SUMMER VILLAGE OF ISLAND LAKE

Climate Adaptation and Resilience Plan

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Report No. 230081000
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EXECUTIVE SUMMARY

Climate change is a global challenge that has local impacts on both the built and natural environment. The Summer Village of Island Lake (SVIL) recognizes the need to prepare for these potential impacts and increase its resilience. The community also has a role to play in helping to build the resilience of other Canadian communities through leading by example. It is crucial that communities of all sizes prioritize resilience to climate impacts even though there is still uncertainty about where, when, and how severe these impacts may be over time.

SVIL retained Morrison Hershfield to develop a Climate Adaptation and Resilience Plan with the funding support provided by the Municipal Climate Change Action Centre. The purpose of this Plan is to reduce some of this uncertainty and to enable the community to embark on a journey to learn about potential climate hazards it faces, as well as the projected changes in the future, and what actions can be taken to increase resilience.

Acknowledging that SVIL values self-sufficiency and citizen action, this Plan is intended to achieve a balance between governance and community approaches, prioritizing multi-solving solutions and actions with co-benefits wherever possible to help overcome the capacity and resourcing challenges that come with being a small rural municipality. This Plan is centered around 4 key community element categories:

- Infrastructure
- Buildings
- Natural systems and assets
- Community

This Plan will assist SVIL in understanding how the climate is projected to change into the future and how climate hazards may interact with and impact community elements. Further, it is designed to build the capacity of the Village's staff and residents to assess their actions through the lens of a changing climate and to ensure that future climate conditions are adequately considered during decision-making. The Plan includes a climate profile for the Village outlining projections of various climate parameters. There are 12 key climate change related hazards included in the risk assessment:

- Change in average temperature
- Extreme heat
- Extreme cold
- Invasive species
- Extreme rainfall / pluvial flooding
- High lake levels
- Low lake levels
- Poor water quality
- Drought
- Extreme storm
- Wildfire
- Wildfire smoke

A risk assessment of the Village's built and natural environment, as well as health and safety of residents, was completed for both the baseline and future (2080s) periods by examining the impact of each of the 12 climate hazards on 15 community elements. High and extreme risks were identified for the future period, and adaptation actions were recommended to address these risks.

The following lists the climate change related hazard / community element interactions that were identified as having a high or extreme level of risk under future climate conditions:

- **Private drinking water systems:** Drought
- **Stormwater systems:** Drought, extreme rainfall
- **Horizontal infrastructure:** Extreme heat, extreme rainfall, wildfire
- **Above-ground power lines:** Extreme heat, extreme storm, wildfire
- **Homes and buildings:** Change in average temperature, extreme heat, extreme rainfall, extreme storm, wildfire, high lake levels, low lake levels (docks)
- **Trees and terrestrial vegetation:** Change in average temperature, drought, extreme heat, extreme rainfall, invasive species, extreme storm, wildfire
- **Wetlands, riparian, and shoreline areas:** Drought, extreme heat, high lake levels, low lake levels, invasive species
- **Fish and aquatic habitat:** Extreme heat, high lake levels, low lake levels, invasive species
- **Community and environment areas:** Wildfire
- **Residents:** Extreme heat, extreme storm, wildfire smoke, wildfire

Climate adaptation planning needs to prioritize actions that reduce the negative impacts of climate hazards and extreme events by protecting individuals, assets, and community resources. For SVIL, solutions need to be practical, affordable, and implementable for a small community with limited capacity and resources. This Plan identifies 49 actions, including 22 high priority actions, that SVIL could implement to increase its resilience to climate hazards while acknowledging existing capacity and resource limitations. Many of these actions build upon and are supported by existing practices and programs including FireSmart. The 22 high priority actions are highlighted below, separated by community element category:

- **Infrastructure:**
  - Conduct a local water resource assessment.
  - Properly inspect and maintain roads, ditches, and catch basins, including a video inspection from a reputable plumber / technical service provider.
  - Employ vegetation and debris management to ensure trees and branches are far enough away from power lines.
- **Buildings:**
  - Install high efficiency cooling systems / better windows / better insulation.
  - Install sump pumps and/or backwater valves or upgrade overall site drainage.

  - For homes, retrofit dock anchoring systems with floating style docks rather than having fixed systems to allow docks to move with varying water levels.
  - Conduct a detailed flood risk assessment to better understand how vulnerable homes are to flooding, particularly those that are low-lying.
  - For homes, assess the ability to move floating docks and boats out into deeper water and have a temporary connecting walkway when lake levels are low.
  - Stormproof/windproof roofing/siding/windows and install storm shutters.
  - Implement tree pruning around homes and buildings.
  - Install river rock around perimeter of homes and buildings to improve resilience to wildfire.
  - Install metal, non-combustible roof and exterior siding to improve resilience to wildfire.
- **Natural systems and assets.**
  - Restore/plant a greater diversity of heat and drought tolerant native grass and tree species.
  - Prepare and implement a detailed Invasive Vegetation Management plan.
  - Implement a tree and vegetation management program to remove standing snags and leaf litter.
- **Community:**
  - Develop/assign refuge areas with additional cooling and hydration stations.
  - Implement a policy for sending staff/volunteers home on extreme heat days.
  - Ensure there is an early warning system for residents in the case of an extreme storm or wildfire event.
  - Ensure every resident has 72 hours of emergency supplies.
  - Implement an accessibility / egress plan for community members to seek refuge inside Community Hall or Fire Hall if needed during an extreme storm event.
  - Develop a Wildfire Emergency Response plan for evacuation and coordination.
  - Manage air intakes with better filters (MERV-13 or higher filtration) to improve air quality during periods with high wildfire smoke concentrations.

The actions presented in this Plan are not mandatory, but it is recommended that SVIL prioritize the implementation of these actions recognizing that the community is vulnerable to climate change and will be at increased risk of climate hazards moving forward over time, and that there are steps that can be taken to become more resilient to these impacts.

ACKNOWLEDGEMENTS

Land Acknowledgement

The Summer Village of Island Lake respectfully acknowledges that the community is located within Treaty 6 Territory, the traditional lands of the Plains Cree and Metis people.

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This project was funded by the Municipal Climate Change Action Centre (MCCAC).

MCCAC was established in 2009 as a partnership initiative between the Alberta Municipalities, Rural Municipalities of Alberta, and the Government of Alberta. They provide municipalities, schools, and non-profit community related organizations with support, technical assistance, and funding programs to implement energy efficiency and renewable energy projects that reduce greenhouse gas emissions and energy costs while increasing community resilience.

DEFINITIONS

Adaptation: Process of adjustment to actual or expected climate and its effects (PIEVC, 2021).

Adaptive Capacity: The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (PIEVC, 2021).

Climate Hazard: A specific impactful event related to the broader climate parameter category (PIEVC, 2021).

Climate Hazard Indicator: A specific climate value (e.g., Tmax > 35C) that is defined by its ability to impact an infrastructure system or component (i.e., exceed a threshold) (PIEVC, 2021).

Climate Parameter: Broader categories of measurable climate conditions in relation to which specific climate hazards or indicators can be defined. Climate parameters include temperature, precipitation, sea-level rise, wind, etc. (PIEVC, 2021).

Consequence: Outcome or impact of a hazard occurrence. Can be assessed using multiple criteria including physical damage, environmental damage, health and safety, and/or community disruption.

Cooling Degree Days: The annual sum of daily mean temperatures above 18º. It indicates the amount of cooling that may be required to maintain comfortable conditions within a building during warm months. Cooling degree days are calculated by measuring the difference between the daily mean temperature and the threshold of 18ºC. Each degree above the threshold equates to one cooling degree day. For example, a daily mean temperature of 21ºC would equate to 3 cooling degree days for that day. The summation of all cooling degree days is then taken to provide the annual number of cooling degree days in a year.

Element: A distinct part of an asset or system. Could include physical, planning, or human resources (PIEVC, 2021).

Exposure: The presence of an interaction between people, species or ecosystems, natural assets, services, infrastructure, or building assets to a particular climate hazard.

Freeze-Thaw Conditions: Conditions resulting from air temperature fluctuating between freezing and non-freezing temperatures.

Global Climate Models: Complex mathematical representations of the behaviour of Earth's climate system including the atmosphere, oceans, land surface, ice, and their interactions at the global scale. Used in the study of global climate system dynamics and future climate scenarios.

Greenhouse Gas: A gas that traps heat in the atmosphere by absorbing infrared radiation from the Earth's surface. The main greenhouse gases (GHGs) are carbon dioxide and methane. Other GHGs include nitrous oxide and fluorinated gases.

Heating Degree Days: The annual sum of daily mean temperature below 18ºC. It indicates the amount of heating that may be required to maintain comfortable conditions within a building during cold months. Heating degree days are calculated by measuring the difference between the daily mean temperature and the threshold of 18ºC. Each degree below the threshold equates to one heating degree day. For example, a daily mean temperature of 15ºC would equate to 3 heating degree days for that day. The summation of all heating degree days is then taken to provide the annual number of heating degree days in a year.

Invasive Species: Species of flora and fauna that are not native to the given region they are found in and that tend to dominate and intrude on native species.

Likelihood: Chance of something occurring; within the context of climate risk assessment, the chance of a defined climate hazard over a given time horizon (PIEVC, 2021).

Regional Climate Models: Downscaled from global climate models, regional climate models are complex mathematical representations of the behaviour of Earth's climate system at a regional level. Used for regional- and local-scale climate risk assessments.

Representative Concentration Pathways: Representative Concentration Pathways (RCPs) represent projections of future greenhouse gas emission scenarios. Developed by the International Panel on Climate Change (IPCC), each pathway has representative risks and impacts based on the associated amount of projected net emissions. The most common scenarios used are RCP2.5, RCP4.5, and RCP8.5 representing low, moderate, and high emission scenarios, respectively. RCP8.5 was used as the basis for climate data used in this report as it currently represents the most likely emissions pathway and associated impacts.

Resilience: The capacity to cope with an extreme event, disturbance, or trend by responding or reorganizing to maintain essential function, identity, and structure (PIEVC, 2021).

Risk: Combined effect of hazard frequency or severity and level of impact on element. This assessment applies the formula Risk = Exposure x Likelihood x Consequence to measure risk.

Tropical Nights: Describes days where the minimum temperature does not fall below 20ºC during the night.

Vulnerability: Propensity or predisposition of element to be adversely impacted by a hazard (PIEVC, 2021).

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1. OVERVIEW

Climate change is already impacting Canadian communities, and impacts are expected to worsen over time due to accelerated changes to the climate system. While some of these impacts may be difficult to quantify with certainty, it is important to act now, even in the face of uncertainty. Climate change is a global challenge which requires collective local action to address the degree of change and adapt to associated impacts. The Summer Village of Island Lake (also referred to as 'SVIL' and 'the Village') has a role to play in building the resilience of Canadian communities.

Acknowledging that SVIL values self-sufficiency and citizen action, this Plan is intended to achieve a balance between governance and community approaches, prioritizing multi-solving solutions and actions with co-benefits wherever possible to help overcome the capacity and resourcing challenges that come with being a small rural municipality.

1.1 Climate Change

Climate change refers to long term shifts in atmospheric conditions including temperature and weather systems (IPCC, 2001). Since the industrial revolution, shifts have been primarily driven by the addition of greenhouse gases (GHGs) to the atmosphere because of human activity (IPCC, 2001). GHGs are critical in trapping heat in the atmosphere to ensure Earth is habitable; however, the addition of GHGs primarily through the burning of fossil fuels and land use change is causing increasing average global temperatures and more extreme weather. The Canadian prairies, including Alberta, have seen higher rates of warming in comparison with other regions of southern Canada (Sauchyn et al., 2020).

Human-induced climate change has already resulted in impacts that we must respond to (Canadian Institute for Climate Choices, 2020). Examples of impacts include but are not limited to increases in wildfire events, increases in flooding frequency and intensity, more intense droughts and water scarcity issues, more severe and frequent storm systems, and a loss in biodiversity (IPCC, 2022). These changes have potentially significant impacts on people, infrastructure, and natural ecosystems – and are only anticipated to worsen over time.

As summarized in Figure 1, community responses to climate change generally fall into two broad categories: mitigation (reducing our contribution to climate change) and adaptation (responding to the impacts of a changing climate). Increasingly, actions that achieve emissions reductions while simultaneously helping communities adapt to climate change are preferred to maximize effectiveness; this emerging work is called low-carbon resilience, as illustrated in the middle portion of the Venn Diagram. This Plan will focus on the adaptation of the Summer Village of Island Lake to climate change.

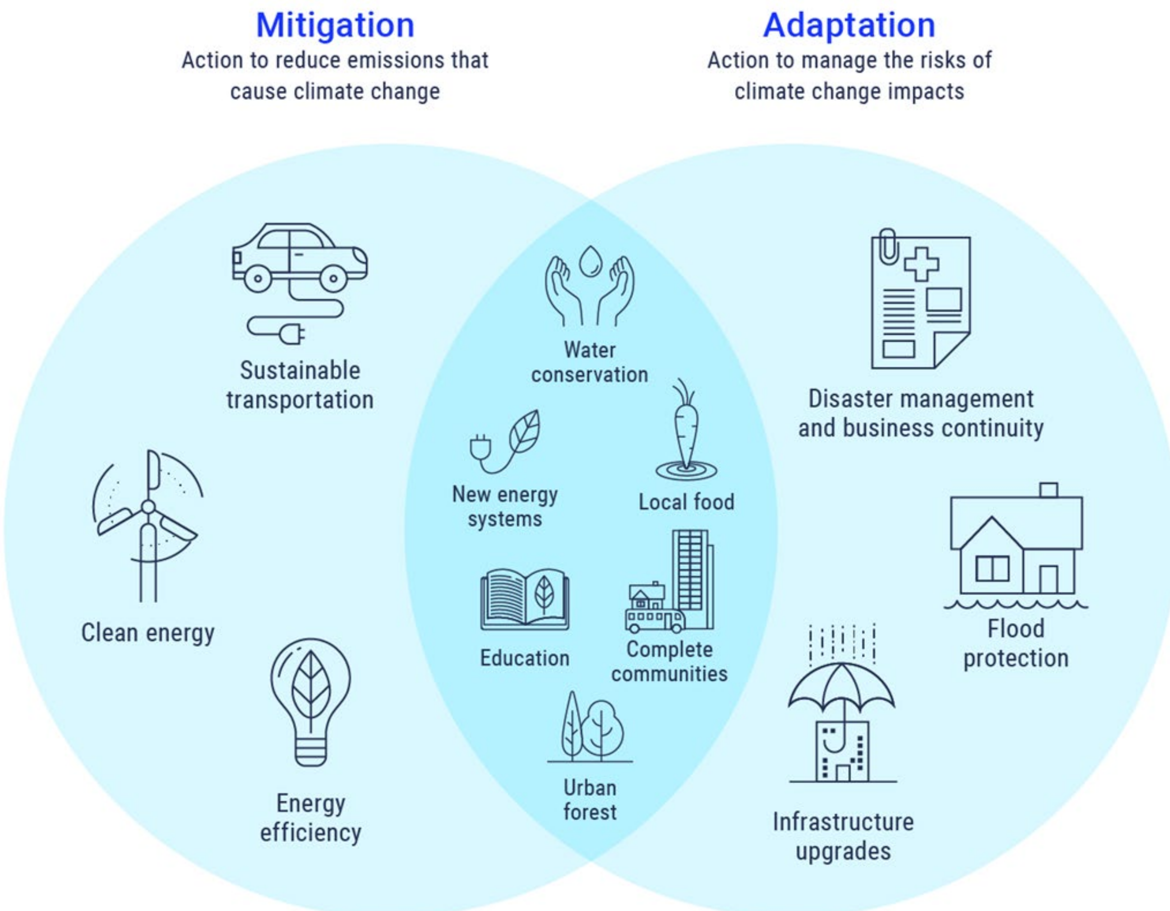

Figure 1: Venn Diagram of Climate Change Adaptation and Mitigation (Sauchyn et al., 2020)

1.2 Regional Climate Context

Climate-related impacts have already been felt by communities / municipalities within Alberta. For example, the 2013 flooding in Calgary and the 2016 wildfire in Fort McMurray were two of the most expensive disasters in Canadian history, and many Prairie communities are working to adopt and implement policies and programs to build resilience in response to these extreme types of events (Sauchyn et al., 2020). Significant warming of the Prairies and Western Canada has resulted in droughts and shifting ecosystems as the environment changes (Sauchyn et al., 2020). To best deal with these impacts, proper planning and adaptive measures must be taken.

This report aims to outline potential climate-related hazards, their interactions with community elements, and their associated impacts on SVIL. Recommendations to adapt to these impacts within the context of what is possible and realistic for a small community with limited resources and capacity are included. With proper knowledge and planning, SVIL can increase its resiliency to climate hazards.

1.3 Climate Adaptation Planning

Climate adaptation planning is a process which helps to identify current and potential climate change impacts and establish a working plan to proactively respond to these impacts and to better prepare the community, natural spaces, buildings, and infrastructure to climate change impacts. Climate adaptation planning also allows communities to take advantage of opportunities by prioritizing **co-benefits** and **multi-solving solutions**. Climate adaptation planning leads to climate resilience, which improves a community's ability to prepare for, recover from, and adapt to disturbances caused by climate change impacts.

Co-Benefits: *Beneficial outcomes that are not directly related to climate change. Examples of co-benefits to climate adaptation include healthier green spaces and wildlife habitat, improved air and water quality, creation of new job and economic development opportunities, and an increased sense of place/community cohesion.*

Multi-Solving Solutions: *Working across different aspects of a community to develop solutions that contribute to solving more than one issue at a time. For example, tree planting initiatives help to reduce GHGs in the atmosphere through carbon sequestration, decrease energy consumption due to shade, reduce the urban heat island effect, and have a positive impact on stormwater management*

While climate change is a global concern, it requires local attention, as many of the most effective actions to become more resilient to climate change are within the jurisdiction of local governments. Actions taken today to respond to climate change can influence how communities respond to impacts in the future; therefore, it is important to use this process as a starting point to adopt a climate lens, where climate considerations are a part of all decision-making processes.

1.4 This Plan

Successful climate action will require the integration of climate considerations into municipal decision-making and planning processes, including decisions about buildings, infrastructure, and natural assets. This Plan is designed to build the capacity of the Summer Village of Island Lake to respond to potential climate change impacts and ensure that projected climate conditions are adequately considered during decision-making.

To be able to effectively work towards climate adaptation and resilience, it is important to understand which climate hazards could potentially impact the community, and which elements of the community are most at risk. From there, conceptualization of how to plan for and respond to these risks can begin.

Determination of climate risk requires looking at:

- Climate hazards which could potentially impact the community.
- Elements of the community which are exposed to these hazards.
- The baseline and future likelihood of exposure to these hazards.

- The consequence, or degree of impact, of these hazards if exposure occurs.

The output of this process provides an understanding of overall climate risk for various hazard-element interactions and thus informs which elements of the community are most vulnerable. Results are then used to frame the community's plan to respond to these risks.

1.5 Study Area

This Plan includes a risk assessment and adaptation plan for community elements within the Summer Village of Island Lake. Residential, commercial, and municipally owned land within SVIL is shown in Figure 2. A Community Hall and Fire Hall are in the Summer Village of Island Lake South, just down the road on the south end of this map, which community members of SVIL also use. While the Community Hall and Fire Hall are outside of the primary study limits, they are included in this Plan as they are facilities of importance to the SVIL community.

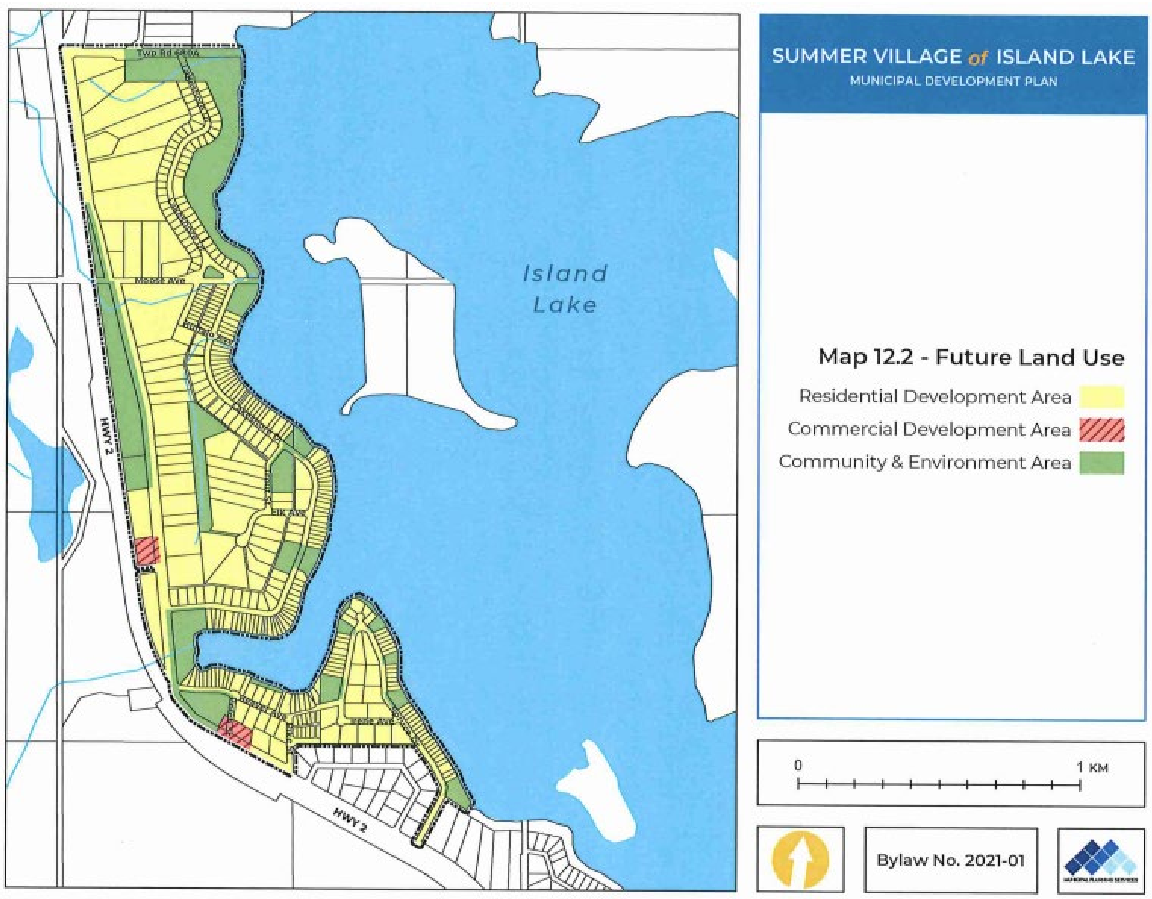

Figure 2: Project Boundary Including Land Use Types Within SVIL (SVIL, 2023c)

1.6 Summer Village of Island Lake Planning Context

There are several relevant planning documents for the Summer Village of Island Lake that helped inform the Climate Adaptation and Resilience Plan. The Alberta planning hierarchy outlines the various plans that currently exist (Figure 3). These documents will have to work alongside this Plan for the most effective and efficient implementation of climate adaptations.

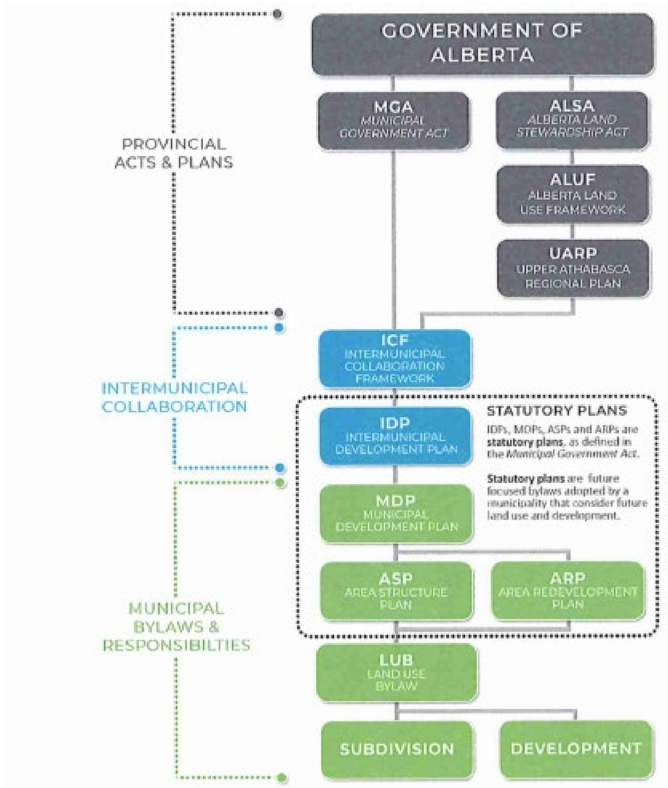

Figure 3: Alberta Planning Hierarchy (SVIL, 2021a)

1.6.1 Intermunicipal Development Plan

The Intermunicipal Development Plan provides a larger picture of the area including Athabasca County, Summer Village of Island Lake, and Summer Village of Island Lake South (SVIL, 2021a). This plan details and guides current and future development in the area and ensures that development meets provincial policies. Following this plan is especially important in this case when many of the regional services are shared between the identified communities. The maps identify key community and environmental features as well as land use.

1.6.2 Municipal Development Plan

The Municipal Development Plan provides the vision and goals, along with guiding principles for the Summer Village of Island Lake (SVIL, 2021c). It details directions for future development and the implementation process of that development. Retirees make up a large portion of the community, and the population increases in the summer as seasonal residents return to the lake. The maps show the plan for future land use and environmentally significant areas.

MDP Vision: *"The Summer Village of Island Lake is committed to providing good governance for residents, businesses, and visitors and aims to maintain a safe caring environment through community partnerships to enhance economic prosperity, cultural appreciation, social equity, and environmental stewardship."*

2. BACKGROUND RESEARCH

Background research was conducted to understand the community context, priorities, and potential climate-related hazards of Summer Village of Island Lake. This research, along with findings from a site visit, helped in developing a list of hazards and community valued components (elements) for the climate risk assessment.

2.1 Regional Perspective

Summer Village of Island Lake was established as a municipality in 1957 and now covers an area of approximately 1.85km^2 (SVIL, 2021c). The village is situated on the western shore of Island Lake and falls within Athabasca County (Figure 4). According to the 2016 Federal Census, the population of the Summer Village is 228 (SVIL, 2021c). The population increases in the summer months when seasonal residents come to the lake, and this population has slowly been increasing (SVIL, 2021c). Island Lake covers an area of approximately 7.81 km^2 and is appreciated by the community for its recreational opportunities and aesthetics (SVIL, 2021c). The surrounding area is comprised of hills and forests that provide habitat for an abundance of wildlife including deer and moose (SVIL, 2023).

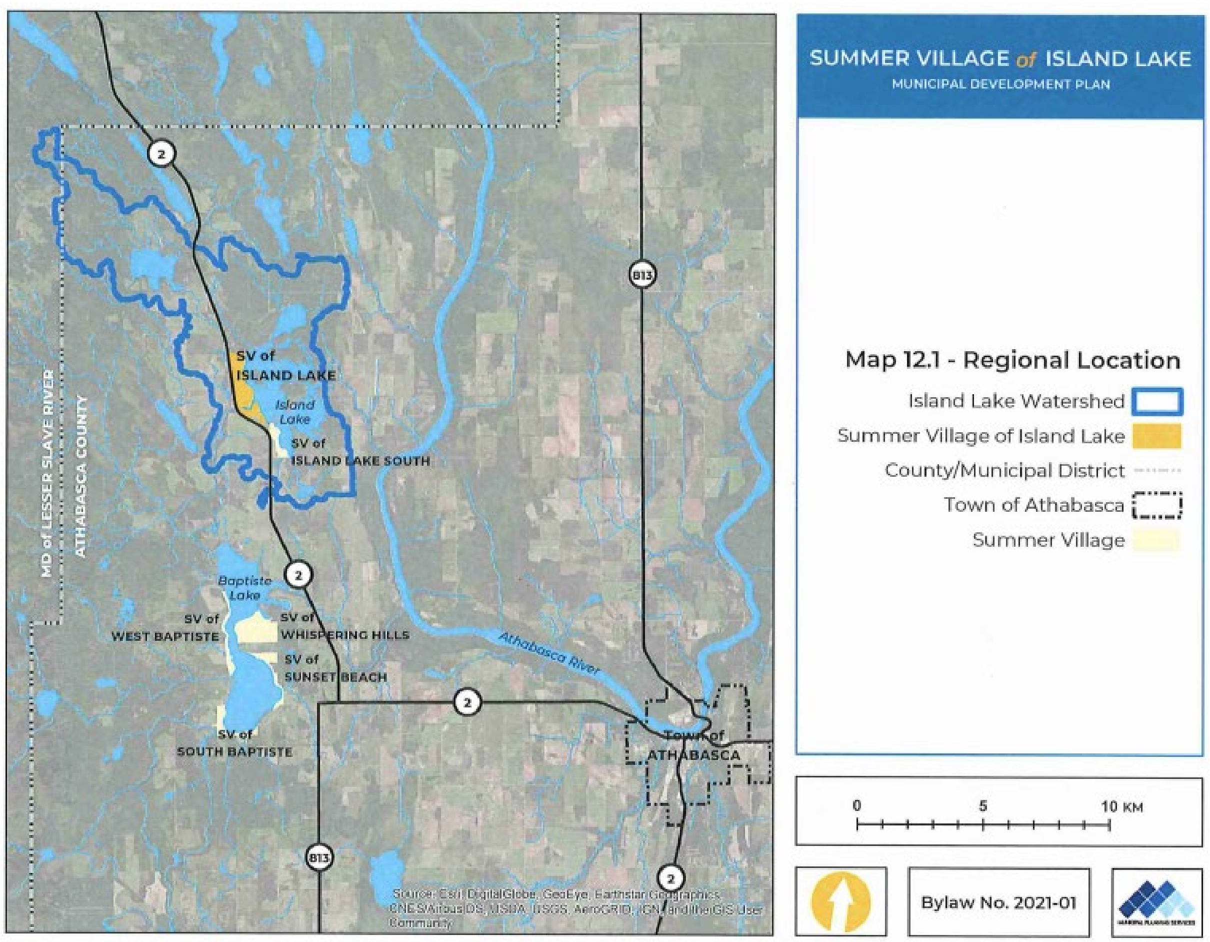

Figure 4: Map of the Region Surrounding SVIL (SVIL, 2023c)

In recent decades there has been growing concern about Baptiste Lake and Island Lake regarding fluctuating water levels, blue-green algae blooms, and poor fishing. This has been identified by the Baptiste and Island Lakes Watershed Management Plan (BAILS, 2019). Water levels can be influenced by natural occurrences such as heavy precipitation events, increased temperature and evaporation, flow blockages, and water withdrawals (BAILS, 2019). Fluctuating water levels can lead to flood or drought events that may cause damage to infrastructure and disrupt recreational activities (BAILS, 2019). In addition, excess nutrients and pollution in the lake can cause blue-green algae blooms, which affect the water quality and aesthetic value (BAILS, 2019). Furthermore, angling fishing, declining water quality, and habitat loss are impacting the recreational fisheries (BAILS, 2019).

The Baptiste and Island Lakes Watershed Management Plan also states that climate variability may be affecting water quality and quantity in the lakes (BAILS, 2019). In response to the changing climate, the plan sets a goal to understand the impact of climate variability on the water quality and quantity of Baptiste and Island lakes (BAILS, 2019). This includes strategies that guide the development of flood and drought mitigation measures, and promotion of the FireSmart community program (BAILS, 2019).

Figure 5 and Figure 6 show the historical water levels of Island Lake and historical fire perimeters (burned area) in the region surrounding SVIL, respectively, over the last 40-50 years. These figures show that water levels have fluctuated somewhat in recent years (variation of around 0.5 m) and that, although no wildfire has burned in the immediate area surrounding SVIL, they have been common in the region.

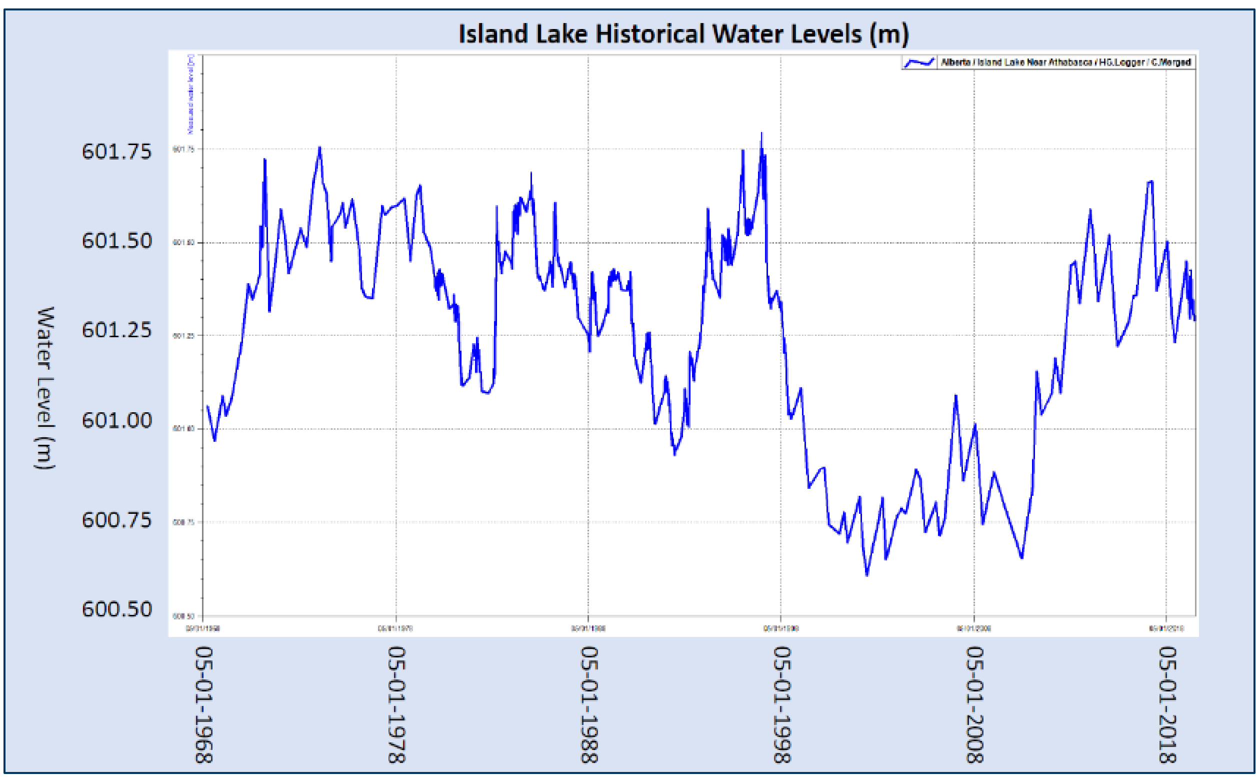

Figure 5: Island Lake Water Levels for the Historical Period 1968-2018 (BAILS, 2023)

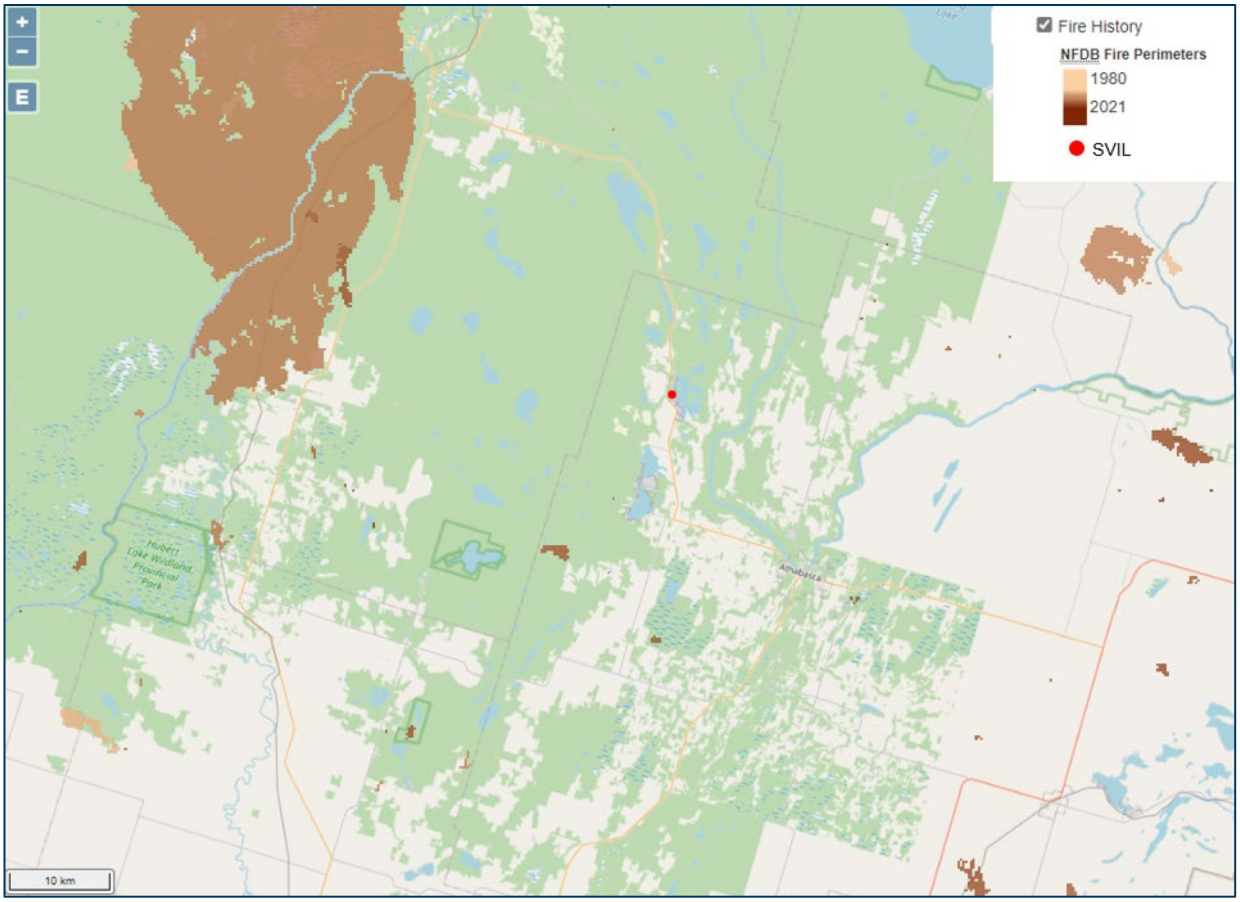

Figure 6: Historical Fire Perimeters from 1980-2020 in Region Surrounding SVIL (NRCan, 2023b)

2.2 Wetlands, Environmentally Significant Areas (ESAs), and Historic Resources

Wetlands can provide a wide variety of ecosystem services. They protect water quality, support water storage and infiltration, provide animal habitats, and maintain biodiversity (SVIL, 2021c). These functions are crucial in maintaining a healthy watershed. Moreover, developing on or near wetlands can alter the surface water drainage patterns and, therefore, maintaining them can help with overland flooding control (SVIL, 2021c).

Several provincially identified wetlands are located within the Plan Area of the Summer Village of Island Lake Municipal Development Plan (MDP) (SVIL, 2021c). The MDP acknowledges the importance of protecting wetlands to achieve its watershed stewardship goal, which states that “new developments and municipal programs protect and enhance Island Lake and unique ecological features within the community” (SVIL, 2021c). While the MDP lacks specific policy to support wetland protection, the Land Use Bylaw (LUB) of SVIL has regulation for wetland protection (SVIL, 2021b). The regulation stipulates that "all subdivision and development must be in accordance with the requirements of the Alberta Wetland Policy." (SVIL, 2021b). Moreover, a proponent may be required to provide a wetland assessment to ensure consistency with this regulation (SVIL, 2021b).

Within and near the MDP Plan Area, there are several quarter sections that the Province of Alberta has identified as Environmentally Significant Areas (Figure 7) (SVIL, 2021c). These areas are considered to have high environmental importance (SVIL, 2021c). Summer Village also has one Historic Resource (Figure 7) which has been assigned a Historic Resource Value (HRV) of 4 and may require avoidance (SVIL, 2021c). This area is considered paleontological in nature.

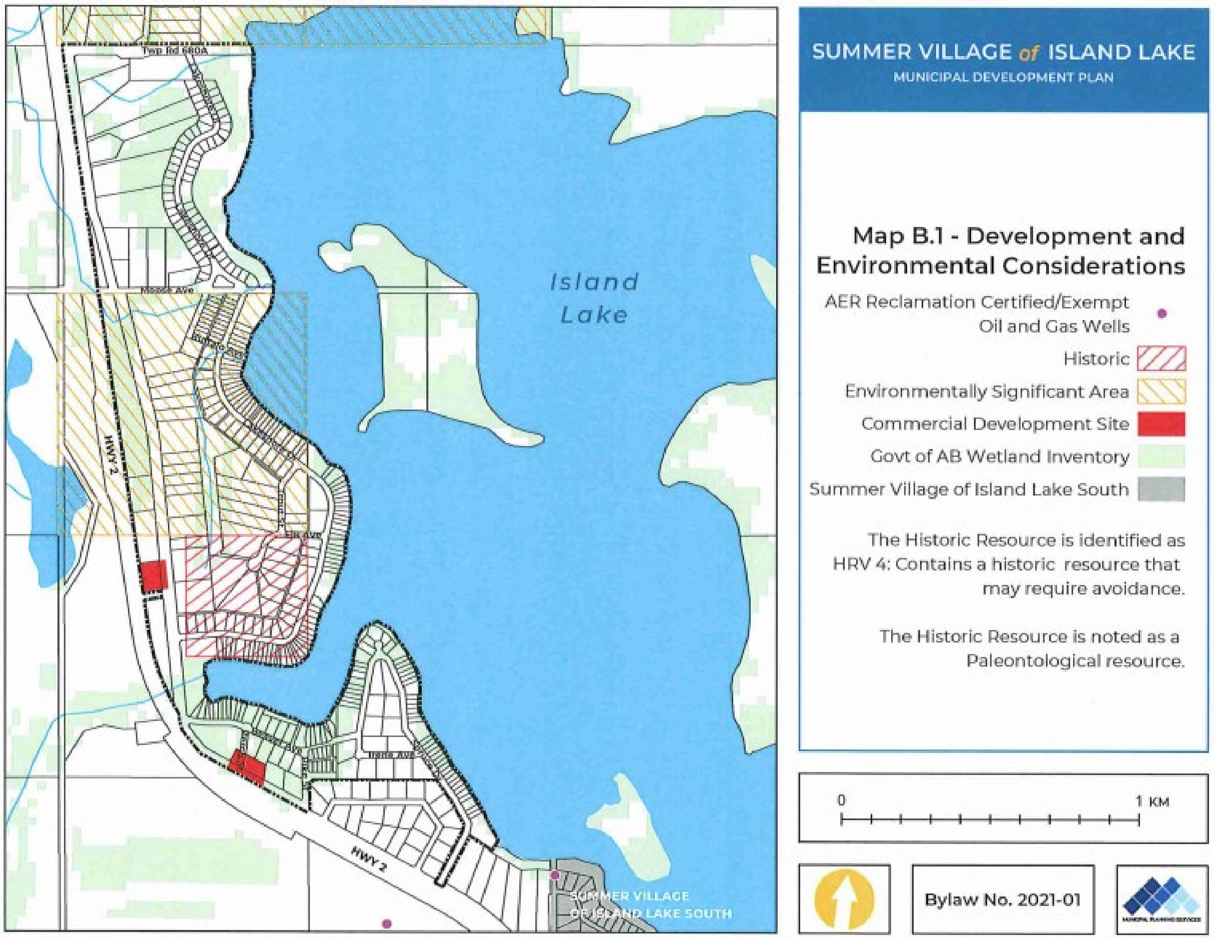

Figure 7: Map Outlining Areas of Development and Environmental Considerations within SVIL (SVIL, 2023c)

2.3 Natural Vegetation

In addition to providing habitat for wildlife, natural vegetation near water plays an important role in preserving water quality of Island Lake (SVIL, 2021c). Riparian ecosystem services include filtering nutrients and sediments, reducing erosion, and stabilizing shorelines (SVIL, 2021c).

Efforts to protect natural vegetation are included in various policies within the MDP, LUB, and other bylaws. The MDP has introduced several policies to safeguard the natural vegetation to ensure the maintenance of healthy water quality in the area. (SVIL, 2021c). In addition, the LUB, highlights that a site plan detailing the protection of existing tree areas and site topography may be required before the permit for development is issued (SVIL, 2021b). Moreover, there is a

Bylaw of Summer Village of Island Lake to control and prohibit clearing of lots within the corporate limits of SVIL. It includes a goal to maximize and preserve natural existing tree cover and vegetation adjacent to lake areas and natural features, to protect against erosion (SVIL, 2015).

2.4 Intermunicipal Cooperation

The Summer Village of Island Lake supports a proactive approach to fostering cooperation with its immediate and regional partners and other levels of government, improving consistency in land use policies and regulations, and anticipating future development and community servicing needs in the region (SVIL, 2021c). Collaboration can lead to several advantages, such as improved coordination in environmental management and planning, as well as expanded opportunities for regional service delivery (SVIL, 2021c). An example of SVIL's cooperation with other municipalities is the Island Lake Intermunicipal Development Plan (the IDP) (SVIL, 2021a). This IDP was adopted by Athabasca County and the Summer Villages of Island Lake and Island Lake South to ensure efficient coordination of future development, land use policies, and long-term growth around Island Lake (SVIL, 2021a). Within this region there is a Fire Hall and Community Hall that services both communities.

2.5 Residential Development Areas, Commercial Development Areas, and Community & Environment Areas

Out of the total of 370 lots in the Summer Village of Island Lake, 345 are designated for residential use, 2 are commercially owned, and 23 are municipally owned (SVIL, 2021c) (Figure 2). Regarding Residential Development Areas, the MDP specifies that development should be carried out in a way that respects the natural environment (SVIL, 2021c). One of the policies for residential development is related to water runoff control, which mentions the development of Low Impact Development (LID) design features such as permeable pavement and rain gardens.

SVIL only has two Commercial Development Areas to meet the needs of its residents and visitors (Photo 1; SVIL, 2021c). The Community & Environment Areas currently features lands that are utilized for natural areas and low-impact recreational activities (Photo 2; SVIL, 2021c). Residents and their visitors can engage in various recreational activities such as biking, walking, boating, basketball, baseball, and softball (SVIL, 2021c).

Photo 1: One of Two Active Commercial Stops in SVIL on July 28, 2023

Photo 2: Aerial of Baseball Diamond, Basketball Court, and Storage Shed in SVIL on July 28, 2023

2.6 Agriculture & Natural Resource Development

The Summer Village of Island Lake is not suited to support large-scale agricultural activities. However, local small scale agricultural activities such as non-commercial gardens and greenhouses are encouraged (SVIL, 2021c).

2.7 Roads, Water & Wastewater, Stormwater Management, and Waste Management

The challenges on roads include freezing rain and heavy snow during the winter months and significant runoff resulting from heavy snow loads in the spring (SVIL, 2022). To tackle these challenges, the Village employs grading and sanding contractors to clear the roads and ensure safe travel during the winter (SVIL, 2022). In the spring, snow is cleared and piled up in critical areas, and culverts are steamed to prevent erosion and sedimentation issues (SVIL, 2022). Furthermore, steaming and pumping are carried out at the bridge to manage the water levels in the creek (SVIL, 2022).

The Summer Village does not include any piped municipal potable water infrastructure (SVIL, 2021c). Individual residents arrange for their own sources of potable water through private systems, such as wells or cisterns, or they look for private delivery options (SVIL, 2021c).

Wastewater services in the Summer Village solely rely on onsite systems developed by individual landowners (SVIL, 2021c). Holding tanks constitute most of the wastewater systems used in the area, while the remaining systems make use of either a pit or septic field (SVIL, 2021c). It is the responsibility of all property owners to ensure that their private sewage disposal systems conform to the prevailing provincial regulations (SVIL, 2021c). Furthermore, to ensure public safety, health, welfare, and protection, the Bylaw to Control and Regulate the Treatment and Disposal of Sewage was enacted in 2012 (SVIL, 2012b).

Stormwater runoff from private residential properties is drained either into the ditches located next to the developed roads or directly into the lake via the surrounding properties (SVIL, 2021c). In the spring or periods of prolonged rainfall, runoff can be a problem for the Summer Village (SVIL, 2021c).

To deal with the stormwater runoff challenge, the Village encourages low impact design (LID) based on MDP (SVIL, 2021c). LID involves small, simple design techniques and landscape features that filter, store, evaporate, and/or detain rainwater and runoffs. Potential options for LID implementation include permeable paving surfaces, bio-swales, and rain gardens (SVIL, 2021c).

SVIL also has an Approach & Culverts Standards Policy which was approved in 2020 (SVIL, 2020). The policy provides guidelines on culvert installation and contributes to the effective drainage of rainwater (SVIL, 2020). In addition, the LUB has a regulation related to stormwater drainage (SVIL, 2021b). It stipulates that grading and drainage plans shall be necessary for all developments if the proposed project is expected to significantly alter the site's natural drainage or increase runoff onto neighbouring lands, as determined by the Development Authority (SVIL, 2021b). Moreover, the LUB has several regulations on the prohibition of development on flood plains, flood hazard areas, and areas with a high water table (SVIL, 2021b).

The Athabasca Regional Waste Management Services Commission was established by a Provincial Government order in council in 1999 and Island Lake is one of the municipal members (Athabasca Regional Waste, n.d.). The commission has several transfer sites and landfills where people can take their waste (Athabasca Regional Waste, n.d.).

2.8 Emergency Preparedness and Disaster Recovery

The 2020 Spring Newsletter of the Summer Village of Island Lake featured a section on emergency preparedness, emphasizing the importance of having an emergency kit that includes 72 hours of supplies, as well as an escape plan (SVIL, 2022). The 2021 May Newsletter reported details of changes to the Alberta Disaster Recovery Program (DRP) (SVIL, 2022). The DRP provides financial assistance to help restore uninsurable property loss due to disasters, typically from overland flooding or wildfire (SVIL, 2022).

2.9 Summary

Several priorities have been identified based on the background research, including water quantity and quality, wetlands, natural vegetation, and stormwater runoff. Protection of Island Lake is a priority because it is valued by residents for its recreational activities and aesthetics (SVIL, 2021c). Climate change may be affecting Island Lake and concerns have been raised on issues such as fluctuating water levels, as is stated in the MDP and Baptiste and Island Lakes Watershed Management Plan (BAILS, 2019; SVIL, 2021c).

Stormwater runoff poses a challenge in the spring or periods of prolonged rainfall for SVIL. The Village has proposed a low impact design (LID) method in its MDP and the Approach & Culverts Standards Policy to deal with the challenge (SVIL, 2021c). The MDP also suggests LID design features such as permeable paving surfaces, bio-swales, and rain gardens for controlling runoff on residential sites (SVIL, 2021c).

3. SITE VISIT

A site visit was conducted to review infrastructure, amenities, and services within the Summer Village of Island Lake and identify potential concerns to the community through the lens of extreme weather events and climate change. The findings were complementary to the background research and enabled refinement of hazards and community valued components (elements) included in the risk assessment. The site visit took place on July 28, 2023. Photo 3 shows an aerial view of SVIL on the date of the site visit.

Photo 3: Aerial of SVIL on July 28, 2023

3.1 Key Findings

During the site visit, the conditions and characteristics of community elements in both the built and natural environment were observed. In addition, there was discussion with community members regarding the community's history, priorities, and concerns regarding climate-related hazards. Key findings have been included below.

3.1.1 Lake Water Levels

- Since 2008, lake water levels have risen by ~30 cm.
- Heavy rain is a concern for some residents. Several properties are set closer to the lake, which can encroach during a heavy rainfall event.

3.1.2 Water and Wastewater Systems

- Ditches have been upgraded in the last few years.
  - All are sloped and filter rainwater before entering lake.
- Residents do not use water from the lake (use ground water from wells).
  - There are plans to extend a water line into the community from Athabasca.

3.1.3 Natural Assets & Water Quality

Photo 4: Wetland in SVIL on July 28, 2023

- Wetlands are undisturbed, are well maintained, and there is no beach area (Photo 4).
- There are five springs that feed the lake.
- Blue-green algae has not been a factor on Island Lake (only regular algae).
  - Nearby Baptiste Lake is prone to blue-green algae.
- Increased weekend activity and boating has caused ‘black gel’ to float to the water surface.

3.1.4 Biodiversity

- The lake was used for commercial fishing dating back to the 1940s, with operations later ceasing; however, jumbo whitefish were left in the lake and are still present today.
- Guidelines on fishing are in place and catch limits are imposed to control declining fish populations.
- Populations of diving ducks, mallards, and grebes have declined due to an increase in boating, higher populations of loons that drown ducklings, and higher populations of Canada Geese that compete for space, food, and nesting sites.
- There are no immediate concerns from residents regarding invasive species.

3.1.5 Residential Trees & Power Lines

- Trees surrounding properties tend to reduce wind.
- Residents receive grants for planting trees every year.
- Power lines are above ground, in front of houses.

3.1.6 Wildfire Risk

- The FireSmart program consists of clearing underbrush annually.

3.1.7 Extreme Heat Risk

- Some of the newer builds have AC; however, most homes/buildings do not have AC.

4. METHODOLOGY

This Plan will assist the Summer Village of Island Lake in understanding how the climate is projected to change and in prioritizing adaptation actions to manage the risks stemming from these changes to ensure the community is resilient in the face of a changing climate. Figure 8 shows the 4-step process followed to complete this Plan, with each step further described in the subsections that follow.

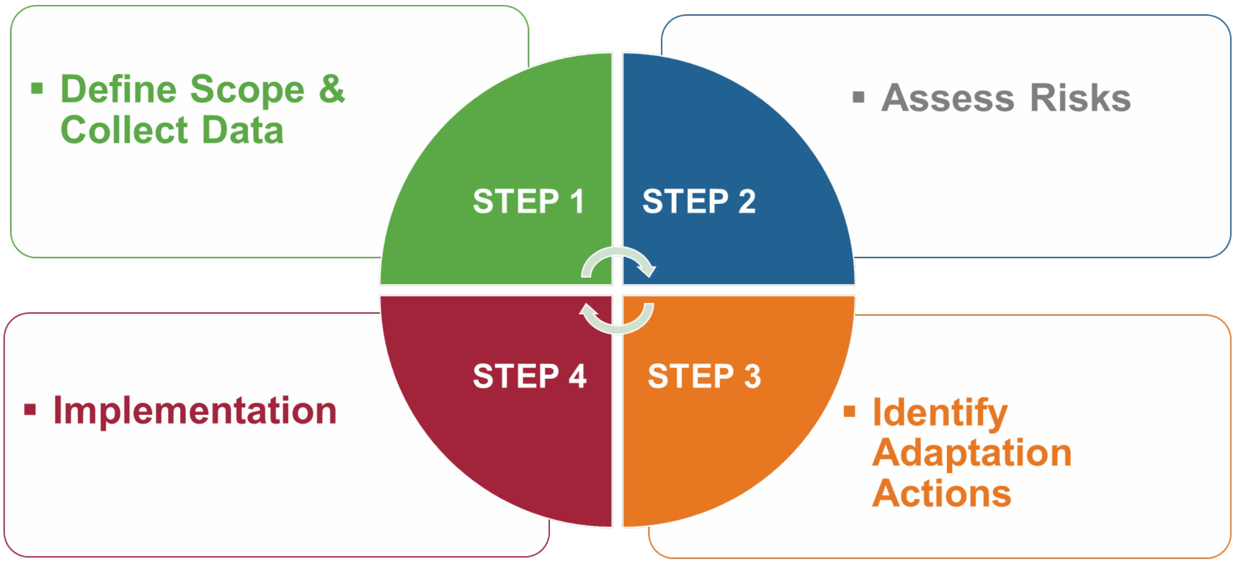

Figure 8. Climate Adaptation Planning Process

4.1 Step 1: Define Scope and Collect Data

4.1.1 Scope of the Assessment

The first step of the climate action planning process is to define the scope. Prior to project initiation, the following determinations were made to inform the scope of the project:

- A higher-level screening process is most suitable for SVIL, as it is a small community with limited staff and resources. The Public Infrastructure Engineering Vulnerability Committee (PIEVC) High Level Screening Guide (PIEVC, 2021) is the framework chosen for the risk assessment. The PIEVC HLSG aligns with international risk management standards ISO 31000 and ISO 14090, and other risk assessment processes.

- The study area is limited to the boundary of SVIL (refer to Figure 2). Therefore, all community elements are within this study area unless noted otherwise (i.e., Community Hall and Fire Hall).

- A site visit is important to inform the climate risk assessment and identification of adaptation actions; otherwise, limited community engagement is required.

4.1.2 Defining Community Elements & Climate Hazards

To define the community elements and climate hazards, the project team used existing planning documents, conducted background research, and completed a site visit to review the infrastructure, amenities, and services within SVIL and identify potential concerns to the community through the lens of extreme weather events and climate change. The lists of community elements and climate hazards included in the risk assessment can be found in Section 5.

4.1.3 Collecting Climate Data

To perform the climate risk assessment in Step 2, climate data relevant to each hazard was collected and compiled to inform how the frequency or intensity of each hazard may change in the future.

During this step of the process, the project team defined the timescale and emissions scenario of the climate data. Climate data was taken for two time horizons – historical, 1981-2010, and future, 2071-2100. Thirty (30) years is the most common length of time used to define a climatology. The 1981-2010 historical baseline period was selected because it is generally aligned with the timeframe for which observational/weather station data is provided. Moreover, Environmental and Climate Change Canada (ECCC) climate normals were provided for the 1981-2010 period at the time of this assessment. The 2071-2100 future period, centred on the 2080s, was selected given the long lifespan of the infrastructure in the Village and to facilitate long-term planning. Since shorter timeframes were not considered, the magnitude of near-term changes was not captured in the assessment. Representative Concentration Pathway 8.5 (RCP8.5) was chosen as the future global GHG emissions scenario, which corresponds to a business-as-usual trajectory and is commonly used in climate risk assessments. For more details on emissions scenarios, please refer to APPENDIX A.

ClimateData.ca was the primary source of climate projection data, which offers a series of climate indicators and modelled climate projections and is supported by the Canadian Centre for Climate Services and Environment and Climate Change Canada. A summary of SVIL's climate profile can be found in Section 5. For a detailed climate profile and full list of data sources, please refer to APPENDIX A.

4.2 Step 2: Assess Risks

In Step 2, the core MH project team and a group of technical specialists gathered to understand the interactions between community elements and climate-related hazards and assess the impact of each hazard on each community element.

In this assessment, the PIEVC High Level Screening Guide (HLSG) was followed (PIEVC, 2021). Using this approach, a simple numeric rating system was defined for climate hazard likelihood and consequence to generate a qualitative risk analysis for each community element. First, each element was assessed to determine if it had the potential to be exposed to the climate hazard. If no exposure was anticipated, the element was "screened out" of the assessment. Where exposures were identified, pre-assigned likelihood scores based on climate projections were applied (criteria can be found in 4.2.1), and consequence scores were collectively agreed upon by the project team (criteria can be found in 4.2.2).

Risk = Exposure (E) x Likelihood (L) x Consequence (C)

Exposure: *Exposure of a community element to a specific climatic hazard. Exposed elements receive a score of 1 while non-exposed elements receiving a score of 0. This results in non-exposed elements being "screened out" of the assessment.*

Likelihood: *The likelihood of a particular climate hazard occurring during a specific time horizon, based on observed trends and climate projection data with scores between 1-5. Existing conditions typically receive a score of 3. Under similar future conditions, likelihood scores remain unchanged. Under increasing (decreasing) climatic trends, likelihood scores increase (decrease).*

Consequence: *The potential severity of an interaction arising from exposure to the climate hazard. These scores were determined in the risk assessment workshop by relevant technical leads at MH. Scores are between 1-5 with 1 being negligible consequence and 5 being very high consequence.*

Interaction: *The relationship between a given climate hazard and community element where an exposure has been identified.*

4.2.1 Likelihood Scoring Criteria

Likelihood scores were assigned using the "middle baseline" approach as per the PIEVC HLSG (PIEVC, 2021) (Table 1). Taking this approach, climate hazards are given a baseline score of 3, and future scores are based on the degree of projected change in the indicators relevant to each climate hazard. Hazards projected to have a reduction in intensity or frequency receive future scores lower than 3, while hazards projected to increase in intensity or frequency receive future scores higher than 3, with degree of change in likelihood scores dependent on the degree of change in climate trends. In the case where future conditions are projected to stay roughly the same as the baseline climate, the likelihood score does not change (i.e., remains at 3). There have been modifications to the middle baseline approach for a few hazards (drought, wildfire, and wildfire smoke) with defined categories and/or rating scales. Methods and rationales are highlighted in Table 2.

Table 1: Likelihood Scoring Criteria Adopted from PIEVC High Level Screening Guide (PIEVC, 2021)

Likelihood Score	Description	Methodology
1	Climate hazard likely to be much less frequent or intense than recent climate.	50-100% reduction in frequency or intensity when compared to baseline mean.
2	Climate hazard likely to be less frequent or intense than recent climate.	10-50% reduction in frequency or intensity when compared to baseline mean.
3	Climate hazard likely to be as frequent or intense as recent climate.	Baseline mean conditions or a change in frequency and intensity of ± 10% when compared to the baseline mean
4	Climate hazard likely to be more frequent or intense than recent climate.	10-50% increase in frequency or intensity when compared to baseline mean.
5	Climate hazard likely to be much more frequent or intense than recent climate.	50-100%+ increase in frequency or intensity when compared to baseline mean.

Table 2: Modified Likelihood Scoring Criteria for Hazards with Defined Categories and/or Rating Scales

Climate hazard	Baseline Likelihood Scoring Method	Change in Future Likelihood Method	Rationale
Drought	Middle baseline approach (score of 3).	Projected change in climate moisture index category as defined by NRCan (2017).	Estimate change in likelihood from defined categories rather than % change in indicator.
Wildfire	Informed by wildfire zone (NRCan, 2021) and historical average fire weather index with categories defined by NRCan (2023a).	Changes in fire weather conditions (mean summer temperature as primary indicator), following PIEVC HLSG % change approach.	Estimate baseline likelihood from defined categories rather than middle baseline approach. There are no indicators specifically for change in likelihood, thus fire weather is used as a proxy.
Wildfire Smoke	Informed by historical 98th percentile hourly PM2.5 concentration (Government of Alberta, 2023) and a defined rating scale (BC Air Quality, 2023).	Changes in fire weather conditions (mean summer temperature as primary indicator), following PIEVC HLSG % change approach.	Estimate baseline likelihood from defined categories rather than middle baseline approach. There are no indicators specifically for change in likelihood, thus fire weather is used as a proxy.

4.2.2 Consequence Scoring Criteria

Consequence scores were assigned using the criteria shown in Table 3. This process was conducted using a facilitated workshop approach, where a team of subject matter experts systematically assessed each interaction to determine the potential exposure and level of impact of each climate hazard on each community element. When assigning consequence scores, there were various criteria (e.g., physical damage, resident health and safety, disruption, and environmental damage) that were considered in terms of how the community element might be impacted by a potential exposure to a climate hazard. Some of these criteria have been adopted from the ICLEI Workbook (ICLEI, 2019) and refined for SVIL. In each hazard-element review, the criteria that was most relevant was used to determine the consequence score.

Table 3: Consequence Scoring Criteria Adopted from the ICLEI Workbook (ICLEI, 2019) and Modified to Reflect SVIL Context

Consequence Rating	Consequence Score	Criteria (at least one condition applies)				
		Infrastructure	Buildings & Site	Public Health & Safety	Services	Environment
Catastrophic	5	Sections or entire infrastructure assets rendered unusable with months/years needed to repair	Sections or entire buildings rendered unusable with months/years needed to repair	Potential for morbidity and/or large numbers of serious injuries	Severe impact on services and community unable to support its residents for months/years	Widespread loss of environmental amenities and irrecoverable environmental damage
Major	4	Significant damage to infrastructure with weeks/months needed to repair	Significant damage to building structure with weeks/months needed to repair	Significant health impacts for many and/or isolated incidents of serious injuries	Major impact on services and quality of life within the community for weeks/months	Major loss of environmental amenities and long-term environment damage
Moderate	3	Damage to infrastructure is manageable but will exceed normal repair budgets	Damage to buildings is manageable but will exceed normal repair budgets	Considerable health impacts for many and/or small number of injuries	General impact on services but community able to rebound within weeks	Isolated but significant environmental damage
Minor	2	Infrastructure repairs are within normal operating costs	Building repairs are within normal operating costs	Minor health impacts and/or injuries	Isolated impact on services	Minor instances of environmental damage
Negligible	1	No damage to infrastructure	No damage to building structure	No health concerns and/or physical harm	No impact on services	No environmental damage

4.2.3 Risk Ratings

The results of the consequence and likelihood scoring exercise were combined by applying the formula provided at the beginning of this section (Risk = Exposure x Likelihood x Consequence) to generate an overall risk score for each hazard-element interaction. Each risk score was then assigned a risk rating. The matrix used to assign the category of risk is shown in Figure 9.

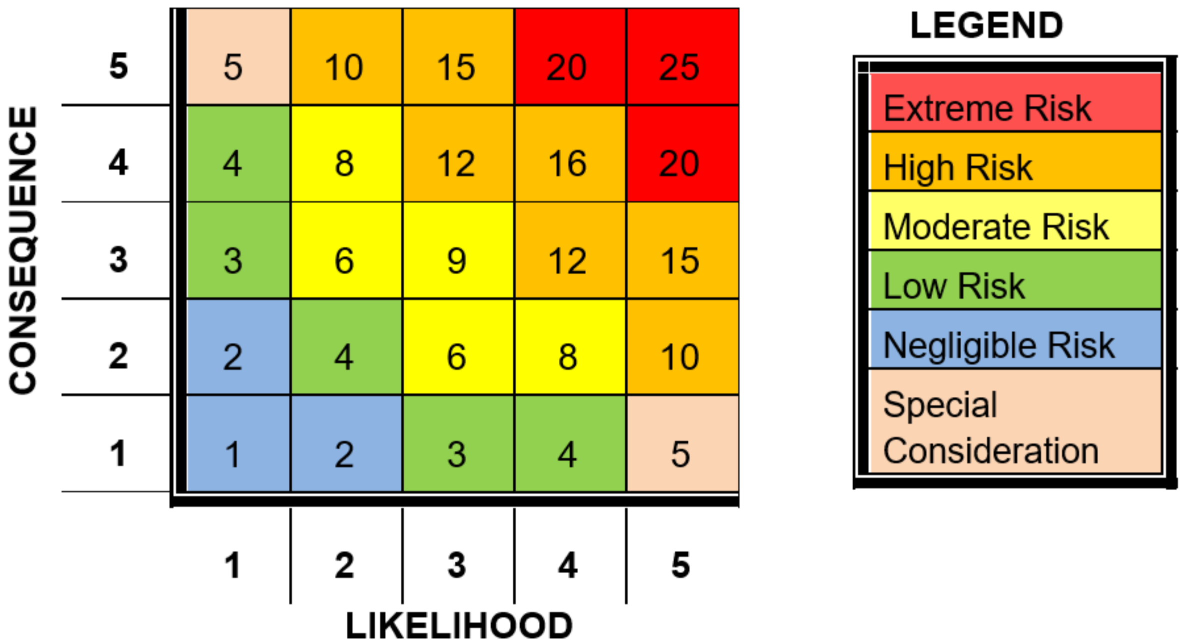

Figure 9: Risk Scoring Matrix and Risk Ratings

Negligible Risk (risk score from 1 to 2): *No further consideration is required.*

Low Risk (risk scores from 3 to 4): *Minimal action is required. Controls are not likely required.*

Moderate Risk (risk score from 6 to 9): *Action may be required.*

High Risk (risk scores from 10 to 19): *Action is required.*

Extreme Risk (risk scores from 20 to 25): *Immediate action is required.*

Special Consideration (risk score of 5): *Describes two unique scenarios. Low likelihood and high consequence interactions would consider events such as tornados, where the likelihood of a direct hit is very low, but the overall consequence could be catastrophic; and high likelihood low consequence events such as ongoing deterioration of elements resulting from continued exposure to various climatic conditions.*

4.3 Step 3: Identify Adaptation Actions

In Step 3 of the climate action planning process, the core project team and a group of technical specialists gathered a second time – this time to identify resilience strategies. Risk treatment and adaptation actions were developed for high and extreme risks. Moderate risks were not carried forward into the action planning stage to focus limited resources and capacity on the highest risks but should be monitored by SVIL into the future.

4.4 Step 4: Prioritize Adaptation Actions

Step 4 involved characterizing and prioritizing actions to help determine priorities for implementation. Actions were evaluated against key decision criteria including resilience benefit, order of magnitude cost, and timeline to then determine an overall priority level.

Step 4 is where SVIL will take the priority areas outlined as part of this project and begin to take action to increase the community's resilience in the face of a changing climate. Implementation should be monitored and evaluated including ways to improve in the future.

4.5 Limitations

As our understanding of climate change improves, climate projections may change which could cause changes to the community's risk profile. As there are uncertainties in every climate risk assessment, the work should be viewed as part of a continuing risk management process and reviewed periodically to identify potential changes resulting from newer climate or other information.

The projections used for this work were based on a high emissions scenario (RCP 8.5). Therefore, this represents the current state of knowledge of a worst-case climate scenario, which means a more conservative risk assessment.

This assessment includes two time horizons, the recent (baseline) climate (1981-2010) and the end-of-century future period (2071-2100). Thus, the work does not include near-term climate projections that may be reflective of conditions in the next 1-3 decades. However, the results are reflective of the worst-case climate scenario over the expected useful service life of community elements.

This analysis is based on the combined professional judgment of the team. It reflects the team's best estimate of expected climate risk over the useful service life of the elements being assessed. Results from the work reflect the state of climate change and element components at the time of the assessment. As climate science develops, periodic reviews of the risk profile and revisions when necessary are recommended.

The work was done as a high-level screening of elements to inform recommendations to improve community resilience to climate change. More data and detailed assessment would be needed to expand the work for wider applications.

5. ELEMENTS, HAZARDS AND CLIMATE PROFILE

This section summarizes the community elements that were included in this assessment, the climate hazards that were assessed for each element, and SVIL's climate profile which provided the data inputs for the risk assessment.

5.1 Community Elements

The community elements were identified based on background research including review of the Village's By-Law documents, as well as a site visit which involved reviewing infrastructure, buildings, and natural assets, and helped provide a better understanding of current conditions and exposures. Community elements were grouped into four categories – Infrastructure, Buildings, Natural Systems and Assets, and Community – as described below. Table 4 provides a list of the community elements under each category, sub-elements, and reasons for inclusion.

Infrastructure: Includes elements for utilities and transportation

Buildings: Includes structures, systems, and landscaping

Natural Systems and Assets: Includes terrestrial and aquatic habitats

Community: Includes residents

Table 4: Summary of Community Elements

Element Category	Element	Sub-Element(s)	Reason for Inclusion
Infrastructure	Private Drinking Water Systems	Wells	Provide essential service to residents that may be vulnerable to changes in climate and extreme events.
	Private Wastewater Systems	Holding tanks (majority), septic fields	Provide essential service to residents that may be vulnerable to changes in climate and extreme events.
	Stormwater Systems	Ditches, catch basins	Provide essential service to residents that may be vulnerable to changes in climate and extreme events.
	Horizontal Infrastructure	Roads, bridge	Provides access to essential services that may be vulnerable to changes in climate and extreme events.
	Above-ground Power Lines	-	Provide essential service to residents that may be vulnerable to changes in climate and extreme events.
Buildings	Residential Lots/Buildings	Structures (houses), systems (mechanical, electrical), private docks, hard and soft landscaping	Building structures, systems, and landscaping may be vulnerable to changes in climate and extreme events.
	Commercial Lots/Buildings	Structures (gas station, stores, above-ground fuel tanks), systems (mechanical, electrical), hard and soft landscaping	Building structures, systems, and landscaping may be vulnerable to changes in climate and extreme events.
	Community Lots/Buildings	Structures (sheds, gazebo)	Building structures may be vulnerable to changes in climate and extreme events.
	Fire Hall (higher priority)	-	Services residents of SVIL and may be vulnerable to changes in climate and extreme events.
	Community Hall (lower priority)	-	Services residents of SVIL and may be vulnerable to changes in climate and extreme events.
Natural Systems and Assets	Trees & Terrestrial Vegetation	-	Sensitive ecosystems may be vulnerable to changes in climate and extreme events.
	Wetlands, Riparian & Shoreline Areas	-	Sensitive ecosystems may be vulnerable to changes in climate and extreme events.
	Fish & Aquatic Habitat	-	Sensitive ecosystems may be vulnerable to changes in climate and extreme events.
	Community & Environment Areas	Parks, baseball field, basketball court	Provide recreational services and greenspaces that may be vulnerable to changes in climate and extreme events.
Community	Residents	Resident health and safety	Health and safety of residents may be impacted by changes in climate and extreme events.

5.2 Climate Hazards

Findings from background research and the site visit helped to identify priorities of the community and potential climate-related hazards. The list of climate-related hazards included in this assessment is shown below:

Given that SVIL is a lakefront community, recreational activities and enjoyment of the lake are assumed to be among the main priorities of residents. Hazards pertaining to Island Lake – including water levels and quality – were found to be of concern through background research and the site visit and thus have been included as climate hazards. Due to concerns about runoff due to heavy rain events discovered from both background research and the site visit, extreme rainfall / pluvial flooding has been prioritized as a hazard. Although invasive species, extreme storms, drought, wildfire, and wildfire smoke were not identified as pressing issues to the community, each of these are highly relevant climate hazards in a regional context and thus have been included. In the context of this assessment, extreme storms refer to convective thunderstorms capable of producing damaging wind gusts and hail with the potential for tornadoes and straight-line winds (which can be tornado-strength in some cases).

Temperature-related hazards, including change in average and extreme temperatures, have also been included in the assessment. Based on background research, challenges posed by winter weather hazards including heavy snowfall and runoff due to snowmelt are addressed through proper winter road maintenance operations. Moreover, extreme snowfall, rain-on-snow, and freeze-thaw cycles are projected to remain the same or decrease significantly in frequency and severity over time, as will be described next. Therefore, winter weather hazards have been screened out of the assessment.

5.3 Climate Profile Summary

By the 2080s under a high global GHG emissions scenario, SVIL is projected to become warmer and wetter overall, with increasing frequency and intensity of heatwaves and increasing intensity of extreme rainfall events. In addition to increasing pluvial (rainfall-driven) flood risk, more extreme rainfall can have multiple cascading impacts including contributing to high lake levels and poor water quality. A significant decrease in extreme cold days and freeze-thaw cycles is projected, and precipitation is expected to increase most in spring and decrease in summer. The frost-free season length is projected to increase significantly, which may benefit plant growth but allow persistence of pests and invasive species. Increases in temperature and evapotranspiration may lead to increases in the frequency and intensity of drought, low lake levels, and conditions favourable for wildfires during periods of low precipitation. Note that periods of high and low lake levels are both possible under future climate conditions at different times, depending on multi-annual precipitation and temperature patterns. The magnitude of extreme snowfall events is projected to decrease slightly, but rain-on-snow is projected to remain around the same with more precipitation falling as rain. Conditions for severe convective events resulting in strong winds and hail are projected to increase in the region. Highlights of the key changes in SVIL's climate profile from the baseline to future (2080s) period are listed below:

- Cooling degree days (CDD), which is a measure of building cooling demand, are projected to increase by nearly 1000%.
- The community is projected to experience over 1 month of days exceeding 30°C compared to a baseline of only 1 day, whereas days below -30°C are projected to occur seldomly over the course of the winter.
- Mean summer temperatures are projected to increase by over 6°C. This is expected to contribute to increased wildfire risk and associated smoke, as well as low lake levels due to more evaporation during periods of low precipitation.
- The frost-free season length is projected to lengthen by over 1 month.
- The 50-year, 1-day storm is projected to increase in intensity by over 20 mm which represents a 20% increase.
- Total annual precipitation is projected to increase by 45 mm which represents a 10% increase. Increases are expected to occur in the winter, spring, and fall.
- The climate moisture index is projected to decrease (i.e., greater potential loss of water from vegetation).
- At a regional scale, the number of days per year with strong wind gusts (>70 km/h) is projected to increase, in large part due to an increase in summertime convective thunderstorms.

Table 5 is an overview of the results of the climate hazard analysis, including key or primary indicators used to determine likelihood scores, the reasons for use of the indicators, baseline values, future projections, trends, magnitude of changes, and percent changes. Changes highlighted in red (green) indicate an increase (decrease) in the likelihood of the hazard. The choice of indicators for high lake levels, low lake levels, and water quality was informed by the Baptiste and Island Lakes Watershed Management Plan (BAILS, 2019). For a complete list of climate hazard indicator results and data sources, please refer to APPENDIX A.

Table 5: Climate Hazard Data Summary

Climate Hazard	Primary Climate Hazard Indicator(s)	Reason for Primary Indicator(s)	Baseline (1981-2010)	Future Projection (2071-2100)	Trend	Magnitude of Change	% Change
Change in Average Temperature	Cooling Degree Days (CDD)	Measure of building cooling demand	38	412	↑	+374	+984%
Extreme Heat	Days per year >30°C	Measure of heat wave frequency and length	1	36	↑	+35	+3500%
Extreme Cold	Days per year <-30°C	Measure of cold wave frequency and length	11.3	1.0	↓	-10.3	-91%
Invasive Species	Frost-free season length (days)	Increased growing season may affect persistence of pests and invasive species	119	174	↑	+55	+46%
Extreme Rainfall / Pluvial Flooding	50-year, 1-day storm (mm)	Magnitude of extreme rainfall events	108.7	130.3	↑	+21.6	+20%
High Lake Levels	Total annual precipitation (mm)	Average precipitation influences overall lake levels	456	501	↑	+45	+10%
Low Lake Levels	Mean summer temperature (°C)	Higher summer temperatures result in increased evaporation	15.2	21.5	↑	+6.3	+41%
Poor Water Quality	50-year, 1-day storm (mm)	Higher magnitude of extreme rainfall events can reduce water quality	108.7	130.3	↑	+21.6	+20%
Drought	Climate moisture index (unitless)	Measure of potential loss of water from vegetation	-10	-30	↑	-20	-200%
Extreme Storm (Wind, Hail)	Days per year w/wind gusts >70 km/h	Wind gusts above this threshold have potential to cause damage	6	7.5	↑	+1.5	+25%
Wildfire	Wildfire zone, mean fire weather index (unitless)	Indicators of fire threat based on regional fire history and fire weather	Moderate/High (zone 3/4), 5-10 (moderate)	Increasing	↑	n/a	n/a
Wildfire Smoke	98th percentile hourly particulate matter 2.5 concentration (μg/m3)	Measure of past air quality in relation to wildfire	58.1 (moderate)	Increasing	↑	n/a	n/a

6. RISK ASSESSMENT RESULTS AND SUMMARY

Using the methodology as described in Section 4.2, 180 interactions (15 elements cross-referenced with 12 hazards) were assessed. Thirty-five (35) of these interactions were considered “no risk” as the element was deemed not exposed to the hazard. Thus, results of 145 hazard-element interactions are highlighted in this section, which range from negligible risk to extreme risk. For both baseline and future climate conditions, risk results are summarized, and ratings are shown for each hazard-element interaction in Table 6 and Table 7. Sixty-one (61) risks rated as high or extreme in the future period have been carried forward for the climate adaptation plan. Complete results for all hazard-element interactions, including likelihood, consequence, and risk scores, can be found in APPENDIX B.

6.1 Baseline Climate Conditions Risk Profile

The risk profile for baseline climate conditions, shown in Table 6, consists of 44 low, 71 moderate, 30 high, 0 extreme, and 0 special consideration risks. Note that white (score of 0) = no exposure; green = low risk; yellow = moderate risk; and orange = high risk. By nature of the methodology used in this risk assessment, there are no special consideration, negligible, or extreme risks that appear under baseline conditions. This is due to the middle baseline approach used for likelihood scoring, in which each hazard is given a baseline likelihood score of 3.

The largest number of high risks were found for wildfire and extreme storm, with 10 and 8 high risks, respectively. High risks were also found for extreme heat (4), invasive species (3), extreme rainfall (2), drought (2), and high lake levels (1).

The following list summarizes the high risks by element:

- **Private drinking water systems:** The risk due to drought is high.
- **Stormwater systems:** The risk due to extreme rainfall is high.
- **Horizontal infrastructure:** The risks due to extreme rainfall and wildfire are high.
- **Above-ground power lines and buildings:** The risks due to extreme storms and wildfire are high. For homes, high lake levels also pose a high risk (depending on elevation of lot).
- **All natural systems and assets:** The risks due to extreme heat and invasive species are high. For trees and terrestrial vegetation, drought, extreme storms, and wildfire also pose high risks.
- **Residents:** The risks posed to health and safety due to extreme heat, extreme storms, and wildfire are high.

Table 6: Risk Ratings for All Hazard-Element Interactions Under Baseline Climate Conditions (1981-2010)

Element	Climate Hazard											
	Change in Average Temperature	Extreme Heat	Extreme Cold	Invasive Species	Extreme Rainfall / Pluvial Flooding	High Lake Levels	Low Lake Levels	Poor Water Quality	Drought	Extreme Storm (Wind, Hail)	Wildfire	Wildfire Smoke
Private Drinking Water Systems												
Private Wastewater Systems												
Stormwater Systems												
Horizontal Infrastructure												
Above-ground Power Lines												
Residential Lots/Buildings												
Commercial Lots/Buildings												
Community lots/buildings												
Fire Hall												
Community Hall												
Trees & Terrestrial Vegetation												
Wetlands, Riparian & Shoreline Areas												
Fish & Aquatic Habitat												
Community & Environment Areas												
Residents												

6.2 Future Climate Conditions Risk Profile

The risk profile for future climate conditions, shown in Table 7, consists of 6 negligible, 36 low, 29 moderate, 42 high, 19 extreme, and 13 special consideration risks. Note that white (score of 0) = no exposure; blue = negligible risk; green = low risk; yellow = moderate risk; orange = high risk; red = extreme risk; and tan = special consideration. There are numerous interactions that have changed to special consideration and extreme risks due to projected changes in climate conditions. Moreover, many moderate risks have increased to a high risk rating.

Extreme heat joins wildfire and extreme storm among the hazards associated with the largest number of high and extreme risks. Wildfire, extreme storm, and extreme heat have 11, 10, and 10 high/extreme risks, respectively. Also worth noting is that high risks for extreme rainfall increase from 3 to 7, while high risks involving increasing average temperatures rises from 0 to 7.

Special considerations resulted from high likelihood, low consequence interactions primarily between infrastructure elements and changes in average temperature and extreme heat. Given the low consequence of these interactions, they are not included in the climate adaptation plan.

The following list summarizes the high and extreme risks by element in comparison to baseline conditions:

- **Private drinking water systems:** The risk due to drought increases from high to extreme.
- **Stormwater systems:** The risk due to drought increases from moderate to high, in addition to the risk caused by extreme rainfall which remains high.
- **Horizontal infrastructure:** The risk due to extreme heat increases from moderate to high, in addition to the risk caused by extreme rainfall which remains high. The risk caused by wildfire increases from high to extreme.
- **Above-ground power lines:** The risk due to extreme heat increases from moderate to high, in addition to the risks caused by extreme storms and wildfire which remain high.
- **Homes and buildings:** The risks due to changes in average temperatures, extreme heat, and extreme rainfall increase from moderate to high. The risks caused by extreme storms and wildfire increase from high to extreme. For homes, the risk due to high lake levels remains high, and the risk caused by low lake levels (impacting docks more than houses) changes from moderate to high.
- **Trees and terrestrial vegetation:** The risks due to changes in average temperatures and extreme rainfall increase from moderate to high, in addition to the risks caused by invasive species, drought, and extreme storms which remain high. The risks due to extreme heat and wildfire increase from high to extreme.
- **Wetlands, riparian, and shoreline areas:** Various risks including high and low lake levels and drought increase from moderate to high, in addition to the risk caused by

invasive species which remains high. The risk due to extreme heat increases from high to extreme.

- **Fish and aquatic habitat:** Various risks including high and low lake levels increase from moderate to high, in addition to the risk caused by invasive species which remains high. The risk due to extreme heat increases from high to extreme.
- **Community and environment areas:** The risk due to wildfire remains high.
- **Residents:** The risk posed to health and safety due to wildfire smoke increases from moderate to high. The risks caused by extreme heat, extreme storms, and wildfire increase from high to extreme.

6.3 High and Extreme Risk Details

High and extreme risks under future climate conditions are focused on in this assessment and have been carried forward for the climate adaptation plan. In Section 7, risk treatment options are provided for these risks to help SVIL prioritize actions that will have the most impact on increasing community resilience.

Moderate and low risks for the future period have not been carried forward to the climate adaptation plan at this time. It is worthwhile to revisit this risk assessment periodically as an important part of plan monitoring and evaluation, to re-evaluate risk scores and priority items. There is the possibility that as data and projections improve, or if SVIL experiences unanticipated impacts, risk levels may change. For example, an interaction that is moderate at the time of this assessment may elevate to a high risk in the future, meaning that action may be required.

Table 8 provides a summary and description of all high and extreme risks identified under future climate conditions, with reference to baseline risk ratings. Note that yellow = moderate risk (applies to some risks in the baseline period); orange = high risk; and red = extreme risk. For each high/extreme risk, there is a description/rationale of the risk regarding impacts of the hazard on the element through the SVIL community context based on background research, the site visit, and the workshop with the team of technical specialists.

Table 7: Risk Ratings for All Hazard-Element Interactions Under Future Climate Conditions (2071-2100)

Element	Climate Hazard											
	Change in Average Temperature	Extreme Heat	Extreme Cold	Invasive Species	Extreme Rainfall / Pluvial Flooding	High Lake Levels	Low Lake Levels	Poor Water Quality	Drought	Extreme Storm (Wind, Hail)	Wildfire	Wildfire Smoke
Private Drinking Water Systems												
Private Wastewater Systems												
Stormwater Systems												
Horizontal Infrastructure												
Above-ground Power Lines												
Residential Lots/Buildings												
Commercial Lots/Buildings												
Community lots/buildings												
Fire Hall												
Community Hall												
Trees & Terrestrial Vegetation												
Wetlands, Riparian & Shoreline Areas												
Fish & Aquatic Habitat												
Community & Environment Areas												
Residents												

Table 8: Summary and Description of High/Extreme Risks Under Future Climate Conditions (2080s)

Element	Climate Hazard	Risk ID	Risk Rating		Risk Description / Rationale
			Baseline	2080s	
Private Drinking Water Systems	Drought	1			Extreme drought can accelerate the loss of aquifer reserves and lower the water table. The community is reliant on these reserves as the sole source of water services.
Private Wastewater Systems	No high/extreme risk interactions identified. The assumption is that septic fields and tanks are buried appropriately for a northern Alberta climate, and that soil intercepts and insulates the systems from extreme changes. Since hot and cold snaps are already a reality, even if they get more severe or last longer, it is expected to be a nominal change from normal operation. Wildfires may burn over access hatches, but the main systems will be protected by the soils they are buried in. Replacement of a hatch is not outside a regular maintenance item.				
Stormwater Systems	Extreme rainfall	2			Extreme rainfall results in high volumes of runoff that can cause erosion of ditches and wear on drainage system elements. These types of damages can lead to washouts and damage to the drainage paths. If the runoff is of a volume that can carry large debris, this debris can cause blockages in the drainage system, causing localized flooding. The risk rating is based on the assumption that the community is not in a floodplain.
	Drought	3			Future increased drought conditions can potentially cause higher repair costs which exceed normal operating budgets.
Horizontal Infrastructure	Extreme Heat	4			Future increased extreme heat conditions can potentially result in higher repair costs which exceed normal operating budgets.
	Extreme Rainfall	5			Extreme rainfall results in high volumes of runoff that can cause erosion of ditches and can lead to washouts. High volume flows have the potential to erode soils around bridge abutments.
	Wildfire	6			Heat from wildfire can cause extreme damage to the pavements, including thermal cracking, and can burn off the asphalt. It would mean repairs or replacements well above normal maintenance. Given that the bridge is wooden, it could be damaged or destroyed. Engineering and then building a new bridge could take weeks or several months, depending on time of year and how quickly the community can receive approvals.
Above-ground Power Lines	Extreme Heat	7			Future increased extreme heat conditions can potentially result in higher repair costs which exceed normal operating budgets.
	Extreme Storm	8			Extreme storms can destroy poles or down overhead lines; these repairs can take weeks to months to repair depending on the extent of damages.
	Wildfire	9			Wildfire can down poles and overhead lines; these repairs can take weeks to months to repair depending on the extent of damages.
Residential Lots/Buildings	Change in Average Temp	10			Significantly increased average temperatures in the future can potentially result in higher cooling and maintenance costs.
	Extreme Heat	11			Significantly increased extreme heat conditions in the future can potentially result in higher cooling and maintenance costs.
	Extreme Rainfall	12			More intense extreme rainfall in the future can potentially result in higher maintenance and repair costs due to, for example, increased incidents of water penetration.
	High Lake Levels	13			Docks are at greater risk than houses for more vulnerable (low lying) properties. High lake levels can dislodge docks.
	Low Lake Levels	14			Potentially more extreme occurrences of low lake levels in the future as a result of increased evaporation due to higher temperatures, coupled with increased drought conditions, may result in higher maintenance and repair costs. Docks are at greater risk than houses and there can be accessibility issues for watercraft.
	Extreme Storm	15			Potential for complete loss of structure in the event of a tornado. There is the potential for major damage in the event of other extreme wind events such as derechos or straight-line winds.
	Wildfire	16			Potential for complete loss of structure in the event of a wildfire.
Commercial Lots/Buildings	Change in Average Temp	17			Significantly increased average temperatures in the future can potentially result in higher cooling and maintenance costs.
	Extreme Heat	18			Significantly increased extreme heat conditions in the future can potentially result in higher cooling and maintenance costs.

Element	Climate Hazard	Risk ID	Risk Rating		Risk Description / Rationale
			Baseline	2080s	
	Extreme Rainfall	19			More intense extreme rainfall in the future can potentially result in higher maintenance and repair costs due to, for example, increased incidents of leakage.
	Extreme Storm	20			Potential for complete loss of structure in the event of a tornado. There is the potential for major damage in the event of other extreme wind events such as derechos or straight-line winds.
	Wildfire	21			Potential for complete loss of structure in the event of a wildfire.
Community Lots/Buildings	Extreme Storm	22			Potential for complete loss of structure in the event of a tornado. There is the potential for major damage in the event of other extreme wind events such as derechos or straight-line winds.
	Wildfire	23			Potential for complete loss of structure in the event of a wildfire.
Fire Hall & Community Hall	Change in Average Temp	24			Significantly increased average temperatures in the future can potentially result in higher cooling and maintenance costs.
	Extreme Heat	25			Significantly increased extreme heat conditions in the future can potentially result in higher cooling and maintenance costs.
	Extreme Rainfall	26			More intense extreme rainfall in the future can potentially result in higher maintenance and repair costs due to, for example, increased incidents of water penetration.
	Extreme Storm	27			Potential for complete loss of structure in the event of a tornado. There is the potential for major damage in the event of other extreme wind events such as derechos or straight-line winds.
	Wildfire	28			Potential for complete loss of structure in the event of a wildfire.
Trees & Terrestrial Vegetation	Change in Average Temp	29			Significantly increased average temperatures in the future can potentially affect moisture regimes in soils, affecting health and vigour of plant species.
	Extreme Heat	30			Extreme heat affects moisture regimes in soils, affecting health and vigour of plant species.
	Invasive Species	31			Invasive species have a high chance of changing existing plant community structures, limiting biodiversity and natural ability to fight disease.
	Extreme Rainfall	32			More intense extreme rainfall in the future can potentially damage trees and terrestrial vegetation due to, for example, greater erosion higher incidents of soil washout.
	Drought	33			Drought increases mortality in trees which increases standing snags and wildfire fuel over time.
	Extreme Storm	34			Potential for major loss of vegetation in the event of a tornado. There is the also the potential for major damage in the event of other extreme wind events such as derechos or straight-line winds.
	Wildfire	35			Potential for complete loss of vegetation in the event of a wildfire.
Wetlands, Riparian & Shoreline Areas	Change in Average Temp	36			Significantly increased average temperatures in the future can potentially cause drying of wetland features, affecting their natural flood retention properties and resulting in plant community changes.
	Extreme Heat	37			Extreme heat causes drying of wetland features, affecting their natural flood retention properties and resulting in plant community changes.
	Invasive Species	38			Invasive species have a high chance of changing existing plant community structures, limiting biodiversity and natural ability to fight disease. Aquatic invasive species may also choke aquatic systems.
	High Lake Levels	39			Potentially more extreme occurrences of high lake levels in the future due to increasing overall precipitation and more intense extreme rainfall events may result in greater shoreline erosion.

Element	Climate Hazard	Risk ID	Risk Rating		Risk Description / Rationale
			Baseline	2080s	
	Low Lake Levels	40			Potentially more extreme occurrences of low lake levels in the future as a result of increased evaporation due to higher temperatures, coupled with increased drought conditions, may result in drying of wetland features, affecting their natural flood retention properties and resulting in plant community changes.
	Poor Water Quality	41			More intense rainfall events in the future may affect the ability of wetlands and riparian systems to filter sediment and pollutants, potentially reducing water quality.
	Drought	42			Future increased drought conditions may result in drying of wetland features, affecting their natural flood retention properties and resulting in plant community changes.
	Extreme Storm	43			Increased frequency of extreme storms in the future may cause damage to wetland vegetation and result in greater shoreline erosion.
	Wildfire	44			Potentially increased wildfire events in the future may destabilize riparian and shoreline areas and result in greater erosion.
Fish & Aquatic Habitat	Change in Average Temp	45			Significantly increased average temperatures in the future may cause algal blooms, impacting the lake system and wildlife.
	Extreme Heat	46			Extreme heat may cause algal blooms, impacting the lake system and wildlife. Northern fish are well adapted to survive in cold temperatures, making them particularly vulnerable to extreme heat
	Invasive Species	47			Invasive species have a high chance of changing existing plant community structures, limiting biodiversity and natural ability to fight disease. Aquatic invasive species may also choke aquatic systems.
	High Lake Levels	48			Potentially more extreme occurrences of high lake levels in the future can stress aquatic habitat through nutrient loading (concentrations too high) and microbial proliferation (growth of harmful bacteria and microorganisms) (Talbot et al., 2018).
	Low Lake Levels	49			Potentially more extreme occurrences of low lake levels in the future can have cascading effects / positive feedbacks including further increases in water temperature and increased concentration of pollutants, placing stress on aquatic habitat (Ballard, 2020).
	Poor Water Quality	50			More intense rainfall events in the future may reduce water quality and adversely impact the health of fish and other aquatic species. In addition, potentially increased wildfire events may introduce contaminants into waters systems (e.g., ash, increased erosion, etc.).
	Extreme Storm	51			Increased frequency of extreme storms in the future can disrupt aquatic habitat and mobilize potentially harmful microorganisms.
Community & Environment Areas	Wildfire	52			Potential for considerable damage to green space and paved surfaces in the event of a wildfire.
Residents	Extreme Heat	53			Extreme heat can have significant health impacts on residents given that most buildings do not have AC. Athabasca would be the nearest evacuation centre / refuge location.
	Extreme Storm	54			Potential for serious health and safety hazards in the event of a tornado. There is also the potential for serious health and safety hazards in the event of other extreme wind events such as derechos or straight-line winds.
	Wildfire	55			A wildfire is generally a hazard for which the community would have lead time for evacuation if needed. Moreover, the community has other means of egress if the bridge is destroyed by wildfire. However, impacts to the community, in terms of services and well-being, can be catastrophic.
	Wildfire Smoke	56			Future increased prevalence of wildfires in the region can pose an increasingly serious health and safety concern.

7. ADAPTATION ACTION PLAN

Climate adaptation planning needs to prioritize actions that reduce the negative impacts of climate hazards and extreme events by protecting individuals, assets, and community resources. For the Summer Village of Island Lake, solutions need to be practical, affordable, and implementable for a small community with limited capacity and resources. As this Plan has conveyed, communities and local governments have a role to play in the global response to climate change. It is important that communities of all sizes prioritize resilience to climate impacts even though there is still uncertainty about where, when, and how severe these impacts may be. This Plan sets a foundation for SVIL which enables the community to embark on a journey to identify, learn about, and prioritize which actions can be taken to improve resilience over time in the face of such uncertainty. Adaptation actions have been developed for high and extreme risks and prioritized based on various criteria including resilience benefit, order of magnitude cost, and timeline.

7.1 Summary of Priority Actions

A total of 22 adaptation actions have been identified as high priority. High priority actions for the four community element categories – Infrastructure, Buildings, Natural Systems and Assets, and Community – are broken down and summarized below. Action IDs are provided; the complete list of 49 adaptation actions and prioritization criteria are included in Section 7.2.

Each category also contains a synopsis, based on the priority actions, on how residents can take individual action to contribute to increasing resilience and reducing vulnerability to climate hazards.

Infrastructure

Action Infra-1. Conduct a local water resource assessment to better understand how vulnerable water supplies are and identify measures to help increase resilience if needed.

Action Infra-5. Properly inspect and maintain roads, ditches, and catch basins. This involves clearing leaf debris every spring and fall as well as a video inspection from a reputable plumber to identify any concerns or potential failures.

Action Infra-12. Employ vegetation and debris management to ensure trees and branches are far enough away from power lines to limit damage from extreme storms, wildfire, and extreme heat.

Resident Action: *Maintain your property by clearing vegetation and debris that may be blocking stormwater flow, as well as trimming large branches that may interfere with power lines.*

Buildings

Action Build-1. Install high efficiency cooling systems / better windows / better insulation to improve thermal comfort.

Action Build-2. Install sump pumps and/or backwater valves or upgrade overall site drainage.

Action Build-3. For residential properties, assess and strengthen dock anchoring systems during periods of high lake levels. Retrofit with floating style docks rather than having fixed systems to allow docks to move with varying water levels.

Action Build-4. Conduct a detailed flood risk assessment to better understand how vulnerable homes are to flooding, particularly those that are low-lying.

Action Build-6. For residential properties, monitor lake levels and adjust access accordingly when levels are low, including assessing the ability to move floating docks and boats out into water and having a temporary connecting walkway.

Action Build-9. Stormproof/windproof roofing/siding/windows and install storm shutters.

Action Build-11. Implement tree pruning around homes and buildings to prevent large branches falling onto structures.

Action Build-13. Install river rock around perimeter of homes and buildings to improve resilience to wildfire.

Action Build-15. Install metal, non-combustible roof and exterior siding to improve resilience to wildfire.

Resident Action: *Improve the resilience of your home and property to extreme events by ensuring that it is properly insulated, has a cooling system, is protected from sewer/stormwater backup, is protected from strong winds, and is resistant to fire. Additionally, ensure that your dock can withstand significant changes in lake levels.*

Natural Systems and Assets

Natural-1. Restore/plant a greater diversity of heat and drought tolerant native grass and tree species to encourage greater resilience to higher temperatures and increased drought conditions.

Natural-3. Prepare and implement a detailed Invasive Vegetation Management plan that provides best management practices (BMPs) on how to prevent, eradicate, or control the spread of invasive species.

Natural-5. Implement a tree and vegetation management program to remove standing snags and leaf litter to reduce risk from drought, to reduce fuel for wildfire, and to minimize destruction in the event of an extreme storm.

Resident Action: *Engage in climate resilient landscaping for your home including choosing heat and drought tolerant native species over ornamental varieties, becoming aware of best practices for dealing with invasive species, and removing dead plant and leaf litter.*

Community

Comm-1. Develop/assign refuge areas with additional cooling and hydration stations.

Comm-2. Implement a policy for sending staff/volunteers home on extreme heat days.

Comm-3. Ensure there is an early warning system for residents in the case of an extreme storm or wildfire event.

Comm-4. Ensure every resident has 72 hours of emergency supplies in the case of an extreme storm event.

Comm-5. Implement an accessibility / egress plan for community members to seek refuge inside Community Hall or Fire Hall if needed during an extreme storm event.

Comm-7. Develop a Wildfire Emergency Response plan for evacuation and coordination.

Comm-9. Manage air intakes with better filters (MERV-13 or higher filtration) to improve air quality during periods with high wildfire smoke concentrations.

Resident Action: *Improve your resilience to climate hazards for your own health and safety, including having at least 72 hours' worth of emergency supplies in the case of an extreme storm, understanding how best to evacuate and where to seek refuge in the case of a nearby wildfire, and improving air filtration in your home during a wildfire smoke event.*

7.2 Plan Implementation

This Plan identifies 49 actions, including 22 high priority actions, that the Summer Village of Island Lake could implement to increase its resilience to climate hazards while acknowledging existing capacity and resource limitations. Many of these actions build upon and are supported by existing practices or previously implemented programs including FireSmart.

This section provides a high-level assessment of adaptation actions based on resilience benefit, order of magnitude cost, timeline, and overall priority level. Criteria definitions used to prioritize actions are shown in Table 9 and the complete list of adaptation actions and criteria selections are shown in Table 10. By considering various criteria to establish priority in implementation, this portfolio of actions can serve as a resource for SVIL, allowing decision-makers to draw upon this list where funding, resources, and capacity allows.

Adaptation actions included in this Plan are classified according to the types shown in Figure 10, with some actions being classified as multiple types. In some cases, actions may involve partnering with other actors, participating in broader (regional) programs, and/or advocating for solutions from larger jurisdictions (e.g., the provincial government) that aim to increase the community's resilience.

Figure 10: Types of Adaptation Actions

Small to medium investments in actions that help reduce vulnerability to climate hazards can result in many social, economic, and environmental co-benefits. The actions presented in this Plan are not mandatory, but it is recommended that SVIL prioritize the implementation of these actions recognizing that the community is vulnerable to climate change and will be at increased risk of climate hazards moving forward, and that there are steps that can be taken to become more resilient to these impacts.

Table 9: Adaptation Action Criteria Definitions

Resilience Benefit		Cost		Timeline		Overall Priority Level	
Low	Action results in a modest risk reduction. This type of action is likely to be an ongoing or supplementary risk treatment option.	**$**	Low cost of implementation, < $10,000 per project.	**Short**	Low complexity project that can be completed in < 6 months. This type of project is likely to be simple and straight forward, with minimal steps involved.	**Low**	Action is a “nice-to-do” item, but may have high costs associated with it, long implementation timelines, or relatively low resilience benefit.
Medium	Action results in a moderate risk reduction. This type of action is likely to be an effective risk treatment option if implemented successfully.	**$$**	Medium cost of implementation, $10,000-$100,000 per project.	**Medium**	Medium complexity project that can be completed between 6 months and 2 years. This type of project is likely to involve more stakeholders and require more approvals, thus extending the timeline.	**Medium**	Action effectively manages a risk (or risks), though it may not necessarily treat the highest risks or have the highest risk reduction impact.
High	Action results in a significant risk reduction. This type of action is likely to be a widely accepted risk treatment option or a multi-solving solution which addresses multiple risks.	**$$$**	High cost of implementation, > $100,000 per project.	**Long**	High complexity project that is expected to take > 2 years to complete. This type of project is likely to involve multi-stakeholder processes and decisions that are beyond SVIL’s control.	**High**	Action is either a low-hanging fruit (high resilience benefit, low cost, and short timeline) or has the potential for a high return on investment through future cost avoidance (damage aversion).

Table 10: Adaptation Action Details and Prioritization

Action ID	Action Description	Action Category	Risk(s) Addressed	Resilience Benefit	Cost	Timeline	Overall Priority Level
Infra-1	Conduct a local water resource assessment to better understand how vulnerable water supplies are. If they are found to be vulnerable, then the assessment may be able to point to measures to help increase resilience (e.g., having a reservoir, deepening wells).	Further Study	1				
Infra-2	Consider trucking water in from a neighbouring community if appropriate during times of drought. Establish emergency management agreements before they are needed as surrounding communities without a water line may also need to import water.	Community Tools, Further Study	1				
Infra-3	Consider investing in a permanent municipal water supply (part of future plan as per site visit findings).	Structural	1				
Infra-4	Develop standards around landscaping to match natural environment to limit water use.	Community Tools	1				
Infra-5	Properly inspect and maintain roads, ditches, and catch basins. This involves clearing leaf debris every spring and fall as well as a video inspection from a reputable plumber. If the video inspection finds no concerns, conduct it every five years. If the video inspection shows some wear in the stormwater system, conduct it every two years. If the stormwater system is newly built, conduct the video inspection every ten years. Issues can be preventable if concerns or potential failures are identified early.	Operational, Further Study	2, 5				
Infra-6	Monitor and control vegetation within close proximity to roads and stormwater management assets (e.g., vulnerable trees or vegetation within close proximity of assets should be removed to prevent blockage/damage during extreme event).	Operational	2				

Action ID	Action Description	Action Category	Risk(s) Addressed	Resilience Benefit	Cost	Timeline	Overall Priority Level
Infra-7	Conduct stormwater analysis to identify properties which are at risk of overland flooding due to extreme precipitation events, identify measures to protect those properties, and identify evacuation routes.	Further Study	2				
Infra-8	Invest in more permanent erosion controls, such as turf reinforcement matting or rolled erosion control products to prevent degradation of water escape route.	Structural	3				
Infra-9	Invest in a higher grade asphalt binder which performs better in temperature extremes (higher priority in sun-facing areas, lower priority in shaded areas). Reach out to any reputable geotechnical group to obtain pavement specs.	Structural	4				
Infra-10	Ensure Emergency Wildfire Plan best practices are followed (FireSmart Program), including clearing debris adjacent to any infrastructure to limit the path of wildfire across the road network.	Community Tools, Operational	6				
Infra-11	Speak to utility owner(s) to ensure most up-to-date standards are met. This would entail speaking to operators to ensure maintenance and upgrade plans as well as tree-clearing policies are followed through with.	Community Tools	7				
Infra-12	Employ vegetation and debris management to ensure trees and branches are far enough away from power lines to limit damage from extreme storms, to reduce burn paths in case of wildfire, and to prevent potential risk from sagging of lines because of extreme heat.	Operational	7, 8, 9				
Build-1	Install high efficiency cooling systems / better windows / better insulation to improve thermal comfort. For homes, consider applying for funding, such as through FCM's local home-energy upgrade financing program (FCM, 2023) or	Structural	10, 11, 17, 18, 24, 25				

Action ID	Action Description	Action Category	Risk(s) Addressed	Resilience Benefit	Cost	Timeline	Overall Priority Level
	any other federal or provincial energy efficiency retrofit program (e.g., Canada Greener Homes Grant).						
Build-2	Install sump pumps and/or backwater valves or upgrade overall site drainage. For homes, consider combining with energy-efficiency measures to leverage funding, such as through FCM's local home-energy upgrade financing program (FCM, 2023).	Structural	12, 19, 26				
Build-3	For residential properties, assess and strengthen dock anchoring systems during periods of high lake levels. Retrofit with floating style docks rather than having fixed systems to allow docks to move with varying water levels.	Structural	13				
Build-4	Conduct a detailed flood risk assessment to better understand how vulnerable the community is to flood, particularly homes that are low-lying. If homes are found to be vulnerable, residents may be able to identify measures to help increase resilience as described in Build-5.	Further Study	13				
Build-5	Depending on the results from a detailed flood risk assessment as described in Build-4, if applicable, erect flood barriers for low-lying homes through either portable type systems or permanent walls.	Structural	13				
Build-6	For residential properties, monitor lake levels and adjust access accordingly when levels are low, including assessing the ability to move floating docks and boats out into water and having a temporary connecting walkway.	Operational, Structural	14				
Build-7	During periods of low lake levels, avoid pumping water from the lake or find alternate sources.	Risk Acceptance	14				
Build-8	During periods of low lake levels, assess the need to extend water lines. Low lake levels can result in a higher	Structural, Risk Acceptance	14				

Action ID	Action Description	Action Category	Risk(s) Addressed	Resilience Benefit	Cost	Timeline	Overall Priority Level
	concentration of algae and thus a higher level of filtration for domestic use is recommended.						
Build-9	Stormproof/windproof roofing/siding/windows and install storm shutters.	Structural	15, 20, 22, 27				
Build-10	Plant natural wind breaks where appropriate using cedar, poplar, or pine tree species – either individually or blended. Note that this must be carefully considered in the context of wind-driven fires (weigh out risk-benefit).	Nature-Based	15, 20, 22, 27				
Build-11	Implement tree pruning around homes and buildings to prevent large branches falling onto structures.	Operational	15, 20, 22, 27				
Build-12	Install fire breaks and external sprinklers. For homes, consider combining with energy-efficiency measures to leverage funding, for example through FCM's local home-energy upgrade financing program (FCM, 2023).	Structural	16, 21, 23, 28				
Build-13	Install river rock around perimeter of homes and buildings to improve resilience to wildfire.	Structural	16, 21, 23, 28				
Build-14	Remove high trees around perimeter of homes and buildings.	Operational	16, 21, 23, 28				
Build-15	Install metal, non-combustible roof and exterior siding to improve resilience to wildfire.	Structural	16, 21, 23, 28				
Natural-1	Restore/plant a greater diversity of heat and drought tolerant native grass and tree species to encourage greater resilience to higher temperatures and increased drought conditions. Contact a local nursery or consulting arborist to	Nature-Based	29, 30, 33, 35				

Action ID	Action Description	Action Category	Risk(s) Addressed	Resilience Benefit	Cost	Timeline	Overall Priority Level
	identify which grass and trees species are best suited to the community.						
Natural-2	If possible, implement programs to translocate native plant species to alternative (appropriate) areas which are less likely to be impacted by heat stress if die-off occurs - as controlling methods can reduce stress on the system making it more resilient to climate change.	Nature-Based	29, 30				
Natural-3	Prepare and implement detailed Invasive Vegetation Management plan that provides BMPs on how to prevent, eradicate, or control the spread of invasive species.	Community Tools	31, 38, 47				
Natural-4	Implement a planting plan to translocate trees from dense areas to more open areas. Adding varied canopy of vegetation will help reduce rain velocity (e.g., interception from taller trees).	Nature-Based	32				
Natural-5	Implement a tree and vegetation management program to remove standing snags and leaf litter to reduce risk from drought, to reduce fuel for wildfire, and to minimize destruction in the event of an extreme storm.	Operational	33, 34, 35, 52				
Natural-6	Install water irrigation system in shared green spaces. Routine watering could minimize dryness within greenspace, lessening the potential for a wildfire to start on site.	Structural	35, 52				
Natural-7	Establish a wetland stewardship group within the community to promote the benefits of the wetland ecosystems surrounding Island Lake and coordinate/implement community-led monitoring programs (wetland plant species identification, wetland boundary delineations) to better understand the impacts of climate change factors and identify actions for specific challenges facing the wetland features.	Community Tools	36, 37, 39, 40, 42, 43, 44				

Action ID	Action Description	Action Category	Risk(s) Addressed	Resilience Benefit	Cost	Timeline	Overall Priority Level
Natural-8	Manage existing stressors (e.g., sources of pollution) of the wetland features of Island Lake, ensure zoning standards omit the development of new structures/infrastructure within close proximity to wetland features.	Community Tools, Risk Acceptance	41				
Natural-9	Establish a community-led monitoring group that surveys the fish community throughout the season to better understand the impacts of climate change factors and identify actions for specific challenges facing fish and aquatic habitat.	Community Tools	45, 46, 51				
Natural-10	Depending on the results of a detailed flood risk assessment as recommended in Build-4, if applicable, establish a water level management practice (control structures like dams or dykes).	Structural	48, 49				
Natural-11	Maintain a vegetated buffer along the lakeshore to help protect water quality and quantity.	Nature-Based, Operational	50				
Natural-12	Monitor surface water quality following extreme rainfall or wildfire events and assess impact on surface water quality.	Operational	50				
Comm-1	Develop/assign refuge areas with additional cooling and hydration stations. This would likely require upgrading of facilities such as the Community Hall.	Community Tools, Risk Acceptance	53				
Comm-2	Implement a policy for sending staff/volunteers home on extreme heat days.	Risk Acceptance	53				
Comm-3	Ensure there is an early warning system for residents in the case of an extreme storm or wildfire event.	Community Tools	54, 55				

Action ID	Action Description	Action Category	Risk(s) Addressed	Resilience Benefit	Cost	Timeline	Overall Priority Level
Comm-4	Ensure every resident has 72 hours of emergency supplies (batteries, flashlights, warming blankets, etc.) in the case of an extreme storm event.	Community Tools, Risk Acceptance	54				
Comm-5	Implement an accessibility / egress plan for community members to seek refuge inside Community Hall or Fire Hall if needed during an extreme storm event.	Community Tools, Risk Acceptance	54				
Comm-6	Hire an arborist to assess the health and condition of trees around houses to identify high-risk trees that may pose potential threats to public safety and have them removed / install rigging if required.	Further Study	54				
Comm-7	Develop Wildfire Emergency Response plan for evacuation and coordination.	Community Tools, Risk Acceptance	55				
Comm-8	Plant/improve vegetation cover to mitigate air pollution from wildfires as well as to improve thermal comfort.	Nature-Based	56, 53				
Comm-9	Manage air intakes with better filters (MERV-13 or higher filtration) to improve air quality during periods with high wildfire smoke concentrations.	Structural	56				

8. MONITORING AND EVALUATION

The actions recommended in this Plan provide a path forward for the Summer Village of Island Lake to respond to climate risk and increase community resilience. This Plan and its implementation should be evaluated regularly; it is recommended that risk levels and implementation plans are assessed periodically to help understand where to prioritize future resources. An evaluation of this Plan should occur at least every five years, using the most up-to-date data available.

This Plan is based on an assessment of a longer-term (2080s) future time horizon relative to the recent historical period and does not consider the state of the climate in the short- to mid-term. Climatic changes are expected to take place over time and therefore taking action over time is recommended. Moreover, interim time horizons (e.g., 2050s) could be included as part of a future updated climate risk assessment.

Through the ongoing monitoring and evaluation process, SVIL can assess what has been achieved, what challenges have arisen, what lessons have been learned, and what new actions need to be added to the prioritized list of actions.

9. CLOSURE

Summer Village of Island Lake retained Morrison Hershfield to conduct the work described in this report, and this report has been prepared solely for this purpose.

This document, the information it contains, the information and basis on which it relies, and factors associated with implementation of suggestions contained in this report are subject to changes that are beyond the control of the author. The information provided by others is believed to be accurate and may not have been verified.

Morrison Hershfield does not accept responsibility for the use of this report for any purpose other than that stated above and does not accept responsibility to any third party for the use, in whole or in part, of the contents of this document. This report should be understood in its entirety, since sections taken out of context could lead to misinterpretation.

We trust the information presented in this report meets Client's requirements. If you have any questions or need addition details, please do not hesitate to contact one of the undersigned.

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APPENDIX A – Climate Data: Sources and Complete Profile

1. TIMEFRAMES AND CLIMATE SCENARIOS

This assessment considered two timeframes (baseline and future period) and one climate scenario (high emissions), with consideration of lifespan of assets and the current trajectory of global greenhouse gas (GHG) emissions.

1.1 Climate Projection Timeframes

Climate data has been compiled for the 1981-2010 baseline period and 2071-2100 future period, approximately 60 years into the future. Due to differences in data availability, not all climate hazard indicators are based on these exact periods; however, all data is reflective of the recent climate and end-of-century climate.

Thirty (30) years is the most common length of time used to define a climatology. The 1981-2010 historical baseline period was selected because it is generally aligned with the timeframe for which observational/station data is provided. Moreover, Environmental and Climate Change Canada (ECCC) climate normals were provided for the 1981-2010 period at the time of this assessment. The 2071-2100 future period, centred on the 2080s, was selected given the long lifespan of the infrastructure in the Village and to facilitate long-term planning.

1.2 Climate Scenario Selection

Given the uncertainty in the trajectory of GHG emission levels in the future, various emissions scenarios have been developed by the Intergovernmental Panel on Climate Change (IPCC). These emission scenarios present insight into a range of potential future climatic conditions based on the concentration of GHGs in the atmosphere. Emissions scenarios are defined by Representative Concentration Pathways (RCPs), which indicate the varying levels of radiative forcing at the top of the atmosphere depending on GHG concentrations. The higher the GHG concentration, the higher the radiative forcing, and the more the climate will change.

RCPs represent various “what-if” scenarios based on future concentrations of GHGs in the atmosphere resulting from a multitude of factors and assumptions including population growth, economic activity, energy intensity, and land use changes to name a few (ClimateData.ca, 2019). Highlights of the three main RCP scenarios are presented in Exhibit 1 below. For this risk assessment, the highest emissions scenario (RCP8.5) has been used as this is considered a conservative approach to assessing risk – particularly for assets with lifespans over longer time horizons at which point there are large differences in climate outcomes between scenarios (largest impacts under RCP8.5).

Exhibit 1: Three Main RCP Scenarios

RCP Scenario	Overview	Selection
RCP2.6	▪ Low emissions scenario ▪ Historic decarbonization efforts are made and human-caused climate change is limited but not reversed	✘

RCP Scenario	Overview	Selection
	▪ Requires global GHG emissions to peak almost immediately and sharply decline afterwards ▪ Current emissions trajectory will need to change drastically to reach this scenario	
RCP4.5	▪ Moderate emissions scenario ▪ Significant decarbonization efforts are made to avoid the most catastrophic consequences of human-caused climate change ▪ Requires global GHG emissions to peak by mid-century and sharply decline afterwards. ▪ Current emissions trajectory will need to change significantly to reach this scenario	✘
RCP8.5	▪ High emissions scenario ▪ Assumes that global GHG emissions continue to increase until the end of this century ▪ Current emissions trajectory is most aligned with this scenario based on the current global context	✓

1.3 IPCC Sixth Assessment Report (AR6) and SSPs

The IPCC is currently on its sixth assessment cycle in which it is producing the Sixth Assessment Report (AR6). The Physical Science Basis Report was released on August 9, 2021, to address the most up-to-date physical understanding of the climate system and the changing climate. In this revised edition, Shared Socioeconomic Pathways (SSPs) have replaced the RCP scenarios, with the AR6 reports having additional consideration for socioeconomic global changes (e.g., population growth, economic activity, energy intensity, and land use) up to the year 2100 (IPCC, 2022). The SSPs are intrinsically linked to and complementary to the RCP scenarios because changes in GHG concentrations are the result of the many socioeconomic factors considered, and thus in this assessment there is the use of climate data corresponding to RCP scenarios when SSP scenarios are unavailable.

2. CLIMATE DATA SOURCES

Background and documentation of the climate data sources used for the risk assessment, with consideration of historical data and future climate projections under a high GHG emissions scenario, is provided in this section.

2.1 Climate Data Portals

Climate data portals part of a national suite of publicly available tools have been used for this assessment, which include:

- ClimateData.ca (primary source of data used in this assessment)
- Climate Atlas of Canada (secondary source of data used in this assessment)

ClimateData.ca is a high-resolution climate data portal that is used to help decision makers build resilience across Canada. Data is primarily generated by the Pacific Climate Impacts Consortium (PCIC), which includes an ensemble of CMIP6 global climate model (GCM) outputs for three RCP scenarios (2.6, 4.5, and 8.5). GCMs evaluate large-scale climate conditions and are calculated at coarse spatial resolutions, which can impact their value for the projection of local-scale climate changes. PCIC has downscaled climate model projections of temperature and precipitation for use at a local scale, including indices of extremes, using the Bias-Correction / Constructed Analogues with Quantile mapping reordering method, Version 2 (BCCAQv2). More details can be found at ClimateData.ca and ClimateAtlas.ca.

Climate Atlas of Canada is an interactive tool that also provides local climate which can be readily explored in chart form and through maps and graphs. Like ClimateData.ca, GCM data is obtained from PCIC and uses the BCCAQv2 method for downscaling GCM outputs. Data is provided for two RCP scenarios – 4.5 and 8.5.

Data sourced from ClimateData.ca references a 10x6 km grid cell that covers the Summer Village of Island Lake, while data sourced from Climate Atlas references a grid cell of slightly lower resolution (approximately 10x10 km).

2.1.1 Data Limitations and Uncertainty

The data from both ClimateData.ca and Climate Atlas of Canada presented within this report depict the median (50th percentile) and mean, respectively, of the statistically downscaled data from an ensemble of climate models. The projections, representative of a range of models, have uncertainty associated with them due to natural variability and limitations of the models themselves, and thus the 10th and 90th percentiles are also provided. It is important that projections from many models (an ensemble) is used to capture a range of possible conditions.

2.1.2 Baseline Data

Modeled baseline data corrects for biases of the modeled data simulations to provide a better comparison with future projections (ClimateData.ca, 2019). Given that climate models are mathematical representations generated to simulate values over larger areas, they generate some systematic differences from observed station data (ClimateData.ca, 2019). The baseline period datasets available on ClimateData.ca are noted to exhibit similar average values and variability when compared with observed conditions for the baseline period (ClimateData.ca, 2019), and thus the modeled baseline data sets have been used for comparative purposes.

2.2 IDF_CC Tool 6.5

Intensity-Duration-Frequency (IDF) curves play an important role in municipal water management in Canada. The Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change – Version 6.5, developed by Western University, is a publicly available web-based IDF tool that provides local scale extreme rainfall data under various emissions scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5) from 2015 to 2100. IDF data under SSP5-8.5 has been used for this assessment.

This tool provides pre-loaded data from 898 Environment and Climate Change Canada (ECCC) rain stations and uses Environment Canada's IDF dataset. The tool allows users to select any rain station with 10 or more years of data and find projected IDF curves based on this baseline period data adjusted to reflect climate change projections. Importantly, the tool also allows the development of IDF curves for ungauged locations in Canada. The ungauged IDF curve estimates are extracted from a gridded dataset produced for the IDF_CC tool. Ungauged IDF data have been used for this assessment.

The IDF_CC tool provides precipitation accumulation depths for a variety of return periods (2, 5, 10, 25, 50, and 100 years) and durations (5, 10, 15, and 30 minutes and 1, 2, 6, 12, and 24 hours) for both baseline (historical) and future periods. Curves can either be presented as rainfall intensity (mm/hr) for the given return period and duration, or as total precipitation (mm).

2.2.1 Data Limitations and Uncertainty

Due to the variable ranges of available historical rainfall data, the baseline period used for projections at ungauged stations is not explicitly defined, therefore some uncertainty is associated with using this baseline data.

Projected data used from the IDF_CC tool in this assessment corresponds to the median (50^{th} percentile) value for the 2080s (2071-2100) time horizon under RCP8.5 using CMIP6 models.

The IDF_CC tool provides statistical ranges for each of the return periods and durations. Available statistics include the 25^{th} and 75^{th} percentile values from the projections, as well as the low (minimum) and high (maximum) range values.

2.3 Design Value Explorer

Design Value Explorer, developed by PCIC, provides climatic design data relevant to the National Building Code of Canada and the Canadian Highway Bridge Design Code as advisory information. As opposed to RCP scenarios, future projections are presented at specified global warming levels in °C above a baseline period (1986-2016). Snow load and rain-on-snow load projections under 3.5°C global warming above 1986-2016 levels, aligned with RCP8.5 by 2090, have been used in this assessment.

Data is extracted from a gridded dataset with a resolution of approximately 4.5 km (true at 60°N). The user can filter data projections by location. If the location of interest is not found, the user can hover over the map to select latitude and longitude coordinates, as was done for this assessment.

2.3.1 Data Limitations and Uncertainty

For projected changes, only central estimates are provided, not ranges as is the norm for climate model projections. Future versions of Design Value Explorer may include ranges of projected changes.

2.4 Additional Data Sources

There are several more complex climate hazards which are based on multiple factors and require background research. Additional data sources were used to assess climate hazards for which data was not available from the climate data portals and tools explained previously, which include the following:

- Climate Moisture Index (CMI) of Canada, provided by Natural Resources Canada (NRCan, 2017).
- Study on future changes in wind gust events on a regional scale across Canada by Cheng et al. (2014).
- 2018 study on hail climatology for Canada by the Institute of Catastrophic Loss Reduction (ICLR).
- Study on future changes in the number of days with favourable severe thunderstorm environments by Diffenbaugh et al. (2013).
- Historical wildfire hazard map of Canada, provided by Natural Resources Canada (NRCan, 2021).
- Historical average fire weather index (FWI) for Canada, provided by Natural Resources Canada (NRCan, 2023a).
- Fire history (past fire perimeters and burned areas) for Canada, provided by Natural Resources Canada (NRCan, 2023b).
- Air Quality Health Index (AQHI) records for Alberta, which includes fine particulate matter (Government of Alberta, 2023). Records for Lac La Biche, about 100 km east of SVIL, have been used in this study as it is the nearest station.

3. CLIMATE HAZARD DATA

3.1 Historical and Future Climate Hazard Data Collection and Analysis

The most current, publicly available climate information was used to guide this assessment. No primary research or additional site-specific climatological analyses (climate modeling or downscaling of climate projections) were conducted for this report. As climate science evolves and emissions trajectories shift, climate projections may change. This could result in variations in the overall climate risk profile for the community. For this reason, the assessment should be reviewed periodically to identify potential deviations resulting from newer, better climate information.

Projections corresponding to the high emissions scenario (RCP8.5 or equivalent) were selected for this analysis, as this is a conservative approach for the long remaining life of the project assets.

Exhibit 2 highlights climate hazards and their corresponding climate hazard indicators, baseline values, future projections, magnitude of changes, and percent changes. Projections are median values from climate model ensembles. The number of decimal places displayed is consistent with outputs from the various data sources used.

Exhibit 2: Climate Baseline and Projection Data

Climate Hazard	Climate Hazard Indicator	Baseline (1980-2010)	Future Projection (2071-2100)	Magnitude of Change	% Change
Change in Average Temperature	Mean annual temperature (°C)	1.9	7.5	+5.6	+295%
	Mean spring temperature (°C)	2.6	7.7	+5.1	+196%
	Mean summer temperature (°C)	15.2	21.5	+6.3	+41%
	Mean fall temperature (°C)	2.7	8.6	+5.9	+219%
	Mean winter temperature (°C)	-13.2	-6.7	+6.5	+49%
	Heating Degree Days (HDD)	5918	4230	-1688	-29%
	Cooling Degree Days (CDD)	38	412	+374	+984%
	Ice days (mean temperature <0°C)	104	74	-30	-29%
Extreme Heat	Maximum temperature (°C)	29.7	36.6	+6.9	+23%
	Days over 30°C	1	36	+35	+3500%
	Tropical nights (days with minimum temperature >20°C)	0	6	+6	-
	Number of heat waves	0.1	2.9	+3	+3550%
	Heatwave length (days)	0.3	5.4	+5	+2067%

Climate Hazard	Climate Hazard Indicator	Baseline (1980-2010)	Future Projection (2071-2100)	Magnitude of Change	% Change
Extreme Cold	Minimum temperature (°C)	-39.8	-28.4	+11.4	+29%
	Days below -15°C	72	31	-41	-57%
	Days below -30°C	11.3	1.0	-10.3	-91%
Invasive Species	Growing degree days (5°C)	1289	2442	+1153	+89%
	Degree days above 0°C	2261	3647	+1386	+61%
	Frost Days (minimum temperature <0°C)	205	152	-53	-26%
	Frost-free season length (days)	119	174	+55	+46%
Temperature Swings	Freeze-thaw cycles (days)	86	52	-34	-40%
Change in Average Precipitation	Total annual precipitation	456	501	+45	+10%
	Spring precipitation	85.4	110.9	+25	+30%
	Summer precipitation	234.4	219.1	-15	-7%
	Fall precipitation	81.7	91.7	+10	+12%
	Winter precipitation	66.0	79.4	+13	+20%
Extreme Precipitation	Max 1-day total precipitation (mm)	32	36	+4	+13%

Climate Hazard	Climate Hazard Indicator	Baseline (1980-2010)	Future Projection (2071-2100)	Magnitude of Change	% Change
	Max 5-day total precipitation (mm)	59	65	+6	+10%
	Days > 20mm	2	3	+1	+88%
	Spring Days > 20mm	0	0.4	+0.4	-
	Summer Days > 20mm	1.6	1.5	-0.1	-5%
	Fall Days > 20mm	0	0	0	-
	Winter Days > 20mm	0	0	0	-
	IDF 1-hour, 50-year storm (mm)	35.9	43.0	+7.1	+20%
	IDF 1-hour, 100-year storm (mm)	40.0	49.9	+9.8	+25%
	IDF 24-hour, 50-year storm (mm)	108.7	130.3	+21.6	+20%
	IDF 24-hour, 100-year storm (mm)	125.3	156.0	+30.7	+25%
Extreme Snowfall	50-year maximum snow load (kPa)	2.2	2.0	-0.2	-8%
Rain-on-Snow	50-year maximum rain-on-snow (kPa)	0.1	0.1	0	0%
Drought	Maximum number of consecutive dry days	25	25	0	0%
	Number of periods with 5 or more consecutive dry days	16	16	0	0%

Climate Hazard	Climate Hazard Indicator	Baseline (1980-2010)	Future Projection (2071-2100)	Magnitude of Change	% Change
	Number of dry days	233.8	234.0	+0.2	0%
	Climate moisture index	-10	-30	-20	-200%
Extreme Storm	Days w/wind gusts >70 km/h	6	7.5	+1.5	25%
	Days w/wind gusts >90 km/h	0.6	1.0	+0.4	65%
	*Hail frequency	Increasing trend	-	-	-
	Days w/severe thunderstorm environments	-	-	+1.5	-
Wildfire	Wildfire zone	Moderate/High (zone 3/4)	-	-	-
	Mean fire weather index (unitless)	5-10 (moderate)	-	-	-
	**Distance to past wildfire (km)	30	-	-	-
Wildfire Smoke	***98th percentile hourly particulate matter 2.5 concentration (µg/m3)	58.1 (moderate)	-	-	-

*Historical trend
**Closest distance to wildfire in historical period
***Based on limited historical data (most recent year, 2022-2023)

APPENDIX B – Climate Risk Assessment: Complete Results

1. RISK DISTRIBUTIONS AND SCORES

Exhibit 1: Baseline (1981-2010) Risk Profile by Element Category

Exhibit 2: Future (2080s) Risk Profile by Element Category

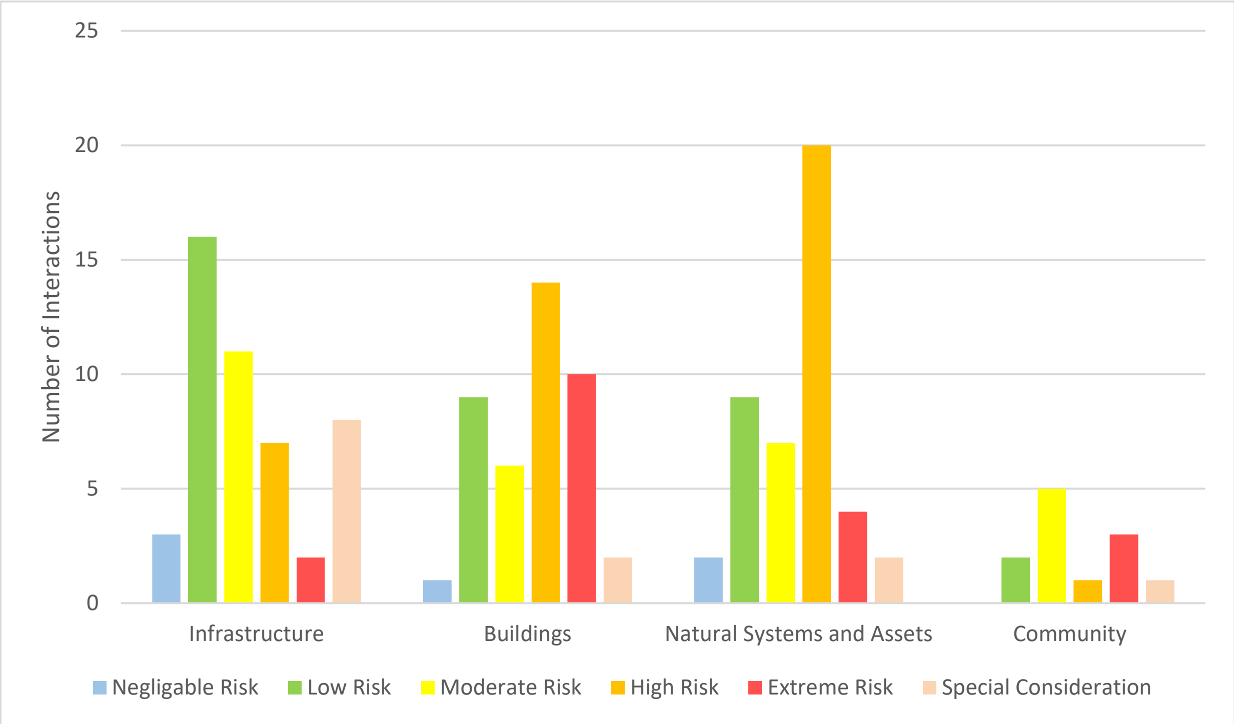

Exhibit 3: Baseline (1981-2010) Risk Profile by Climate Hazard

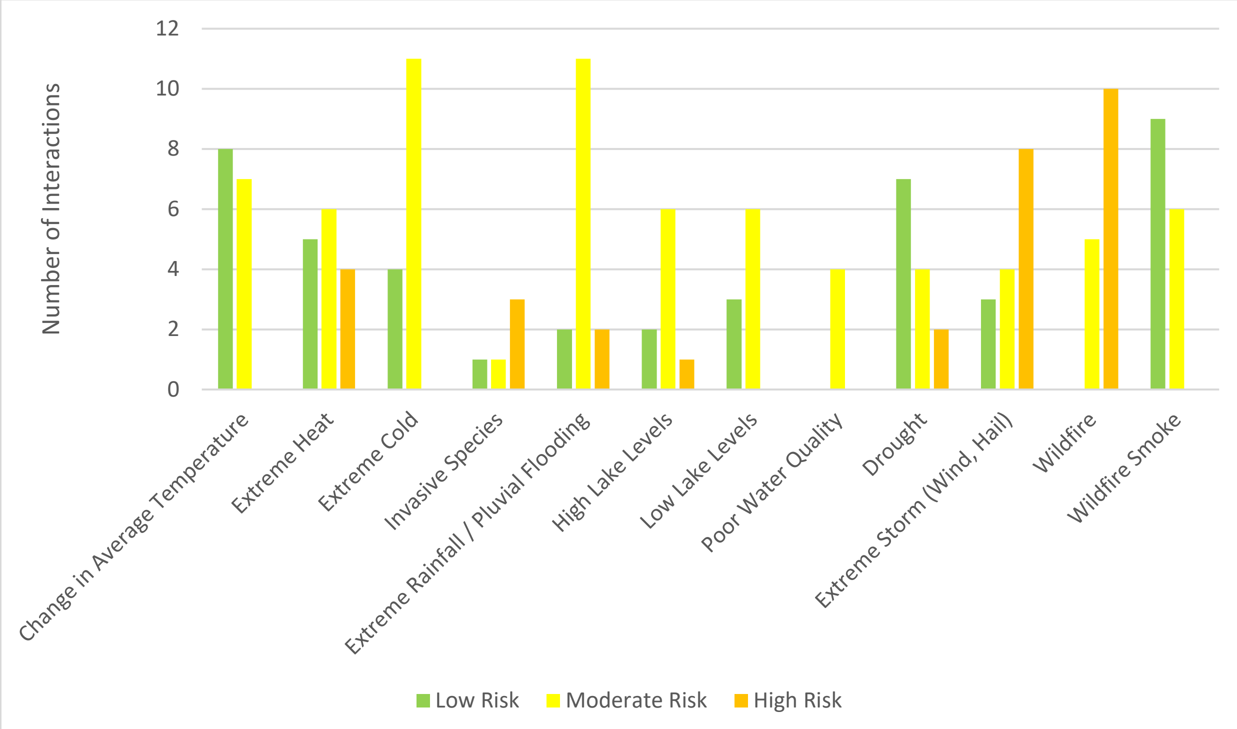

Exhibit 4: Future (2080s) Risk Profile by Climate Hazard

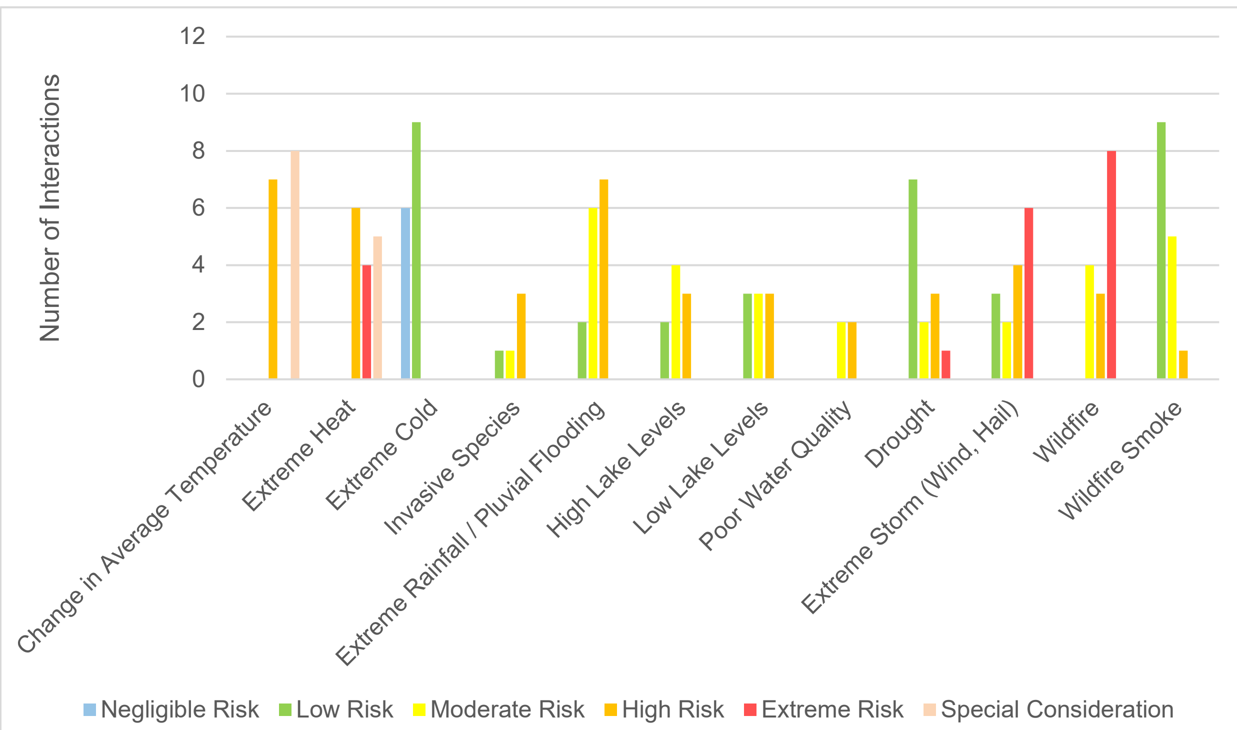

Exhibit 5: Likelihood, Consequence, and Risk Scores for Each Hazard-Element Interaction. E = Exposure, L = Likelihood, C = Consequence, and R = Risk. Moderate (yellow), High (orange), and Extreme (red) Risks are Highlighted.

Element	Time Horizon	Climate Hazard																																															
		Change in Average Temperature				Extreme Heat				Extreme Cold				Invasive Species				Extreme Rainfall / Pluvial Flooding				High Lake Levels				Low Lake Levels				Poor Water Quality				Drought				Extreme Storm (Wind, Hail)				Wildfire				Wildfire Smoke			
		E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R
Private Drinking Water Systems	Baseline	1	3	1	3	1	3	1	3	1	3	2	6	0	3	0	0	1	3	2	6	1	3	2	6	1	3	2	6	1	3	2	6	1	3	5	15	1	3	1	3	1	3	2	6	1	3	1	3
	2080s		5		5		5		5		1		2		4		0		4		8		4		8		4		8		4		8		4		20		4		4		4		8		4		4
Private Wastewater Systems	Baseline	1	3	1	3	1	3	1	3	1	3	1	3	0	3	0	0	1	3	2	6	1	3	2	6	1	3	1	3	0	3	0	0	1	3	1	3	1	3	1	3	1	3	2	6	1	3	1	3
	2080s		5		5		5		5		1		1		4		0		4		8		4		8		4		4		4		0		4		4		4		4		4		8		4		4
Stormwater Systems	Baseline	1	3	1	3	1	3	1	3	1	3	1	3	0	3	0	0	1	3	4	12	1	3	1	3	1	3	1	3	0	3	0	0	1	3	3	9	1	3	2	6	1	3	2	6	1	3	1	3
	2080s		5		5		5		5		1		1		4		0		4		16		4		4		4		4		4		0		4		12		4		8		4		8		4		4
Horizontal Infrastructure	Baseline	1	3	1	3	1	3	3	9	1	3	3	9	0	3	0	0	1	3	4	12	1	3	1	3	1	3	1	3	0	3	0	0	0	3	0	0	1	3	2	6	1	3	5	15	1	3	1	3
	2080s		5		5		5		15		1		3		4		0		4		16		4		4		4		4		4		0		4		0		4		8		4		20		4		4
Above-ground Power Lines	Baseline	1	3	1	3	1	3	3	9	1	3	3	9	0	3	0	0	1	3	1	3	0	3	0	0	0	3	0	0	0	3	0	0	0	3	0	0	1	3	4	12	1	3	4	12	1	3	1	3
	2080s		5		5		5		15		1		3		4		0		4		4		4		0		4		0		4		0		4		0		4		16		4		16		4		4
Residential Lots/Buildings	Baseline	1	3	3	9	1	3	3	9	1	3	3	9	0	3	0	0	1	3	3	9	1	3	4	12	1	3	3	9	0	3	0	0	1	3	1	3	1	3	5	15	1	3	5	15	1	3	2	6
	2080s		5		15		5		15		1		3		4		0		4		12		4		16		4		12		4		0		4		4		4		20		4		20		4		8
Commercial Lots/Buildings	Baseline	1	3	2	6	1	3	3	9	1	3	3	9	0	3	0	0	1	3	3	9	0	3	0	0	0	3	0	0	0	3	0	0	1	3	1	3	1	3	5	15	1	3	5	15	1	3	2	6
	2080s		5		10		5		15		1		3		4		0		4		12		4		0		4		0		4		0		4		4		4		20		4		20		4		8
	Baseline	1	3	1	3	1	3	1	3	1	3	1	3	0	3	0	0	1	3	2	6	0	3	0	0	0	3	0	0	0	3	0	0	1	3	1	3	1	3	5	15	1	3	5	15	1	3	2	6

Climate Hazard

Element	Time Horizon	Change in Average Temperature				Extreme Heat				Extreme Cold				Invasive Species			
		E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R
Community lots/buildings	2080s		5		5		5		5		1		1		4		0
Fire Hall	Baseline	1	3	3	9	1	3	3	9	1	3	3	9	0	3	0	0
	2080s		5		15		5		15		1		3		4		0
Community Hall	Baseline	1	3	3	9	1	3	3	9	1	3	3	9	0	3	0	0
	2080s		5		15		5		15		1		3		4		0
Trees & Terrestrial Vegetation	Baseline	1	3	2	6	1	3	4	12	1	3	3	9	1	3	4	12
	2080s		5		10		5		20		1		3		4		16
Wetlands, Riparian & Shoreline Areas	Baseline	1	3	2	6	1	3	4	12	1	3	3	9	1	3	4	12
	2080s		5		10		5		20		1		3		4		16
Fish & Aquatic Habitat	Baseline	1	3	2	6	1	3	4	12	1	3	2	6	1	3	4	12
	2080s		5		10		5		20		1		2		4		16
Community & Environment Areas	Baseline	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
	2080s		5		5		5		5		1		1		4		4
Residents	Baseline	1	3	1	3	1	3	4	12	1	3	3	9	1	3	2	6
	2080s		5		5		5		20		1		3		4		8

Element	Time Horizon	Extreme Rainfall / Pluvial Flooding				High Lake Levels				Low Lake Levels				Poor Water Quality			
		E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R
Community lots/buildings	2080s		4		8		4		0		4		0		4		0
Fire Hall	Baseline	1	3	3	9	0	3	0	0	0	3	0	0	0	3	0	0
	2080s		4		12		4		0		4		0		4		0
Community Hall	Baseline	1	3	3	9	0	3	0	0	0	3	0	0	0	3	0	0
	2080s		4		12		4		0		4		0		4		0
Trees & Terrestrial Vegetation	Baseline	1	3	3	9	1	3	2	6	1	3	2	6	0	3	0	0
	2080s		4		12		4		8		4		8		4		0
Wetlands, Riparian & Shoreline Areas	Baseline	1	3	2	6	1	3	3	9	1	3	3	9	1	3	3	9
	2080s		4		8		4		12		4		12		4		12
Fish & Aquatic Habitat	Baseline	1	3	2	6	1	3	3	9	1	3	3	9	1	3	3	9
	2080s		4		8		4		12		4		12		4		12
Community & Environment Areas	Baseline	1	3	1	3	0	3	0	0	0	3	0	0	0	3	0	0
	2080s		4		4		4		0		4		0		4		0
Residents	Baseline	1	3	2	6	1	3	2	6	1	3	2	6	1	3	2	6
	2080s		4		8		4		8		4		8		4		8

Element	Time Horizon	Drought				Extreme Storm (Wind, Hail)				Wildfire				Wildfire Smoke			
		E	L	C	R	E	L	C	R	E	L	C	R	E	L	C	R
Community lots/buildings	2080s		4		4		4		20		4		20		4		8
Fire Hall	Baseline	1	3	1	3	1	3	5	15	1	3	5	15	1	3	2	6
	2080s		4		4		4		20		4		20		4		8
Community Hall	Baseline	1	3	1	3	1	3	5	15	1	3	5	15	1	3	2	6
	2080s		4		4		4		20		4		20		4		8
Trees & Terrestrial Vegetation	Baseline	1	3	4	12	1	3	4	12	1	3	5	15	1	3	1	3
	2080s		4		16		4		16		4		20		4		4
Wetlands, Riparian & Shoreline Areas	Baseline	1	3	3	9	1	3	3	9	1	3	3	9	1	3	1	3
	2080s		4		12		4		12		4		12		4		4
Fish & Aquatic Habitat	Baseline	1	3	2	6	1	3	3	9	1	3	2	6	1	3	1	3
	2080s		4		8		4		12		4		8		4		4
Community & Environment Areas	Baseline	1	3	2	6	1	3	1	3	1	3	4	12	1	3	1	3
	2080s		4		8		4		4		4		16		4		4
Residents	Baseline	1	3	1	3	1	3	5	15	1	3	5	15	1	3	3	9
	2080s		4		4		4		20		4		20		4		12