree of risk each poses for the province to help prepare.

Key Findings of the Provincial Assessment:

- The greatest risks to BC are severe wildfire season, seasonal water shortage, heat wave, ocean acidification, glacier loss, and long-term water shortage.
- Other risks that have the potential to result in significant consequences include severe river flooding and severe coastal storm surge, although these events are less likely to occur.
- Nearly all risk event scenarios (except moderate flooding and extreme precipitation and landslide) would have major province-wide consequences in at least one category.
2.0 The Science of Climate Change

The climate system is complex, comprising of many interrelated and interacting components. Climate is the result of a culmination of various biogeophysical factors over a long period of time and differs from weather (Richardson et al., 2012). Climate change can be simply defined as any change in global or regional climate patterns over time and can be the cause of natural factors and human activity (Bales et al, 2015; Lemmen & Warren, 2016). Although natural variation has characterized the Earth’s climate system for millions of years, the past 10,000 have been relatively stable – until recently.

Human activities are directly impacting the Earth’s climate (IPCC, 2014) The two main ways that these activities are affecting the Earth’s climate are through changes in land-use (e.g., deforestation) and the combustion of fossil fuels (e.g., carbon-based energy sources) (Richardson et al., 2012). Burning fossil fuels such as coal, oil, and natural gas releases carbon dioxide (CO$_2$) and other of GHGs into the atmosphere. Carbon dioxide is a heat-trapping gas that builds up in the atmosphere over time, it functions like a blanket, trapping in heat that would otherwise be lost to the upper layers of the atmosphere (Bales et al., 2015; Richardson et al., 2012) (see Figure 2). This “blanket effect” is causing the planet’s atmosphere to warm, which disrupts the stability of the climate system. Although CO$_2$ is necessary for life, the role of CO$_2$ in the climate system goes beyond plants taking it in and humans breathing it out. Burning fossil fuels puts more CO$_2$ into the atmosphere than the system can handle which causes CO$_2$ to build up in the Earth’s atmosphere and oceans, leading to a series of ecological and climatic issues (Bales et al., 2015).

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*Figure 2.* Image representing the sources, mechanisms, and impacts of climate change. Image retrieved with permission from the City of Victoria’s Climate Leadership Plan (2018).
In October 2018, the IPCC released its most urgent report to date, stating that the global community may have as little as 10 to 12 years to slow GHG emissions and limit global temperature increase to 1.5°C (IPCC, 2018). To limit warming, there must be “rapid and far-reaching” transitions in how we use our lands, energy, industry, buildings, transportation, and design our cities (IPCC, 2018). Now more than ever, it is crucial that cities work together to protect human and natural systems through innovation and collaboration. The IPCC recommends a mix of adaptation and mitigation options to limit global warming to 1.5°C, implemented in a participatory and integrated manner (IPCC, 2018).

It is important to note the role that uncertainty plays in the study of climate change. While the exact outcomes of climate change are difficult to predict with absolute certainty, it is not a question of ‘if’ impacts are occurring, but rather ‘when’ (Corner, Lewandowsky, Phillips, & Roberts, 2015). Ninety seven percent of scientists are concerned about anthropogenic climate change and the associated risks (Bales et al., 2015; IPCC, 2018). The risks associated with climate change are increasing globally, which will have unequivocal impacts on local businesses, schools, hospitals, and other community services. If we act now, we can significantly lessen the severity of climatic risks and start transitioning toward an aspirational vision of the future (Corner et al., 2015).
2.1 Climate Change Projections for Colwood

All around the world extreme weather events are occurring more frequently – which aligns with predictions made by scientists many decades ago (Corner et al., 2015). Recent events in and around Colwood including flooding, winter storms, and other extreme weather events are also consistent with these global predictions – highlighting the need to integrate climate change into the municipal planning framework in order to safeguard built, natural, and socioeconomic systems within the City. Given that climatic impacts vary greatly across regions, it is important to develop an understanding of local impacts of climate change in order to understand the implications for key municipal service areas and industry sectors that support the residents of Colwood. A detailed summary of local climate projections is included in Colwood’s Risk Assessment Backgrounder Report (Appendix B).

The following data highlights a summary of the projected impacts of climate change on the City of Colwood, located within the Greater Victoria area. The summary table below (Table 1) represents an ensemble approach, which incorporates a combination of 12 different global climate models using a high-emissions (RC8.5) scenario (Prairie Climate Centre [PCC], 2020). Six major trends have been identified and need to be considered: increased average temperatures; more frequent and intense heat waves; drier summers (wetter winters); more frequent and intense rainfall events; increased wind and storm events; and sea level rise (CRD, 2017; PCC, 2019; IPCC, 2014).

Table 1. Summary of Climatic Changes for the Greater Victoria area (including Colwood).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>Annual</td>
<td>9.4</td>
<td>11.1</td>
<td>12.7</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>3.7</td>
<td>5.3</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>8.3</td>
<td>10.0</td>
<td>11.4</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>15.6</td>
<td>17.5</td>
<td>19.5</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>9.8</td>
<td>11.3</td>
<td>13.1</td>
</tr>
<tr>
<td>Precipitation (mm)</td>
<td>Annual</td>
<td>1312</td>
<td>1351</td>
<td>1418</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>568</td>
<td>597</td>
<td>639</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>249</td>
<td>256</td>
<td>260</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>103</td>
<td>95</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>392</td>
<td>403</td>
<td>428</td>
</tr>
<tr>
<td>Summer Days (over 25°C, days)</td>
<td>Annual</td>
<td>16.6</td>
<td>31.4</td>
<td>54.5</td>
</tr>
<tr>
<td>Freeze-thaw days (days)</td>
<td>Annual</td>
<td>8.6</td>
<td>3.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Cooling Degree days (days)</td>
<td>Annual</td>
<td>37.8</td>
<td>106.8</td>
<td>242.9</td>
</tr>
<tr>
<td>Relative Sea level rise2.</td>
<td>Average 8.83 mm/yr</td>
<td>Relative sea level rise is expected to be 0.5 m by 2055 and 1.0 m by 2100s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water temperatures</td>
<td>Increasing at varying degrees in ocean and streams</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. This value is based on the Provincial Guidelines SLR baseline year of 2000; an SLR increase rate of +10 mm/yr; a land uplift rate around Victoria of +1.2 mm/yr (10 mm/yr -1.2 mm/yr = 8.8 mm/yr)
3.0 Our Process

The City of Colwood, through the Together for Climate project, followed the framework of ICLEI Canada’s Building Adaptive and Resilient Communities (BARC) program, moving through Milestones 1 to 3 of a 5-milestone municipal climate change planning process. This is a comprehensive planning methodology that guides municipalities through the process of researching and assessing climate impacts, action-setting, implementation planning, and monitoring and review strategies (see Figure 3). For Colwood, the outcome of working through Milestones 1 to 3 has been the development of this guiding document that has identified key strategies and a suite of actions to address the priority risks.

**MILESTONE ONE – INITIATE**

Within this milestone, communities identify stakeholders to review and understand existing knowledge on how the regional climate is changing, followed by a brainstorming exercise to identify potential climate change impacts.

**MILESTONE TWO – RESEARCH**

The second milestone is meant to further develop a community’s understanding of climate change impacts and the major service areas which are likely to feel these impacts most acutely. Within this milestone, a municipality will scope the climate change impacts for the region and conduct both a vulnerability and risk assessment. This milestone correlates with the first and second workshops that were held with Together for Climate participants in November 2018 and April 2019.
respectively. Forty local impacts were identified during the first workshop, which then underwent a vulnerability and risk assessment. Details of the vulnerability and risk assessment process for Colwood can be found in Appendix B.

**MILESTONE THREE – PLAN**

The third milestone provides guidance on how to establish a vision, set adaptation goals and objectives, identify adaptation options, and examine possible constraints and drivers to various actions. An action brainstorming workshop was held in September 2019 where a total of 77 adaptation actions were identified which were then further refined to a total of 37 actions. This list represents a suite of options to address the identified priority risks. A low carbon resilience lens (LCR) was applied to the actions, which will be a priority moving into the next phases of this project. A list of these actions can be found in Appendix A.

**MILESTONE FOUR – IMPLEMENT**

In the fourth milestone, communities work to ensure that they have the approval and support of council, municipal staff, and the community in order to move forward on implementation. Communities will also make sure they have the appropriate implementation tools to ensure the ongoing success of the Strategy. Colwood did not include implementation in this project since it is intended to feed into the eventual creation of an LCR Strategy to guide the City’s adaptation planning.

**MILESTONE FIVE – MONITOR & REVIEW**

The fifth and final milestone serves to assess whether the goals and objectives of the Strategy have been achieved, and helps communities identify any problems that have been encountered and develop solutions. Additionally, the fifth milestone helps communities communicate their progress to council and the general public.
4.0 Climate Hazards, Impacts, and Actions

This Climate Change Adaptation Strategies document is organized by climate hazard, top climate impacts (based on vulnerability and risk assessment), and actions to address the prioritized impacts. The impacts are broken out across four main climate hazards specific to Colwood, including increased average temperature, seasonal variability in precipitation and temperature (e.g., hotter, drier summers, wetter winters), extreme weather, and sea level rise. Contained within each climate hazard section are the priority climate impacts and risks along with the actions that have been developed in collaboration with the Together for Climate project team to address the priority impacts. A total of 14 climate impacts and risks were identified, and 35 adaptation actions were identified to mitigate the risks. A detailed version of the Action tables, including Low Carbon Resilience considerations and co-benefits for each supporting action is included in Appendix A.

4.1 Increased Average Temperature

Temperatures in the City of Colwood are expected to rise in congruence with the provincial projections, with a local expected temperature increase of 1.7°C by the 2050s (CRD, 2017; Warren & Eggington, 2008). Rising temperatures have many direct and indirect ecological and socio-economic impacts (CRD, 2017; Richardson et al., 2012). There are human health and equity considerations with rising temperatures; warmer weather increases the occurrence of heat-related illness and mortality therefore, accessibility to shade and cooling areas needs to remain at the forefront of planning (Gasper, Blohm, Ruth, 2011). Food systems are also increasingly impacted by increasing temperatures (and extreme weather) which puts pressure on food availability, access, and use (CRD, 2017; VICRA, 2011). The impacts of rising temperatures are affecting ecosystems – for example, the phenology, reproduction, nutrient cycling, and other essential processes required for the functioning of robust and resilient ecosystems. Please refer to Appendix B for more details on the impacts of increasing temperatures in Colwood.

Impact #1: Hotter air and surface water temperatures increasing the incidence of vector-borne diseases (e.g., West Nile Virus, Lyme Disease).

➢ Action 1.1: develop a municipal plan to minimize the spread of vector-borne diseases

Impact #2: Rising annual temperatures impacting access to traditional foods and medicines (e.g. First Nations shellfish harvesting).

➢ Action 2.1: Work directly with local First Nations to conduct a socio-cultural and ecological impact assessment in order to identify areas of vulnerability within traditional Indigenous food systems.
➢ Action 2.2: Support local First Nations in developing Indigenous Guardians monitoring and stewardship program for monitoring the impacts of climate change on local food systems within the traditional territory of the Esquimalt and Songhees First Nations.
Impact #3: Rising annual temperatures increasing prevalence of invasive species and pests.

➢ Action 3.1: Develop a strategic maintenance and control management plan for invasive species within the City (using an ecosystem-based management approach).
➢ Action 3.2: Increase drought-tolerant native plantings on City-owned and managed lands.
4.2 Seasonal Variability in Precipitation and Temperature

Recall the precipitation projections for the Colwood area noted in the above climate projections section; in addition to increasing annual (and summer) temperatures, there is expected to be a decrease in precipitation during the summer months (and an increase during the fall, winter, and spring months). This seasonal variability in precipitation and temperature has a myriad of impacts on ecological and socio-economic systems, from human health impacts to ecosystem and vulnerable species disruption. Pre-existing respiratory illnesses can be worsened by extended periods of heat, increased prevalence of forest fires, and increases in ground-level ozone (on days over 25°C) (CRD, 2017; Yao, 2019). Additionally, an increase in the severity of drought conditions in the region can cause significant stress to urban trees and other native vegetation (CRD, 2017; Lemmen et al., 2008). As mentioned above, local ecosystems, species, and ecological processes may not have the adaptive capacity required to adapt to the rate and magnitude of the projected changes in climate, resulting in widespread disruption in “ecosystems and vulnerable species” (CRD, 2017, p. 46). Please refer to Appendix B for more details on the impacts of seasonal variability in temperature and precipitation in Colwood.

Impact #4: Increased risk of wildfires in surrounding areas affecting air quality and human health (e.g., respiratory issues, less exercise from decreased outdoor activity, impact on outdoor workers).

➢ Action 4.1: Establish community clean air shelters to mitigate the impact of wildfire smoke on vulnerable populations.
➢ Action 4.2: Improve public awareness of the health and safety risks and best practices for responding to extreme heat and smoke events.

Impact #5: Rising annual temperatures and hotter drier summers negatively affecting urban trees.

➢ Action 5.1: Continue developing the Urban Forest Strategy and implement identified priority actions to enhance the resilience of the urban tree canopy to the impacts of climate change (e.g., wind, drought, etc.).
Impact #6: Rising annual temperatures and hotter drier summers causing native habitat loss and loss of native species (e.g., nesting bird habitat, salmonids, vegetation loss).

➢ Action 6.1: Explore and research climatic modeling with regard to projections for shifting vegetation zones and patterns within the Colwood area (e.g., Garry oak ecosystems and marine habitat in other areas) in order to identify management strategies.
➢ Action 6.2: Support the dissemination of information on the potential of “novel” and/or “hybrid” ecosystems to replace known ecosystems and species diversity in the face of climatic change, in order to simultaneously increase public acceptance and knowledge of land managers activities.

Impact #7: Hotter and drier summers increase the risk of wildland-urban interface fire in Colwood, creating direct impacts to the community. There is also risk of fires in the surrounding regions (e.g., Saanich or Sooke Watershed) that could affect the City’s emergency response capacity.

➢ Action 7.1: Proactively mitigate wildland urban interface fire risk at the community-scale using FireSmart prevention principles.
➢ Action 7.2: Develop a public education campaign and communications to enhance public awareness regarding fire safety and evacuation protocols and procedures.
➢ Action 7.3: Work with local partners (e.g., regional and provincial governments) to prepare a regional fire risk analysis.
4.3 Extreme Weather Events

Increases in extreme weather and high wind events, specifically during fall and winter, can cause damage to infrastructure and disruption to transportation networks (Black, Bruce, & Egener, 2010; CRD, 2017; Lemmen et al., 2008). Extreme precipitation events can also affect ecosystems and impacts aquatic habitat and biodiversity in different ways; the two main causal factors being eutrophication and channel erosion and sediment deposition (CRD, 2017). Additionally, extreme weather events can have direct and indirect impacts on human health and well-being. The impacts of climate change are not evenly distributed within a population and some populations are disproportionately impacted by extreme weather and climatic events, thus making it a priority to consider how extreme weather differentially impacts populations, and to apply an equity lens in all climate adaptation planning. Please refer to Appendix B for more details on the impacts of this climate hazard in Colwood.

Impact #8: Increase in extreme weather and high wind events causing damage to infrastructure (e.g. damage to power lines leading to electricity disruptions).
- Action 8.1: Continue to encourage developers to install power and communications utilities underground where feasible.
- [Action 5.1 from above is also related to this impact]

Impact #9: More extreme weather events causing disruption to transportation network and infrastructure (e.g. Ocean Blvd and Lagoon Bridge).
- Action 9.1: Conduct a study which analyzes the management options for high risk flood and coastal inundation areas (e.g., Esquimalt Lagoon)
- Action 9.2: Plan to increase for snow removal during winter months to ensure accessibility of roads during winter storms.
- Action 9.3: Develop localized contingency plan that includes procedures in the event of storm surges and coastal inundation and road closure (e.g., Ocean Blvd. road).
Impact #10: More extreme heat events impacting at-risk or vulnerable populations (e.g. homeless, youth, elderly).

- Action 10.1: Communicate the extension of hours in critical public buildings (e.g., libraries, community centres, etc.) during extreme heat events.
- Action 10.2: Work with local partners to expand emergency and community services offered to the community in the face of extreme climatic events (e.g., extreme heat, wildfires).
- Action 10.3: Promote higher building standards to protect against extreme heat events by updating by-laws, development guidelines, and zoning regulations.

Impact #11: More extreme weather events causing loss of habitat and biodiversity at Esquimalt Lagoon and impacts to bird sanctuary (e.g., coastline erosion).

- Action 11.1: Monitor and manage coastal erosion on City-owned and managed lands (e.g., coastal erosion at Esquimalt Lagoon).
- Action 11.2: Develop a public education campaign to increase awareness of the socio-ecological significance of the Esquimalt Lagoon in order to enhance local stewardship and protection.
- Action 11.3: Identify plants and ecosystems vulnerable to climatic impacts (e.g., extreme weather events like flooding or drought) and develop management strategies that aim to protect at risk habitat and biodiversity.
- Action 11.4: Enhance the protection of the Esquimalt Lagoon and native wildlife habitat from climate-related impacts to habitat through targeted habitat restoration efforts and policy mechanisms.
Impact #12: Managing mental health impacts of extreme events, but also in reaction to climate change generally (e.g., eco/climate grief, helplessness among young people).

➢ Action 12.1: Partner with other local agencies (e.g., Island Health, School Boards) to develop effective communications strategies and other educational activities that offer the opportunity for youth, students, and others dealing with the cognitive and wellbeing aspects of a changing climate to connect with nature to re-establish connection, hopefulness, and stewardship.

Photo: City of Colwood
4.4 Sea Level Rise

Sea level rise, in combination with extreme weather events (increase in extreme precipitation events leading to increased runoff and rainfall) can proliferate erosion and subsequently lead to “slope instability and overfilling of wetlands and lakes” (CRD, 2017, p. 43). In areas “where streams flow into the ocean, extreme precipitation events combined with sea level rise during periods of high tides can lead to a back-up of flows and expanded flooding of low-lying areas” (CRD, 2017, p. 43). Please refer to Appendix B for more details on the impacts of this climate hazard in Colwood.

Impact #13: Sea level rise and more extreme weather events (storm surges, extreme rainfall, and wind events) causing coastal inundation and erosion of developed and developable land (e.g. at Royal Roads, Coburg Peninsula).

➢ Action 13.1: Use flood maps and updated climate projections to conduct local sea-level rise and storm surge modeling to inform the placement and protection of critical infrastructure and map and inspect inundation areas over time (e.g., Royal Bay Beach, Esquimalt Lagoon).
➢ Action 13.2: Explore regulatory and planning tools that deter development in areas prone to sea level rise.
➢ Action 13.3: Develop a public education campaign targeted at developers regarding the projected impacts of sea level rise (e.g., causing coastal inundation and coastal erosion) and the implications on coastal development and land-use.
➢ Action 13.4: Incorporate adaptive management into the maintenance and long-term planning of critical infrastructure (e.g., Lagoon Bridge), planning for changing priorities over time.
➢ Action 13.5: Promote higher building standards which reflect climate projections by updating by-laws, development guidelines, and zoning regulations.
➢ Action 13.6: Ensure essential and important services to the community have adequate working backup power.
➢ Action 13.7: Explore “soft armouring” techniques and/or natural infrastructure to expand or mimic natural buffers.
➢ Action 13.8: Explore options to harden shorelines with “hard engineering” techniques, if necessary.
Impact #14: Sea level rise inundating tourist and recreation areas, as well as local historic sites (e.g., archaeological, cultural, and spiritual sites for First Nations) [Medium-low risk].

- Action 14.1: Work with local First Nations to develop an inventory of cultural sites (e.g., village sites, burial sites, clam gardens and other sacred/archaeological sites) vulnerable to sea level rise and coastal erosion.
- Action 14.2: Develop a plan to implement natural asset management within the City of Colwood

5.0 Next Steps

The need to proactively plan for climatic impacts is a priority within the City, and options for developing a climate change strategy moving forward have been laid out in this Climate Change Adaptation Strategies document. This document will be a component of Colwood’s development of a comprehensive plan for climate action that addresses climate mitigation and adaptation, through the lens of low carbon resilience (LCR). The immediate next steps will involve the completion of the Integrated Climate Action for BC Communities Initiative which will further inform the creation of Colwood’s climate action plan.
6.0 References


### 7.0 Appendices

**Appendix A: Climate Action Tables w/ LCR Considerations**

<table>
<thead>
<tr>
<th>Impact</th>
<th>Action</th>
<th>Supporting LCR Actions</th>
<th>Lead</th>
<th>Support</th>
<th>Co-Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INCREASED AVERAGE TEMPERATURE</strong></td>
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</tbody>
</table>
| #1: Hotter air and surface water temperatures increasing the incidence of vector-borne diseases (e.g., West Nile Virus, Lyme Disease). | 1.1 – Develop a municipal plan to minimize the spread of vector-borne diseases. | - Examples of actions that can be taken to minimize the spread of West Nile Virus include:  
  o Remove standing water that collects in tire ruts, storage drums, tarps, flat roofs, etc.  
  o Clear decaying grass, leaves or other organic matter from drains, gutters or refuse areas  
  o Pump-out accumulated sludge in catch basins or trench drains (public and private property)  
  o Install fountains or aerators in bio-ponds or other artificial water bodies  
  - Important to consider how these actions will be powered | City of Colwood Public Works | | Climate change is expected to exacerbate vector borne diseases in the Capital Region (CRD, 2017). Nature-based solutions such as habitat protection and creation and urban forest preservation and expansion have the capacity to moderate climate and temperatures (ICABCCI, 2020). Therefore, nature-based solutions indirectly have a positive impact on the occurrence of vector borne diseases, while also having mitigative co-benefits (carbon sequestration) (Institute for European Environmental Policy, 2014). |
| | #2: Rising annual temperatures impacting access to traditional foods and medicines (e.g. First Nations) | 2.1 – Work directly with local First Nations to conduct a socio-cultural and ecological impact assessment in order to identify | | | |
| | | - Work with local partners (e.g., First Nations, regional government, and/or Royal Roads University) to map out areas of vulnerability in conjunction with locations of significance for traditional food and medicine harvesting  
  - Work with local First Nations in developing culturally appropriate and sensitive plans and policies to enhance the protection of these resources within the City of | City of Colwood; Capital Regional District; First Nations (Songhees and Capital Region Food and Agriculture Initiative Roundtable; First Nations Health | | If the mapping and ecological and social impact assessments result in native habitat restoration, then there would be emissions reduction benefits related to this action. |
### shellfish harvesting.

- **Areas of vulnerability within traditional Indigenous food systems.**
  - Colwood (e.g., Royal Roads University forest and foreshore area, etc.)
    - E.g., Indigenous Protected and Conserved Areas
    - Consider protections under changing climate conditions
  - Esquimalt); Health Professionals
  - City of Esquimalt; Vancouver Island Health Authority; Parks Canada;

### 2.2 – Support local First Nations in developing Indigenous Guardians monitoring and stewardship program for monitoring the impacts of climate change on local food systems within the traditional territory of the Esquimalt and Songhees First Nations.

- Adapt and model an Indigenous Guardians program that will provide local First Nations with the authority and ownership over things such as local resource management, enforcement of environmental laws and regulations, wildlife, and habitat monitoring, etc.
  - Would need to be developed and led by the local nations themselves
  - Includes understanding and monitoring of changing climate conditions and the influence on traditional territories and harvests over time, and possible ways to contribute to food security and reduced emissions, e.g., transportation and increased sinks, e.g., forest protection
  - City can support by giving First Nations the right to manage and monitor resources in areas of particular cultural significance on City-owned land

Support local nations in finding and securing potential sources of funding for this work (e.g., ECCC’s Indigenous Guardians Pilot Program, see Notes section)

### #3: Rising annual temperatures increasing prevalence of

#### 3.1 - Develop a strategic maintenance and control management plan for invasive species

- Continue to manage invasive species, including staying up to date on new and emerging risks.
  - Conduct an inventory of invasive species and emerging threats
  - Take an “early detection and rapid response approach”

Support local nations in finding and securing potential sources of funding for this work (e.g., ECCC’s Indigenous Guardians Pilot Program, see Notes section)

### Enhanced stewardship and protection of native ecosystems by local First Nations would likely result in enhanced carbon sequestration – but this would have to incorporate a growth in the area and percentage of natural habitats.

There are co-benefits associated with this action such as enhanced local autonomy, improved biodiversity and habitat creation, improved equity/improvements for marginalized populations, improves green space, supports local food security initiatives, improved community vitality (ICABCCI, 2020).
invasive species and pests. within the City (using an ecosystem-based management approach).

- Consider conducting an invasive species risk assessment and prioritize management based on risk
- Work across jurisdictional boundaries with local government partners and environmental non-government organizations
- Strengthen regulations and rules that prevent the introduction and spread of invasive species

Develop training and awareness program for public works staff to identify and report invasive species that have been prioritized for management.

Invasive Species Program; Invasive Species Council of BC

3.2 – Increase drought-tolerant native plantings on City-owned and managed lands.

- Increase the variety of drought-tolerant native plant species planted in parks and open spaces
- Increase the proportion of native ecosystems in the parks and open spaces system; and restore native ecosystem areas that are currently degraded.

City of Colwood Parks; Capital Region Invasive Species Council of BC

Co-benefits: biodiversity enhancement and habitat creation/protection; improves green space, supports local food security initiatives (e.g., indigenous food systems), improves human health and wellbeing, improves air and water quality, improves water retention and absorption, optimizes energy savings, reduces burden on grey infrastructure, and captures pollutants (ICABCCI, 2020).

Natural, biodiverse ecosystems have a higher capacity to provide ecosystem services in regard to water filtration and absorption, carbon sequestration/storage, biodiversity, soil stabilization, et cetera (Pojar, 2019). Invasive species and climate are interacting to decrease biodiversity, potentially changing ecosystem function and delivery of ecosystem services. Although the role of biodiversity in carbon sequestration is still being researched, Mekonnen & Sintayehu (2018) note the following key findings:

- “Increasing biodiversity may result in increased ecosystem service provision;
- Biodiversity and its ecosystem service has great role in carbon sequestration and reducing greenhouse gases from the atmosphere in order to mitigate climate change;
- Ecosystem-based adaptation and mitigation to climate change could ensure future human wellbeing;
- Therefore, strengthening the science and policy interface for biodiversity and ecosystem services will contribute to the management and sustainable use of biodiversity...and has a great role to play in carbon sequestration” (p. 7).

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Identify opportunities to expand re-naturalization beyond garden bed
Develop community education and stewardship programs focused on native ecosystem condition requirements and species, and promote native plants that can replace “exotics” in urban landscapes

Program; Capital Regional District; Invasive Species Council of BC

services. Although the role of biodiversity in carbon sequestration is still being researched, Mekonnen & Sintayehu (2018) note the following key findings:
- “increasing biodiversity may result in increased ecosystem service provision;
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### SEASONAL VARIABILITY IN PRECIPITATION AND TEMPERATURE (E.G., WETTER WINTERS, DRIER SUMMERS).

<table>
<thead>
<tr>
<th>#4: Increased risk of wildfires in surrounding areas affecting air quality and human</th>
<th>4.1 – Establish community clean air shelters to mitigate the impact of wildfire smoke</th>
<th>Clean air shelters can be a room/area or an entire building that has a filtration system that minimizes particulates generated from wildfire smoke. There are no specific standards for clean air shelters, but the objective is to</th>
<th>City of Colwood Planning and Bylaw Services</th>
<th>Community organizations, local faith</th>
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<tbody>
<tr>
<td>Clean air shelters can be a room/area or an entire building that has a filtration system that minimizes particulates generated from wildfire smoke. There are no specific standards for clean air shelters, but the objective is to</td>
<td>This action could potentially be maladaptive – depending on the energy source required for the cooling centres. However, this action could incorporate LCR considerations by considering the potential of microgrids, community energy generation, and other systems of renewable energy that could support this necessary adaptation</td>
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<td>section</td>
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| 3.1 | Health (e.g., respiratory issues, less exercise from decreased outdoor activity, impact on outdoor workers). minimize the amount of outdoor air that is entering the building/space. Establish partnerships and develop policies and procedures to use community spaces for this purpose (prioritize new/retrofitted spaces where possible). In the community space in Colwood this could include:  
  - Royal Bay and Belmont Secondary Schools (have modern air-heat pumps for cooling and NEPA filtration with levels that can be checked)  
  - Westshore Parks and Recreation  
  - Churches  
  - Identify the best sites to locate these clean air shelters within the community, targeting vulnerable populations  
| 4.2 | Improve public awareness of the health and safety risks and best practices for responding to extreme heat and smoke events. Develop information networks to get message out to vulnerable populations  
  - Establish who needs the information (prioritization), who can help share the information (trusted communications partners), and who has the information (reliable sources of information)  
<p>| organizations, School District | action while also providing mitigation co-benefits (ACT, 2019). Other building-level LCR opportunities could include the use of green roofs and other building techniques that reduce the need for additional cooling and absorb carbon dioxide (ACT, 2019; ICABCCI, 2020). | City of Colwood; Songhees and Esquimalt First Nations; Consultants | Capital Regional District; Parks Canada | No direct mitigation benefits. |</p>
<table>
<thead>
<tr>
<th>#5: Rising annual temperatures and hotter drier summers negatively affecting urban trees</th>
<th>5.1 – Continue developing the Urban Forest Strategy and implement identified priority actions to enhance the resilience of the urban tree canopy to the impacts of climate change (e.g., wind, drought, etc.).</th>
</tr>
</thead>
</table>
|  | • Link information on the health and safety risks with related social/economic impacts to make more of an impact  
• Ensure information on risks includes information on local programs/services to help, where applicable (e.g. available cooling/warming centres, clean air centres, etc.)  
• Identify key players and coordinate a working group of city staff from multiple departments (e.g., Planning and Land-use, Parks, Recreation, and Culture, and Transportation and Public Infrastructure) ensuring early engagement and input  
• Maintain a geospatial tree inventory of public trees and vacant sites (available for planting)  
  o Include tree risk and health assessment in inventory (which is also helpful in understanding the carbon sequestration/storage capacity of the trees).  
  o Ensure to properly maintain from an early age (e.g., use structural pruning techniques to shape the tree to avoid problems down the road)  
• Establish targets for tree canopy cover, impermeable surfaces, and planting opportunities across the city  
  o Measure city-wide tree canopy cover (LiDAR) and re-measure every 4 years  
• Ensure appropriate tree species selection and planting location, considering future climate projections and impacts such as heat, wind, and drought as well as sequestration potential (e.g., select trees that reach a maximum height which is lower than hydro lines, relocate the tree planting location to avoid the hydro lines as much |
|  | City of Colwood Planning; BC Hydro |
|  | City of Colwood Parks, Transportation |
|  | Urban forests provide a myriad of benefits from ecosystem services (provisioning, regulating, supporting, and cultural) to other co-benefits. Specifically, urban trees help to provide clean water, wildlife habitat, and enhance urban biodiversity while also enhancing pollination services, rainwater filtration and absorption, temperature regulation, and more. Urban trees are fundamental to human health and wellbeing (ICACCI, 2020).  
From a climate risk perspective, urban forests help to mitigate flood risk through enhanced water absorption, moderate urban heat islands and summer heat events (via shade and increased evapotranspiration), improves biodiversity, and helps with soil stabilization (ICABCCI, 2020).  
From a mitigation perspective, urban forests have the capacity to sequester large amounts of carbon dioxide (approx. 25.1 tons C/ha) (but dense stands of natural forest are an essential component to integrate into climate solutions since they sequester up to 53.5 t C/ha) (ICABCCI, 2020). Urban forests also help to reduce urban energy consumption through temperature moderation (reducing the need for cooling in summer months and insulating in colder months) (ICABCCI, 2020). |
#6: Rising annual temperatures and hotter drier summers causing native habitat loss and loss of native species (e.g., nesting bird habitat, salmonids, vegetation loss).

| 6.1 – Explore and research climatic modeling with regard to projections for shifting vegetation zones and patterns within the Colwood area (e.g., Garry oak ecosystems and marine habitat in other areas) in order to identify management strategies. | Identify currently protected areas, sensitive ecosystems, biodiversity hotspots, SAR habitat, and locations to implement corridors for habitat connectivity.  
- Various mapping tools can be used to access this information (e.g., community mapping and Terrestrial Ecosystem Mapping).  
- Encourage network linkages to promote both habitat connectivity and LCR objectives. | City of Colwood Planning; Habitat Acquisition Trust; Peninsula Streams Society; Garry Oak Ecosystems Recovery Team. | Habitat creation and biodiversity enhancement and preservation are critical to buffering the impacts of climate change. Biodiversity creates redundancy within ecosystems which enhances ecosystem resilience (Holling et al., 2002). Natural areas deliver key ecosystem services (water filtration and absorption, pollination, temperature regulation, filtering of air-borne pollutants) (ICABCCI, 2020). Natural areas act as carbon sinks, enhancing the storage capacity of carbon dioxide, while also reducing energy usage (less need for cooling) (ICABCCI, 2020). |
| Inventory should also include a list or map of habitat locations and size, a list of Garry-oak dependent species, and a catalogue of ecosystem services.  
- Garry Oak Ecosystems Recovery Team (GOERT) has already mapped out priority areas for Garry oak conservation and restoration can be used as a starting point.  
- Can work with GOERT and other community groups working in this area to further citizen science. | Bioclimatic envelope modelling can be used as a tool to map future projections of habitat suitability for Garry oak ecosystems and management techniques can be adapted based on the results (e.g., assisted species migration) (Bodtker et al., 2009). | Ecological thresholds of Garry oak ecosystems are important to define and can be used in risk management in order to avoid abrupt changes in ecosystem state (Garmestani, et al., 2011). |
<table>
<thead>
<tr>
<th>6.2 – Support the dissemination of information on the potential of “novel” and/or “hybrid” ecosystems to replace known ecosystems and species diversity in the face of climatic change, in order to simultaneously increase public acceptance and knowledge of land managers activities.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Work with local partners (e.g., Victoria Natural History Society and scientists (e.g., Garry Oak Ecosystems Recovery Team) to support ongoing research in ecological restoration and adaptive ecosystem management</td>
</tr>
<tr>
<td>• Disseminate new information as it is developed to relevant people working on landscape-level ecological restoration and conservation both within and outside of the City limits</td>
</tr>
<tr>
<td>City of Colwood; Victoria National History Society; Garry Oak Ecosystems Recovery Team; University of Victoria (Restoration of Natural Systems program)</td>
</tr>
<tr>
<td>Habitat Acquisition Trust; Parks Canada; Greater Victoria Green Team</td>
</tr>
<tr>
<td>It is difficult to ascertain the mitigative capacity of natural areas that are composed of different structural and compositional diversity than ecosystems historically native to a place. Nature-based solutions have mitigation potential (ICABCCI, 2020). However, it is argued that diverse natural ecosystems have higher carbon sequestration potential than novel (likely less diverse) ecosystems (Pojar, 2019; BC Environmental Protection and Sustainability, 2017). Although the role of biodiversity in carbon sequestration is still being researched, Mekonnen &amp; Sintayehu (2018) note the following key findings:</td>
</tr>
<tr>
<td>• “Increasing biodiversity may result in increased ecosystem service provision;</td>
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<tr>
<td>• Biodiversity and its ecosystem service has great role in carbon sequestration and reducing greenhouse gases from the atmosphere in order to mitigate climate change;</td>
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<td>• Ecosystem-based adaptation and mitigation to climate change could ensure future human wellbeing</td>
</tr>
<tr>
<td>Therefore, strengthening the science and policy interface for biodiversity and ecosystem services will contribute to the management and sustainable use of biodiversity…and has a great role to play in carbon sequestration.” (p. 7).</td>
</tr>
<tr>
<td>#7: Hotter and drier summers increase the risk of wildland-urban interface fire in Colwood, creating direct impacts to</td>
</tr>
<tr>
<td>7.1 – Proactively mitigate wildland urban interface fire risk at the community-scale using FireSmart</td>
</tr>
<tr>
<td>• Maintain and establish “buffer zones” between at the urban-wildland interface</td>
</tr>
<tr>
<td>o Consider the use of active transportation corridors as buffers and for LCR considerations</td>
</tr>
<tr>
<td>• Conduct maintenance regimes that focus on forest thinning and fuel load removal, reducing vulnerability and avoiding wildfire emissions into the future</td>
</tr>
<tr>
<td>City of Colwood; Fire Department; Capital Regional District</td>
</tr>
<tr>
<td>Homeowners; BC Ministry of Forestry Lands Natural Resource Operations;</td>
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<tr>
<td>Effectively mitigating wildland urban interface fire risk (assuming it results in less or less intense wildfires) can reduce GHG emissions (since wildfire smoke releases CO2 into the atmosphere) (BC Environmental Protection &amp; Sustainability, 2017). Wildfires are occurring with more frequency and intensity than before – which is further complicated by the increasing prevalence</td>
</tr>
<tr>
<td>Prevention principles.</td>
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<td>------------------------</td>
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<tr>
<td><strong>7.2 – Develop a public education campaign and</strong></td>
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</table>

There is also risk of fires in the surrounding regions (e.g., Saanich or Sooke Watershed) that could affect the City’s emergency response capacity.

- Manage vegetation, landscaping, and general maintenance around buildings following FireSmart principles and guidelines for both private and public property.
- Remove dead trees in community green spaces.

Therefore, it is important to prevent catastrophic wildfire (if possible). This will not be easy and “requires the right mix of legislation, policy, licensee incentives, some prescribed fire, and most importantly, building a network of landscape level discontinuity that is sensitive to both fire management objectives and ecological function. We should resist preoccupation with the stand level and embrace forest complexity at the landscape level” (Pojar, 2019, p. 11). This needs to be fundamentally embedded into BC’s Ministry of (FLNRO) (Pojar, 2019).

It is important to note the role that forestry and forest management practices play in the fate of carbon (e.g., in a logged stand versus a stand that experienced a widespread wildfire) – the carbon from the wildfire persists on site “for a very long time, with residence times of several thousand years” whereas much of the carbon from logging practices (and subsequent milling and transportation) is lost to the atmosphere. Wildfires play a fundamental role in ecosystem function – allowing for system renewal and regeneration and a recycling of stored resources (e.g., energy and nutrients) but a carbon stewardship strategy is essential in preventing catastrophic wildfires and undue loss of carbon to the atmosphere (Pojar, 2019).
| 7.3 – Work with local partners (e.g., regional and provincial governments) to prepare a regional fire risk analysis. |  • Increase no smoking signage on trails and in parks to raise awareness and reduce fire risk  • Increase awareness of the need to reduce fire load on private property and around buildings (especially in rural residential areas)  • Increase no smoking signage on trails and in parks to raise awareness and reduce fire risk  • Increase awareness of the need to reduce fire load on private property and around buildings (especially in rural residential areas) | Regional District; West Shore Emergency Support Services | 7.3 – Work with local partners (e.g., regional and provincial governments) to prepare a regional fire risk analysis.  • Develop policies for fire prevention in “high-risk” areas in coordination with neighbouring communities  • Coordinate activities with provincial agencies | City of Colwood Emergency Planning; Capital Regional District  • Develop policies for fire prevention in “high-risk” areas in coordination with neighbouring communities  • Coordinate activities with provincial agencies | Provincial government; MELNRO | Effectively mitigating wildland urban interface fire risk (assuming it results in less or less intense wildfires) can reduce GHG emissions (since wildfire smoke releases CO2 into the atmosphere) (BC Environmental Protection & Sustainability, 2017). Wildfires are occurring with more frequency and intensity than before – which is further complicated by the increasing prevalence of pests and diseases (Pojar, 2019). The amount of GHG emissions from wildfire smoke in BC is variable; in 2017 wildfires resulted in a release of 176,550 (Kt CO$_2$e) into the atmosphere (2017 was particularly bad for wildfires across the province) compared to 64,565 (Kt CO$_2$e) in 2014, and 2,880 in 2011 (BC Environmental Protection & Sustainability, 2017). Therefore, it is important to prevent catastrophic wildfire (if possible). This will not be easy and “requires the right mix of legislation, policy, licensee incentives, some prescribed fire, and most importantly, building a network of landscape level discontinuity that is sensitive to both fire management objectives and ecological function. We should resist preoccupation with the stand level and embrace forest complexity at the landscape level” (Pojar, 2019, p. 11). This needs to be fundamentally embedded into BC’s Ministry of (FLNRO) (Pojar, 2019). |
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| #8: Increase in extreme weather and high wind events causing damage to infrastructure (e.g., damage to power lines leading to electricity disruptions). | 8.1 – Continue to encourage developers to install power and communications utilities underground where feasible. | • Continue to study feasibility of undergrounding power lines in priority areas  
• Review case studies of other municipalities that have implemented undergrounding to estimate costing and other feasibility factors  
• Consider local alternative energy opportunities to protect critical assets and facilities during electricity/energy disruptions  
• Ensure to consider the soil depth required for City trees planted on boulevards (e.g., undergrounding utilities means there is less space for new trees)  
• In areas where undergrounding is determined to be appropriate – would need to consider shallow-rooting tree species | City of Colwood Engineering; BC Hydro  
City of Colwood Planning, Parks, Underground Utilities | No direct LCR benefits or opportunities. |
### #9: More extreme weather events causing disruption to transportation network and infrastructure (e.g. Ocean Blvd and Lagoon Bridge)

<table>
<thead>
<tr>
<th>9.1 – Conduct a study which analyzes the management options for high risk flood and coastal inundation areas (e.g., Esquimalt Lagoon)</th>
<th>Many of the lower lying areas that may have higher levels of inundation coincide with developed and populated areas, leading to the potential for infrastructure damage, safety risk and service disruption. Actions to address these issues could include:</th>
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<tbody>
<tr>
<td></td>
<td>Research various options for flood risk mitigation from engineered infrastructure versus green infrastructure versus managed retreat</td>
</tr>
<tr>
<td></td>
<td>• Develop a risk and cost analysis of the various options, including ability to reduce vulnerability and emissions and increase co-benefits</td>
</tr>
<tr>
<td></td>
<td>• Protecting and expanding natural assets has the potential to reduce risk and vulnerability while sequestering carbon and contributing to biodiversity and community health and well-being</td>
</tr>
<tr>
<td></td>
<td>• Work with local First Nations (Esquimalt, Songhees) to determine appropriate actions</td>
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<tr>
<td></td>
<td>• Create a long-term vision and plan for key roads and transportation routes, including Ocean Boulevard – include opportunities for active transportation to diversify mobility options</td>
</tr>
<tr>
<td>City of Colwood Engineering and Planning Departments</td>
<td>BC Ministry of Transportation &amp; Infrastructure; Esquimalt and Songhees First Nations; local citizens; Royal Roads Sustainability students</td>
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<tr>
<td></td>
<td>This action in and of itself does not offer a mitigation benefit; however, the outcome of the study and the option chosen for intervention would determine if the action is beneficial for an LCR approach.</td>
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<tr>
<td></td>
<td>The outcomes of the study would exist on a spectrum from most beneficial to least (in terms of mitigation). For example, wetlands and coastal foreshores (e.g., habitat restoration and/or managed retreat) have immense carbon sequestration potential and other co-benefits such as enhancing biodiversity, access to green space, and human health and well-being. Whereas most grey infrastructure solutions have the potential to be maladaptive (ICABCCI, 2020).</td>
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</tbody>
</table>

### 9.2 – Plan to increase for snow removal during winter months to ensure accessibility of roads during winter storms.

|  | Analyze budget and operations to determine amount of increase necessary to meet demand |
|  | Continue to ensure that City contractors have enough heavy equipment preferentially available to the City during severe weather events (e.g., snow) |
|  | • Identify additional heavy equipment needs and contractors |
|  | • Consider low or zero emissions fleet options to avoid emissions and fossil fuel price fluctuations into the future |
| City of Colwood Public Works | Contractors |
|  | Increasing snow removal has the potential to be maladaptive, depending on the fleet used to do this (e.g., high emissions vehicle versus low). An LCR approach could be to consider adopting a “green fleet” for municipal operations (ACT, 2019). Ensure that green fleet infrastructure is not at risk of flooding, and/or other extreme weather damage. |
### 9.3 – Develop localized contingency plan that includes procedures in the event of storm surges and coastal inundation and road closure (e.g., Ocean Blvd. road).

- Ensure organizational charts are refined and updated with the appropriate contact information
- Develop procedures to close Ocean Blvd road if flooded
- Develop secondary road access in the event of flooding, and in anticipation of future sea level rise and coastal inundation
- Establish a viable detour route management program
- An LCR suggestion could be to incorporate more active transportation routes into the planning to lessen the dependence on both personal vehicles and Ocean Boulevard road for commuting.

**Co-benefits associated with this action include improved cost savings (re: emergency management response); improved human health and wellbeing; optimized resources (human and emergency response) (ICABCCI, 2020).**

### 10.1 – Communicate the extension of hours in critical public buildings (e.g., libraries, community centres, etc.) during extreme heat events.

- Extending the hours of public and/or private buildings during extreme heat events provides a space for individuals to seek refuge from the heat.
  - Map these services to ensure that there is one approximately 15 minutes walking distance to all community members.
- Develop more indoor infrastructure to support indoor community programs in the face of extreme heat or wildfire smoke events.
  - Utilize the cooling (and heating) and clean air centres identified in Actions 3.6 and 3.8 below
  - Enhance the capacity to provide professional support to help people affected by extreme event
  - Collective ‘safe facilities’ avoid household emissions from air conditioning, for instance, and can improve efficiency by expanding into low or zero carbon energy and/or insulation from green roofs and walls, for instance.

**This action could potentially be maladaptive – depending on the energy source required for the cooling centres. However, this action could incorporate LCR considerations by considering the potential of microgrids, community energy generation, and other systems of renewable energy that could support this necessary adaptation action while also providing mitigation co-benefits (ACT, 2019). Other building-level LCR opportunities could include the use of green roofs and other building techniques that reduce the need for additional cooling and absorb carbon dioxide (ACT, 2019; ICABCCI, 2020).**
10.2 – Work with local partners to expand emergency and community services offered to the community in the face of extreme climatic events (e.g., extreme heat, wildfires).

- Establish partnerships and a policy mechanism that facilitates the availability of cooling (heating) centres in Colwood (linked to Action 3.8 below – these would potentially be the same locations)
- Work with local emergency services to establish criteria that will withstand the need for such services (i.e., ensure there is enough capacity)
- Survey and collect data on vulnerable populations in order to better understand their needs

City of Colwood Engineering and Public Works; West Shore Emergency Support Services

West Shore Recreation Centre; Churches;

This action could potentially be maladaptive – depending on the energy source required for the cooling centres. However, this action could incorporate LCR considerations by considering the potential of microgrids, community energy generation, and other systems of renewable energy that could support this necessary adaptation action while also providing mitigation co-benefits (ACT, 2019). Other building-level LCR opportunities could include the use of green roofs and other building techniques that reduce the need for additional cooling and absorb carbon dioxide (ACT, 2019; ICABCCI, 2020).

10.3 – Promote higher building standards to protect against extreme heat events by updating by-laws, development guidelines, and zoning regulations.

- Continue to pursue the adoption of the BC Energy Step Code and green building practices (e.g. shade trees, orientation, etc.) integrate into necessary bylaws and policies
- Quantify and develop a better understanding of the severity of extreme temperatures (hot and cold) and report this information to inform “Passivhaus” recommendations

City of Colwood Planning and Bylaw services

Building-level LCR opportunities could include the use of green roofs, cool roofs, and other building techniques that reduce the need for additional cooling and absorb carbon dioxide (ACT, 2019; ICABCCI, 2020). Green roofs have other mitigation co-benefits including increased rainwater absorption, improved air quality, and enhanced urban biodiversity (ACT, 2019).

11.1 – Monitor and manage coastal erosion on City-owned and managed lands (e.g., coastal

- Create infrastructure improvements to reduce damage by humans (e.g. pathways)
- Promote land-use designation for Seaside Village during community events (instead of at the Esquimalt Lagoon)
- Initiate a monitoring program that measures the extent of erosion along shoreline and riparian areas

Esquimalt Lagoon Stewardship Initiative; Canadian Wildlife

Nature-based solutions have enhanced benefits. Promoting shoreline stabilization, riparian habitat protection, urban forest enhancement, and increasing natural habitat and protected areas can all help in stabilizing soils, while also providing carbon sequestration (ICABCCI, 2020).
<table>
<thead>
<tr>
<th>Activity</th>
<th>Responsible Parties</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undertake restoration work in priority areas identified, prioritizing naturalization where possible</td>
<td>Service; City of Colwood</td>
<td>Habitat creation and protection can result in increased capacity of the ecosystems and habitats that make up the Esquimalt Lagoon to deliver key ecosystem services while also sequestering carbon (ICABCCI, 2020). Access to natural spaces increases physical and mental well-being among residents. It is a place of refuge, promoting biodiversity and physical and mental well-being. Address access to green areas using an equity lens, to ensure these refuges are evenly distributed across diverse socio-economic demographics.</td>
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<tr>
<td>Consider developing networks of naturalized spaces for animals/insects/birds to travel amongst and relocate to in extreme weather events.</td>
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<tr>
<td>Support and work with local partners to develop environmental communications programming</td>
<td>City of Colwood; Capital Regional District; Canadian Wildlife Service; Esquimalt Lagoon Stewardship Initiative</td>
<td>Habitat creation and protection can result in increased capacity of the ecosystems and habitats that make up the Esquimalt Lagoon to deliver key ecosystem services while also sequestering carbon (ICABCCI, 2020). Access to natural spaces increases physical and mental well-being among residents. It is a place of refuge, promoting biodiversity and physical and mental well-being. Address access to green areas using an equity lens, to ensure these refuges are evenly distributed across diverse socio-economic demographics.</td>
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<td>Create interpretive signage to educate visitors about the significance of the local dune habitat and the bird sanctuary.</td>
<td>City of Colwood; Capital Regional District; Canadian Wildlife Service; Esquimalt Lagoon Stewardship Initiative</td>
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<tr>
<td>Reinforce that natural spaces absorb overland stormwater and reduce urban heat while also sequestering carbon.</td>
<td>City of Colwood; Capital Regional District; Canadian Wildlife Service; Esquimalt Lagoon Stewardship Initiative</td>
<td>Habitat creation and protection can result in increased capacity of the ecosystems and habitats that make up the Esquimalt Lagoon to deliver key ecosystem services while also sequestering carbon (ICABCCI, 2020). Access to natural spaces increases physical and mental well-being among residents. It is a place of refuge, promoting biodiversity and physical and mental well-being. Address access to green areas using an equity lens, to ensure these refuges are evenly distributed across diverse socio-economic demographics.</td>
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<td>Develop policy mechanisms that use the municipal park system and EDPAs to protect sensitive ecosystems</td>
<td>City of Colwood; Capital Regional District; Canadian Wildlife Service; Esquimalt Lagoon Stewardship Initiative</td>
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<td>Explore the potential expansion of protected areas across the City (and region) based on the identification of refugia, focusing on expansion opportunities that help to minimize flood and heat risks</td>
<td>City of Colwood; Capital Regional District; Canadian Wildlife Service; Esquimalt Lagoon Stewardship Initiative</td>
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<td>Implement actions identified to protect biodiversity (through the Urban Forest Strategy), including but not limited to:</td>
<td>City of Colwood; Capital Regional District; Canadian Wildlife Service; Esquimalt Lagoon Stewardship Initiative</td>
<td>Habitat creation and protection can result in increased capacity of the ecosystems and habitats that make up the Esquimalt Lagoon to deliver key ecosystem services while also sequestering carbon (ICABCCI, 2020). Access to natural spaces increases physical and mental well-being among residents. It is a place of refuge, promoting biodiversity and physical and mental well-being. Address access to green areas using an equity lens, to ensure these refuges are evenly distributed across diverse socio-economic demographics.</td>
</tr>
<tr>
<td>Implement mitigation strategies related to climate change impacts on marine shorelines</td>
<td>City of Colwood; Capital Regional District; Canadian Wildlife Service; Esquimalt Lagoon Stewardship Initiative</td>
<td>Habitat creation and protection can result in increased capacity of the ecosystems and habitats that make up the Esquimalt Lagoon to deliver key ecosystem services while also sequestering carbon (ICABCCI, 2020). Access to natural spaces increases physical and mental well-being among residents. It is a place of refuge, promoting biodiversity and physical and mental well-being. Address access to green areas using an equity lens, to ensure these refuges are evenly distributed across diverse socio-economic demographics.</td>
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<tr>
<td>Explore the potential to complete a Green Shores shoreline restoration project</td>
<td>City of Colwood; Capital Regional District; Canadian Wildlife Service; Esquimalt Lagoon Stewardship Initiative</td>
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**Notes:**
- **bird sanctuary** (e.g., coastline erosion).
- Erosion at Esquimalt Lagoon.
- Habitat creation and protection can result in increased capacity of the ecosystems and habitats that make up the Esquimalt Lagoon to deliver key ecosystem services while also sequestering carbon (ICABCCI, 2020). Access to natural spaces increases physical and mental well-being among residents. It is a place of refuge, promoting biodiversity and physical and mental well-being. Address access to green areas using an equity lens, to ensure these refuges are evenly distributed across diverse socio-economic demographics.

**Key Points:**
- Undertake restoration work in priority areas identified, prioritizing naturalization where possible.
- Consider developing networks of naturalized spaces for animals/insects/birds to travel amongst and relocate to in extreme weather events.
- Support and work with local partners to develop environmental communications programming.
- Create interpretive signage to educate visitors about the significance of the local dune habitat and the bird sanctuary.
- Reinforce that natural spaces absorb overland stormwater and reduce urban heat while also sequestering carbon.
- Develop policy mechanisms that use the municipal park system and EDPAs to protect sensitive ecosystems.
- Explore the potential expansion of protected areas across the City (and region) based on the identification of refugia, focusing on expansion opportunities that help to minimize flood and heat risks.
- Implement actions identified to protect biodiversity (through the Urban Forest Strategy), including but not limited to:
  - Implement mitigation strategies related to climate change impacts on marine shorelines.
  - Explore the potential to complete a Green Shores shoreline restoration project.

**Additional Notes:**
- Access to natural spaces increases physical and mental well-being among residents. It is a place of refuge, promoting biodiversity and physical and mental well-being. Address access to green areas using an equity lens, to ensure these refuges are evenly distributed across diverse socio-economic demographics.
- Development of green areas can provide numerous benefits, including increased capacity to deliver ecosystem services, physical and mental well-being, and carbon sequestration.
- Collaboration with local partners and stakeholders is crucial for effective implementation of these strategies.
- Continuous monitoring and evaluation of restoration efforts are necessary to assess their impact and adapt strategies as needed.
habitat and biodiversity.

- Identify marine shorelines within the parks system that are vulnerable to climate change impacts and develop mitigation strategies
- Take a landscape approach to regional conservation of sensitive ecosystems that may not be captured within the City’s jurisdiction
- Quantify and monitor local biodiversity
- Conduct a risk analysis for native species versus the future climate vegetation/habitat

11.4 – Enhance the protection of the Esquimalt Lagoon and native wildlife habitat from climate-related impacts to habitat through targeted habitat restoration efforts and policy mechanisms.

- Change accounting practices to value the ecosystem services provided by the Lagoon to the community, including reducing vulnerability against storm surge and SLR, sequestering carbon, and avoiding emissions of substitute infrastructure
- Apply policy instruments and regulatory mechanisms that reduce the impact of land-use and development on the lagoon (e.g., limit development in ecologically sensitive areas; embed habitat impact analysis into development projects)
- Habitat impact analysis should include the process of identifying, predicting, evaluating, and mitigating the effects of development on shoreline/lagoon habitats before planning decisions have been made
- Enhance habitat restoration at Esquimalt Lagoon to improve resilience of shoreline to inundation
- Increase stewardship of area from local residents

City of Colwood; Esquimalt Lagoon Stewardship Initiative

Other environmental organizations; Parks Canada

Re-naturalization of foreshores and the creation of tidal wetlands provide immense LCR opportunities, with many co-benefits including habitat creation, water conservation, job creation, improved human health and wellbeing, carbon sequestration, reduced extreme temperatures, improved green space and recreation areas, reduced risk to homes, water saving potential, and reduction in pollutants (ICABCCI, 2020).

#12: Managing mental health impacts of extreme events,

12.1 – Partner with other local agencies (e.g., Island Health, City of Colwood; Island Health;)

- Train staff on how to communicate with the public during extreme events

City of Colwood; Island Health;

No mitigation co-benefits in and of itself.
but also in reaction to climate change generally (e.g., eco/climate grief, helplessness among young people) School Boards) to develop effective communications strategies and other educational activities that offer the opportunity for youth, students, and others dealing with the cognitive and wellbeing aspects of a changing climate to connect with nature to re-establish connection, hopefulness, and stewardship.

- Establish an appropriate frame through which to deliver the climate message, one that does not minimize the impacts, but does focus on hope*
  - These frames may be different, depending on the information that is being communicated, and the desired response
- Deliver targeted messages that act to increase social connectedness and cohesion in order to build resilience and enhance wellbeing
- Communicate LCR in order to reinforce a hopeful future by reducing risks (proactive community), reducing emissions (an active community), and prioritize community-building and community actions through multiple co-benefits that build resilience and foster connection

School Districts

- However, the case could be made that building community and individual resilience as a climate coping mechanism could potentially lead to a deeper connection with nature which could lead to behaviour changes that support climate mitigation and adaptation strategies (e.g., active transportation) (Capaldi, Dopko, & Zelenski, 2014). Collective resilience could result in more people working together to take action – but community needs to feel empowered and inspired in doing so (enhanced efficacy) (Bales et al., 2015). Framing the uncertainty and risk positively has the potential to lead to stronger intentions to act (Morton et al., 2011). When community members are empowered and they feel their actions can make a difference (efficacy), the feelings of helplessness and climate/ecogrief can be effectively addressed.

### SEA LEVEL RISE

**#13: Sea level rise and more extreme weather events (storm surges, extreme rainfall, and wind events) causing coastal inundation and erosion of**

13.1 – Use flood maps and updated climate projections to conduct local sea-level rise and storm surge modeling to inform the placement and protection of

- Create an updated floodplain map for the Colwood area, using the CRD’s Coastal Sea Level Rise and Risk Assessment document as a starting point
- Conduct a vulnerability/risk assessment to identify critical infrastructure and low-lying neighbourhoods and developed/developable lands vulnerable to sea level rise
- Determine and target actions to high risk neighbourhoods and areas (e.g., Royal Bay Beach, Esquimalt Lagoon)

City of Colwood - Planning

- The action of conducting SLR modeling does not have mitigation co-benefits in and of itself, but the risk-reduction strategy used would determine this outcome. For instance, nature-based solutions avoid future emissions, avoid costs of infrastructure expansion, contribute to biodiversity, provide shade, improve air/water quality, and contribute to human health and well-being (ICABCCI, 2020).

Capital Regional District
<table>
<thead>
<tr>
<th>developed and developable land (e.g. at Royal Roads, Coburg Peninsula).</th>
<th>critical infrastructure and map and inspect inundation areas over time (e.g., Royal Bay Beach, Esquimalt Lagoon).</th>
<th>• Develop an action strategy for reducing risk in the prioritized areas, including LCR criteria in the decision making in order to identify options that reduce vulnerability and emissions and advance co-benefits (e.g. options that minimize stormwater infrastructure expansion and pumping, such as nature-based solutions, for instance).</th>
</tr>
</thead>
</table>
| 13.2 – Explore regulatory and planning tools that deter development in areas prone to sea level rise. | Explore land acquisition programs – purchase coastal land that is damaged or prone to damage and use it for conservation purposes, rather than protecting it with emissions-intensive and costly shoreline infrastructure.  
- Develop a policy mechanism for the acquisition of waterfront property by the City for ‘re-naturalization’ (e.g., Land trusts)  
- Restrict or prohibit development in erosion zones (e.g., impose special conditions as a condition of a development permit), promoting zoning that minimizes/avoids costs to public and private assets and infrastructure into the future  
- Establish/increase shoreline setbacks/buffers  
  - Could increase mandatory setbacks from the coast, establish setbacks based upon projected shoreline position using calculations of increased flood and/or erosion rates or create a tiered setback system permitting smaller structures with less of a setback and greater setbacks for larger development  
  - Could require that development adjacent to the shore leave buffers to provide natural protection to development, while allowing for upland migration of beaches | City of Colwood - Planning |
| | | Re-naturalization of foreshores and the creation of tidal wetlands provide immense LCR opportunities, with many co-benefits including habitat creation, water conservation, job creation, improved human health and wellbeing, carbon sequestration, reduced extreme temperatures, improved green space and recreation areas, reduced risk to homes, water saving potential, and reduction in pollutants (ICABCCI, 2020). |
| 13.3 – Develop a public education campaign targeted at developers regarding the projected impacts of sea level rise (e.g., causing coastal inundation and coastal erosion) and the implications on coastal development and land-use. | • Explore foreshore tenure opportunities for the acquisition of land. | • Encourages support from local developers of local government and regional policy and planning mechanisms that aim to reduce the risk of sea level rise and coastal inundation. | City of Colwood; Planning, Communications; CRD | Protecting the coast from development and using nature-based solutions are essential to reduce the risk of sea level rise and coastal inundation and erosion. Tidal wetlands and coastal foreshore protection add a buffer between the ocean and coastline and also contribute to significant carbon sequestration (ICABCCI, 2020). |
| 13.4 – Incorporate adaptive management into the maintenance and long-term planning of critical infrastructure (e.g., Lagoon Bridge), planning for changing priorities over time. | • Create incentives that ‘climate proof’ infrastructure, including residential and commercial buildings. | • Enhance the resilience and emissions profiles of critical infrastructure by applying modifications where applicable (e.g., raising floor levels, modifying drainage networks, planting trees, weatherizing, installing energy efficient technology, fuel switching, etc.). | City of Colwood Engineering and Public Works | Considering LCR in planning saves costs and time over the long term. |
| 13.5 – Promote higher building standards which reflect climate projections by updating by-laws, development guidelines, and zoning regulations. | City of Colwood Development Services, Building and Bylaw Services | Interventions such as green roofs, cool roofs, solar panel roofs, and alternative cooling mechanisms are LCR opportunities to consider in regard to this action. These various interventions have multiple co-benefits, depending on which intervention is chosen (ACT, 2019).
Co-benefits of green roofs: carbon sequestration; improved air quality and wellbeing; cost savings (reduced energy usage); potential for food production/pollinator habitat; creation of green jobs (ACT, 2019).
Co-benefits of cool roofs: improved air quality (lower temperatures and reduced ozone); extended roof life; and creation of green jobs (ACT, 2019).
Co-benefits of solar roofs: cost savings; significant ROI; improved water savings (less water is used for energy production); reduced GHG emissions (ACT, 2019). |
| --- | --- | --- |
| • Expand existing building code requirements to include green/resilience building standards, and continued improvement/adoption as changes arise  
• Research what other municipalities have done regarding higher building standards that can help to increase resilience to climate change impacts (especially with regard to sea level rise) and reduce emissions over time  
• Consider costing the impact of development on City natural assets – i.e. cost of ecosystem services lost per tree removed and standards for replacement trees. | 13.6 – Ensure essential and important services to the community have adequate working backup power. | BC Hydro |
| 13.6 – Ensure essential and important services to the community have adequate working backup power. | City of Colwood Public Works | Microgrids reduce the vulnerability of a large power grid and foster local resilience since the local subsystems operate autonomously from the larger grid. Various renewable energy sources can be used (e.g., solar, wind, hydro, biomass). Microgrids can be especially useful in providing power to neighbourhoods and health facilities during power outages caused by extreme weather. Additionally, renewable energy has the potential to significantly reduce GHG emissions (ACT, 2019). |
| • Identify critical infrastructure requiring back up power, consider energy planning over time that applies microgrids that use to zero or low carbon technology options that foster local supply and resilience during increased main grid disruptions  
• Create an inventory of infrastructure at risk and make available to the public to increase public awareness of these risks  
• Establish system redundancy for critical services throughout Colwood  
• Ensure back-up power for essential and important services is not vulnerable to sea level rise or flooding and that they have adequate fuel for extended power shortages |  |  |
### 13.7 – Explore “soft armouring” techniques and/or natural infrastructure to expand or mimic natural buffers.

- Develop an action plan for employing soft armouring techniques in areas of critical habitat and importance
  - Conduct an environmental assessment to inform action plan
  - Consider reduction of risk and vulnerability to climate impacts, emissions avoidance/reduction, and advanced co-benefits over time.
- Determine areas where coastal wetlands can act as buffers to storm surge events (e.g., areas of re-naturalization)
- Protect and restore natural wetland habitats along the shoreline
  - E.g., beach nourishment, planting vegetation, etc.
- Other options include:
  - Allow for shoreline migration
  - Stabilize sediment and reduce erosion by planting native vegetation
  - Create dunes along the backshore of the beach
  - Create marsh by planting appropriate native species – grasses, sedges, or rushes
- Use natural breakwaters of oysters to dissipate wave action and protect shorelines
- Create new recreation opportunities in restoration areas along the foreshore

<table>
<thead>
<tr>
<th>City of Colwood Engineering, Recreation (Parks), and Planning; Environmental Consultants</th>
<th>BC Ministry of Transportation and Infrastructure; local citizens and private landowners</th>
</tr>
</thead>
</table>

Naturalization of foreshores is a form of ecological restoration that reintroduces natural buffers to the shoreline – buffers can differ depending on local ecosystem types and localized climate risks. This technique results in fewer GHG emissions during installation and throughout its lifetime (including embodied emissions) and has the capacity to sequester carbon (ACT, 2019). Specific climate risks that re-naturalization can help to mitigate include sea level rise, storm surge and flooding, and ecosystem and species loss and decline (ACT, 2019).

Re-naturalization of foreshores and the creation of tidal wetlands provide immense LCR opportunities, with many co-benefits including cost savings, habitat creation, water conservation, job creation, improved human health and wellbeing, carbon sequestration, reduced extreme temperatures, improved green space and recreation areas, reduced risk to homes, water saving potential, and reduction in pollutants (ICABCCI, 2020).

### 13.8 – Explore options to harden shorelines with “hard engineering” techniques, if necessary.

- Apply a strategic grey-green approach, whereby multiple defences are considered, and where restored wetlands and coastlines are used to offset emissions from seawalls, and other hard engineering
- Determine if/where hard armouring techniques (e.g., levees, dikes, and seawalls) would be appropriate solutions to local sea level rise (e.g., areas of existing development or critical infrastructure)

<table>
<thead>
<tr>
<th>City of Colwood Engineering and Public Works</th>
<th>Developers/BUILDERS</th>
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</table>

This action has the potential to be maladaptive due to the higher emissions associated with installation and maintenance of grey infrastructure solutions as opposed to nature-based. However, depending on the local circumstances these engineered solutions may be required in preventing immediate risk. An important consideration includes the effectiveness of the identified solutions (e.g., sea wall, dike, etc.) to mitigate the impacts, while considering the local context. For example, “hard, straight seawalls…exacerbate
| #14: Sea level rise inundating tourist and recreation areas, as well as local historic sites (e.g., archaeological, cultural, and spiritual sites for First Nations). | Determine if/where other engineering options could be suitable (e.g., elevated or floating development)  
Collaborate with neighbouring municipalities to research and explore ways of planning for sea level rise in capital budgets | overtopping effects”, so this might not be the best adaptation solution for sea level rise and coastal storm surges (ACT, 2019, p. 52). It is important to consider the potential of implementing nature-based solutions where possible given the many mitigation potential associated with these solutions. Natural assets “are more adaptive to changing climate conditions than grey infrastructure solutions in the long term, if managed correctly. They also have lower embodied emissions and are cheaper to install, maintain and operate, with the tendency to increase in value over time, unlike built assets” (ICABCCI, 2020, p. 6). |
| 14.1 – Work with local First Nations to develop an inventory of cultural sites (e.g., village sites, burial sites, clam gardens and other sacred/archaeological sites) vulnerable to sea level rise and coastal erosion. | Continue to build relationships with local First Nations, based on mutual trust and reciprocity  
Work with First Nations and other consultants to identify sites at risk  
- Identify what can be protected; what needs to be moved; and what potentially is lost  
Work with local First Nations to explore culturally appropriate options to mitigate the impacts of sea level rise on cultural sites  
- Develop plans/policy mechanism for protection or preservation of identified locations  
Explore funding opportunities to support First Nations capacity building with regard to the implementation of climate adaptation actions, in a culturally meaningful way  
Partner with local First Nations to establish opportunities to build public awareness of the importance of cultural sites to traditional cultures | City of Colwood Long Range Planning; Esquimalt and Songhees First Nations  
Local archaeologists and consultants | No direct mitigation benefits. However, if this local assessment and inventory leads to heightened protection of sensitive ecological (and cultural) areas then this action could have mitigation co-benefits. For example, if sea level rise adaptation efforts included the restoration of foreshore habitat and/or tidal wetlands, then there is the potential for heightened carbon sequestration. If this action results in habitat creation/restoration then there are many other co-benefits including enhances local autonomy, captures, pollutants, improves human health and wellbeing, improves water retention/absorption, reduces extreme temperatures, improves equity, improves community livability, supports local food security initiatives (indigenous food systems), and increases carbon sequestration (ICABCCI, 2020). |
| 14.2 – Develop a plan to implement | Explore best practices for valuing natural assets among other BC municipalities | City of Colwood Long | Accounting for natural assets is a crucial LCR strategy and is “considered to be a primary LCR approach that can help...” |
| Natural Asset Management within the City of Colwood. | Integrate climate projections into natural asset management to obtain a full picture of how the asset is likely to perform in the long term.  
Consider the proxy data to be included in natural asset valuation.  
Develop an inventory of the assets (i.e., ecosystem services) to be included in the valuation process (e.g., foreshores, wetlands, and forests) and the benefits (e.g., air and water filtration, stormwater management, moderate temperatures, and sequester carbon).  
Normally categorized by provisioning, regulating, supporting, and cultural services.  
Explore best practices to determine the value of ecosystem services. There are two main approaches:  
"Willingness to pay" approach and "Willingness to accept" approach. | Range Planning | Communities reduce vulnerability to current and projected climate impacts and emissions over time" (ICABCCI, 2020, p. 4). |

**LCR Table References**


BC Environmental Protection and Sustainability. (2017). Provincial greenhouse gas inventory. Retrieved from [https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory](https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory)


Purpose of Report
The intention of this report is to inform the outputs of the vulnerability and risk assessment phase of the Together for Climate project with the City of Colwood, tie the impacts to projections, provide a scientific basis for the results of the risk assessment, and to validate the vulnerability and risk assessment process used for this project. This report is broken down into the following sections: Global and National Climate Change, Developing Climate Change Projections, Climate Change Projections for Greater Victoria (including Colwood), Climate Change Impacts for Greater Victoria (including Colwood), and Risk Assessment Methodology Validation.

Together for Climate Project
To address the projected impacts of climate change and adapt to changing climate conditions, the City of Colwood is participating in the Together for Climate Project. Led by ICLEI Canada, the Together for Climate project involves eight communities from British Columbia in developing community climate change adaptation plans.

The purpose of a climate change adaptation plan is to mainstream adaptation actions into City operations and to reduce the risks climate change poses to a community’s physical, economic, social, and ecological systems. Each participating municipality will have a community-wide adaptation strategy that includes actionable elements for all participating stakeholders. This process involves:

- Identifying locally relevant climate change impacts
- Completing organizational vulnerability and risk assessments
- Establishing long-term adaptation vision and goals
- Identifying relevant adaptation actions
- Developing implementation action plans

Global and National Climate Change
Since the late 1800s, the Earth’s temperature has risen by 1°C largely due to human activities (International Panel on Climate Change [IPCC], 2014). As fossil fuel extraction and consumption continues around the world, warming is accelerating at a faster rate. Earth’s average surface temperature in 2018 was the fourth hottest year on record, and 2019 was the second hottest year on record, since record-keeping began in the 1880s (North American Space Academy [NASA], 2019; NASA, 2020; National Oceanic and Atmospheric Association [NOAA], 2019). As of 2019, the five warmest recorded years have occurred during the past five years, and the 20 warmest years on record have occurred over the past 22 years (NASA, 2019). July 2019 was the hottest month ever recorded, shrinking Arctic and Antarctic sea ice to historic lows 19.8% below average (NOAA, 2019).

Similar to global trends, Canada has been warming over the last six decades, with average temperatures over land increasing by 1.5°C between 1950 - 2010 (Bush, Loder, James, Mortsch, & Cohen, 2014). This rate of warming is almost double the global average reported over the same period, meaning an increase of 2°C globally could result in a 3-4°C change in Canada. The years 2011 and 2012 were found to be 1.5°C and 1.9°C warmer than the 1961-1990 average in Canada, with 2018 now standing as the warmest year on record globally.
Canada has also generally become wetter over the past several decades, with average annual precipitation across the country increasing by approximately 16% between 1950-2010. This increase is dominated by large changes in British Columbia and Atlantic Canada. Extreme precipitation events are also likely to become more intense and more frequent – recent studies show that a 1-in-20-year storm event are likely to become 1-in-10-year storm events by the 2050s (Bush et al., 2014).

Developing Climate Change Projections
Developing climate change projections requires the use of climate models, which are based on mathematical representations of atmosphere, ocean, ice cap, and land surface processes. These climate models are then run through various emissions scenarios - socioeconomic storylines used by analysts to make projections about future greenhouse gas emissions (GHG) and to assess future vulnerability to climate change. It is unknown what future greenhouse gas (GHG) emissions will be. In order to account for multiple possible future emissions scenarios, the IPCC developed four Representative Concentration Pathways (RCP) as part of a new initiative for the Fifth Assessment Reports (Taylor et al. 2012).

The data presented in this report is based on global climate models (GCMs) and emission scenarios defined by the Intergovernmental Panel on Climate Change (IPCC), drawing from the Fifth Assessment Report (AR5) – unless otherwise stated. Projections will use RCP 8.5, as it represents a ‘business as usual’ pathway with emissions continuing to increase. If current emissions trends continue, the higher emissions scenarios and associated temperature increases will likely apply. Additionally, it is important that municipalities are aware of some of the most potentially dramatic effects of climate change should global emissions persist.

More information on climate modelling or emissions scenarios can be found in the IPCC’s AR5 Synthesis Report: Climate Change 2014.

Uncertainty
It is important to note that uncertainty is an integral part of the study of climate change. Uncertainty is factored into climate change scenarios, models, and data, and reflects the complex reality of environmental change and the evolving relationship between humans and the planet. While it is not possible to anticipate future climactic changes with absolute certainty, climate change scenarios help to create plausible representations of future climate conditions. These conditions are based on assumptions of future atmospheric composition and on an understanding of the effects of increased atmospheric concentrations of GHG, particulates, and other pollutants.

Data Collection
This report is informed by data collected through several platforms. Primarily, localized climate change data was collected from three online, publicly available tools. These tools provide access to downscaled climate data for the City of Colwood (Greater Victoria region). Other information pertaining to expected climatic changes in British Columbia were taken from various academic or government reports. These are identified and cited where applicable.
The tools include:
- Climate Change Data and Scenarios Tool – http://climate-scenarios.canada.ca
- Climate Atlas of Canada Tool – https://climateatlas.ca/
- Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change Version 3.0 – http://www.idf-cc-uwo.ca/home

Scientific data sources include:
- Temperature and precipitation indicators:
  - The Climate Projections for the Capital Region Report
- Sea level rise (SLR) projections:
  - The Province of BC amended Flood Hazard Area Land Use Management Guidelines
  - The Province of BC Sea Level Rise Adaptation Primer
  - CRD Coastal Sea Level Rise Risk Assessment Report
- Wind projections:
  - Possible Impacts of Climate on Wind Gusts under Downscaled Future Climate Conditions

Climate Change Projections for the Greater Victoria Area

Climatic changes in BC during the twentieth century have often exceeded global trends but vary significantly by region. Recent events in the City of Colwood including water shortages, winter storms, and other occurrences of extreme weather over the past several decades have highlighted the need to be prepared for ongoing challenges.

The following data highlights the projected impacts of climate change on the City of Colwood, located within the Greater Victoria area. The parameters included in this report are temperature, precipitation, and sea level rise; these metrics will form the basis of the City’s climate adaptation planning effort. Six major trends have been identified and need to be considered: increased average temperatures; more frequent and intense heat waves; drier summers (wetter winters); more frequent and intense rainfall events; increased wind and storm events; and sea level rise (CRD, 2017; Prairie Climate Centre [PCC], 2019; IPCC, 2014).

Key findings include increased mean annual temperature, with the most increases noticed during summer months; increased annual precipitation, with the most notable increases in fall, winter, and spring; and increased intensity of rainfall. In addition, sea levels and ocean and stream temperatures are expected to rise. Table 1 provides a summary of these climatic changes for the Greater Victoria area.
**Table 1. Summary of Climatic Changes for the Greater Victoria area (including Colwood).**

<table>
<thead>
<tr>
<th>Climate Indices 1</th>
<th>RCP 8.5</th>
<th>Baseline (1976-2005)</th>
<th>2021-2050</th>
<th>2051-2080</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean annual temperature (°C)</td>
<td>RCP 8.5</td>
<td>9.4</td>
<td>11.1</td>
<td>12.7</td>
</tr>
<tr>
<td>Days over 30°C (days)</td>
<td>2</td>
<td>5</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Freeze-thaw days</td>
<td>8.6</td>
<td>3.9</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Mean annual precipitation (mm)</td>
<td>1312</td>
<td>1351</td>
<td>1418</td>
<td></td>
</tr>
<tr>
<td>Relative Sea level rise²</td>
<td>Average 8.8 mm/year³</td>
<td>Approximately 0.5 m by 2055 and 1.0 m by 2115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water temperatures</td>
<td>Increasing at varying degrees in ocean and streams</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Temperature**

**British Columbia**

Over the last six decades, Canada has become warmer, with average temperatures over land increasing by 1.5°C between 1950 and 2010 (Warren & Eggington, 2008). This rate of warming is almost double the global average reported over the same period. Assuming emissions continue at the current rate of global output, the Province of British Columbia is projected to experience an average annual temperature rise of approximately 7.7°C by the end of the century (Warren & Eggington, 2008).

Table 2 displays the expected seasonal temperature change in British Columbia based on the IPCC Fifth Assessment Report (AR5) and informed by Environment and Climate Change Canada’s Climate Data and Scenarios Tool. An ensemble of global climate models was used, and the high emissions scenario was selected because if current emissions trends continue, RCP8.5 and associated temperature increases will likely apply (Walker & Sydneysmith, 2008). Table 2 shows the projected changes for the following timeframes, 2016-2035; 2046-2065; and 2081-2100; the degrees in the table are the not actual temperatures, but the degrees by which temperature is projected to change from the baseline under the business as usual climate scenario RCP8.5.

---

1 The first four climate variables taken from the PCC (2019) climate summary report for Greater Victoria.


3 This value is based on the Provincial Guidelines SLR baseline year of 2000; an SLR increase rate of +10 mm/yr; a land uplift rate around Victoria of +1.2 mm/yr (10 mm/yr - 1.2 mm/yr = 8.8 mm/yr).
Table 2. Seasonal Temperature Change in British Columbia for RCP 8.5.

<table>
<thead>
<tr>
<th>Season</th>
<th>RCP 8.5</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2016-2035</td>
<td>2046-2065</td>
<td>2081-2100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>Range</td>
<td>Median</td>
<td>Range</td>
</tr>
<tr>
<td>Winter</td>
<td>1.5°C</td>
<td>0.9-2.0°C</td>
<td>3.1°C</td>
<td>2.2-3.9°C</td>
</tr>
<tr>
<td>Spring</td>
<td>1.3°C</td>
<td>0.8-1.7°C</td>
<td>2.5°C</td>
<td>1.9-3.5°C</td>
</tr>
<tr>
<td>Summer</td>
<td>1.3°C</td>
<td>0.9-1.5°C</td>
<td>3.0°C</td>
<td>2.3-3.8°C</td>
</tr>
<tr>
<td>Autumn</td>
<td>1.1°C</td>
<td>0.7-1.5°C</td>
<td>3.0°C</td>
<td>2.3-3.8°C</td>
</tr>
<tr>
<td>Annual</td>
<td>1.3°C</td>
<td>0.8-1.6°C</td>
<td>2.9°C</td>
<td>2.1-3.5°C</td>
</tr>
</tbody>
</table>

Baseline: 1986-2005

City of Colwood

Temperatures in the City of Colwood are expected to rise in congruence with the provincial changes observed in the data above. The Climate Atlas of Canada tool was used to collect downscaled climate projections, using a baseline of 1976-2005, shown in Table 3. Data includes the regional area of Greater Victoria, including Colwood.

Table 3. Baseline Mean Temperatures (1976-2005) for the Greater Victoria area.

<table>
<thead>
<tr>
<th>Season</th>
<th>Annual</th>
<th>Winter (DJF)</th>
<th>Spring (MAM)</th>
<th>Summer (JJA)</th>
<th>Autumn (SON)</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>9.4°C</td>
<td>3.7°C</td>
<td>8.3°C</td>
<td>15.6°C</td>
<td>9.8°C</td>
</tr>
</tbody>
</table>

In Colwood, the average annual temperature is expected to increase by 1.7°C by the 2050s. Table 4 depicts the projected temperatures using an ensemble of global climate models and applying the RCP 8.5 (business as usual) scenario from the Climate Atlas of Canada.

Table 4. Projected Seasonal Temperature for the Greater Victoria area under RCP 8.5.

<table>
<thead>
<tr>
<th>Season</th>
<th>2021-2050 Mean</th>
<th>Range</th>
<th>2051-2080 Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>5.3°C</td>
<td>3.4-6.9°C</td>
<td>6.9°C</td>
<td>5.0-8.8°C</td>
</tr>
<tr>
<td>Spring</td>
<td>10.0°C</td>
<td>8.4-11.7°C</td>
<td>11.4°C</td>
<td>9.6-13.6°C</td>
</tr>
<tr>
<td>Summer</td>
<td>17.5°C</td>
<td>16.2-18.9°C</td>
<td>19.5°C</td>
<td>17.7-21.3°C</td>
</tr>
<tr>
<td>Autumn</td>
<td>11.3°C</td>
<td>10.1-12.6°C</td>
<td>13.1°C</td>
<td>11.5-14.7°C</td>
</tr>
<tr>
<td>Annual</td>
<td>11.1°C</td>
<td>10.0-12.1°C</td>
<td>12.7°C</td>
<td>11.4-14.2°C</td>
</tr>
</tbody>
</table>
Hot Days
Temperature extremes can pose significant threats to communities across the country. From health impacts to increasing energy demands, “hot days” (days where the temperature exceeds 30°C) can be particularly concerning for communities. Outdoor workers can experience health risks and delays due to inhospitable temperatures. Vulnerable populations such as low income or elderly residents without access to air conditioning can also be susceptible to sickness and injury in such high temperatures.

Table 5 shows hot day projections for the Greater Victoria region, which includes the City of Colwood, using an ensemble climate model and data obtained from the Canadian Climate Atlas, and applying the high emissions RCP8.5 scenario. The figures are based on the baseline average from 1976-2005. The City can expect to start experiencing hot days (days where the temperature exceeds 30°C) that did not previously occur based on historical data.

The Capital Regional District’s (CRD) data uses the metric “Summer days” which refers to the number of days temperatures are over 25°C and is an indicator of how often we can expect to experience “summer weather” in the future. In the past (1971-2000), the Colwood region experienced 12 summer days annually – we can expect significantly more in the future. The ensemble of models used by Pacific Climate Impacts Consortium (PCIC) (which has a weather station in Victoria, BC) project triples the number of summer days by the 2050s, and 5 times more by the 2080s. This means that future summers may have 36 days above 25°C by the 2050s, and 59 days by the 2080s (CRD, 2017).

Table 5. Projected Hot Days for the Greater Victoria area under RCP8.5
Freeze-Thaw
A freeze-thaw cycle is any day where the minimum temperature is below 0˚C and the maximum temperature is above 0˚C. The RCP 8.5 ensembles project that freeze-thaw cycles will decrease significantly due to overall warmer temperatures. Table 6 outlines the baseline freeze-thaw cycles in comparison to the projections for the immediate future (2021-2050) and the near future (2051-2080) (PCC, 2019).

Table 6. Projected Freeze-Thaw Days for the Greater Victoria area under RCP8.5

<table>
<thead>
<tr>
<th>RCP8.5</th>
<th>Number of freeze-thaw days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-2005</td>
<td>8.6 days</td>
</tr>
<tr>
<td>2021-2050</td>
<td>3.9 days</td>
</tr>
<tr>
<td>2051-2080</td>
<td>1.5 days</td>
</tr>
</tbody>
</table>

Precipitation
British Columbia
Canada has, on average, become wetter during the past half century, with average precipitation across the country increasing by approximately 13%. Projections for British Columbia show even more significant increases in precipitation, particularly during winter, spring, and fall. Projections suggest that British Columbia will experience regional variability in summer water availability, with trends toward lower water levels typically due to loss of glaciers and snowfall (Lemmen, Warren, James, & Mercer-Clark, 2016). Periodic water scarcity during summer months is expected to increase due to warming temperatures and changing precipitation patterns. Table 7 represents the projected precipitation changes for the Province of British Columbia under the RCP8.5 scenario. Data was informed by Environment and Climate Change Canada’s Climate Data and Scenarios Tool

Table 7. Seasonal Precipitation Change (%) in British Columbia - RCP8.5 (Baseline 1986-2005)

<table>
<thead>
<tr>
<th>Season</th>
<th>RCP8.5</th>
<th>2016-2035</th>
<th>2046-2065</th>
<th>2081-2100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
<td>Range</td>
<td>Median</td>
<td>Range</td>
</tr>
<tr>
<td>Winter</td>
<td>3.4%</td>
<td>-1.4-8.4%</td>
<td>10.0%</td>
<td>2.6-17.8%</td>
</tr>
<tr>
<td>Spring</td>
<td>3.3%</td>
<td>-1.3-18.3%</td>
<td>9.2%</td>
<td>3.6-15.4%</td>
</tr>
<tr>
<td>Summer</td>
<td>0.7%</td>
<td>-5.1-7.1%</td>
<td>2.1%</td>
<td>-4.0-8.1%</td>
</tr>
<tr>
<td>Autumn</td>
<td>4.3%</td>
<td>-0.7-9.8%</td>
<td>11.1%</td>
<td>6.0-16.4%</td>
</tr>
<tr>
<td>Annual</td>
<td>2.9%</td>
<td>-2.1-8.4%</td>
<td>8.1%</td>
<td>2.1-14.4%</td>
</tr>
</tbody>
</table>

Moreover, while average precipitation is expected to increase, climate change will also have an impact on the timing and intensity of precipitation events, and on its form (rain or snow). By the 2080s,
average precipitation may increase by roughly 10%, relative to a 1961–1990 baseline, in all seasons except summer, where a 10% decrease is projected (Lemmen et al., 2016). Higher winter and springtime temperatures will reduce the percentage of total precipitation occurring as snowfall. By the 2050s, winter snowfall is projected to decrease by about 25% and spring snowfall by about 50% (Lemmen et al., 2016). For the 2080s, the projected reduction in spring snowfall may reach 72% (compared with the 1961–1990 baseline). Less snow and more rain would lead to faster runoff and could contribute to water-scarcity issues because less water will be stored as snow and ice.

City of Colwood
Annual precipitation in Colwood is expected to rise slightly, in congruence with the provincial changes observed in the data above, with decreases in precipitation during the summer months, and increases during the fall, winter, and spring months. The Climate Atlas of Canada provides data from the PCIC in Victoria, BC. The below data uses a baseline of 1976-2005 and depicts projected precipitation for the RCP8.5 emissions scenario (PCC, 2019).

Projections are based on increases from the precipitation baseline, which is the average amount of precipitation from 1976-2005, and is represented in Table 8. For Colwood, the average annual precipitation over this period was 1312 mm. The projections to 2050 and 2080 reflect the projected amount of precipitation, in millimetres, from the annual and seasonal baselines and are represented in Table 9. In a high emission scenario, Colwood can expect to experience an average annual precipitation increase of 39 mm during 2021-2050 and 106 mm during 2051-2080.

Table 8. Baseline Mean Precipitation (1976-2005) for the Greater Victoria area.

<table>
<thead>
<tr>
<th></th>
<th>Annual</th>
<th>Winter (DJF)</th>
<th>Spring (MAM)</th>
<th>Summer (JJA)</th>
<th>Autumn (SON)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>1312</td>
<td>568</td>
<td>249</td>
<td>103</td>
<td>392</td>
</tr>
</tbody>
</table>

Table 9. Projected Seasonal Precipitation for Greater Victoria under RCP 8.5.

<table>
<thead>
<tr>
<th></th>
<th>2021-2050</th>
<th>2051-2080</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>Winter (mm)</td>
<td>597</td>
<td>386-822</td>
</tr>
<tr>
<td>Spring (mm)</td>
<td>256</td>
<td>150-381</td>
</tr>
<tr>
<td>Summer (mm)</td>
<td>95</td>
<td>37-168</td>
</tr>
<tr>
<td>Autumn (mm)</td>
<td>403</td>
<td>233-594</td>
</tr>
<tr>
<td>Annual (mm)</td>
<td>1351</td>
<td>1045-1674</td>
</tr>
</tbody>
</table>

The following climographs show the seasonal changes in precipitation and temperature from the baseline (1976-2005). Figure 2 shows the projections from 2021-2050 and Figure 3 shows the projections from 2051-2080.
Figure 2. Projected seasonal variations in precipitation and temperature between 2021-2050 for the Greater Victoria area under RCP 8.5 (PCC, 2019).

Figure 3. Projected seasonal variations in precipitation and temperature between 2051-2080 for the Greater Victoria area under RCP 8.5 (PCC, 2019).
Extreme Weather Events
Canada has seen more frequent and intense extreme events over the last 50-60 years than ever before. These events come in the form of extreme heat days, more instances of extreme precipitation and flooding, windstorms, and ice storms. In Canada, models show shorter return periods of extreme events – that is, the estimated interval of time between occurrences – in the future (McBean & Henstra, 2009). For example, the number of heat waves that the Greater Victoria region will experience is going to increase, as is the duration, intensity, and frequency of storms (CRD, 2017).

Heavy or Extreme Precipitation
Extreme and heavy rain events are expected to become more intense and more frequent. The increase in precipitation will be concentrated in the wettest days, making for more frequent and intense rainfall events. Using data collected from the CRD, which uses a baseline of 1971-2000 (different than the Climate Atlas Data used above), the wettest day of the year will see an average of 20% more rain by the 2050s, and 36% more rain by the 2080s; however, most of the increases will be from heavy rainfall days becoming more frequent (as opposed to an increase in the amount of precipitation in each event) (CRD, 2017). Figure 4 below shows the number of heavy precipitation days (>20 mm) for both timeframe projections (2021-2050) and (2051-2080) (PCC, 2019).

**Figure 4. Heavy precipitation days (>20mm) (PCC, 2019).**

Wind and Storm Events
Using data obtained from the CRD climate report, using a baseline of 1971-2000, the region is expected to experience more frequent and intense wind gusts; hourly wind gusts above 40
km/hr are likely to increase by about 10%, while wind gusts above 70 km/hr may increase by 30-50% by the 2050s. It is projected that the number of days with 40 km/hr winds are likely to increase by about 5%, and days with winds above 70 km/hr will increase by about 15%, suggesting that the increase is likely to be concentrated in existing wind events, rather than more windy days overall (Cheng et al., 2014).

**Sea Level Rise**

Sea levels vary widely depending on several temporal, atmospheric, and oceanographic factors. Climate variabilities such as El Niño/La Niña Southern Oscillation contribute to extreme water levels, temperatures and storm surge flooding. Climate change impacts such as melting glaciers, warmer temperatures (thermal expansion), and changes in salinity have also contributed to changing sea levels. Between 1900–2009, the trend of global sea-level rise (SLR) was on average 1.7 ±0.2 mm/year. This is expected to rapidly increase. The IPCC projects a range of global sea-level rise of 26–98 cm by the year 2100, based on the RCP emissions scenarios (Lemmen et al., 2016).

On the British Columbia coast, the projected amount of sea level rise is not uniform. The most drastic sea level rise is projected to occur on the Fraser Lowland, southern Vancouver Island, and the north coast (British Columbia Ministry of Environment [BCMOE], 2013; Lemmen et al., 2016). Guidance from the province is to plan for 0.5m of SLR by 2050, 1m of SLR by 2100 and 2m of SLR by 2200 (see Figure 5). This direction was first drafted in 2011 and updated in the Flood Hazard Area Land Use Management Guidelines (S.3.5 and 3.6) that came into effect in January 2018, along with two options on methodologies for setting flood construction levels (FCL) (BCMOE, 2017).

![Recommended Curve for Sea Level Rise Policy in BC](image_url)

*Figure 5. Recommended curve for sea level rise policy in BC (BCMOE, 2017).*

In 2015, the CRD undertook a Coastal Sea Level Rise Risk Assessment, including a simplified mapping exercise to assess SLR extents in 24 focus areas across the region. The methodology
did not account for wave effects or freeboard so does not meet the Province’s recommended guidelines for setting FCLs. The Esquimalt Lagoon was mapped for the City of Colwood, which is likely to be one of the most heavily impacted areas of Colwood, with 0.33 square km affected during a 500-year storm surge event in 2100 (CRD, 2015). An economic analysis of this impact based on 2014 BC Assessment data estimated the total value of assets within the impacted area was $25.4M, with $13.5M of this in residential property values, $2.8M in commercial values, and $9.1M in Civic Assets (e.g., Royal Roads University grounds, Ocean Blvd. [road], 3301 Ocean Blvd. Lift Station [sewage], 205 Portsmouth Drive Lift Station [sewage], Building 32 Pump Station [sewage], and the Esquimalt Lagoon Bridge). Figure 6 represents mapped areas that will be permanently inundated by the year 2100, under a 500-year storm surge.

**Figure 6. CRD Inundation Mapping - Esquimalt Lagoon**

**Water Temperatures**

Sea surface temperatures have warmed significantly in British Columbia. Similar to sea level rise, sea surface temperature change varies across the region. Stream temperatures could rise by up to 2°C, and when coupled with lower flow levels, can have a significant impact on fisheries (Harford, 2008).

**Water Quantity**

Many regions in British Columbia are expected to experience increasing water shortages (Lemmen et al., 2008). Loss of snowpack and glaciers as well as precipitation changes are
expected to limit water supply during peak demand periods during summer (Harford, 2008). Saltwater intrusion resulting from sea level rise can also impact groundwater. In addition to water supply, reduced summer stream flows will affect aquatic ecosystems such as critical salmon habitat as well as can increase the risk of fire risk due to increased evapotranspiration (CRD, 2017).
Top Climate Drivers and Risks for Colwood

The above climate change projections will have varied impacts on the social, natural, built system. The following information includes an analysis of the expected climate impacts in the Greater Victoria area (including Colwood). The risks outlined in the tables below are a summary of the most significant climate risks (as related to the local climate projections) to Colwood as determined by stakeholder participation in workshops held to date, additional information collected through online surveys and correspondence, interviews with experts in the region, and consultation with the Together for Climate team and City of Colwood staff. The text noted above each priority risk provides support and validation (from peer-reviewed literature and broad sources) for each risk prioritization.

Increased average temperatures
Recall the temperature projections for the Greater Victoria area noted in the above climate projections section (p.7); expected temperature increase of 1.7°C by the 2050s. Increasing annual temperatures have many ecological and human health impacts (CRD, 2017, p. 43). Increasing temperatures impact the ability of ecosystems, species, and key ecological processes to adapt; therefore, the distribution and composition of ecosystems across the region will shift, and as a result some species will be unable to cope with the rate and magnitude of change (p. 46). This has important implications for the accessibility and availability of traditional foods and medicines for local First Nations since some of the species that are particularly susceptible to rising temperatures are also culturally significant such as salmon, western red cedar, and certain shellfish species (CRD, 2017, p. 46; Turner, 2005). Warming temperatures can disrupt biological cycles and relationships that depend on temperature threshold cues (e.g., predator-prey, parasite-host, and the phenology of flowering plants and pollinator emergence). This could lead to a decline in desirable species and an increase in the prevalence of invasive species and pathogens (p. 46). Water temperatures in surface water bodies and streams are also rising in congruence with rising atmospheric temperatures, which has implications on aquatic species that need cool water to survive (e.g., salmon and trout) (p. 46).

<table>
<thead>
<tr>
<th>Priority Risk</th>
<th>Description</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotter air and surface water temperatures increasing the incidence of vector-borne diseases (e.g., West Nile Virus, Lyme Disease).</td>
<td>[Medium-low risk]</td>
<td></td>
</tr>
<tr>
<td>Rising annual temperatures impacting access to traditional foods and medicines (e.g. First Nations shellfish harvesting).</td>
<td>[Medium-low risk]</td>
<td></td>
</tr>
<tr>
<td>Rising annual temperatures increasing prevalence of invasive species and pests.</td>
<td>[Medium-low risk]</td>
<td></td>
</tr>
</tbody>
</table>
Seasonal Variability in Precipitation and Temperature (e.g., hotter, drier summers)

This risk is determined by a combination of the temperature (above) and precipitation variables. Recall the precipitation projections for the Greater Victoria area noted in the above climate projections section (p.9); in addition to increasing annual (and summer time) temperatures, there is expected to be a decrease in precipitation during the summer months (and an increase during the fall, winter, and spring months). Pre-existing respiratory illnesses can be worsened by extended periods of heat, increased prevalence of forest fires, and increases in ground-level ozone (on days over 25°C) (CRD, 2017; Yao, 2019). The urban heat island effect has the potential to make these impacts more severe in urban centre, unless adaptive measures are taken (e.g., air conditioning, cooling stations, and increasing urban tree canopy cover) (CRD, 2017, p. 43). Longer periods of drought combined with warmer weather “likely mean increases in evapotranspiration and potential increases in wildfire activity” (CRD, 2017, p. 44; Lemmen et al., 2008). Seasonal drought conditions can also lead to reduced water levels in streams in the Greater Victoria region, impacting their ability to flow in the summer months, which further increases the “vulnerability of forests to wildfire” (CRD, 2017, p. 46). Inhalation of smoke emitted by wildfires has implications on human health and measures should be taken to reduce exposure promptly (Yao, 2019).

An increase in the severity of drought conditions in the region can cause significant stress to urban trees and other native vegetation (CRD, 2017; Lemmen et al., 2008). “Stressed plants are more susceptible to competition with other plants, and damage from insects and diseases. Some tree species, such as western red cedar, may be particularly susceptible to increases in drought.” (CRD, 2017, p. 46). As mentioned above, local ecosystems, species, and ecological processes may not have the adaptive capacity required to adapt to the rate and magnitude of the projected changes in climate, resulting in widespread disruption in “ecosystems and vulnerable species” (p. 46).

| More frequent wildfires in surrounding areas reducing air quality, affecting human health (e.g., respiratory issues, less exercise from decreased outdoor activity, impact on outdoor workers). | [Medium risk] |
| Rising annual temperatures and hotter drier summers negatively affecting urban trees. | [Medium-low risk] |
| Rising annual temperatures and hotter drier summers causing native habitat loss and loss of native species (e.g. nesting bird habitat, salmonids, vegetation loss). | [Medium-low risk] |
| Hotter and drier summers increase the risk of wildland-urban interface fire in Colwood, creating direct impacts to the community. There is also risk of fires in the surrounding regions (e.g., Saanich or Sooke Watershed) that could affect the City’s emergency response capacity. | [Medium-low risk] |
Extreme Weather Events

Extreme weather is projected to increase across Canada. Recall from the extreme precipitation projections for the Greater Victoria area as noted in the above climate projections section (p. 11, 12); the number of heat waves is going to increase, as is the duration, intensity, and frequency of storms, extreme and heavy rain events are also expected to become more intense and frequent; and wind-related storm events are also expected to increase in frequency.

Increases in extreme weather and high wind events, specifically during fall and winter, can cause damage to infrastructure and disruption to transportation networks (Bruce & Egner, 2010; CRD, 2017; Lemmen et al., 2008). Extreme precipitation events can impact aquatic habitat and biodiversity in different ways. Increased runoff can lead to nutrient overloading of surface water bodies and streams (a process called eutrophication). In extreme cases, eutrophication can cause hypoxic or anoxic conditions (extremely low levels of dissolved oxygen), which can lead to increased mortality of sensitive aquatic species. Eutrophication can also have implications for “recreational water users, fishing, and tourism” due to associated aesthetic impacts. (CRD, 2017). Increased extreme precipitation events can also “negatively affect fish-spawning habitat through channel erosion, and the deposition of sediment. Such storms can also wash pollutants from roadways and parking lots into aquatic and marine ecosystems” (CRD, 2017, p. 46). Additionally, vulnerable populations are more susceptible to the impacts of extreme heat events, which has “implications for human health and related social services, especially with an aging population” (CRD, 2017, p. 47).

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in extreme weather and high wind events causing damage to infrastructure (e.g. damage to power lines leading to electricity disruptions).</td>
<td>Medium risk</td>
</tr>
<tr>
<td>More extreme weather events causing disruption to transportation network and infrastructure (e.g. Ocean Blvd and Lagoon Bridge).</td>
<td>Medium risk</td>
</tr>
<tr>
<td>More extreme weather events causing loss of habitat and biodiversity at Esquimalt Lagoon and impacting bird sanctuary.</td>
<td>Medium-low risk</td>
</tr>
<tr>
<td>More extreme heat events impacting at-risk or vulnerable populations (e.g. homeless, youth, elderly).</td>
<td>Medium risk</td>
</tr>
<tr>
<td>Managing mental health impacts of extreme events, but also in reaction to climate change generally (e.g., climate grief among young people).</td>
<td>[risk not assessed]</td>
</tr>
</tbody>
</table>

1 This climatic risk was added after the impacts went through the risk and vulnerability assessment process and was therefore not given a risk score. However, it is deemed an important social and human health impact to remain in the forefront of the climate change planning process for Colwood.
Sea level rise

Sea level rise combination with extreme weather events (increase in extreme precipitation events leading to increased runoff and rainfall) can proliferate erosion and subsequently lead to “slope instability and overfilling of wetlands and lakes” (CRD, 2017, p. 43). In areas “where streams flow into the ocean, extreme precipitation events combined with sea level rise during periods of high tides can lead to a back-up of flows and expanded flooding of low-lying areas” (CRD, 2017, p. 43).

<table>
<thead>
<tr>
<th>Sea level rise and more extreme weather events (storm surges, extreme rainfall and wind events) causing coastal inundation and erosion of developed and developable land (e.g. at Royal Roads, Coburg Peninsula). [Medium risk]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea level rise inundating tourist and recreation areas, as well as local historic sites (e.g. archaeological, cultural and spiritual sites for First Nations). [Medium-low risk]</td>
</tr>
</tbody>
</table>

(CRD, 2017; PCC, 2019; IPCC, 2014).

Risks to Monitor

The following climate impacts were evaluated as lower priorities but are still important to monitor and consider when planning for a future climate. Resources for adaptation planning should be directed towards the highest priority impacts first but designed to address as many of the impacts below whenever possible. These risks should also be re-evaluated at five-year intervals.

Hotter, Drier Summers

Significant shifts in cooling and heating demand are expected across the province, “with an increase in cooling demand and decreasing heating demand over time” (CRD, 2017, p. 47). It is recommended that building retrofits be used to address these changes, in addition to including other storm-resistant design and building techniques (CRD, 2017). Drinking water in the Greater Victoria area is predominantly “supplied by surface water reservoirs and lakes”; with the anticipated changes in seasonable variability in precipitation, and increased summer demand of water, “water conservation initiatives will remain a priority in the region” (CRD, 2017, p. 44).

<table>
<thead>
<tr>
<th>Hotter, drier summers increasing cooling demand in buildings and public facilities (e.g., need for more cooling stations). [Low risk]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotter, drier summers decreasing soil moisture and impacting stormwater absorption. [Low risk]</td>
</tr>
<tr>
<td>Hotter, drier summers impacting the Capital Regional District Reservoir and drinking water supply. [Low risk]</td>
</tr>
</tbody>
</table>

---

1 Medium-high risk identified in Black, Bruce & Egener (2010).
More Extreme Weather and Rainfall Events and Sea Level Rise

More extreme weather events, combined with sea level rise, can “cause inflow and infiltration of rainwater into our sanitary system in crossover areas” (CRD, 2017, p. 43). This has been identified as an especially high risk for the sewage pump station on Ocean Boulevard Road and has already received approval for relocation. Extreme rainfall events can increase the occurrence of erosion and landslides; “the combination of increased runoff and rainfall can increase erosion, leading to slope instability” (CRD, 2017, p. 43). In areas where freshwater streams flow “into the ocean, extreme precipitation events combined with sea level rise during periods of high tides can lead to a back-up of flows and expanded flooding of low-lying areas” (CRD, 2017, p. 43).

<table>
<thead>
<tr>
<th>More extreme weather events and sea level rise causing inundation of sewage pump station on Ocean Boulevard (already identified as high risk and relocation approved).</th>
</tr>
</thead>
<tbody>
<tr>
<td>More extreme rainfall events causing erosion and landslides, affecting development (e.g., Royal Bay, Triangle Mountain). [Low risk]</td>
</tr>
<tr>
<td>More extreme rainfall events causing an overloading of drainage and stormwater management systems leading to localized flooding [Low risk]</td>
</tr>
</tbody>
</table>

Vulnerability and Risk Assessment Process

This section focuses on the vulnerability and risk assessment process used in the Together for Climate project with the City of Colwood (BARC Milestone 2; Workshop 2). The two main approaches to conducting vulnerability assessments are discussed briefly below (e.g., top-down versus bottom up), as well is the introduction of impact assessments and how the two types of assessments fit more broadly within the risk assessment framework used in ICLEI Canada's BARC program. Beyond ICLEI's BARC methodology, the participatory, bottom-up approach is validated through both peer-reviewed literature and government resources.

BARC Framework

ICLEI Canada’s Five Milestones for Climate Adaptation methodology provides a structured approach to adaptation planning which moves participating local governments through a series of progressive steps. While each milestone builds off of the findings of the one before, the methodology as a whole creates an opportunity to re-evaluate and review findings and decisions.

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1 High risk identified in Black, Bruce, & Egener, 2010).
BARC Milestone Two involves research in local climate change impacts and vulnerability and risk assessments. Vulnerability assessments are commonly characterized by either being top-down or bottom-up approaches. Top-down approaches start with an analysis of climate change and its impacts (e.g., impact assessments). Bottom-up approaches start with a local analysis of the people affected by climate change, identifying areas where the community is sensitive and exposed to change (Bhatt, 2014; Fussel & Klein, 2006). Both approaches can sit comfortably within a broad risk assessment framework—a systematic methodology to identify, assess, communicate and manage risks. The ICLEI milestones follow this risk assessment format. The Five ICLEI Milestones are: Initiate, Research, Plan, Implement and Monitor/Iterate (Figure 6).

**Figure 6. BARC Milestone Framework**

Vulnerability and Risk Assessment Methodology: Bridging Perspectives
Climate change impacts are not felt evenly across geographic and socio-economic scales; assessing vulnerability therefore becomes an important way of understanding and defining the local risks associated with climate change. The impacts of climatic changes are dependent on the magnitude of change (exposure), local system characteristics (sensitivity), and the capacity of human societies and ecosystems to manage the impacts (adaptive capacity). Together, these factors (exposure, sensitivity, and adaptive capacity) determine how vulnerable a system is to change (Bhatt, 2014).

Given the extent and breadth of scientific literature across a wide range of sustainability fields (e.g., natural hazards, food security, poverty analysis, climate change etc.) it is clear that
vulnerability is complex and multi-dimensional (e.g., includes socio-economic, political, and geographic factors) (BC Ministry of Forests, Lands, and Natural Resource Operations [MFLNRO], 2013; Bhatt, 2014; Black, Bruce, & Egener, 2010; Fussel & Klein, 2006). It is widely accepted that “vulnerability is bound to a specific location and context” (Bhatt, 2014, para. 3). As such, the importance of conducting localized vulnerability and risk assessments becomes clear. “Vulnerability assessments may be conducted to set priorities for more detailed studies and monitoring, to understand the economic costs of climate impacts, and to inform policy, planning, and implementation of adaptation actions” (CRD, 2017, p. 49).

As mentioned above, vulnerability assessments can follow a bottom-up or top-down assessment framework; bottom-up assessments are carried out locally using participatory methods and collaborative tools in conjunction with local climate data projections and top-down assessments occur at provincial, national, or global levels, using “large-scale simulation models and statistical methods” (Bhatt, 2014). A bottom-up (or co-production, co-development) approach recognizes the abundance of skills and experiences among partners or stakeholders to an organization and utilizes these to develop the vulnerability and risk assessments, strengthening the representativeness of the assessments across diverse groups (Bhatt, 2014; ICLEI Canada, 2020). Additionally, a multi-perspective viewpoint can be gained on current or planned climate change adaptation measures and policies when using a participatory method (Bhatt, 2014). There is no ‘one-size-fits all’ solution to adaptation planning and either method can be used in developing local climate change adaptation plan.

ICLEI Canada’s BARC methodology uses a mixed methods approach by starting with an assessment of climate change projections and impacts to inform the vulnerability assessment and it focuses mainly on the participatory, community-based components of the bottom-up approach. Participatory, community-based approaches are commonly recommended at the provincial level in British Columbia (BCMOE, 2010; BC Ministry of Forests, Lands, and Natural Resource Operations [MFLNRO], 2013).

Next Steps
Using the outputs from the risk assessment process, the City of Colwood will be brainstorming adaptation actions to address priority impacts, and improve the adaptive capacity of people, assets, and services. Adaptation can take many forms, and new actions will cover a variety of approaches, including research and monitoring programs, education and awareness actions, green/grey/blue infrastructure, changes to operations and practices, policy interventions, and more. Information will be informed by best practice research and input from local stakeholders.
References


Yao, J. (2019). Assessing sub-daily exposure to wildfire smoke and its public health effects in
Appendix C: Glossary of Terms

**Adaptation:** Includes any initiatives or actions in response to actual or projected climate change impacts and which reduce the effects of climate change on built, natural and social systems.

**Adaptive Capacity:** The ability of built, natural and social systems to adjust to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities, or to cope with the consequences.

**Baseline:** A climatological baseline is a reference period, typically three decades (or 30 years), that is used to compare fluctuations of climate between one period and another. Baselines can also be called references or reference periods.

**Climate:** The weather of a place averaged over a period of time, often 30 years. Climate information includes the statistical weather information that tells us about the normal weather, as well as the range of weather extremes for a location.

**Climate Change:** Climate change refers to changes in long-term weather patterns caused by natural phenomena and human activities that alter the chemical composition of the atmosphere through the build-up of greenhouse gases which trap heat and reflect it back to the earth’s surface.

**Climate Change Atlas of Canada:** The Climate Atlas of Canada is an interactive tool that combines climate science, mapping, and storytelling to depict expect climatic changes across Canada to the end of the century. The 250-layer map is based on data from 12 global climate models. Users are shown a baseline period of warming trends by region that spans from 1950 to 2005 and can toggle between two future projection periods, 2021 to 2050 and 2051 to 2080.

**Climate Projections:** Climate projections are a projection of the response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols. These projections depend upon the climate change (or emission) scenario used, which are based on assumptions concerning future socioeconomic and technological developments that may or may not be realized and are therefore subject to uncertainty.

**Climate Change Scenario:** A climate change scenario is the difference between a future climate scenario and the current climate. It is a simplified representation of future climate based on comprehensive scientific analyses of the potential consequences of anthropogenic climate change. It is meant to be a plausible representation of the future emission amounts based on a coherent and consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change) and their key relationships.

**Ensemble Approach:** An ensemble approach uses the average of all global climate models (GCMs) for temperature and precipitation. Research has shown that running many models provides the most realistic projection of annual and seasonal temperature and precipitation than using a single model.

**Extreme Weather Event:** A meteorological event that is rare at a place and time of year, such as an intense storm, tornado, hail storm, flood or heat wave, and is beyond the normal range of activity. An extreme weather event would normally occur very rarely or fall into the tenth percentile of probability.

**Greenhouse Gas (GHG) Emissions:** Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths
within the spectrum of thermal infrared radiation, emitted by the Earth’s surface, the atmosphere itself, and by clouds. Water vapour (H\textsubscript{2}O), carbon dioxide (CO\textsubscript{2}), methane (CH\textsubscript{4}), nitrous oxide (N\textsubscript{2}O), ozone (O\textsubscript{3}), and chlorofluorocarbons (CFCs) are the six primary greenhouse gases in the Earth’s atmosphere in order of abundance.

**Climate Impact:** The effects of existing or forecast changes in climate on built, natural, and human systems. One can distinguish between potential impacts (impacts that may occur given a projected change in climate, without considering adaptation) and residual impacts (impacts of climate change that would occur after adaptation).

**Impact Statement:** Climate-related impact statements are concise statements that outline locally-relevant projected threats and how those changes are expected to affect the built, natural, social, and economic systems of the municipality.

**Mitigation:** The promotion of policy, regulatory and project-based measures that contribute to the stabilization or reduction of greenhouse gas concentrations in the atmosphere. Renewable energy programs, energy efficiency frameworks and substitution of fossil fuels are examples of climate change mitigation measures.

**Representative Concentration Pathways:** Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. It supersedes Special Report on Emissions Scenarios (SRES) projections published in 2000.

**Resilience:** The capacity of a system, community or society exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure.

**Risk:** The combination of the likelihood of an event occurring and its negative consequences. Risk can be expressed as a function where risk = likelihood \(\times\) consequence. In this case, likelihood refers to the probability of a projected impact occurring, and consequence refers to the known or estimated outcomes of a particular climate change impact.

**Sensitivity:** Measures the degree to which the community will be affected when exposed to a climate related impact. Sensitivity reflects the ability of the community to function (functionality) as normal when an impact occurs.

**Vulnerability:** Vulnerability refers to the susceptibility of the community to harm arising from climate change impacts. It is a function of a community’s sensitivity to climate change and its capacity to adapt to climate change impacts.

**Weather:** The day-to-day state of the atmosphere, and its short-term variation in minutes to weeks.
Appendix D: Infographic – Climate Projections for the City of Colwood

**ANNUAL MEAN TEMPERATURES**

Mean temperatures are projected to increase annually and in every season.

- **12.7°C**
  - 2051-2080
- **9.4°C**
  - Annual Baseline
- **11.1°C**
  - 2021-2050

**SEASONAL MEAN TEMPERATURES**

- **6.9°C**
  - 2051-2080
  - **5.3°C**
    - 2021-2050
    - **3.7°C**
      - Baseline
  - **13.1°C**
    - 2051-2080
    - **11.3°C**
      - 2021-2050
      - **9.8°C**
        - Baseline
  - **19.5°C**
    - 2051-2080
    - **17.5°C**
      - 2021-2050
      - **15.6°C**
        - Baseline
  - **11.4°C**
    - 2051-2080
    - **10.0°C**
      - 2021-2050
      - **8.3°C**
        - Baseline

**DAYS WITH FREEZE-THAW CYCLES**

- **8.6 days** Baseline
- **3.9 days** 2050s
- **1.5 days** 2080s

**FREEZE-THAW CYCLES**

A decrease in freeze-thaw days is expected.

**DAYS ABOVE 25°C**

- **54.5** 2080s
- **31.4** 2050s
- **16.6** Baseline

**TEMPERATURE EXTREMES**

More "Summer days" expected.
City of Colwood

FUTURE CLIMATIC PROJECTIONS

ANNUAL MEAN PRECIPITATION
Rising sea levels could cause increased coastal erosion, loss of low-lying lands, soil salination, and saltwater intrusion.

SEASONAL MEAN PRECIPITATION

WINTER
December-February

SPRING
March-May

SUMMER
June-August

FALL
September-November

Baseline

Baseline

Baseline

Baseline

1351 mm
2021-2050

1312 mm

1418 mm
2051-2080

539 mm
2051-2080

597 mm
2021-2050

568 mm
Baseline

260 mm
2051-2080

256 mm

249 mm
Baseline

91 mm

95 mm

103 mm
Baseline

428 mm
2051-2080

403 mm

392 mm
Baseline
City of Colwood

FUTURE CLIMATIC PROJECTIONS

**PRECIPITATION EVENTS**

- Precipitation will fall at a faster rate (mm/h)
- Shorter storms will have an increasingly high intensity
- Return periods of heavy storms will shorten, meaning increased frequency

**SEA-LEVEL RISE**

In the City of Colwood, sea levels are expected rise 50 to 100 cm by the year 2115.

Rising sea levels could cause increased coastal erosion, loss of low-lying lands, soil salination, and saltwater intrusion.

**SEA SURFACE TEMPERATURES**

Sea surface temperatures have been higher during the past three decades than at any other time since reliable data collection began in 1880.

Warmer sea surface temperatures could cause changes in aquaculture productivity, increased spread of aquatic invasive species, changes to marine ecosystems and species distribution, and more.

**Sources:**