Preliminary Climate Adaptation Strategy

Kwantlen Polytechnic University (KPU)

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1 Introduction

1.1 Adapting to Climate Change

As the Earth's temperature rises due to climate change, we can expect more extreme events (i.e. shocks, such as heat waves) and gradual changes (i.e. stresses, such as shifting precipitation patterns) that cause damage and disruption to the natural environment and human systems. Despite global efforts to reduce greenhouse gas (GHG) emissions (i.e. climate change **mitigation**), recent disasters and mounting scientific evidence make it clear that the impacts of climate change are already occurring and will continue to worsen in the future.

Because of its northern latitude, Canada is experiencing a rate of warming approximately twice the global average and has already warmed by an average of 1.7°C (and up to 2.3°C in more northern areas) since 1948, when historical records became available. Without drastic GHG emissions reductions at a global scale, the country is projected to warm by an average of up to 6°C by 2100, relative to the period from 1986 to 2005[1].

In the last five years, British Columbians experienced some of the most disruptive and costly climate-related extreme events ever recorded, each resulting in significant economic losses and human harm. Key examples include:

- **2021 atmospheric river flooding:** The costliest natural disaster in the province's history, during which after two days of intense precipitation in the region, floods and landslides caused at least five fatalities, cut off the Lower Mainland from the rest of Canada by road and rail, displaced thousands of people and killed over 640,000 farm animals[2]. Such events have been found to be made at least 60% more likely by the effects of climate change[3].
- **2021 heat dome event:** A record-breaking heat wave caused temperatures to reach over 40°C in many parts of British Columbia, with 619 heat-related deaths recorded in the province[4]. Extreme heat events of this magnitude were found to have been at least 150 times less common without human-induced climate change[5].
- **2018 wildfire season:** More than 1.3 million hectares of land burned with a total cost of over $615 million, coupled with 22 days of air quality advisories in the Lower Mainland[6].

Kwantlen Polytechnic University (KPU) is already experiencing the effects of climate change impacts across its campuses. These impacts include overheating of classrooms and mechanical equipment, leaking building envelopes, and localized flooding after heavy rainfall. These impacts will have serious consequences on KPU campuses' operations, asset management (including natural assets), service delivery, and the health and well-being of the community. As a result, decision-making and investment priorities must take these impacts into careful consideration.

Fortunately, there are ways to mitigate the impact of climate change on KPU's campuses. By taking preventative measures and preparing for extreme events (i.e. climate change **adaptation**), the costs can be substantially reduced. Recent studies from leading organizations have shown that investing in climate change adaptation can yield high rates of return on investment, with a cost-benefit ratio ranging from 2:1 to 10:1. On a global scale, estimates show that investing $1.8 trillion between 2020 and 2030 could yield $7.1 trillion in economic benefits[7]. In the North American context:

[1] Environment and Climate Change Canada. (2019). *Canada's Changing Climate Report.*
[2] Global News. (2021). 1.3 million farm animals dead due to climate change: What can B.C. do to stop the next catastrophe?
[3] Gillett et al. (2022). *Human influence on the 2021 British Columbia floods.*
[4] BC Coroners Service. (2022). *Extreme Heat and Human Mortality: A Review of Heat-Related Deaths in B.C. in Summer 2021.*
[5] Philip et al. (2022). *Rapid attribution analysis of the extraordinary heat wave on the Pacific coast of the US and Canada in June 2021.*
[6] BC Wildfire Service. (2018). *Wildfire Season Summary.*
[7] Global Commission on Adaptation. (2019). *Adapt Now: A Global Call for Leadership on Climate Resilience.*

- The American National Institute of Building Sciences (NIBS) suggests that proactive prevention measures to eliminate, reduce or adapt to climate hazards can generate savings of $6 for every $1 invested, depending on hazard type and location[8];
- The Insurance Bureau of Canada (IBC) and the Federation of Canadian Municipalities (FCM) report that the benefits of climate adaptation outweigh the costs by a ratio of 6 to 1[9].

This *Strategy* uses the terms climate change adaptation and **resilience** interchangeably. These terms refer to activities that increase the ability to prepare for, respond to and recover from the shocks and stresses associated with a changing climate, and to take advantage of the opportunities. By integrating these measures with climate mitigation efforts, organizations can strive to achieve **low carbon resilience**. Moreover, actions that bolster climate resilience can generate multiple co-benefits, such as promoting other values like human health, well-being, and biodiversity.

1.2 Project Objectives and Scope

In line with Provincial commitments for a carbon neutral public sector, KPU has reported on its climate change mitigation efforts since 2008 through its annual *Carbon Neutral Action Reports*. In addition, KPU has many existing plans and actions in place that form a strong foundation for climate change adaptation, such as the *Emergency Planning Policy* and *KPU2050 Official Campus Plan*. However, there is still a need to develop an overarching low-carbon resilience plan that outlines adaptation measures and captures co-benefits. As a first step in this process, a team of consultants and KPU staff members developed a *Preliminary Climate Adaptation Strategy* for KPU's four campuses.

The *Strategy* aims to identify:

- Climate-related hazards each campus is exposed to and the general hazard intensity today and in the future;
- The impacts these hazards pose for the campuses today and over time given information from past events and future climate projections; and
- The opportunities to intervene to enhance resilience including low-hanging fruit, synergies with planned decarbonization actions and future longer-term considerations and next steps.

The assessment was completed at the campus scale to consider how major buildings, infrastructure, and services at the KPU campuses could be broadly affected by climate impacts. It did not consider climate impacts on individual buildings or building systems (e.g. electrical system, mechanical system) or infrastructure assets in detail.

Four KPU campuses were included in the scope of this project:

- **KPU Langley** (20901 Langley Bypass, Langley, B.C., V3A 8G9),
- **KPU Richmond** (8771 Lansdowne Road, Richmond, B.C., V6X 3X7),
- **KPU Surrey** (12666 72 Avenue, Surrey, B.C., V3W 2M8), and
- **KPU Tech** (5500, 180 Street, Surrey, B.C., V3S 6R1).

The KPU Civic Plaza campus (13485 Central Avenue, Surrey, B.C., V3T 4B8) was excluded from the assessment.

It should be noted that this scope of work should only be considered as high-level guidance for decision-makers and that more detailed studies might be necessary to fully understand the consequences of the hazards. While the methodology is based on leading climate risk assessment frameworks (e.g. the *BC Climate Risk Assessment Framework*[10]), this work was not designed to serve as a comprehensive climate change resilience assessment or to fulfil funding or certification requirements.

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[8] National Institute of Building Sciences. (2017). *Natural Hazard Mitigation Saves: 2017 Interim Report.*
[9] Insurance Bureau of Canada (IBC) & Federation of Canadian Municipalities (FCM). (2019). *Investing in Canada's Future: The Cost of Climate Adaptation.*
[10] Government of BC. (2019). *Strategic Climate Risk Assessment Framework for British Columbia*.

2 Methodology

2.1 Climate Adaptation Planning Process

To inform the climate adaptation planning, a climate change risk assessment was undertaken following the general steps laid out in the *BC Climate Risk Assessment Framework*, modified to fit the context of adaptation planning for public sector organizations (see Figure 1). It also drew from the *Provincial Hazard and Risk Vulnerability Assessment (HRVA)*[11] and the *ICLEI (Local Governments for Sustainability) Building Adaptive and Resilient Communities (BARC)*[12] program.

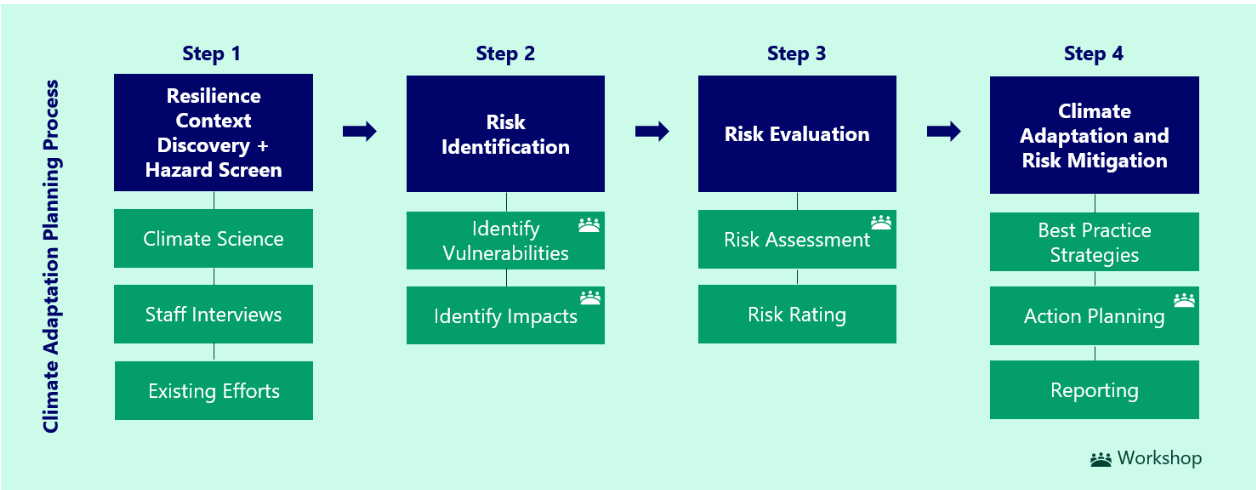

Figure 1. A four-step climate adaptation planning process was adopted for this project.

The four steps of the climate adaptation planning process are described in more detail in the following sections.

2.2 Step 1: Context Setting and Climate Hazard Exposure Screen

Step 1 involved a review of climate science and projections, staff interviews and campus visits, along with a review of existing climate adaptation efforts and related plans and policies.

2.2.1 Climate Science and Hazard Exposure Screen

Climate projections are a vital tool for climate adaptation and resilience planning. They offer insight into how the local climate is changing and what conditions we can expect in the future By understanding these projections, we can anticipate the impacts of climate change and take steps to avoid or mitigate them. Additionally, climate projections can reveal new opportunities that we can leverage to adapt and thrive in a changing world.

Weather refers to the atmospheric conditions at a given location at a given time. These conditions generally occur over a short period and are subject to frequent change.

Climate refers to the weather conditions prevailing in an area in the long term (i.e. over several decades).

Climate change refers to variations in climatic conditions over time that have been observed in the past, along with future conditions that are anticipated based on these projections.

[11] Government of BC. (2019). *Hazard, Risk & Vulnerability Analysis for Local Authorities and First Nations.*
[12] ICLEI Canada. (2017). *Building Adaptive & Resilience Communities (BARC) Program.*

2.2.1.1 Climate Projections

For this study, projections specific to the four campus locations were obtained from the Pacific Climate Impacts Consortium (PCIC) at the University of Victoria and Climate Data Canada[13] (climatedata.ca). They are based on local historical temperature and precipitation data combined with an ensemble of 12 global climate models projecting future conditions. The result is locally relevant, statistically downscaled and bias-corrected climate projections.

The extent to which the climate will change depends directly on how effectively the global community coordinates to achieve greenhouse gas (GHG) emissions reductions. Representative Concentration Pathways (RCP) are used to describe several possible GHG emissions scenarios for the 21st century and are based on factors that drive human-caused GHG emissions (e.g. population growth, technology adoption)[14]. All climate indicators presented in this report are for the RCP8.5 or "business-as-usual" scenario (Figure 2). This scenario assumes that countries around the world are unable to achieve global, coordinated action on reducing GHG emissions, and is recommended by most institutions for climate change adaptation planning as a best practice for planning for the worst, and perhaps most likely, scenario.

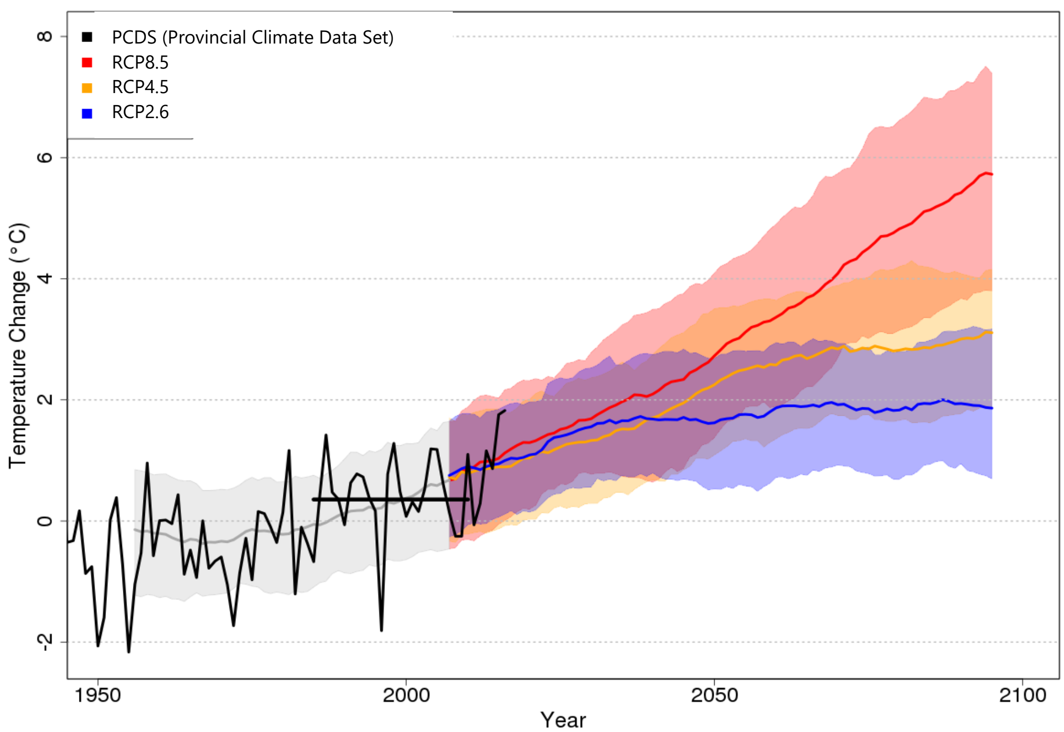

Figure 2. RCP pathways showing projected temperature changes in British Columbia under different GHG concentration scenarios based on global mitigation action (figure courtesy of PCIC)

All climate parameters used in this assessment use a historical baseline period of 1971 to 2000 (presented as the "past/baseline" in the tables) and values are averaged over this 30-year period to smooth out annual variability. Climate projections are presented for a "time slice" that represents the average for a 30-year period. The future projections are for the 2050s (2041 to 2070) and 2080s (2071 to 2100).

For each indicator, the mean values from the ensemble projections were used. Unless noted, the projections represent the change from the past/baseline period to the 2050s time slice.

[13] Climatedata.ca is a collaboration between Environment and Climate Change Canada (ECCC), the Computer Research Institute of Montréal (CRIM), Ouranos, the Pacific Climate Impacts Consortium (PCIC), the Prairie Climate Centre (PCC), and HabitatSeven.
[14] United Nations Intergovernmental Panel on Climate Change (IPCC). (2013). Anthropogenic and Natural Radiative Forcing. In: *Climate Change 2013: The Physical Science Basis*.

2.2.1.2 Other Climate Parameters and Data Sources

In addition to the climate projections described above, a range of other climate hazard parameters and other sources were used to assess the four campus sites' past/baseline and future exposure to climate-related hazards. Information sources include national- and provincial-level studies and assessments, environmental monitoring data depositories, academic articles, regional hazard mapping, and municipal strategies, plans, and bylaws. Please refer to the full climate hazard screen spreadsheet for a list of sources for each campus site. Some of the parameters include either only historical data or projected values.

2.2.1.3 Climate Hazard Exposure Screen

The assessment considered 20 climate hazards, which are listed in Table 1 below.

Table 1. Climate change hazards included in the assessment, based on the C40 City Climate Hazard Taxonomy[15]

Meteorological	**Temperature** (Gradual Increase in Temperature; Extreme Heat, Extreme Cold; Freeze-Thaw Cycles; Thawing Permafrost; Ground-level Ozone)
	Precipitation (Gradual Increase in Precipitation; Snowstorm)
	Wind (Windstorm; Tornado; Cyclone)
Climatological	**Water Scarcity and Drought**
	Wildfire (Interface Wildfire; Wildfire Smoke)
Hydrological	**Flooding** (Pluvial Flooding, Fluvial Flooding; Inundation from Sea Level Rise; Coastal Flooding, Including Storm Surge)
	Groundwater (Saltwater Intrusion and Surface Ponding)
Geophysical	**Landslide or Debris Flow**

Overall, 47 climate parameters were assessed to determine which of the assessed hazards could have significant impacts on the campus sites. The tables in Appendix A summarize the relevant climate-related hazards the campuses will be exposed to in the future (for a full set of hazards see the Climate Hazard Screen spreadsheets).

2.2.2 Existing Adaptation-related Efforts

The consultant team conducted a site visit to the four KPU campuses to gain an understanding of each campus' unique characteristics, such as location, building age and form, landscaping and campus layout, and location of mechanical equipment and infrastructure. Through this visit, the consultant team was able to evaluate the current conditions of each campus and identify any areas that may require adaptation measures. Additionally, the team was able to gather valuable insights from the facilities and operations staff on observed climate impacts and related concerns. A list of existing climate adaptation-related efforts undertaken at each campus is provided in Appendix B.

2.3 Step 2: Climate Impact and Risk Identification

Step 2 built on the learnings from Step 1 to determine the specific impacts and risks of relevant climate hazards on KPU's campuses. Based on the identified climate hazards of concern at KPU, the consulting team developed four future climate hazard event scenarios, building on the BC Climate Risk Assessment[16] scenarios and climate projections

[15] C40.org. 2015. City Climate Hazard Taxonomy.
[16] Government of BC. (2019). *Strategic Climate Risk Assessment Framework for British Columbia*.

for the Metro Vancouver area (see section 2.2.1.3). Scenarios for the 2050s helped provide a common reference point among risk assessment process participants and further defining the magnitude of the event being assessed.

In an online workshop format, staff from KPU's Facilities Services, Campus and Community Planning, Emergency Planning, Risk and Security and Administration participated in brainstorming and discussion of **potential impacts of extreme heat, wind, air quality (wildfire smoke and ground-level ozone), rainstorms and pluvial flooding, and coastal and riverine flooding**. Based on staff feedback, the impacts of changing snow and ice conditions were included in the assessment. Workshop participants were guided through an interactive exercise of identifying specific impacts and vulnerabilities of each climate scenario based on six categories: buildings, people, grounds and natural areas, transportation, parking and mobility, utilities and infrastructure, and operations and finance.

Following a plenary discussion, participants discussed existing vulnerabilities to the same future climate scenarios. **Vulnerability** is a function of three factors:

- **Exposure:** The extent to which people or systems are located where it can be affected by a climate-related shock or stress (e.g. KPU Langley is located in a designated floodplain and exposed to flood risk KPU Surrey is located at a higher elevation and away from waterways with flood risk);
- **Sensitivity:** The degree to which people or systems may be either positively or negatively impacted by changing climate conditions (e.g. individuals with pre-existing respiratory conditions are generally more sensitive to smoke events and older buildings are generally more sensitive to overheating); and
- **Adaptive capacity:** The ability to prepare for and respond to impacts and consequences (e.g. a system or a person that is already under stress has lower adaptive capacity).

Instead of rating vulnerability, as is done in some climate risk assessment methodologies, participants discussed the various areas where the four campuses have a higher degree of vulnerability to various shocks and stresses. These vulnerabilities were then carried into subsequent steps of the assessment.

2.4 Step 3: Risk Evaluation

Information on climate impacts obtained in Step 2 was used to develop discrete impact statements. Over 120 concise impact statements specific to KPU's unique context were generated and then scored for their likelihood and consequence to determine a risk score, following a simple equation (Figure 3).

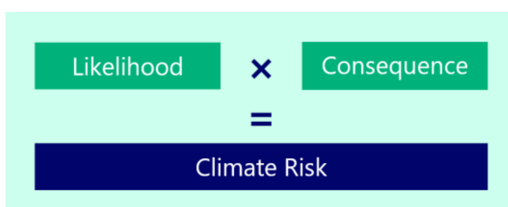

Figure 3. A climate risk score is a function of the likelihood of impact and its consequence

Likelihood ratings characterize how likely the impact could occur, based on the expected return period or probability of the hazard event occurring at KPU campuses. Likelihood ratings were assigned to each climate hazard scenario and were consistent across its impacts. Likelihood ratings on a 5-point scale were assigned for the past/baseline, the 2050s, and the 2080s.

Consequence ratings evaluate the severity of the consequences of the impact, should it occur. Consequence ratings were assigned on a 4-point scale to each impact statement under five categories. The categories were developed based on KPU's Enterprise Risk Management Framework and included consequences on **people's health, people's satisfaction, economy, environment, and service delivery**.

The average consequence score across the five consequence categories was then used, together with the likelihood rating, to determine the climate risk in the past/baseline, the 2050s and the 2080s. Each impact was assigned a risk category based on a scale from minor to extreme (see the risk score matrix in Table 2 below). Likelihood and consequence scales are provided in Appendix C.

Table 2. Risk scoring matrix, based on the KPU Enterprise Risk Management Framework

Likelihood	5	Moderate	Major	Extreme	Extreme
	4	Moderate	Moderate	Major	Extreme
	3	Minor	Moderate	Moderate	Major
	2	Minor	Minor	Moderate	Major
	1	Minor	Minor	Minor	Moderate
		1	2	3	4
		Consequence			

The purpose of the risk scoring process was to review potential climate-related impacts to KPU and help make decisions as to which impacts to focus on for resilience strategy planning based on the following Table.

Table 3. Recommended risk treatment for each risk category

Minor	**Low priority.** Monitor for changes; might require some mitigation.
Moderate	**Requires some attention.** Determine whether acceptable risk. If not, plan risk mitigation action(s).
Major	**Requires significant attention.** Take risk mitigation action(s), prepare and plan for response.
Extreme	**Priority for treatment.** Requires significant mitigations.

These prepopulated ratings were reviewed in the second online workshop with the same cross-departmental group of KPU staff. Participants were asked to ground truth and edit the ratings based on their local expertise. Early ideas on opportunities to address the highest risks were also collected during the second workshop.

Based on staff feedback, a follow-up buildings-focused discussion was hosted to further discuss the highest risks and opportunities and potential adaptation actions for buildings. It included considerations for retrofits and upgrades, new buildings and building operations.

2.5 Step 4: Climate Adaptation and Risk Mitigation Planning

Initial ideas on adaptation opportunities gathered in the second workshop and the buildings-focused session were refined, supplemented by the consulting team based on their expertise, and finally refined in the last, third online workshop with KPU staff. Participants brainstormed various interventions to reduce climate risks and take advantage of opportunities.

A list of selected examples of climate adaptation strategies taken by universities across North America was developed to support the process of generating KPU's key adaptation opportunities. The list is included in Appendix D.

2.6 Limitations

Efforts have been made throughout the planning process to verify the results with individuals who have site-specific knowledge and local expertise. However, climate change risk assessment and adaptation planning are iterative processes that continuously evolve along with the science. The consulting team acknowledges that there may be omissions due to the complexity of the issue and missed participation of some knowledge-holders.

The risk assessment process is qualitative and subjective. It serves as the initial stage in climate adaptation planning, where the first set of actions is prioritized based on identified impacts. The consulting team rated likelihood based on their expertise, ratings for similar impacts, and climate scientists' ratings of the scenarios. Consequence was also rated by the consulting team, based on their best understanding of the potential implications of each impact. Workshop participants then reviewed the ratings. Therefore, there may be biases in risk ratings, such as:

- Recently experienced impacts may be rated higher;
- Impacts of importance to those participating may be ranked higher; and
- More familiar impacts may be rated differently than less familiar impacts.

The participants in the risk assessment shape the outcomes, and the outcomes of Phase 1 do not fully consider the concerns of all stakeholders. Not all KPU departments were represented in the workshops, and no external stakeholders, rightsholders, partners or community members were involved in the process.

Stakeholder involvement is crucial for comprehensive risk assessments and adaptation planning. It helps to ensure diverse perspectives are considered, resulting in inclusive action plans. Involving stakeholders builds trust and support for the plans, leading to their success. It also identifies potential risks and vulnerabilities for more effective planning tailored to the institution's unique needs.

3 Relevant Climate Hazards for KPU Campuses

Anticipated climatic changes relevant to KPU's campuses are summarized below in six general categories: extreme heat, wind, air quality (ground-level ozone and wildfire smoke), rainstorms (and stormwater flooding), flooding (riverine and coastal), and snow and ice. These acute stresses will also be accompanied by general trends, such as increasing year-round temperatures and shifting precipitation patterns.

As the four campuses are geographically close and with only slight differences in projections, climate trends below are presented for all four, with specific values reflecting the Surrey campus, which is centrally located among the campuses (except for coastal and riverine flooding, which are reported for Richmond and Langley campuses). For a full list of climate projections pertaining to each hazard, see Appendix A. When a change from the past is described below, the *past* refers to the common baseline period used internationally, i.e. the period from 1971 to 2000.

3.1 Extreme Heat

KPU can expect an overall increase in temperatures across all seasons (average annual temperature to increase by 3°C). Warmer summers are anticipated with hotter days, more heat waves, and longer dry spells. Winter highs and lows will both be warmer.

- The hottest **summer daytime high** temperature will increase to approximately 35°C from 31°C by the 2050s and the number of days above 27°C will increase from 12 days to 44 days by the 2050s[17].
- Hot **night-time temperatures** (above 18°C) that were exceedingly rare in the past climate will occur over 34 days in the summer by the 2080s[17].
- **Cooling degree-days** (a measure of demand for air-conditioning in buildings) is projected to increase significantly by the 2050s (375% increase) and 2080s (779%), while **heating degree days** (a measure of demand for heating in buildings) will decrease by 30% and 45% in the same timeframe [17].

3.2 Air Quality

Two impacts of climate change on air quality were found to be relevant for the KPU campuses: increased concentration of ground-level ozone and increased intensity and severity of wildfire smoke events.

- The **annual mean concentration of ground-level ozone** at the site is slightly above the national average and will increase as temperatures rise. National projections show a 47% increase by the 2050s[18].
- Wildfire smoke is a current concern and **wildfire smoke instances and intensity** are expected to increase with climate change due to increases in wildfire occurrences across the province and the Pacific Northwest[19].

3.3 Rainstorm

KPU can anticipate more days of rainfall in every season except for summer. This occurrence is primarily attributed to the rising temperature levels, leading to an increase in the atmosphere's capacity to retain more moisture, thereby causing more frequent and intense rainfall. Intense and prolonged rainfall can lead to pluvial (stormwater) flooding, which was identified as a relevant hazard for all four KPU campuses.

- The amount of **rain that falls over a consecutive five-day period** is projected to increase over 10% by the 2050s and 15% by the 2080s from 120mm in the past[17].

[17] ClimateData.ca. 2022. Values for Surrey.
[18] Canadian Institute for Climate Choices. 2021. The Health Costs of Climate Change.
[19] Wotton et al. 2010. Forest Fire Occurrence and Climate Change in Canada.

- The number of **wet and very wet days** will increase. The number of wet days (with more than 20mm of rain), will increase by 19% by the 2050s and 27% by the 2080s from a baseline of 15 days[20].
- What is currently a **100-year return period rainfall event** (1% chance of occurring in any year) will become an 11-year return period event by the 2050s and a 5-year return period event by the 2080s[21].

3.4 Flooding

Fluvial (riverine) flooding exposure, identified as relevant to the Richmond and Langley campuses, depends on a range of factors in addition to climate change, many of which could be made worse by climate change.

- The **increased fall, winter, and spring precipitation** is expected to contribute to a higher risk of riverine flooding. For example, total winter precipitation is projected to increase by 9% by the 2050s and 14% by the 2080s from 1971-2000 baseline levels[20].
- Updated localized projections indicate that the **sea level is projected to rise** by 20 cm by the 2050s and by 40 cm by the 2080s relative to baseline[20].

The Langley campus is adjacent to Logan Creek, a Nicomekl River tributary, and approximately **half of the campus site is in a designated floodplain**) for a 200-year flood event[22]. A designated flood level at the site is 8.95 metres of elevation (the observed or calculated water surface elevation for the designated flood), and the flood construction level is at 9.55 metres of elevation.

- Flooding on the Nicomekl River could become more frequent with sea level rise, as the sea dam (a flood control structure) will remain closed for longer periods in the future, obstructing the flow of the river into the sea freely[23].

The Richmond campus **site is also located within a designated floodplain**[24] in the low-lying city of Richmond, which is surrounded by the Fraser River and the ocean. The Fraser River is influenced by the ocean tides, with the highest water elevation event being a winter storm at high tide, which would be larger than a Fraser River freshet (snow melt) flood event. The increased fall, winter, and spring precipitation is expected to contribute to increased spring freshet.

- Combined with one metre of **sea level rise, the flooding of the Fraser River could impact the site** by the year 2100, when a 100-year flood would reach a depth of 0.5-1 metre, and a 500-year flood would reach 1.0-2.0 metres[25]. The areas surrounding the site could be inundated by even deeper floods, further exacerbating the impacts.

The Richmond campus could also be directly impacted by inundation from sea level rise in the future, due to its low elevation and reliance on dike infrastructure to keep the area dry. Existing dike infrastructure in Richmond will need to continue to be upgraded over time to meet seismic guidelines and protect Richmond from sea level rise. The City of Richmond has a dike upgrade plan and is confident the diking infrastructure will provide protection from rising sea levels[26]. Sea level rise could also impact the groundwater levels at the site, which vary with the tide.

- By 2100, the land in Richmond is expected to **subside by 20 centimetres**, further exacerbating the impact of sea level rise[27].

[20] ClimateData.ca. 2022. Values for Surrey.
[21] Metro Vancouver. 2018. Study of the Impacts of Climate Change on Precipitation and Stormwater Management.
[22] City of Langley. 2009. Flood Elevation Bylaw, 2009, No. 2768.
[23] City of Surrey. 2019. Coastal Flood Adaptation Strategy.
[24] City of Richmond. 2008. Floodplain Designation and Protection Bylaw No. 8204.
[25] Fraser Basin Council. 2019. Lower Fraser River Freshet Flood Scenarios Maps.
[26] City of Richmond. 2019. Flood Protection Management Strategy.
[27] City of Richmond. 2022. Flood Protection Story Map.

3.5 Wind

While wind exposure is more location-specific and can depend on the geography immediately surrounding the site, wind speed intensity is expected to increase due to climate change.

- A national peer-reviewed study suggests that mean-annual **hourly wind gust events** of 70 km/h in the region could increase by 13% by the 2050s and by 23% by the 2080s from 1994-2009 baseline levels[28].
- 10- and 50-year return period **maximum hourly wind pressure** will also slightly increase (2% by the 2050s)[29].

3.6 Snow and Ice

With climate change, the hazard of snowstorms will decrease substantially, especially for locations closer to the coast. However, in the shorter term, as the amount of precipitation gradually increases, there may be a potential for more intense winter storms, even though the chances of precipitation falling as snow will be much lower due to increasing temperatures. This hazard will likely still be relevant in the 2050s, but not in the 2080s[30].

- Total annual **precipitation as snow** is to decrease by 73% by the 2050s[31].
- The maximum **rain-on-snow load** (load of snow, followed by rain) computed over a 50-year return period (2% annual exceedance probability) will decrease by 29% by the 2050s[32].

[28] Cheng et al. 2014. Possible Impacts of Climate Change on Wind Gusts under Downscaled Future Climate Conditions: Updated for Canada
[29] PCIC. 2022. Design Value Explorer.
[30] Personal Communication from Environment and Climate Change Canada staff T. Murdock.
[31] PCIC. 2022. Plan2Adapt Tool.
[32] PCIC. 2022. Design Value Explorer.

4 Climate Change Impacts and Risk

4.1 Impacts

Over 120 climate-related impacts were identified through this assessment. Table 4 provides examples of the impacts from each hazard to campus systems. A full list of impacts is provided in the companion document.

Table 4. Examples of climate related-impacts of six climate hazards to six campus systems

	Buildings and Operations	People	Grounds and Natural Areas	Transportation, Parking and Mobility	Utilities and Infrastructure	Services and Programs
Extreme Heat	Failure of mechanical systems where not designed for temperature extremes.	Increased direct health risks for vulnerable populations (e.g. very young or old, pregnant, those with pre-existing health conditions).	Risk of damage and loss of important plants and trees (cedar forest, farms, etc.) and potential for a loss or change in species on campus.	Fewer students, staff, and faculty using active and public transportation to get to and from campus as heat is unbearable, increasing reliance on single-occupancy vehicles	Important equipment for campus operation (IT/servers) is temperature sensitive and may experience issues during long periods of hot weather.	Academic program interruption and safety concerns resulting in a campus shutdown if a power outage occurred during a heat wave.
Air Quality	Smoke odour infiltrating buildings and furnishings, reducing indoor air quality and occupant comfort.	Increased incidence of mental and physical health impacts, potentially increasing first aid response needs.	Lower use of outdoor spaces, especially for outdoor sports.	Ground-level ozone impacts on health, which are worsened in areas with large expanses of pavement (surface parking lots) due to the urban heat island effect.	Increased wear and tear on systems and reduced durability.	Program studies with outdoor components (i.e. horticulture) may be impacted by reduced willingness or ability to work outside.
Rainstorm	Damage to buildings from water ingress, especially older buildings those with flat roofs and those with complex roof shapes.	Access to campus and around campus impeded by ponding/ flooding.	Changes to stream and creek flow could impact ecological composition.	Parking lots would flood or have ponding from rainwater, reducing available parking and impacting access to campus.	Plugged storm drains and overflowing detention ponds could cause flooding and damage to surrounding areas and nearby infrastructure.	External service providers may not be able to respond in timely manner, preventing remediation work and academic program delivery.
(Coastal / Riverine) Flooding*	Sewer back-ups from sinks and toilets requiring clean-up and causing damage.	Evacuation of a campus may be required in an extreme event.	Disruption to on-campus and nearby habitats and landscaped areas from floodwaters.	Impediments to campus access due to regional or local flooding.	Disruption to campus power supply (power outages) from off-campus flooding or on-campus flooding of utility rooms.	Damage to or loss of academic farm grounds and animals, impacting ability to host classes and requiring remediation.
Wind	Damage to roofing, rooftop equipment, and cladding.	Reduced ability to safely navigate campus in high winds.	Damage to or loss of on-site landscaping including trees blowing down (could lose large specimen trees).	Disruption to transportation routes and public transportation due to debris, downed trees, etc.	Power outage could knock out IT systems requiring campus shutdown.	Power outage could cause cancellation of all programs.
Snow and Ice	Structural damage and water contamination from ponding on older roofs following snow melt or rain-on-snow events.	Individuals with mobility challenges may be deterred from commuting to and across campuses.	Impacts on nearby waterbodies from salt contamination.	Decreased mobility around campus where snow clearing is not complete or during icy conditions.	Damage and service interruptions from freezing pipes, including exterior sprinklers.	Disruption of academic programming impacting staff, students and the institution's reputation.

* Applicable to KPU Richmond and KPU Langley

Overall, KPU Richmond and KPU Langley were brought up more frequently as being potentially impacted by climate hazards due to a combination of higher sensitivity to impacts and higher exposure to a range of hazards.

The KPU campuses are largely reliant on the campus community commuting from across the Lower Mainland. Access and transportation to the campuses will be impacted by many climate hazards and may favour single occupancy vehicles over transit and active transportation modes. Transportation and access issues, along with the lowered perception of indoor and outdoor comfort on campus may lead to lowered productivity, increased absenteeism, and an increased potential for labour relation conflicts.

Damage to buildings, decreased durability and higher operational burden and cost are shared impacts across hazards. Space planning may be impacted by summer heat while outdoor programming and research may be disrupted frequently by inclement weather and hazard events, such as poor air quality due to wildfire smoke.

Natural areas, landscaping and mature trees on campus (especially at KPU Surrey and KPU Langley) are exposed to a range of hazards and can also cause secondary impacts such as damage to buildings as they fall, impediments to access and increased maintenance burden over time with climate change.

4.2 Vulnerabilities

While specific vulnerabilities of the KPU campuses were not the focus of this assessment, several cross-hazard vulnerabilities were identified. Key vulnerabilities are summarized below in Table 5.

Table 5. Key vulnerabilities at KPU's four campuses

	Vulnerability	Campus
Buildings and Operations	Building mechanical systems not designed for future heat loads in all buildings (especially in upper floors, south/west-facing spaces, some labs, and spaces with internal heat gains)	All campuses
	Spaces with no mechanical cooling (including electrical vaults)	All campuses
	Limited backup power capacity	All campuses
	The Cedar building often overheats; the library building was identified as vulnerable to heat and smoke/dust	Surrey
	Older buildings	Richmond
	Reliance on external services for many acute events on campus	All campuses
People	People with pre-existing medical conditions	All campuses
	People with disabilities (physical and mental)	All campuses
	People working in labs/workshops/kitchens with heat-generating equipment	All campuses
	People who don't own single-occupancy vehicles	All campuses
	People working/learning/teaching outdoors	All campuses
	Children in future childcare facilities	Surrey
Grounds and Natural Areas	Logan Creek and surrounding areas, including parking lots	Langley
	Trees, forested (and culturally significant) areas on campus	Surrey, Langley
Transportation, Parking and Mobility	Extensive parking lots are vulnerable to flooding and urban heat island	All campuses
Services and Programs	Temperature- and moisture-sensitive research equipment and specimens	All campuses

Some new, high-efficiency buildings have anecdotally been more vulnerable to heat and poor air quality due to the inability to make nimble changes needed to maintain occupant comfort and safety. Older buildings tend to be more vulnerable to other climate hazards such as heavy rain and rain-on-snow due to old building envelopes.

KPU relies heavily on external services for day-to-day maintenance and for emergencies. External service providers may be unable to access the KPU campuses if the climate hazard event is regional in nature, or may be unavailable due to the volume of service requests. This lack of self-sufficiency during emergencies is a vulnerability. KPU campuses also have no designated areas for refuge or shelter in place in the event of a significant regional event. Backup power is limited to life safety for evacuation, critical isolated mechanical equipment (e.g. Brew Lab) and IT networks. In cases of an extended power outage, the campuses need to shut down.

Temperature-sensitive research, farms and farm animals, horticulture material, living labs, etc. are all more vulnerable to extreme temperatures and events and risk damage, loss and disruption. Many research projects and programs are in partnership and important to KPU's reputation.

Individuals that rely on transit or active transportation were described as more vulnerable to climate hazards, as were those with mobility challenges and disabilities. KPU community members living in inadequate housing and with fewer resources or social connections are also likely to be disproportionately impacted by climate hazards at home.

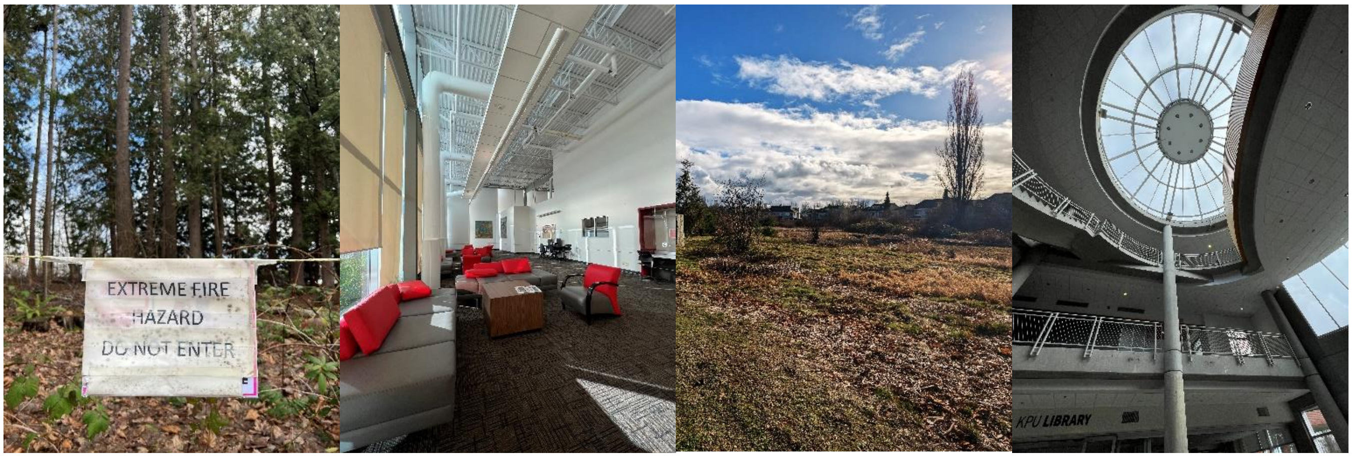

Figure 4. Examples of features at each campus identified as vulnerable (from left to right: KPU Surrey – forested area, KPU Tech – south-facing area in the main building, KPU Langley – Logan Creek and surrounding habitat, KPU Richmond – upper floor of main building under glass dome)

4.3 Risk

All 120 impact statements were rated for risk in the past/baseline, the 2050s and the 2080s. Table 6 summarizes the number of impacts of each climate hazard in each risk category for each of the three time periods.

Table 6. Summary of the number of impact statements for each category in three time periods

	Extreme Heat	Air Quality	Rainstorm	Flooding (Coastal)	Flooding (River)	Wind	Snow and Ice	
Extreme	0	0	0	0	0	0	0	**Past/baseline**
Major	0	0	0	0	0	0	0	
Moderate	7	14	3	0	7	7	7	
Minor	28	8	15	25	16	8	14	
Extreme	0	0	0	0	0	0	0	**2050s**
Major	7	14	0	0	0	0	0	
Moderate	28	8	13	0	17	15	12	
Minor	0	0	5	25	6	0	5	
Extreme	7	0	0	0	0	0	0	**2080s**
Major	23	14	3	0	7	0	0	
Moderate	5	8	14	19	16	15	0	
Minor	0	0	1	6	0	0	17	

As can be observed from Table 6, the risks associated with climate change will increase over time, with a greater proportion of risks falling into the extreme and major categories in the future compared to the past/baseline. The only hazard where risks are expected to decrease over time is snow and ice. Of all the hazards, extreme heat had the highest total number of identified impacts and was the only one noted with extreme risk for the 2080s time period. For the 2080s, the impacts of extreme heat, air quality, rainstorms, and riverine flooding were all deemed major risks. However, no risks were classified as extreme in the 2050s or in the past/baseline. Even though the impacts of coastal and riverine flooding are expected to be similar, their risk varies due to the lower likelihood of coastal floods occurring.

Impacts identified as extreme risk in the 2080s are provided in Table 7 below. For all other impacts and associated risk categories, see the companion spreadsheet document.

Table 7. Summary of impact statements rated as extreme risk

Impact Statements Rated as Extreme Risk	Climate hazard	Likelihood (2050s/2080s)	Consequence (average / rounded)
Failure of mechanical systems not designed for temperature extremes.	Extreme heat	4 / 5	2.6 / 3
Cooling for IT systems requiring manual shutdown in the case of a power outage, resulting in a business shutdown.	Extreme heat	4 / 5	2.6 / 3
Increased direct health risks for vulnerable populations (e.g. people who are very young or old, pregnant, or have pre-existing health conditions).	Extreme heat	4 / 5	2.8 / 3
Increased risk of wildfire in natural areas of campuses.	Extreme heat	4 / 5	2.6 / 3
Issues with temperature-sensitive equipment important for campus operation (IT/servers).	Extreme heat	4 / 5	2.6 / 3
Increased energy use for cooling would increase costs and impact emission reduction targets.	Extreme heat	4 / 5	2.6 / 3
Academic program interruption and safety concerns resulting in a campus shutdown if a power outage occurred during a heat wave.	Extreme heat	4 / 5	2.6 / 3

5 Key Climate Adaptation Opportunities

Over 80 opportunities were identified in collaboration with KPU staff. They are designed to apply to all KPU campuses and are presented in the following sections, grouped by campus systems. Three types of opportunities are identified:

- **current/ongoing** (opportunities or actions that are ongoing or that have been initiated),
- **quick start** (opportunities with potential to be initiated within the next one to two years), and
- **future priority** (opportunities with a high potential impact on addressing key vulnerabilities).

Important to note is that this is only the beginning of the climate resilience action planning process for KPU. The outcomes presented in this section are key adaptation opportunities (or preliminary actions) and will need to be further refined through subsequent phases, involving a broader range of internal and external stakeholders. These opportunities or actions should be assessed based on factors such as risk reduction potential, implementation ease, and return on investment. Next, the project team should conduct a follow-up evaluation of any gaps, and supplement this with further action brainstorming. Once the preferred actions are determined, they should be evaluated for any co-benefits that align with climate mitigation efforts and other KPU priorities.

5.1 Buildings and Operations

5.1.1 New Buildings

#	**Key Opportunities for Climate Adaptation** (Priority opportunities are highlighted)	**Relevant Hazard**	**Type of Opportunity**		
			Current/ Ongoing	Quick Start	Future Priority
	Potential Partners: Province of BC (e.g., Public Sector Climate Risk and Resilience Community of Practice), Consultants, Other Post-Secondary Institutions, Municipalities (to determine upcoming requirements)				
NB1	Create/incorporate resilience into sustainable building design guidelines, including measures to: • Increase energy efficiency and reduce emissions associated with building construction and operations • Reduce vulnerability to flooding (e.g. locate critical equipment above flood levels) • Integrate low-carbon transportation options • Encourage/incentivize mass timber as a base building material • Consider more resilient finishes over more conventional materials (e.g. carpet, gypsum) • Ensure suitable max indoor temperatures are modelled and addressed • Situate more permanent building occupants and areas of respite in cooler spaces and transient occupants in daylit and higher risk spaces • Explore trade-offs with high vaulted ceiling and daylight with air quality, acoustics, etc. (new construction and renovation)	All Hazards			×
NB2	Ensure new building projects use future climate energy and weather files when modelling building performance and consider design changes necessary to adapt to a changing climate (e.g. building shaft sizing)	Extreme Heat			×
NB3	Implement resilience standards/guidelines when they are adopted (e.g. the province's framework for PSOs)	All Hazards			×
NB4	Liaise with other post secondary and public sector institutions to learn what design approaches have worked elsewhere	All Hazards		×	
NB5	Integrate experience with planning and designing for future climate into new building procurement qualifications	All Hazards		×	

#	**Key Opportunities for Climate Adaptation** (Priority opportunities are highlighted)	**Relevant Hazard**	**Type of Opportunity**		
			Current/ Ongoing	Quick Start	Future Priority
NB6	Ensure master planning stages explore and take advantage of adaptation opportunities (e.g. heating/cooling load balancing)	All Hazards		×	
NB7	Identify the need for and approach to outdoor gathering spaces as a part of new buildings (vs. a whole new standalone unit), consider completely passive structures for outdoor programming (e.g. amphitheatre) and plan for flexible indoor spaces that can accommodate outdoor programming during extreme weather events	All Hazards	×		

5.1.2 Existing Building Retrofits

#	**Key Opportunities for Climate Adaptation** (Priority opportunities are highlighted)	**Relevant Hazard**	**Type of Opportunity**		
			Current/ Ongoing	Quick Start	Future Priority
	Potential Partners: Province of BC (e.g., Public Sector Climate Risk and Resilience Community of Practice), Other Post-Secondary Institutions, Municipalities (to determine upcoming requirements), BC Hydro, FortisBC, Service Contractors				
EB1	Require future climate to be incorporated in building condition assessments and into capital renewals	Extreme Heat Rainstorm		×	×
EB2	Conduct an assessment of cooling needs, study performance of buildings on very hot days and suitability of existing equipment to identify priority upgrades, targeting areas that require a specific focus during retrofits or are dependent on a single zone/system; including developing an approach for areas that are no longer serving a need. Identify criteria regarding implementation needs; apply lessons learned from COVID-19	Extreme Heat Air Quality		×	×
EB3	Explore innovative approaches to heat recovery	Extreme Heat			×
EB4	Explore low-cost options for water reuse, e.g. rain barrels	Drought		×	
EB5	Develop proactive maintenance strategies to prepare for isolated extreme weather events for operations	All Hazards		×	
EB6	Ensure future climate is integrated into all upgrade decisions: • Require an Integrated Design Process type approach in upgrade projects assessments • Include equals for resilience (explore hybrids)	Extreme Heat Rainstorm Air Quality	×	×	
EB7	Install air quality monitors to allow for easy measurement of indoor temperatures and air quality	Extreme Heat Air Quality	×	×	
EB8	Assess and correct overventilation of buildings	Extreme Heat	×	×	
EN9	Ensure envelopes are maintained via condition studies, roofing audits, and identify a funding strategy for replacement, while considering opportunities to respond to future climate (e.g. increased thermal insulation and high albedo materials on roofs)	All Hazards	×		
EB10	Identify opportunities for mechanical efficiency improvements, e.g. replace RTUs with high-efficiency units, as well as opportunities to enhance filtration levels to safeguard against wildfire smoke events (note that adding filters not always possible, need to explore capacity limits)	Extreme Heat Air Quality	×		
EB11	Engage in continuous controls optimization	Extreme Heat	×		
EB12	Develop an airtightness improvement plan	Air Quality	×		
EB13	Purchase additional standalone pumps to use during flooding events under condition of power outage	Flood Rainstorm	×		

5.1.3 Operations and Maintenance

#	Key Opportunities for Climate Adaptation (Priority opportunities are highlighted)	Relevant Hazard	Type of Opportunity		
			Current/ Ongoing	Quick Start	Future Priority
	Potential Partners: KPU's OHS and Communications departments, Faculty members (especially regarding operating times), Emergency Planning, Finance Department. Teaching & Learning, Human Resource Services, Service Contractors on Site (e.g. Cleaners & Security)				
OM1	Assess and map out current building utilization to help determine priority areas for upgrades	All Hazards		×	×
OM2	Develop a heat response management strategy, including: • A formalized program of night cooling/purging to reduce the impact of extreme heat events • Adaptations in building controls/optimization by space to account for changes in climate	Extreme Heat			×
OM3	Explore the possibility of a shift in overall campus operating times to cooler times of the day (e.g. to evening programming)	Extreme Heat			×
OM4	Explore opportunities for greater efficiency in building operations, including any needs for equipment upgrades, resources, and prediction tools, that will enable better response to heavy snow events	Snowstorm			×
OM5	Map out and change backup power generator settings/connections to include cooling for key areas, e.g. IT, electrical vault; add backup generator capacity if needed	Extreme Heat	×		×
OM6	Increase storage space for and storage of non-perishable goods to increase the ability to stock up in advance of extreme events.	Wind Rainstorm Snowstorm		×	
OM7	Ensure adequate maintenance and operations budgets that reflect increased wear and tear of mechanical systems due to extreme heat	Extreme Heat		×	
OM8	Create educational materials for staff and other building users on how best to use buildings during extreme heat or air quality events	Extreme Heat Air Quality		×	
OM9	Draft and implement a formal protocol for poor air quality events (e.g. adjust outdoor air, windows, communications, mechanical system settings to avoid system failure; increased filtration)	Air Quality		×	
OM10	Evaluate the capacity of roofs to sustain increased loads of rain on wet snow and identify resilient strategies to address it (e.g. snow bricks)	Snowstorm		×	
OM11	Develop an equipment response plan for flood events that focuses on campus operations being able to provide an effective first 48 hours response independently	Flood Rainstorm		×	
OM12	Ensure that the emergency supplies containers are regularly maintained and inspected	All Hazards	×		
OM13	Regularly inspect and clear drains, especially before and during heavy rainfall events	Flood Rainstorm	×		
OM14	Continue to implement an emergency protocol for rain- and snowfall events, monitoring weather forecast and keeping FSG staff on call, reporting on status/accessibility of campus via visual patrols	Rainstorm Snowstorm	×		

5.2 People

#	**Key Opportunities for Climate Adaptation** (Priority opportunities are highlighted)	**Relevant Hazard**	**Type of Opportunity**		
			Current/ Ongoing	Quick Start	Future Priority
	Potential Partners: WorkSafeBC, Municipalities, Health Authorities, EMS Service (Fire department, BC Ambulance, RCMP), Peer support groups and networks, KPU's OHS and Communications departments, Teaching & Learning, Human Resource Services, Employee Assistance, External Service Providers				
P1	Plan to support people working/studying from home during extreme weather events (supporting them in their homes, as well as ensuring sufficient space is available on campus with appropriate environment if they do come to campus)	All Hazards		×	×
P2	Develop and communicate a protocol for extreme heat, focusing on activities in non-air-conditioned spaces, including recommendations for instructors on optimal curriculum planning to adjust the timing of heat-intensive activities and allowing breaks in air-conditioned spaces, providing iced water for students, information on employee safety procedures by WorkSafeBC, symptoms of heat exhaustion etc.	Extreme Heat			×
P3	Explore creating a plan to support the community in case of hazard events and emergencies, including opening "cooling centres" for the public	All Hazards			×
P4	Assess the need for training to ensure adequate safety of staff, faculty and students under hazard events	All Hazards			×
P5	Align emergency weather/response plans with host municipalities' approaches and form partnerships with their responsible departments	All Hazards	×		×
P6	Develop and implement a communications strategy to educate people on expected climate changes and its impacts	All Hazards		×	
P7	Identify strategies for support staff, vendors and partners who work outdoors and ensure plans are clearly communicated ahead of extreme weather events; plan for staff redundancy	All Hazards		×	
P8	Develop a strategy to increase internal capacity and understanding of best practice approaches to supporting most vulnerable individuals on campus (students, faculty and staff) and in the community	All Hazards		×	
P9	Create a shelter-in-place protocol if people get stranded on campus due to road closures or other disasters	Flooding			
P10	Develop a protocol and communications strategy to support students living on campus during extreme weather events	All Hazards			
P11	Provide accommodations to support individuals with different needs and those who are more vulnerable (include both mental and physical disabilities/vulnerabilities)	All Hazards			
P12	Explore options to protect valuable cultural items and personal belongings (consider their location, protection, insurance, etc.)	Flooding			

5.3 Grounds and Natural Areas

#	**Key Opportunities for Climate Adaptation** (Priority opportunities are highlighted)	**Relevant Hazard**	**Type of Opportunity** Current/ Ongoing	Quick Start	Future Priority
	Potential Partners: Relevant faculty, Host First Nations, Natural Space Advisory Committee, Municipalities, Remediation contractors, External service providers, Campus & Community Planning, Master Planning Consultants for Natural Spaces, Faculty of Horticulture and others				
GN1	Explore landscape-level strategies for comprehensive adaptation and rainwater management: • Explore opportunities for stormwater retention/green infrastructure. • Rainwater management strategies to reduce water from parking areas (permeability, directing flow)	Extreme Heat Rainstorm			×
GN2	Develop a landscaping strategy and open space strategy that are synergetic and consider the benefits that natural spaces can provide to mitigate the impacts of climate hazards (including green drainage infrastructure), while ensuring that these natural spaces continue to thrive in a changing climate; and provide opportunities for people to safely enjoy the outdoors during extreme weather	Extreme Heat Rainstorm			×
GN3	Identify problematic areas for flooding and redesign/restore landscapes to minimize damage during flooding, including through the use of permeable materials	Flooding			×
GN4	In partnership with the local First Nations, develop a strategy to protect culturally significant natural areas	All hazards			×
GN5	Explore approaches to support the local flora and fauna during extreme weather to protect the biodiversity of on-campus natural areas	Extreme Heat Drought Rainstorm			×
GN6	Create a shading strategy using trees (in conjunction with fixed shading devices and built form)	Extreme Heat			×
GN7	Work with faculty to identify risks posed by invasive species and implement approach to shift/diversification of plantings	Wind Flooding			×
GN8	Identify and implement fire management protocols (e.g. Fire Smart), including communications regarding forest area use and risk of smoking around interface areas	Extreme Heat Air Quality Drought	×		×
GN9	Assess and shift plant profile around Logan Creek to better manage flood and drought	Drought Flood	×		×
GN10	Replace plants that die with drought and heat tolerant species; continue to plant drought and heat tolerant species with all new landscaping projects	Extreme Heat		×	
GN11	Research approaches to remediation following a flood or sewer overflow taken by neighbouring jurisdictions and institutions	Flooding		×	
GN12	Identify and communicate multiple egress routes	Rainstorm Flooding		×	
GN13	Identify and address tree root issues that are hindering drainage	Rainstorm	×		
GN14	Engage in proactive landscape and tree management, including watering (installing water bags) during summer drought periods to protect specimen trees, and increased maintenance to remove invasive species	Wind	×		

5.4 Transportation, Parking and Mobility

#	**Key Opportunities for Climate Adaptation** (Priority opportunities are highlighted)	**Relevant Hazard**	**Type of Opportunity**		
			Current/ Ongoing	Quick Start	Future Priority
	Potential Partners: TransLink, Student Association, Extreme Weather Committee, Local Governments, Remediation Contractors, External Service Providers, Marketing & Communications				
TP1	Explore and address impact of ground-level parking on flood risk/water ingress	Flood Rainstorm			×
TP2	Explore strategic placement of natural and structural shading elements to shade the parking lots as well as other transportation infrastructure (e.g. bike parking, transit shelters) from solar exposure, reducing heat island effect (include vegetated spaces)	Extreme Heat			×
TP3	Create stormwater resilient parking lot designs through natural overflow water capture areas	Rainstorm Flooding			×
TP4	Use permeable paver infrastructure instead of impermeable surfaces	Rainstorm Flooding			×
TP5	Encourage public transportation use during high heat and/or air quality events; work with TransLink to help improve and communicate transit options to the campus	Extreme Heat Air Quality		×	
TP6	Locate and design new EV infrastructure to reduce the likelihood of damage from flooding	Flood Rainstorm		×	
TP7	Assess the status of existing active transportation infrastructure and ensure that it is maintained/designed for future climate, to continue to play the important role of addressing climate mitigation and adaptation goals	All Hazards	×	×	
TP8	Evaluate and potentially expand the internal shuttle service as an alternate transportation option to help avoid the need for single-occupancy vehicle use between campuses	Air Quality	×		
TP9	Initiate a communications strategy to help ensure awareness of transportation options and when they are best used under different conditions (high heat, air quality, flood, snow), including when not to come to campus	All Hazards			

5.5 Utilities and Infrastructure

#	**Key Opportunities for Climate Adaptation** (Priority opportunities are highlighted)	**Relevant Hazard**	**Type of Opportunity**		
			Current/ Ongoing	Quick Start	Future Priority
	Potential Partners: BC Hydro, FortisBC, Insurance Companies, UCIPP, External Service Providers, Remediation Contractors, OHS, Campus Safety and Security, Risk & Emergency Planning, Campus & Community Planning				
UI1	Prioritize and over time transition to low-carbon backup power sources	All Hazards			×
UI2	Explore impact of wind on any decentralized energy generation (e.g. PV)	Wind			×
UI3	Assess buildings for current mechanical capacity and the need for secondary cooling (e.g. in buildings housing IT servers)	Extreme Heat			×
UI4	Conduct a hydrology study of various campuses to better understand presence of water and ideal management strategies; explore ways of keeping water on the grounds, considering on-site detention systems where possible, and look for ways to shed water from the site where necessary	Rainstorm Flooding			×

#	**Key Opportunities for Climate Adaptation** (Priority opportunities are highlighted)	**Relevant Hazard**	**Type of Opportunity**		
			Current/ Ongoing	Quick Start	Future Priority
UI5	Conduct an energy independence feasibility study and explore opportunities for on-site power generation/dual utility (e.g. cogeneration, other)	Wind Extreme heat Flooding			×
UI6	Explore back-up plans for when external service providers are unable to respond to emergencies	All Hazards		×	
UI7	Explore the need to procure portable cooling units as a backup to top up existing cooling systems in key areas (e.g. IT server rooms)	Extreme Heat		×	
UI8	Identify buildings/zones of buildings that could remain operational/independent under condition of power outage; compile a list of buildings/zones that are in need of backup power	Wind Extreme heat Flooding		×	
UI9	Update and implement a protocol for assessing and remediating post-hazard event damage, especially for events that are likely to become more frequent	Rainstorm Flooding Wind		×	

5.6 Services and Programs

#	**Key Opportunities for Climate Adaptation** (Priority opportunities are highlighted)	**Relevant Hazard**	**Type of Opportunity**		
			Current/ Ongoing	Quick Start	Future Priority
	Potential Partners: Municipalities, KPU faculty, KPU broader community, OHS, Campus Safety and Security, Risk & Emergency Planning, WorkSafeBC/Communications				
SP1	Develop an approach to ensure the health and safety of farm animals during extreme weather	All hazards			×
SP2	Establish a means of integrating research into operations (e.g. work proactively with KPU researchers to identify potential impacts from flooding to research projects, and identify potential measures to mitigate damage)	All Hazards		×	
SP3	Develop a protocol for outdoor learning programs during extreme weather events (including specifying when/where to seek refuge close to where the instruction is being conducted, so it can resume when appropriate)	All Hazards		×	
SP4	Develop a response plan in the event of a building shut down due to overheating, loss of power, air quality or other impacts to relocate programs to other spaces where possible or switch to online work/learn methods	All Hazards		×	
SP5	Identify learning spaces that cannot be replicated/taught elsewhere and prioritize them for upgrades	All hazards		×	
SP6	Map out impacts of, and identify and implement an overall strategy for, managing smoke events, following WorkSafeBC guidelines	Air Quality		×	

6 Conclusion and Next Steps

KPU's campuses are already experiencing the effects of climate change, and this will only intensify in the future. If not addressed proactively, projected gradual changes in the climate and increased frequency of extreme weather events can have a profound impact on the university's operations and the daily lives of its students, faculty, staff, and visitors. For instance, during the hotter and drier summers, the university's cooling systems will be put to the test, and students may have to contend with uncomfortable classroom and study environments. Similarly, warmer winters may require less heating, but the university will need to invest in infrastructure to manage potential flooding and snowmelt. Moreover, more frequent and severe precipitation events, such as heavy rainfall and snowstorms, could disrupt transportation, cause power outages, and lead to property damage.

Compounding impacts, for example, power outages co-occurring with – or due to – climate hazards will make responding to these threats more challenging. The KPU campuses could also be impacted by climate-related events happening elsewhere in the region. Although many of the impacts will be challenging to cope with, such as increased wildfire smoke events and heavy rainfall, there are also potential benefits like reduced heating costs and new research opportunities.

Through the development of this Preliminary Climate Adaptation Strategy, the project team identified system vulnerabilities to climate change, a broad set of impacts, and several opportunities. Impacts of greatest concern were identified to guide resource allocation and key opportunities for action were proposed. This project represents a thorough foundation for investment in climate resilience and it will be essential for KPU to continue to develop actionable adaptation strategies to mitigate the effects of climate change on its people, assets, and services. It is a crucial first step towards building resilience, ensuring the university's sustainability in the face of climate change and meeting the KPU2050 Campus Plan Vision.

6.1 Future Considerations and Recommended Next Steps

6.1.1 Equity Considerations

Vulnerability to the effects of climate change is not uniform across a population. Rather, it varies depending on a person or community's exposure to climate hazards, their sensitivity to those hazards, and their capacity and resources to adapt. As KPU works to refine, integrate and implement adaptation actions, it is vital to consider that while climate change will impact everyone in a community, some individuals will be disproportionately impacted and may struggle to recover or adapt to these impacts. Individuals and groups that may be more highly impacted by climate-related shocks and stresses include:

- Those experiencing systemic inequity, including racialized groups;
- New Canadians, including recent immigrants and refugee communities;
- People with lower incomes;
- People experiencing homelessness or poorly housed;
- Older adults;
- Pregnant women and young children; and
- Those with disabilities and pre-existing health concerns.

As described by the Urban Sustainability Directors Network (USDN), an equitable approach to climate change preparedness planning aims "*to fairly distribute the benefits and burdens of climate change and climate action through a community-driven planning process that empowers those most affected to shape the decisions that will impact their* *lives*"[33]. Engagement with a broader group of stakeholders, focusing on vulnerable populations, can improve equitable outcomes of climate adaptation planning. By involving those who could be most affected, KPU can ensure that its adaptation measures are tailored to the unique needs and concerns of different communities. This could include addressing underlying causes of inequity, empowering communities to develop and shape adaptation strategies, and addressing barriers to adaptation actions.

6.1.2 Process-based Actions

Many operational opportunities were generated through this process. Complementing them with process-based changes is important to build organizational capacity and resilience. Future questions KPU could consider include:

- How is climate risk considered in decision-making for key initiatives?
- How well-versed are staff and decision-makers about climate risks?
- How are climate risks considered in asset and financial management?
- What governance structures will support the implementation of climate action?

Actions that respond to these questions can be some of the hardest to implement as they represent a change in how things are done, but can also be instrumental in a shift to a more resilient organization.

6.1.3 Co-benefits

Low carbon resilience strategies, such as increasing green infrastructure and promoting active transportation, can not only reduce greenhouse gas emissions but also enhance community resilience. Many other co-benefits can be realized by acting on climate adaptation, such as cost savings, optimization of resources, and community livability. Integrating climate mitigation and adaptation actions with other priorities such as health and well-being, asset renewal, water quality and biodiversity makes for wise investment decisions and can address competing priorities. In future phases of work, it will be crucial to clearly identify and promote the co-benefits of climate resilience action.

6.1.4 Next Steps

Recommended next steps for the KPU are to:

- **Engage Kwantlen First Nation and other Indigenous representatives in the process.** They can be engaged from the initial discussions of recent climate impacts to identifying potential resilience actions.
- **Engage with individuals and groups likely to be most affected by the impacts of greatest concern.** Engage these groups in reviewing impacts for any missed impacts and suggesting actions.
- **Refine actions.** Review key opportunities for action with staff across departments to ensure they are accurate and align with existing initiatives and funding streams. Identify any service areas not addressed and review impacts and actions with associated staff.
- **Contrast and compare adaptation action opportunities with work that has taken place on climate change mitigation**, looking for potential crossover and synergies. Identify low-carbon resilience actions that have a high number of co-benefits.
- **Prioritize actions for implementation,** working with all participants and relying on co-benefits and other evaluation criteria.
- **Identify implementation details** and potential indicators of success for each action.
- **Integrate actions** into existing plans and/or create an integrated plan for low carbon resilience, and review it in regular intervals or when major changes to university programs or climate data emerge.

[33] Urban Sustainability Directors Network (USDN). (2017). Guide to Equitable Community-driven Preparedness Planning.

Appendix A: Relevant Climate-Related Hazards

The tables provided herein summarize the climate-related hazards relevant to each of the four KPU campuses considered in this study. For a full list of climate parameters, including those deemed not relevant to the campuses, projections for the 2080s and data sources, see the Climate Hazard Exposure Screen companion spreadsheets.

A.1 KPU Langley

Table 8. Relevant climate-related hazards and projections for KPU Langley campus

Hazard		Climate Parameter (units)	Past/baseline (1971-2000)	2050s (2041-2070)	Change to 2050s
Temperature	Gradual Increase in Temperature	**Average annual temperature** (°C)	9.8	12.9	+3.1
		Cooling degree days (CDD)	64	288.2	+350%
		Heating degree days (HDD)	3054	2154	-29%
	Extreme Heat	**Hottest day** (°C)	31.7	35.5	*+3.8*
		Days above 32°C (# of days)	0.7	9.8	+1300%
		Days above 27°C (# of days)	14	45.3	+224%
		Tropical nights (T_{min} >18°C) (# of nights)	0	4.9	*+4.9*
	Ground-level Ozone	**Ground-level ozone national trend** (ppb)	38	No data	+47%
		Annual mean concentration of ground-level ozone (ppb)	53	No data	No data
Precipitation	Gradual Increase in Precipitation	**Total annual precipitation** (mm)	1595.5	1705.7	+7%
		Total autumn precipitation (mm)	467.9	503.4	+8%
		Total winter precipitation (mm)	598.9	654.4	+9%
		Total spring precipitation (mm)	339.2	359.2	+6%
	Snowstorm	**50-year return period max. snow load** (kPa)	1.5	0.81	-46%
		50-year return period max. rain-on-snow load (kPa)	0.8	0.66	-17%
		Precipitation as snow (mm)	No Data	-50%	
Wind	Windstorm	**10-year return period max. hourly wind pressure** (kPa)	0.31	0.32	+3%
		50-year return period max. hourly wind pressure (kPa)	0.39	0.40	+2%
		Mean annual frequency of daily wind gust events of 70 km/h (days)	6	6.8	+13%
Wildfire	Wildfire Smoke	**Wildfire Occurrences**	No data	Increasing	
		Realized [fire] spread days (realized spread days)	1 (Baseline)	1.5 to 2	75%
		Percentage of days of PM2.5 concentration greater or equal to 25 μg/m³ (2009-2020) (%)	3.4 - 3.5	It is expected that wildfire smoke occurrence and severity will increase as wildfire occurrences increase.	
Flooding	Pluvial (Stormwater) Flooding	**Maximum 1-day total precipitation** (mm)	57.6	63.6	+10%
		Maximum 5-day total precipitation (mm)	136.6	149.4	+9%
		Wet days ≥ 10 mm (# of days)	54.9	57.7	+5%
		Wet days ≥ 20 mm (# of days)	18.7	22.0	+18%
		Change in annual exceedance probability (AEP) / return period for a historical 100-year return period event (%/years)	1% (100)	9% (11)	Increase in AEP from 1% to 9%.
	Fluvial (Riverine) Flooding	**Projected flood depth from a 1% AEP (100-year) Fraser River freshet flood with sea level rise following the BC Sea Level Rise Policy** (m)	Not exposed	Not exposed	Not applicable
		Projected flood depth from a 0.2% AEP (500-year) Fraser River freshet flood with sea level rise following the BC Sea Level Rise Policy (m)	Not exposed	Not exposed	Not applicable
		Exposure to a 0.5% AEP (200-year) Nicomekl River flood	Yes	No data	Not applicable

A.2 KPU Richmond

Table 9. Relevant climate-related hazards and projections for KPU Richmond campus

Hazard		Climate Parameter (units)	Past/baseline (1971-2000)	2050s (2041-2070)	Change to 2050s
Temperature	Gradual Increase in Temperature	**Average annual temperature** (°C)	10.1	13.2	*+3.1*
		Cooling degree days (CDD)	46.7	272.5	+484%
		Heating degree days (HDD)	2882	2015	-30%
	Extreme Heat	**Hottest day** (°C)	28.8	32.6	*+3.8*
		Days above 32°C (# of days)	0	1.9	+1.9
		Days above 27°C (# of days)	4.7	31.9	+579%
		Tropical nights (T_{min} >18°C) (# of nights)	0	9.9	*+9.9*
	Ground-level Ozone	**Ground-level ozone national trend** (ppb)	38	No data	+47%
		Annual mean concentration of ground-level ozone (ppb)	46	No data	No data
Precipitation	Gradual Increase in Precipitation	**Total annual precipitation** (mm)	1094.5	1176.5	+7%
		Total autumn precipitation (mm)	321.3	345.6	+8%
		Total winter precipitation (mm)	430	473.2	+10%
		Total spring precipitation (mm)	220.3	231.2	+5%
	Snowstorm	**50-year return period max. snow load** (kPa)	1.2	0.67	-44%
		50-year return period max. rain-on-snow load (kPa)	0.6	0.44	-28%
		Precipitation as snow (mm)	No data	-45%	
Wind	Windstorm	**10-year return period max. hourly wind pressure** (kPa)	0.33	0.33	+1%
		50-year return period max. hourly wind pressure (kPa)	0.41	0.42	+2%
		Mean annual frequency of daily wind gust events of 70 km/h (days)	6	6.8	+13%
Wildfire	Wildfire Smoke	**Wildfire Occurrences**	No data	Increasing	
		Realized [fire] spread days (realized spread days)	1 (Baseline)	1.5 to 2	75%
		Number of days of PM2.5 concentration greater or equal to 25 $\mu g/m^3$ (in 2015, 2017 and 2018 (# of days) *note: this parameter is different than for the other three sites*	19.8-21.5	It is expected that wildfire smoke occurrence and severity will increase as wildfire occurrences increase.	
Flooding	Pluvial (Stormwater) Flooding	**Maximum 1-day total precipitation** (mm)	50.9	56	+10%
		Maximum 5-day total precipitation (mm)	120.1	131.8	+10%
		Wet days ≥ 10 mm (# of days)	47.5	50.1	+5%
		Wet days ≥ 20 mm (# of days)	14.5	17.2	+19%
		Change in annual exceedance probability (AEP) / return period for a historical 100-year return period event (%/years)	1% (100)	9% (11)	Increase in AEP from 1% to 9%.
	Fluvial (Riverine) Flooding	**Projected flood depth from a 1% AEP (100-year) Fraser River freshet flood with sea level rise following the BC Sea Level Rise Policy** (m)	0	0	
		Projected flood depth from a 0.2% AEP (500-year) Fraser River freshet flood with sea level rise following the BC Sea Level Rise Policy (m)	0	0	Not applicable
	Sea Level Rise	**Relative sea level change** (m)	0	0.19	+0.19
	Coastal Flooding	**Potential year 2100 coastal flood risk**	Not applicable	Not applicable	Not applicable
Intrusion	Saltwater Intrusion, Surface Ponding	**Groundwater level** (m)	There are no observation wells in the vicinity of the campus site.		

A.3 KPU Surrey

Table 10. Relevant climate-related hazards and projections for KPU Surrey campus

	Hazard	Climate Parameter (units)	Past/baseline (1971-2000)	2050s (2041-2070)	Change to 2050s
Temperature	Gradual Increase in Temperature	**Average annual temperature** (^{0}C)	10.1	13.2	*+3.1*
		Cooling degree days (CDD)	63.1	299.5	+375%
		Heating degree days (HDD)	2917	2040	-30%
	Extreme Heat	**Hottest day** (°C)	30.9	34.7	*+3.8*
		Days above 32°C (# of days)	0.1	6.9	+6800%
		Days above 27°C (# of days)	11.6	43.5	+275%
		Tropical nights (T_{min} >18°C) (# of nights)	0	7	+7
	Ground-level Ozone	**Ground-level ozone national trend** (ppb)	38	No data	+47%
		Annual mean concentration of ground-level ozone (ppb)	45	No data	No data
Precipitation	Gradual Increase in Precipitation	**Total annual precipitation** (mm)	1376.1	1475.3	+7%
		Total autumn precipitation (mm)	382.2	412.3	+8%
		Total winter precipitation (mm)	497.9	547.1	+10%
		Total spring precipitation (mm)	266.3	281.3	+6%
	Snowstorm	**50-year return period max. snow load** (kPa)	1.5	0.49	-67%
		50-year return period max. rain-on-snow load (kPa)	0.8	0.57	-29%
		Precipitation as snow (mm)	No data	-73%	
Wind	Windstorm	**10-year return period max. hourly wind pressure** (kPa)	0.31	0.32	+2%
		50-year return period max. hourly wind pressure (kPa)	0.38	0.39	+2%
		Mean annual frequency of daily wind gust events of 70 km/h (days)	6	6.8	+13%
Wildfire	Wildfire Smoke	**Wildfire Occurrences**	No data	Increasing	
		Realized [fire] spread days (realized spread days)	1 (Baseline)	1.5 to 2	75%
		Percentage of days of PM2.5 concentration greater or equal to 25 µg/m³ (2009-2020) (%)	3.5-3.6	It is expected that wildfire smoke occurrence and severity will increase as wildfire occurrences increase.	
Flooding	Pluvial (Stormwater) Flooding	**Maximum 1-day total precipitation** (mm)	50.9	56	+10%
		Maximum 5-day total precipitation (mm)	120.1	131.8	+10%
		Wet days ≥ 10 mm (# of days)	47.5	50.1	+5%
		Wet days ≥ 20 mm (# of days)	14.5	17.2	+19%
		Change in annual exceedance probability (AEP) / return period for a historical 100-year return period event (%/years)	1% (100)	9% (11)	Increase in AEP from 1% to 9%.

A.4 KPU Tech

Table 11. Relevant climate-related hazards and projections for KPU Tech campus

Hazard		Climate Parameter (units)	Past/baseline (1971-2000)	2050s (2041-2070)	Change to 2050s
Temperature	Gradual Increase in Temperature	**Average annual temperature** (°C)	9.9	13	+3.1
		Cooling degree days (CDD)	64.8	294.4	+354%
		Heating degree days (HDD)	2993	2103	-30%
	Extreme Heat	**Hottest day** (°C)	31.5	35.2	+3.7
		Days above 32°C (# of days)	0.3	8.7	+2800%
		Days above 27°C (# of days)	13.4	44.8	+234%
		Tropical nights (T_{min} >18°C) (# of nights)	0	5.8	+5.8
	Ground-level Ozone	**Ground-level ozone national trend** (ppb)	38	No data	+47%
		Annual mean concentration of ground-level ozone (ppb)	53	No data	No data
Precipitation	Gradual Increase in Precipitation	**Total annual precipitation** (mm)	1488.6	1594.9	+7%
		Total autumn precipitation (mm)	467.9	503.4	+8%
		Total winter precipitation (mm)	598.9	654.4	+9%
		Total spring precipitation (mm)	339.2	359.2	+6%
	Snowstorm	**50-year return period max. snow load** (kPa)	1.3	0.71	-45%
		50-year return period max. rain-on-snow load (kPa)	0.7	0.50	-29%
		Precipitation as snow (mm)	No data	-50%	
Wind	Windstorm	**10-year return period max. hourly wind pressure** (kPa)	0.3	0.31	+2%
		50-year return period max. hourly wind pressure (kPa)	0.38	0.39	+2%
		Mean annual frequency of daily wind gust events of 70 km/h (days)	6	6.8	+13%
Wildfire	Wildfire Smoke	**Wildfire Occurrences**	No data	Increasing	
		Realized [fire] spread days (realized spread days)	1 (Baseline)	1.5 to 2	75%
		Percentage of days of PM2.5 concentration greater or equal to 25 µg/m³ (2009-2020) (%)	2.8-3.3	It is expected that wildfire smoke occurrence and severity will increase as wildfire occurrences increase.	
Flooding	Pluvial (Stormwater) Flooding	**Maximum 1-day total precipitation** (mm)	54.8	60.3	+10%
		Maximum 5-day total precipitation (mm)	128.9	141.2	+10%
		Wet days ≥ 10 mm (# of days)	51.4	54.0	+5%
		Wet days ≥ 20 mm (# of days)	16.7	19.4	+16%
		Change in annual exceedance probability (AEP) / return period for a historical 100-year return period event (%/years)	1% (100)	9% (11)	Increase in AEP from 1% to 9%.
Intrusion	Saltwater Intrusion, Surface Ponding	**Groundwater high/low level** (m)	2.9 m (above ground surface) in September, 3.3 m (above ground surface) in April.	No data	No data

Appendix B: Existing Adaptation-related Efforts

No organization or institution is starting climate change adaptation planning from scratch. Existing adaptation efforts can be found in day-to-day operations or adjustments made to procedures over time to respond to climate changes already experienced. Existing efforts to plan for or respond to climate-related events or prepare for changing conditions were reviewed as part of this assessment, including information about recently completed adaptation actions obtained from in-person site visits.

Table 12. Adaptation-related actions undertaken or underway at KPU campuses

Campus	Adaptation action	Climate hazard
KPU Langley	Upgrading chiller units for buildings where overheating was a problem (ISH research lab and Brewery lab – replacement underway; Main building West – replacement completed)	Extreme heat
	Installing improvised temporary misting units at the existing chiller for the Brewery Lab	Extreme heat
	Upgrading the louvred glass on the walkthrough between the Main buildings with solid glass panels	Extreme cold
	Installing temporary heaters on ladders to prevent sprinkler lines from freezing in the walkthrough between the Main buildings before the glass replacement was completed	Extreme cold
	Clearing drains more often during heavy rainfall events (e.g. atmospheric river event in fall 2021)	Rainstorms
	Installing water bags around trees during summer drought periods to protect specimen trees	Drought
KPU Richmond	Replacing the roof on the main building with increased thermal insulation and using high albedo materials for the flat portion of the roof	Extreme heat, extreme cold
KPU Surrey	Cooling down the coils of the condenser system on Cedar building with water, when it failed due to high outdoor temperatures (above 30°C)	Extreme heat
	Topping up cooling with other cooling systems when the geothermal cooling system (in parts of Main North and Arbutus buildings) was not keeping up with high outdoor temperatures	Extreme heat
	Topping up existing cooling systems with portable units when the main IT server rooms were at risk of overheating from high outdoor temperatures	Extreme heat
	Closing a building when it overheated from high outdoor temperatures	Extreme heat
	Installing heat curtains at high-traffic doorways to prevent cold drafts	Extreme cold
	Upgrading to higher-rating air filters during COVID-19 pandemic and maintaining the same level of ratings from there on (MERV 13)	Air quality & Wildfire smoke
	Providing emergency overnight shelter for students when the inter-campus shuttle was cancelled due to the Alex Fraser bridge closure	Flooding, Snowstorms
KPU Tech	Installing reflective solar films on the glass of all south-facing windows; installing solar panels on some south-facing windows to provide shading	Extreme heat
	Moving the admissions office away from large south-facing windows and creating a lounge to reduce overheating issues	Extreme heat

Campus	Adaptation action	Climate hazard
	Creating air flow to the electrical vault by propping the outside and inside doors open and using fans to move cool air from the hallway/outside into the vault	Extreme heat
	Adjusting the curriculum for some classes to allow a break in the air-conditioned classrooms to avoid long stretches in the non-air-conditioned workshops	Extreme heat
	Providing iced water for students during hot weather	Extreme heat
	Adjusting the timing of heat-intensive activities (welding) where possible during hot weather in the farrier barn	Extreme heat
	Remedying drainage issues in the buildings adjacent to the courtyard by installing permeable/breathable floor tiles and using the building HVAC system for removing the excess humidity from the air	Stormwater flooding
	Flushing the stormwater drainage system annually to remove the sand accumulating in the system	Stormwater flooding
	Pumping out the flood water from the shipping/receiving ramp; using a forklift to receive shipments temporarily	Stormwater flooding
	Upgrading the sealing on the hallway skylights following leakage incidents	Rainstorms
	Reducing the amount of outdoor air intake during wildfire smoke events	Wildfire smoke
System-wide	Planting more drought-tolerant species with all new landscaping projects	Drought
	Providing containers with supplies to use in a disaster or an emergency (e.g. power generators, blankets, basic provisions) for all campuses	Multiple
	Backup power supply (diesel generators) for key uses (security, basic lighting, IT servers, some wall plugs, some lab equipment), with enough fuel for at least approximately one day	Windstorms, Flooding
	Winter weather emergency protocol for cold weather/snow events, monitoring the weather forecast and FSG staff on call, reporting on status/accessibility of campus	Snowstorms, Windstorms
	Visual patrols during windstorms and heavy rain	Windstorms, Rainstorms

Appendix C: Risk Scoring and Matrix

Risk scoring matrices were adapted from KPU Enterprise Risk Management Framework (2018), including the likelihood scoring table, the consequence scoring table, and the risk matrix.

Likelihood

Likelihood of impact	**Rare**	**Unlikely**	**Possible**	**Likely**	**Certain**
Likelihood score	**1**	**2**	**3**	**4**	**5**
Frequency	Event is expected to occur less than once every 100 years.	Event is expected to occur about once every 51-100 years.	Event is expected to occur about once every 11-50 years.	Event is expected to occur about once every 3-10 years.	Event is expected to occur every 2 years or more frequently.
Probability	Annual chance <1%	1% ≤ annual chance < 2%	2% ≤ annual chance < 10%	10% ≤ annual chance < 50%	Annual chance ≥ 50%

Labels of likelihood categories adapted from KPU Enterprise Risk Management Framework (2018)

Consequence

Consequence of impact		**Low**	**Medium**	**High**	**Very High**
Consequence score		**1**	**2**	**3**	**4**
People	Impacts on student and staff mental and physical health	Localized or off-campus injury or harm Minimal injury or harm, limited fear/anxiety	Single campus-wide injury or harm. Managed through existing processes Localized fear and anxiety	Multiple campus-wide injuries or harm, external medical involvement required Temporary widespread fear and anxiety	All campus-wide major multiple injuries or harm Widespread, long-term psychological impacts
People	Impacts on staff recruitment, morale, retention and productivity; student satisfaction and productivity	Potential impact on productivity and absenteeism of staff and student satisfaction and productivity	Discomfort or distraction impeding core job responsibilities or pursuit of studies for the most exposed staff/students (limited)	High number of complaints, absenteeism and productivity impacting delivery of isolated programs/services	Majority of students expressing dissatisfaction Recruitment and retention significantly impacted
Economy	Impacts KPU physical assets and financial resources such as the following: research grants, tuition, endowment, budget, investments, credit rating etc.	<$250K	$250K-$500K	$500K - $1M	>$1M

Consequence of impact		Low	Medium	High	Very High
Consequence score		1	2	3	4
Environment	Impacts on landscape, grounds, natural areas (on-site and surrounding) and cultural areas of significance	Minimal or no impacts expected	Minor short-term impacts requiring increased attention and some restoration	Damage impacting ecosystems, aesthetics, cultural sites and use Restoration is expensive and time-consuming	Significant prolonged impacts or reoccurring impacts wherein restoration to same is not possible
Service Delivery	Impacts on the ability to manage day-to-day programs, projects and efficient and effective use of resources	Minor difficulty in delivering program or service	Change management required to deliver program or service	Inability to deliver on key aspects of program or service	Inability to deliver on program or service

Consequence matrix adapted from KPU Enterprise Risk Management Framework (2018), based on severity of impact categories

Risk

Likelihood					
	5	Moderate	Major	Extreme	Extreme
	4	Moderate	Moderate	Major	Extreme
	3	Minor	Moderate	Moderate	Major
	2	Minor	Minor	Moderate	Major
	1	Minor	Minor	Minor	Moderate
		1	2	3	4
		Consequence			

Consequence matrix adapted from KPU Enterprise Risk Management Framework (2018)

Risk Classification	Recommended Risk Treatment
Minor	**Low priority.** Monitor for changes; might require some mitigation.
Moderate	**Requires some attention.** Determine whether acceptable risk. If not, plan risk mitigation action(s).
Major	**Requires significant attention.** Take risk mitigation action(s), prepare and plan for response.
Extreme	**Priority for treatment.** Requires significant mitigations.

Appendix D: Best Practices for Campus Resilience Strategies

This table includes climate resilience actions and strategies, as identified by selected universities in Canada and the United States in their climate plans. It can be used by KPU in its climate adaptation planning efforts. See page 38 for sources.

Hazard Addressed	Actions/Goals	Source(s)
All Hazards	Identify opportunities for water & resource independence to increase resilience and reduce reliance on external infrastructure.	*2*
All Hazards	Update emergency response and operations plans to consider and address climate change impacts.	*2*
All Hazards	Identify back-up power system needs and/or redundancies. Prioritize back-up power supply to critical equipment.	*5* *6*
All Hazards	Encourage working from home to reduce dependency on transportation.	*5, 6, 10, 11*
All Hazards	Use nature-based solutions to improve infrastructure on campus and incorporate natural assets into asset management.	*5*
All Hazards	Support systems for non-electronic communication that require no electricity or internet, such as emergency wayfinding signage.	*8*
All Hazards	Fundraise for Climate Action.	*1*
All Hazards	Update emergency Operations Plans (helps community understand how climate crisis outcomes are related to emergency situations).	*1*
All Hazards	Expand outreach & marketing to inform the community about the potential impacts of climate change and ways to adapt.	*1*
All Hazards	Regularly report on climate resilience metrics in planning, design, construction & operational capacities.	*2*
All Hazards	Adopt a value system such that the value of resilience can be included in Life Cycle Cost Analysis.	*2*
All Hazards	Develop an Essential Persons Plan for those who would need to stay on site during a disaster event.	*5*
All Hazards	Dedicate a team towards the progression of climate resiliency on campus.	*9*
All Hazards	Promote more meaningful and purposeful recognition of the land. Create spaces for refuge and rest through Indigenous practices.	*5*
All Hazards	Formalize potential arrangements and connections of labour sharing between campuses.	*5*
Air Quality	Install filters suited to meet a building's level of critical classification during a wildfire scenario.	*5*
Air Quality	Upgrade building envelope to decrease air filtration demand.	*5*
Air Quality	Monitor indoor air quality for pollutants.	*6*
Air Quality	Design new buildings with specific measures to minimize occupant exposure to wildfire smoke, such as main entrances on opposite side from main wind exposure.	*8*
Air Quality	Designate and equip indoor clean air respite centers to protect the most vulnerable from hazardous air pollution.	*8*
Air Quality Extreme Heat	Replace mechanical equipment with higher efficiency equipment, optimally sized for service area and to meet long-term future needs.	*5* *6*
Extreme Heat Air Quality	Asses buildings in terms of occupancy, HVAC system and heating & cooling to identify most valuable spots to improve building envelope & optimize systems.	*5*

Hazard Addressed	Actions/Goals	Source(s)
Extreme Heat	Plan for heat island effect mitigation by increasing shading of walkways & buildings through strategic tree planting & architectural interventions.	*4, 5, 6, 10*
Extreme Heat	Update building requirements to suite the increase in cooling demand to come from an increase in global temperature, focusing on passive cooling methods.	*4, 5, 6, 10, 11*
Extreme Heat	Re-insulate service rooms to reduce load on cooling & heating system.	*7*
Extreme Heat Drought	Select drought and heat tolerant species to be planted.	*5*
Drought	Convert irrigation spray nozzles to those that are more efficient.	*1*
Drought	Develop a system to use reclaimed water for non-potable purposes, such as irrigation.	*1, 8*
Drought	Evaluate alternative water source options for non-potable water (e.g. rainwater for irrigation).	*6, 11*
Drought Flooding Freeze/thaw cycles	Review all pipe locations to determine level of vulnerability.	*11*
Heavy Rainfall	Use stormwater detention to capture flooding and detain some storm events to prevent overland flows that could cause damage to the natural & built environments.	*3, 11*
Heavy Rainfall	Identify buildings at risk of exterior (primarily roof) drain flooding.	*5*
Heavy Rainfall	Ensure all exterior drains and catch basins are regularly cleared and cleaned & have them check prior to major storm events. Prioritise those in parking lots and near buildings (particularly building entrances).	*5*
Heavy Rainfall	Use future rainfall projections (updated IDF curves) when designing new buildings to ensure future heavy rainfall volumes can be managed.	*5, 6*
Heavy Rainfall	Assess buildings with poor envelope seals and perform necessary upgrades to prevent future leaks.	*5*
Heavy Rainfall	Increase use of raingardens and stormwater management systems to infiltrate overland flooding. Develop and execute a Stormwater Management Plan.	*5*
Heavy Rainfall	Integrate Low Impact Development elements, such as permeable pavement and bioswales, into new projects where it is feasible.	*8, 10, 11*
Heavy Rainfall	Reduce erosion through landscaping strategies and green infrastructure.	*11*
Heavy Rainfall	Establish wetland restoration projects to increase flood buffers, enhance water retention, and improve water quality.	*11*
Heavy Rainfall Coastal Flooding	Identify equipment that is in current or future floodplain and devise a relocation plan.	*11*
Coastal Flooding	Use sea level rise and future coastal flooding projections to avoid construction of new buildings in future flood-prone zones.	*6*
Heavy Rainfall Drought	Develop on-site wastewater treatment.	*11*
Heavy Snowfall	Identify roofs and roof equipment at risk from heavy snow, rain, and wind and undertake preventative maintenance and heat tracing installation where appropriate.	*5*
Heavy Snowfall	Analyze the Return on Investment of snowmelt system for integration/expansion.	*11*
Wildfire	Construct new buildings with and upgrade existing buildings to have fire-resistant exterior walls and roofs.	*5*
Wildfire	Take steps to reduce wildfire risk (e.g. clear deadfall, prevent accumulation of dead grass).	*5*
Windstorm	Have dead trees cut down to avoid falling trees during heavy windstorms.	*5, 6, 10*
Windstorm	Remove all unused equipment from roofs and ensure what remains is secured properly and is regularly inspected.	*5*

Sources		
	Document Title and Link	Notes
1	California State University, Long Beach - Climate Action & Adaptation Plan 2022	- Actions are split into Mitigation & adaptation (some are considered in both capacities) - Adaptation actions each list vulnerabilities considered by action (Overall list has: Extreme heat, floods, air pollution, drought, educational mission & wellness)
2	University of Utah (U of U) Resilience Actions - Climate Change Action Plan	Document prepared by Introba.
3	UBC Integrated Stormwater Management Plan	- A plan put in place at UBC to ensure the campus is able to respond to and control the increase in stormwater that will be seen in the future, as a result of climate change.
4	UBC Vancouver Campus - Climate Action plan 2030	- Document details primarily methods to reduce impact, but also includes a section regarding adaptation. - Document also refers to their Climate Ready Requirements for UBC Buildings document, which was recently updated as a part of an adaptation plan
5	Simon Fraser University (SFU) Climate Change Risk Assessment	Document prepared by Introba.
6	John Hopkins University (JHU) Sustainability Plan - Climate Adaptation Report	Document prepared by Introba.
7	University of Oregon - Emissions Reductions Actions	See *Steam tunnel re-insulation project*
8	Cal Poly Humboldt - Climate Action Plan 2.0	See *Climate Resilience Plan* section
9	Massachusetts Institute of Technology - MITOS In Depth: Fast Forward Campus Climate Commitments	See *Resiliency* section
10	University of Illinois Chicago - STRATEGY 7.0 Climate Resilience	
11	Rochester Institute of Technology - Climate Action Plan	