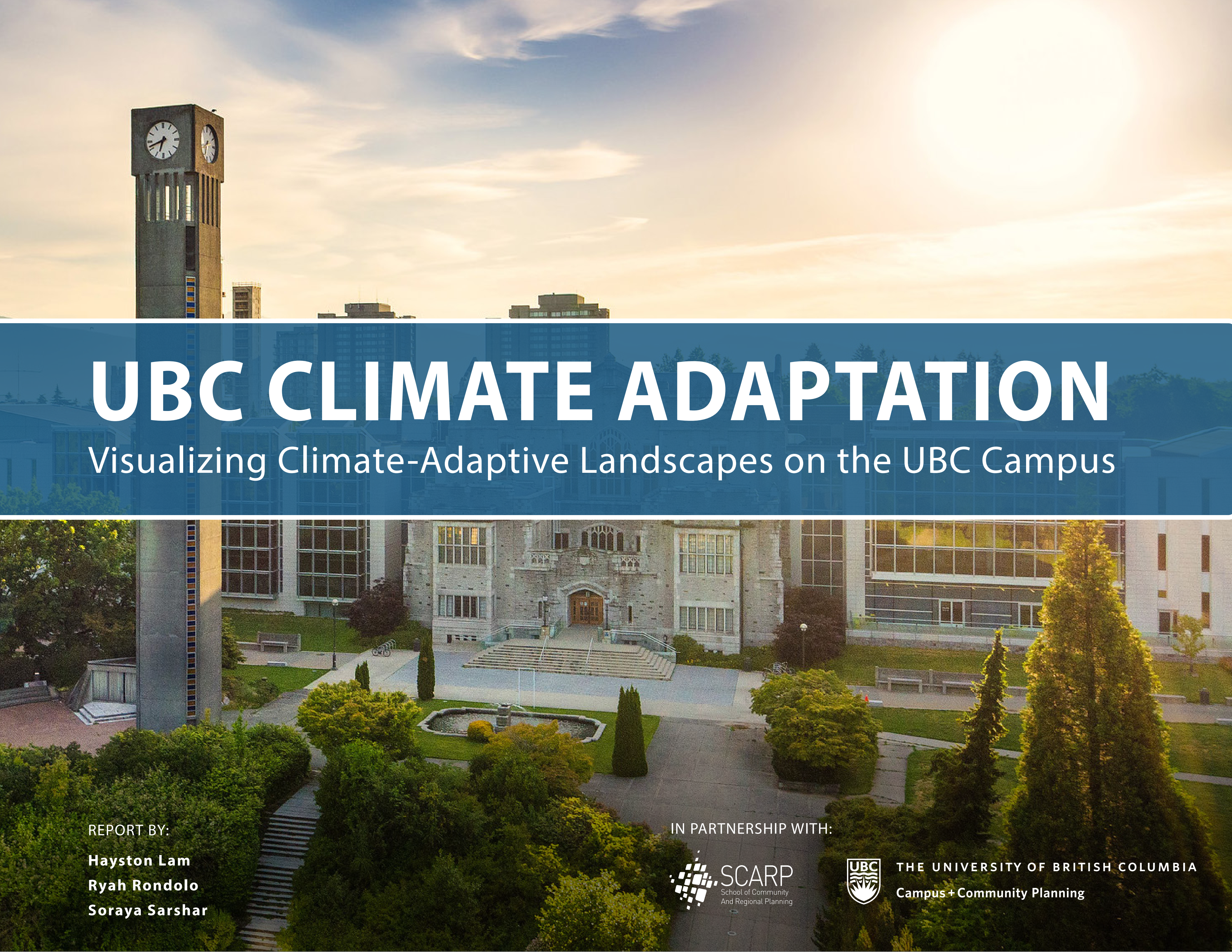

UBC CLIMATE ADAPTATION

Visualizing Climate-Adaptive Landscapes on the UBC Campus

REPORT BY:

Hayston Lam
Ryah Rondolo
Soraya Sarshar

IN PARTNERSHIP WITH:

SCARP School of Community And Regional Planning

THE UNIVERSITY OF BRITISH COLUMBIA Campus + Community Planning

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Rowan Waldron

David Gill

Dean Gregory

Executive Summary

The University of British Columbia (UBC) has been a leader in climate change mitigation, as the first Canadian university to set a net zero emissions target by 2050 (UBC, 2016); however, the UBC Climate Action Plan 2020 particularly focuses on mitigation and does not include adaptation components (UBC, 2016). While mitigation seeks to prevent impacts of climate change, adaptation responds to climate change impacts (City of Vancouver, 2012). The purpose of this studio project is to increase UBC's climate adaptability and inform UBC's next iteration of its Climate Action Plan by providing evidence-based climate adaptation strategy recommendations. Our project particularly focuses on enhancing the climate adaptability of UBC's public realm and outdoor spaces. Our recommended strategies address two key risks identified for the Metro Vancouver region: hotter, drier summers and warmer, wetter winters (Metro Vancouver, 2016). Through an iterative and collaborative process with our project partner, UBC Campus + Community Planning, we conducted an academic and grey literature review of climate adaptation best practices as well as expert interviews with campus professionals and faculty. These helped inform our campus-wide adaptation strategy recommendations (see Figure 1) as well as our campus site study for the area surrounding the Irving K. Barber Learning Centre.

Overall, by implementing the recommended strategies highlighted in this report, UBC can further establish its climate change planning leadership not only in mitigation but also in adaptation, promoting a safer and more resilient campus community in the face of climate change.

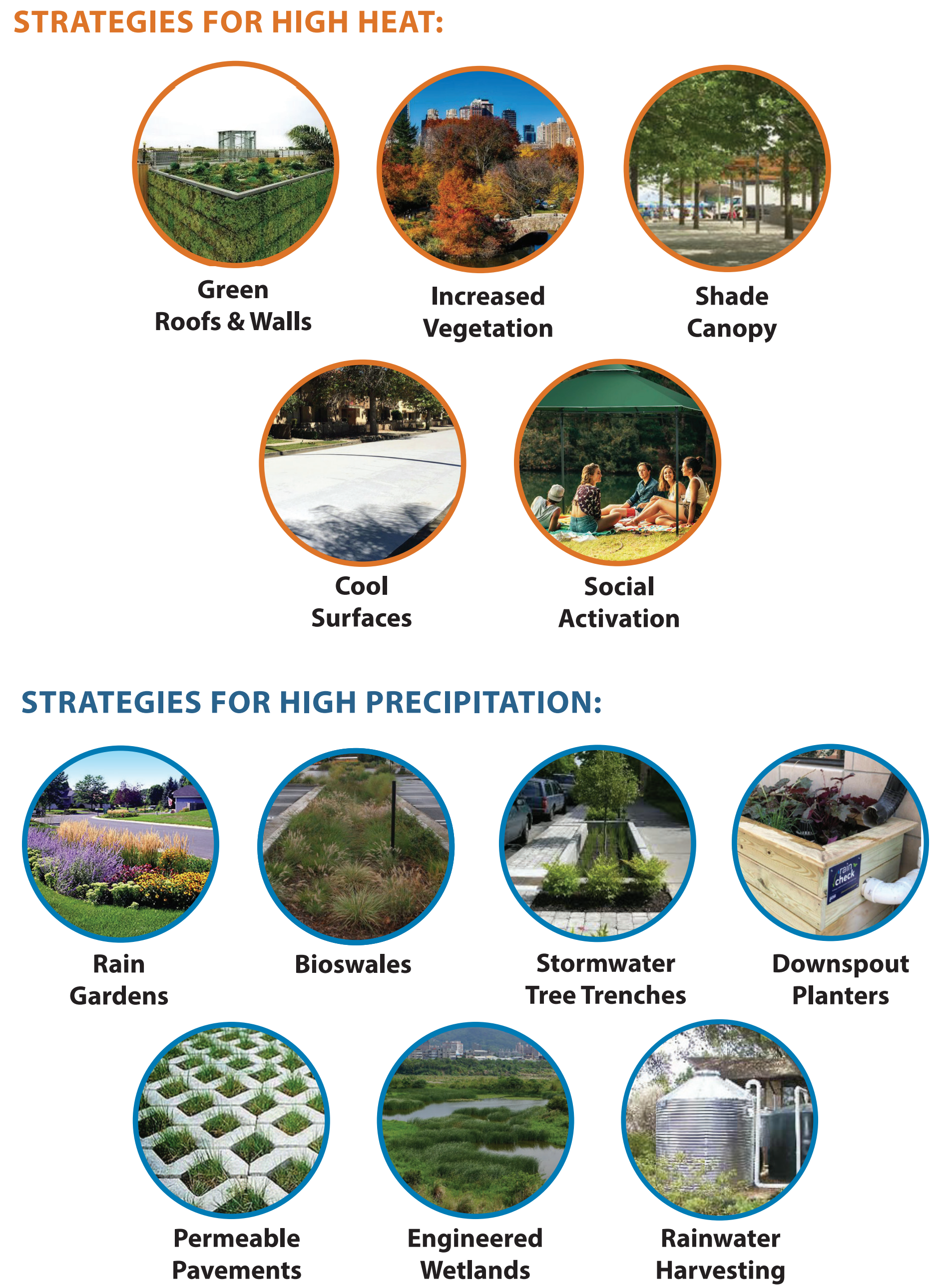

Figure 1. Summary List of Climate Adaptation Strategy Recommendations

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Key Terms

Adaptation: practices that involve responding to the impacts of climate change

Climate change: a change in typical global or regional climate patterns

Coastal erosion: the gradual, permanent retreat of a shoreline as a result of wave and wind action removing material along the shoreline

Green infrastructure: a set of urban design and rainwater management tools that use both engineered and nature-based solutions to protect and restore urban ecology

Hazard: an event that can cause harm to a group or system

Heat island effect: the effect where near-surface air temperatures are higher in cities than in surrounding suburban or rural areas. Heat islands are caused by human activity (e.g. emissions, smog), dark surfaces, and lack of vegetation.

Impermeable surfaces: surfaces that do not permit water and other liquids to infiltrate the ground

Mitigation: practices that involve minimizing the impacts of climate change

Resilience: the capacity for a system to withstand and recover from an event

Risks: the likelihood and severity of an event occurring

Stormwater runoff: rainwater that has landed on an urban landscape and does not permeate through the ground

Vulnerabilities: the factors that worsen the impact of an event on a group or system

Context

Why Climate Adaptation?

Global climate models project an average increase of approximately 3 °C in the Metro Vancouver region by 2050 (Metro Vancouver, 2016). This warming will lead to significant changes in temperature and precipitation. Two main impacts predicted to affect Metro Vancouver by 2050 include:

Hotter, drier summers

- **2x** as many days with temperatures above 25 °C
- **Increased** frequency and severity of heat waves
- **Health risks** for vulnerable people

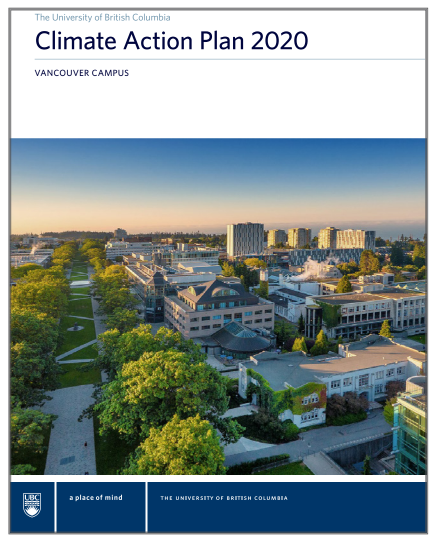
Warmer, wetter winters

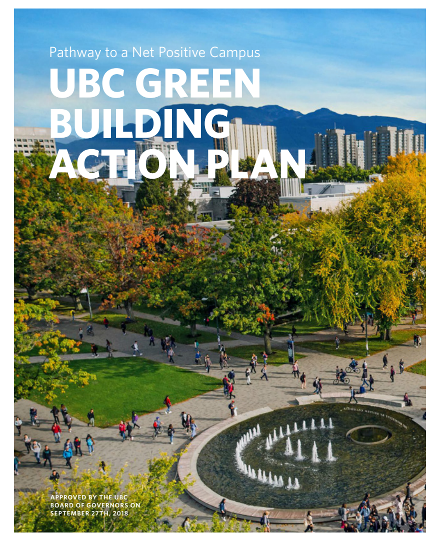
- **5-12%** increase in precipitation during fall, winter, spring
- **36%** increase in precipitation during extreme rain events
- **Increased** risk of flooding

The impacts of climate change are already being felt in the Metro Vancouver region, including extreme rainfall causing street flooding, hotter and drier summers, and increased air quality issues due to wildfires outside the region (City of Vancouver, 2018). Extreme rain events and heatwaves are expected to increase in frequency and intensity (City of Vancouver, 2018). In order to ensure the health and wellbeing of the UBC campus community, it is essential to implement strategies that increase UBC's adaptability to current and expected climate impacts.

Existing UBC Plans and Policies

As the first Canadian university to set a net zero greenhouse gas emissions target by 2050, UBC is a leader in climate change mitigation (UBC, 2016). UBC's Campus + Community Planning has produced numerous planning documents that have addressed climate change, including the UBC Green Building Action Plan and the Climate Action Plan 2020. However, their current Climate Action Plan 2020 does not include adaptation components. The Green Building Action Plan highlights that climate adaptation is an emerging area (UBC, 2018); one of the key priority actions in the plan is to develop a set of principles for landscapes and green roofs that consider the ability to adapt to climate change (UBC, 2018). Further work is needed to determine best practices for effectively addressing campus adaptation challenges and opportunities.





Project Goal

To inform UBC's future climate change plans and increase UBC's adaptability by providing evidence-based strategy recommendations.

Project Scope and Approach

This project focuses on enhancing the climate adaptability of UBC's public realm and outdoor spaces. Our team interviewed UBC campus staff and faculty to gain insight on campus-specific climate risks and vulnerabilities, current gaps and challenges, and suggestions for increasing UBC's adaptability. We also conducted a literature review of climate adaptation best practices. Using the key findings from these steps, our team developed strategy recommendations for the UBC Vancouver campus. We then envisioned how these strategies could be implemented on campus through our site study of Irving K. Barber. Overall, this project involved a highly iterative and collaborative process as we developed and refined our final strategy recommendations (see Figure 2).

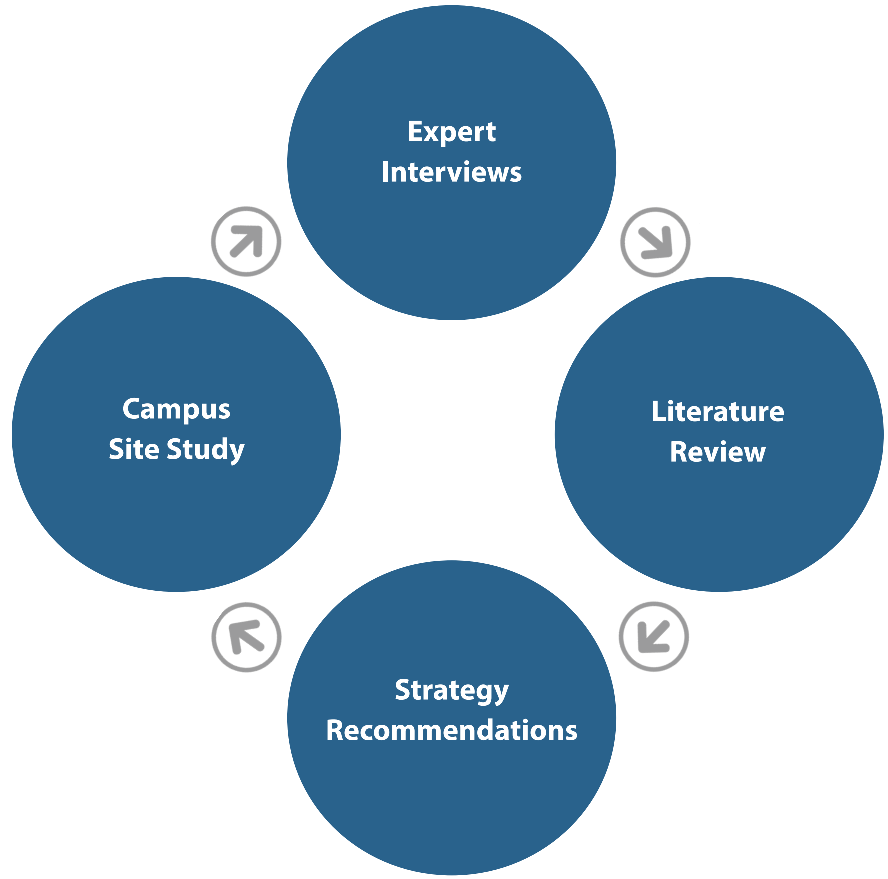


Figure 2. Main Project Components

Interview Findings

We conducted nine semi-structured interviews with campus staff and faculty to identify and explore campus-specific climate risks and existing campus adaptation initiatives, gaps, and opportunities. Interviewees included representatives from the following departments:

- UBC Campus + Community Planning
- UBC Safety and Risk Services
- UBC Faculty of Forestry - Collaborative for Advanced Landscape Planning
- School of Architecture + Landscape Architecture

Past Climate-Related Incidents on Campus

Interviewees highlighted that there has not been many climate-related incidents experienced on the UBC campus thus far. In the past 30 years, the worst storm has been a 1 in 15 year storm event, which was very short in duration (D. Doyle, personal communication, November 11, 2019). Furthermore, UBC does not experience flooding from the vast majority of regularly occurring rain events. Nevertheless, interviewees highlighted that the severity of events is only expected to increase with time.

In terms of drought, approximately five years ago, UBC had a significant summer drought (D. Gregory, personal communication, November 26, 2019). During this time, the campus lost many plants because many areas of campus lack irrigation. Even in areas where irrigation existed, water restrictions prevented irrigation of plants. This highlights the need to design landscapes that can withstand drought conditions and require minimal irrigation.

Campus-Specific Risks and Vulnerabilities

Through the interviews, we identified key campus-specific risks and vulnerabilities in the next 20 to 30 years. These include increased rainfall, increased heat, and wildfires. East Mall is particularly prone to flooding since it is one of the major channels on campus for stormwater; when the pipes get full, they can eventually surcharge to the street (D. Doyle, personal communication, November 11, 2019).

Heat events are also expected to increase in the near future. UBC has not provided for cooling in many of the buildings, and most are not easily retrofitted (D. Doyle, personal communication, November 11, 2019). Irving K. Barber is an example of a building particularly vulnerable to heat as it has large windows and is south facing. The area outside the Nest, also known as University Commons Plaza, was also identified as a heat-vulnerable site, as it is a large, open, and paved area with minimal tree cover.

UBC is also vulnerable to wildfires, as it is surrounded by the heavily-wooded Pacific Spirit Park. There will be increased risk during drought seasons; wildfires would impact air quality, health, and access to UBC (D. Doyle, personal communication, November 11, 2019).

Finally, coastal erosion is also a concern for the exposed Point Grey Cliffs on the north part of campus which face the Strait of Georgia. An average of 7.5 cm of material from the base of the Point Grey Cliffs is lost annually due to wave action and precipitation (UBC, 2004). An increase in precipitation and heavy rain events would heighten the risk of slope instability and failure due to stormwater runoff which can potentially destabilize materials that support the slopes (Lee, Coster, & Liu, 2016).

Existing Campus Adaptation Policies

We asked interviewees about current adaptation plans, policies, and initiatives at UBC. The plans mentioned by interviewees include:

- **Integrated Stormwater Management Plan (2017)** - This plan highlights that rapid development of the UBC campus over the last 20 years has increased the amount of stormwater runoff that the campus stormwater has to handle. While this plan does not explicitly address climate adaptation, it encourages measures such as green roofs, bioswales, and rain gardens, which can help manage future climate-related increases in precipitation.

- **Green Building Action Plan (2018)** - One of the eight interrelated component areas of the Green Buildings Action Plan is climate adaptation. One of the interviewees highlighted that the Green Buildings Action Plan considers not only the physical buildings, but also the outdoor areas surrounding the buildings. One of the key priority actions in the plan is to develop a set of principles for landscapes and green roofs that consider the ability to adapt to climate change. It also includes low-impact development recommendations such as climate-adaptive landscapes.

- **Leadership in Energy and Environmental Design (LEED)** - From 2008 onwards, all new campus construction and major renovations at UBC are mandated to have LEED Gold certification.

- **Sustainable Sites Initiative (SITES)** - UBC has taken into account principles from the SITES initiative, which can be considered as the "LEED for landscapes" - it is a set of comprehensive, voluntary guidelines together with a rating system that assesses the sustainable design, construction, and maintenance of landscapes (UBC Campus and Community Planning, 2017; American Society of Landscape Architects, 2019). UBC is attempting to build these principles into best practice strategies and approaches for UBC campus design and development.

Challenges and Gaps

Current climate adaptation challenges and gaps on campus include:

- **Increased development** and **net loss of biomass** - Proposed landscape plans often do not achieve the same amount of biomass of what is already there (D. Gregory, personal communication, November 26, 2019). For example, several trees had to be cut down during the development of Walter Gage student residences. A net loss of trees means a loss of the ecosystem benefits associated with plants including natural stormwater management and shade.

- **Limited resources and budget -** One of the main reasons for the lack of adaptation interventions on campus (e.g., green roofs) is limited operations or maintenance staff and budget (D. Gregory, personal communication, November 26, 2019). For example, there is reluctance to establish green roofs on campus because of the required staff resources.

- **Lacking policy on heat and cooling -** Currently, there are many buildings on campus that do not provide adequate cooling. Nonetheless, there will be a thermal cooling policy update for new and renewed spaces at UBC to meet certain indoor cooling design conditions (e.g. passive ventilation, natural conditioning, exterior shading) (P. Martyn, personal communication, November 22, 2019). Interviewees mentioned that it is particularly challenging to find strategies to retrofit existing spaces to meet thermal comfort guidelines.

- **Uncertainty in terms of budget and timeframe -** One interviewee mentioned that if Campus + Community Planning's adaptation guidelines or recommendations are unclear, developers may be hesitant to adopt them because they are unable to budget that into their development plan and they wouldn't know how much time will be lost (L. Guaditis, personal communication, November 22, 2019).

Opportunities for Campus Adaptation

Our team asked interviewees what they would hope to see in the future in terms of UBC campus adaptation. Common themes included:

- **Restoration of biomass and increased green infrastructure** (e.g., more green roofs, rain gardens, resilient species, trellis structures on blank walls so that vines can grow up buildings) to enhance ecosystem benefits such as stormwater management, reduce the urban heat island effect by reflecting heat, and increase resilience to extreme events. UBC Campus + Community Planning conducted test calculations of adding green roofs on Brock, Technology Enterprise Facility 4 (TEF4), and Pacific Residences developments; they found that with the green roofs, they could maintain or exceed the existing biomass (D. Gregory, personal communication, November 26, 2019). Thus, with careful planning, green roofs may potentially be an effective adaptation strategy on campus.

- **A policy that addresses thermal cooling**, particularly strategies for retrofitting existing buildings and spaces

- **Increased budget and staff resources** for the implementation of adaptation strategies (e.g. operations/maintenance staff for green roofs)

- **More creative solutions for tackling the problem,** for example:
    - Multi-function stormwater detention facilities (e.g. a floodable skateboard bowl, amphitheatre, or parking space). These installations would minimize flooding during a severe rain event, and during other times, they would provide useful functions such as park and recreational space (D. Doyle, personal communication, November 11, 2019).
    - To address the problem of fire and smoke, the University of Victoria will be adding air filters to the lounge area of an on-campus residence building, so that it can be a centralized space with conditioned and filtered air where all students could go to (P. Martyn, personal communication, November 22, 2019).
    - Placing water tanks that are 5,000 to 10,000 liters, by bigger residences and University Commons, to provide a source of potable water that everyone can attend to during emergencies or when something goes wrong with the pipes. The water tanks can also be art installations that blend with the environment (D. Smutylo, personal communication, November 28, 2019).

In addition to conducting these interviews throughout the term, we have also identified adaptation themes and strategies from existing literature and other resources to help inform our campus-wide policy recommendations.

> **"The culture of landscape needs to be more resilient and drought-tolerant and require less irrigation. We don't want elaborate landscapes that need a lot of water and maintenance."**
> *- Green Building Manager, Campus + Community Planning*
>
> **"The more green we can have on campus, the better."**
> *- Landscape Architect, Campus + Community Planning*

Strategy Recommendations

In recent years, several municipalities and organizations have adopted climate change adaptation plans due to the increased awareness of the current and expected effects of climate change; however, very few universities have developed climate adaptation plans (Kautto, Trundle, & McEvoy, 2018). For this reason, in our literature review and case study analysis we reviewed both existing university-level and municipal-level climate change adaptation plans. Based on our literature review and interview findings, our team has developed a list of adaptation strategy recommendations for the UBC Vancouver campus. Each strategy helps meet one or more of the adaptation objectives identified from our literature review and interviews:

- **Reduced heat island effect**
- **Provision of stormwater management services**
- **Increased ecosystem services and biodiversity**
- **Enhanced social functions, amenity space, and aesthetic value**

We have categorized the strategies by the two main risks they address: increased heat and increased precipitation (see Figure 3 & Figure 4). While we will be focusing on these two risks, it is important to note that they are interconnected with other climate risks and impacts; for example, high heat relates to forest fires, water supply shortages, and an increased pressure on cooling systems. High precipitation can lead to greater flooding risk and cliff erosion (Metro Vancouver, 2016).

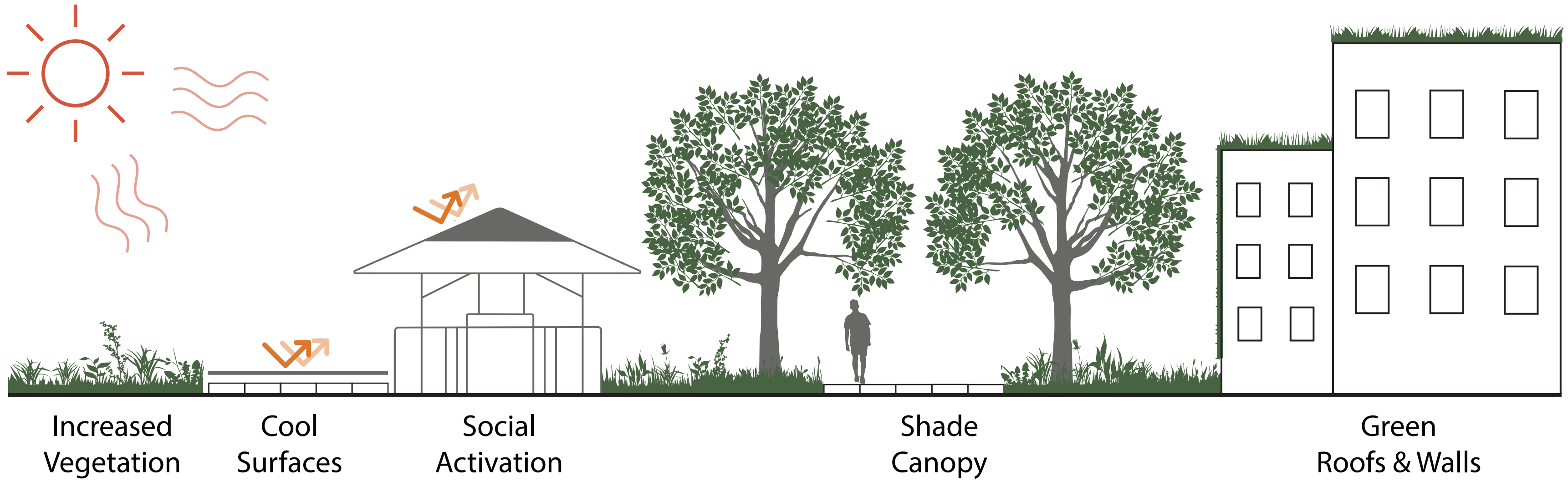


Figure 3. Strategy Recommendations for Addressing Increased Heat

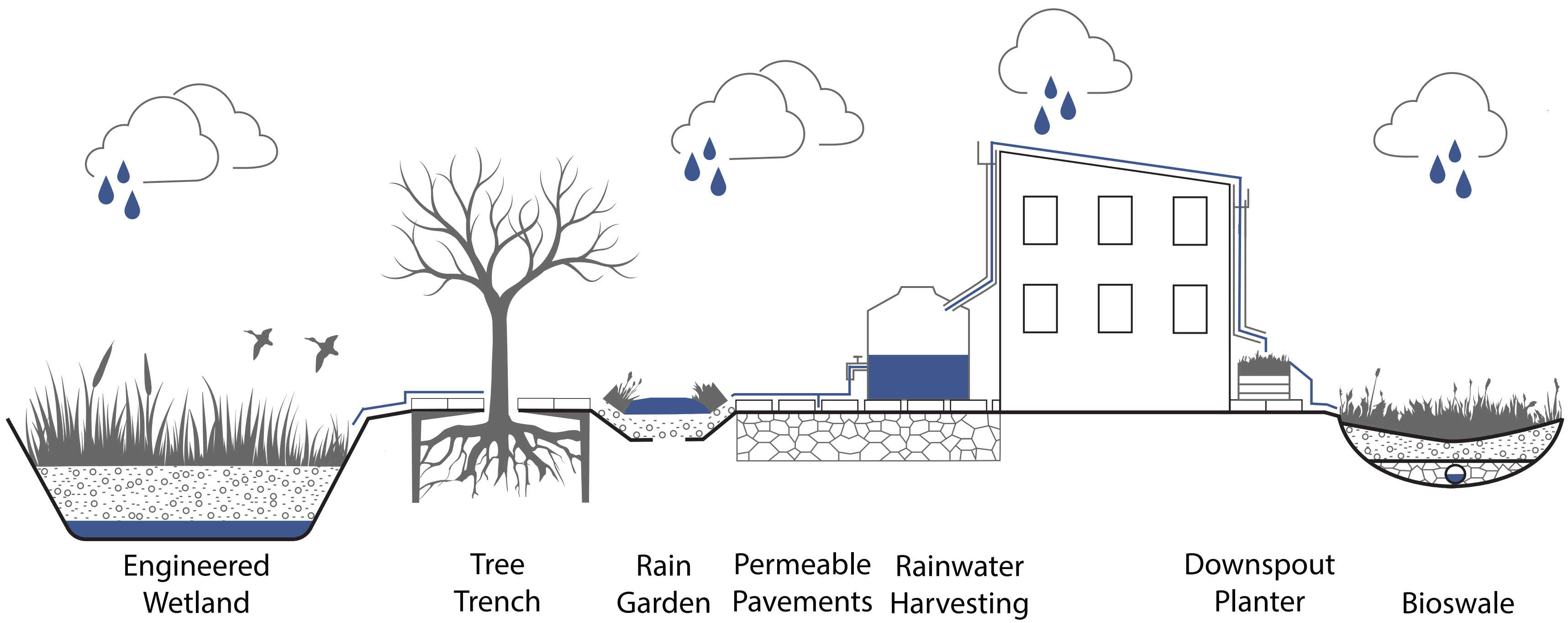
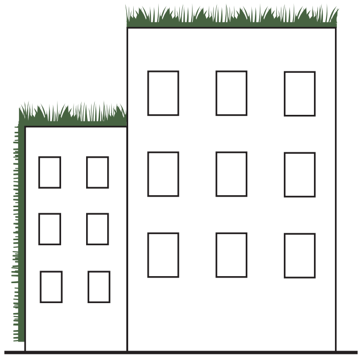


Figure 4. Strategy Recommendations for Addressing Increased Precipitation

1 Green Roofs



Description: A green roof is a rooftop with a vegetative/soil layer. Not only do green roofs reduce runoff, they also reduce surface temperatures (GrowNYC, 2015; GCCA, 2012; Dalhousie University, 2019). There are two types of green roofs. Extensive green roofs are simpler vegetated roofs with a soil layer that supports mainly grasses and other thin ground cover. They have shallower soil layers, require less maintenance, and weigh much less per sq. ft than intensive green roofs (GCCA, 2012). Intensive green roofs, on the other hand, have deeper soil layers and can support larger plant material. They require more inputs and are more expensive compared to extensive roofs, but they may be more productive and/or aesthetically pleasing.

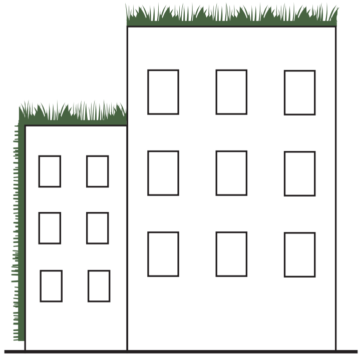
Pros:

- Keeps surface cool and reduces cooling demand of buildings
- Reduces stormwater runoff and filters stormwater
- Provides thermal insulation to buildings, reducing their energy use for heating and cooling and the associated greenhouse gas emissions; reduces energy costs in both summer and winter (City of Vancouver, 2019; GCCA, 2012).
- Increases biodiversity and habitat (ARUP, 2016)
- Provides opportunity for urban agriculture (Hewitt, Mackres, & Shickman, 2014)
- Provides aesthetic value, amenity space, and increased connection to nature ("biophilia") (Hewitt, Mackres, & Shickman, 2014; San Francisco Planning Department, 2016)
- Improves air quality (Hewitt, Mackres, & Shickman, 2014)
- May extend roof longevity by protecting buildings' waterproofing membranes (San Francisco Planning Department, 2016; US GSA, 2011)

Cons:

- Higher construction and maintenance costs compared to cool roofs
- Requires greater structural support than cool roofs
- Not reflective, so they would not have a significant impact on global temperatures even if they were widely implemented (GCCA, 2012)
- Requires flat or nearly flat roofs to work
- Green roofs (even extensive roofs) are generally more expensive than a cool roof with a stormwater management system (GCCA, 2012)
- Must consider the potential need for a supplementary supply of water other than from rainwater harvesting; natural irrigation can be supplemented with stored rainwater in times of drought (CIRIA, 2015)

1 Green Roofs (Cont.)



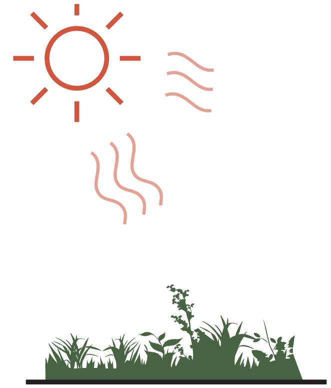
Other Variations:

- Similar to green roofs, **green walls** can reduce runoff and provide insulation; they are installed on the sides of buildings.
- **Blue roofs** store water at roof level, without the use of vegetation (CIRIA, 2015). They are composed of gravel or open trays designed to temporarily store and gradually drain rainwater off a building's rooftop. This slows the rate of stormwater release into sewer systems, effectively reducing the peak runoff from a roof during a storm event (San Francisco Planning Department, 2016; SPUR, 2013). The stored water could also be used for irrigation (e.g., of adjacent green roof areas), cooling water (e.g, reducing the temperature of the roof on hot days), non-potable use within the building, and/or for recreational purposes (CIRIA, 2015).
- A **blue-green roof** is a green roof designed to increase the volume of water stored underneath the green roof and control the amount of water released (City of Vancouver, 2019).

Design Considerations:

- Important to know the weight bearing capacity of the roof
- Additional support is often necessary to hold the additional weight of soil and water
- Check if there are any regulations that may limit the amount of roof area that can be covered by a green roof
- The climate of a rooftop can be hotter than at street level and more windy, which tends to dry out soil. A drip irrigation system can help ensure that the soil does not dry out

2 Increased Vegetation



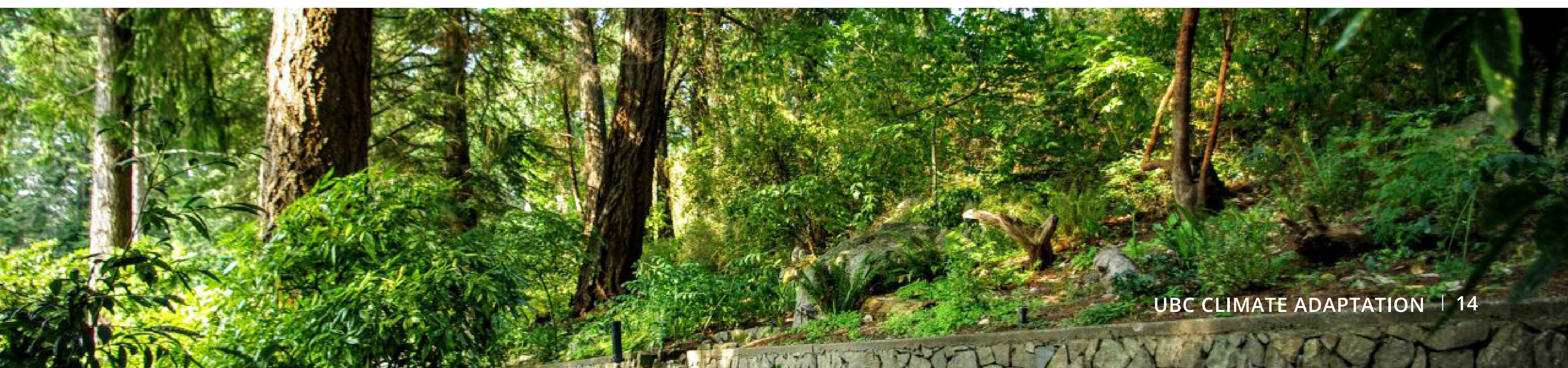
Description: Increasing vegetation on a site helps increase climate adaptability by reducing the overall surface temperature as well as helping to mitigate against floods (Carlson, 2012). Additionally, it can lead to several other benefits such as providing habitat for organisms and making a landscape more aesthetically pleasing. Ideally, climate-resilient plant species are used which are able to thrive in periods of high heat and high precipitation.

Pros:

- Reduces urban heat island effect on a site by reducing the amount of hard surfaces through added vegetation
- Reduces stress on sewer systems
- Filters stormwater and recharges groundwater
- Improves public recreation space and aesthetic value
- Provides habitat and food for animals
- Reduces demand for electric cooling

Cons:

- May require more maintenance depending on plant species
- Variety of climate-resilient plants may not be available



3 Shade Canopy

Description: With extreme heat as one of the primary undesirable outcomes of climate change, shading in the urban environment is crucial to providing citizens cooling relief (City of Vancouver and Vancouver Park Board, 2018). Shading works by preventing sunlight from reaching walls and pavements, and decreasing the heat in buildings and surrounding air (Hoverter, 2012). In the natural environment, large mature tree canopy covers can provide residents refuge from the heat through strategic placement (Toronto Cancer Prevention Coalition [TCPA], 2010).

Pros:

- Provides a cooling effect in the shaded area
- Reduces direct sunlight onto urban features that will absorb the heat
- Minimizes urban heat island effect
- Provides buildings with energy savings from reduced cooling needs
- Can increase usable lifetime of urban features (e.g. pavement) by moderating temperatures
- Improves air quality by trapping pollution and lowering temperatures
- Captures atmospheric carbon dioxide
- Improves water quality by reducing water pollution and slowing and filtering runoff
- Provides food and habitat for animals
- Provides aesthetic value and health benefits

Cons:

- Can be costly or timely to implement/maintain depending on the approach
- Can obscure views of a building or a viewing point
- Existing flora may be hindered by the shade if the plant species requires constant sunlight

4 Cool Surfaces

Description: Cool reflective surfaces are light-coloured pavements that reflect solar radiation that would otherwise be absorbed by conventional dark pavements, overall decreasing surface temperature. Dark pavements contribute to the urban heat island effect, as they absorb 80-95% of sunlight (Heat Island Group, 2017). Cool pavements, on the other hand, provide a simple solution to high heat in urban settings by reducing the overall surface temperature by 2-3 °C by providing an albedo effect (Heat Island Group, 2017). Cool reflective surfaces can be found on pavements, roofs and walls providing improved comfort and health as they reduce the chance of heat-related illnesses, and the creation of smog, as well as provide cooler air.

Pros:

- Reduces surface and air temperatures
- Reduces building energy use by reducing air conditioning needs
- Improves urban air quality by preventing the formation of smog from hot air
- Improves water quality by cooling stormwater and reducing the damage to local watersheds due to warm runoff
- May increase road or sidewalk visibility at night
- Lasts longer than traditionally-coloured pavements due to decreased heat stress (Hewitt, Mackres, & Shickman, 2014)

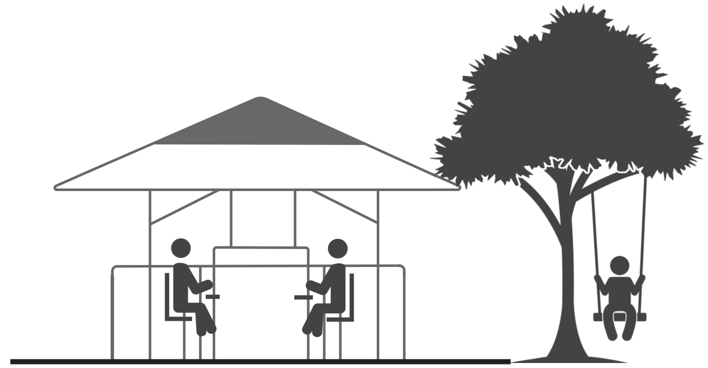
Cons:

- Higher cost than dark pavements
- May require more energy and carbon to manufacture than conventional materials
- Can produce an unwanted glare
- May require maintenance (e.g., cleaning of dirt) to maintain solar reflectance
- Traps more heat than green roofs (Hoverter, 2012)
- Provide fewer environmental benefits than green roofs
- May bounce light onto taller neighbouring buildings, warming those buildings instead

Design Considerations:

- To keep warmth in buildings during the winter while enhancing energy savings year round, proper ceiling and roof insulation should be installed

5 Social Activation



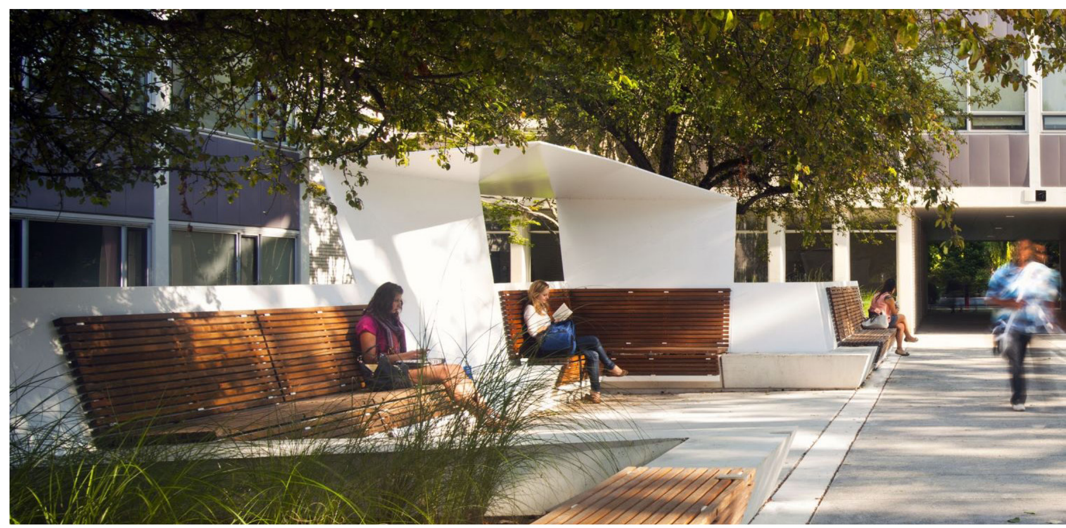
Description: Climate change does not only impact our physical environment, it can also impact people's health and well-being in various ways (Kabisch & van den Bosch, 2017; Taylor & Murray, 2020). Climate adaptation strategies can counteract some of these social impacts. Social activation of a space intends to foster the creation of a more vibrant atmosphere and encourage people to gather together (Project for Public Spaces [PPS], 2016). Socially activating a space can attract more pedestrian traffic into that area and contribute to a greater sense of community on campus (PPS, 2016). Examples include turning empty spaces into plazas, mini-parks, and gathering spaces which can be used and enjoyed by the community and also provide benefits such as shade or stormwater retention (City of Vancouver, n.d.).

Pros:

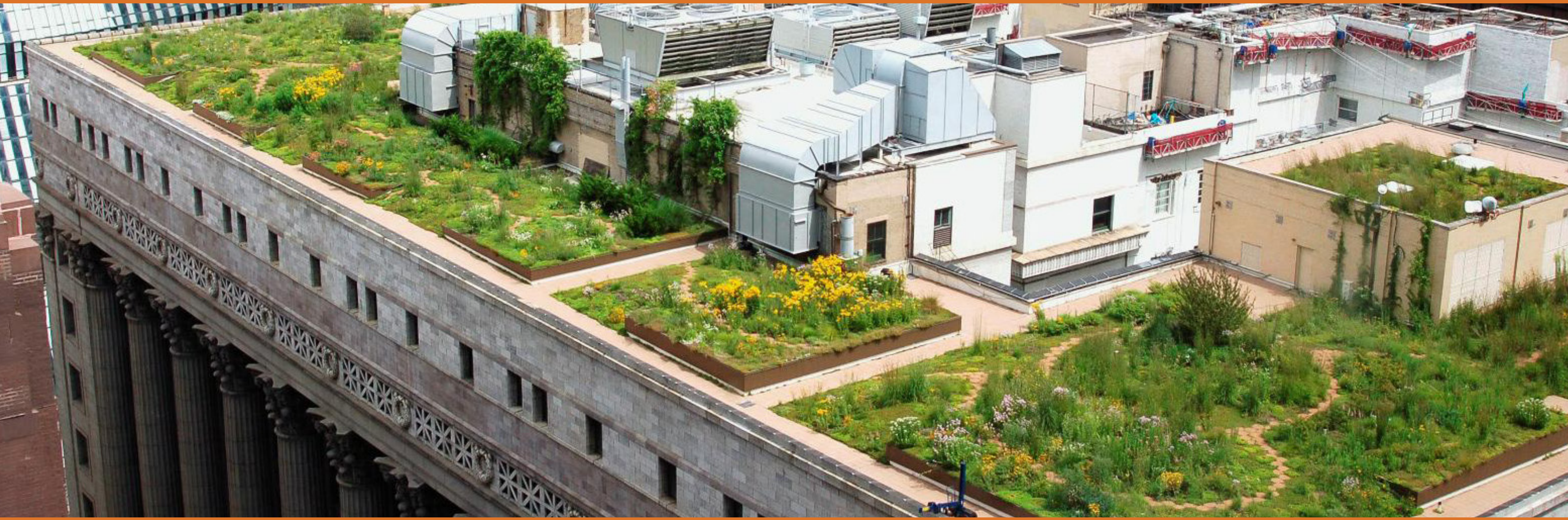
- Creates a stronger sense of community and place attachment
- Fosters social resilience through promoting the development of social networks
- Allows organizations/businesses near the socially activated space to more easily promote their event programming or any products
- Can provide benefits such as shade canopy and increased vegetation

Cons:

- May not achieve its purpose of social activation if there is low traffic or interest in the designed use



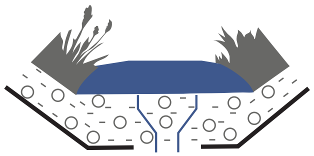
CASE STUDY: CITY OF CHICAGO



Chicago's Climate Impacts Report acknowledges that the City of Chicago is already experiencing rising annual temperatures (City of Chicago, 2008). Furthermore, the City of Chicago recognizes that there will be increased frequency and severity of heatwaves (City of Chicago,2008). To combat these climate impacts, the City of Chicago has implemented green infrastructure strategies including increased vegetation and trees, green roofs, and rooftop gardens (United States Environmental Protection Agency, 2020). Additionally, the City of Chicago has utilized strategies such as cool or reflective roofs and pavements to further adapt the city to the projected climate impacts (United States Environmental Protection Agency, 2020). The intention of these strategies is to reduce heat island effect while providing ecosystem services where possible (United States Environmental Protection Agency, 2020).

To support these strategies, a number of programs have been implemented including: (1) Green Streets Program to promote tree canopy amongst other ecosystem services; (2) Green Roof Program to financially incentivize green roofs for residential and small commercial buildings; and (3) Green Permit Program to financially incentivize new green building constructions (United States Environmental Protection Agency, 2010). To attest to the City of Chicago's green infrastructure strategies, there is a 20,300 sq. ft. green roof on Chicago's City Hall that has effectively reduced stormwater runoff and reduced heating and cooling costs (City of Chicago, 2008). Between January 2011 to April 2019, an estimated 42,000 trees were planted by the City of Chicago (City of Chicago, 2019). In 2019, Chicago also publicly announced their intentions to plant 4,500 trees during the year (City of Chicago, 2019).

1 Rain Gardens



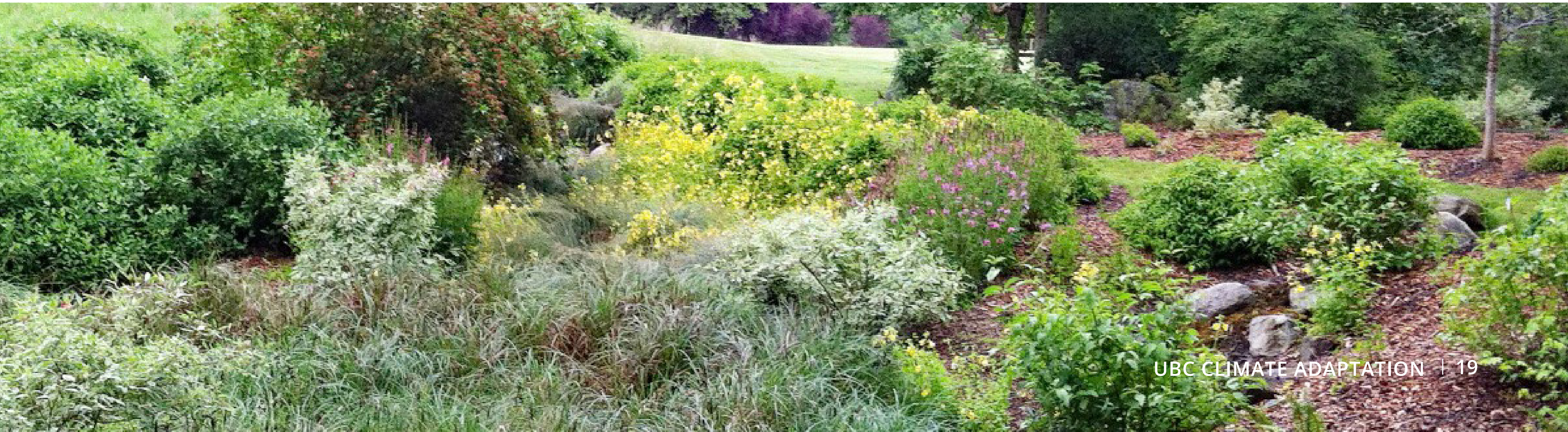
Description: Rain gardens are shallow sunken areas that manage runoff from nearby urban landscapes (United States Environmental Protection Agency, n.d.). Rain gardens include soil and plants appropriate for the climate that retain, filter, and drain urban stormwater runoff before it is received in sewers and other stormwater systems (City of Victoria, n.d.).

Pros:

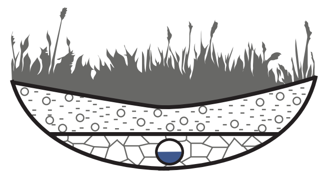
- Filters water to improve water quality for the surrounding habitat
- Provides food and shelter for animals
- Contains more runoff in comparison to a regular lawn
- Can make a landscape more aesthetically pleasing

Cons:

- Restricted to a smaller size as it may clog when used for larger areas
- Requires sporadic management or may not function as intended due to clogging



2 Bioswales



Description: Bioswales are predominantly found on larger sites and are characterized as linear, sloped, retention areas (Grow NYC, 2016). They help to capture stormwater and allow it to infiltrate at a slower rate to the groundwater through vegetation. Typically, bioswales are planted with native species and help minimize erosion and velocity of water. Additionally, they can retain larger plant species such as bushes and trees and remove debris and pollution from water.

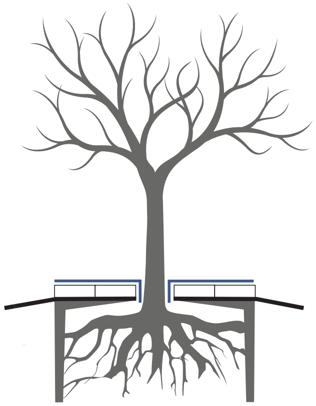
Pros:

- Lowers flood risk
- Recharges groundwater and provides irrigation for surrounding vegetation
- Improves water quality by filtering pollutants found in nearby roads and parking lots
- Provides habitat and food for different animals
- Prevents the occurrence of standing ponds, reducing the chances of still-water borne diseases
- Prevents erosion
- Provides aesthetically value, typically designed with native species

Cons:

- Requires maintenance that may lead to higher costs compared to other strategies such as rainwater tree trenches (City of Vancouver, 2019)
- Accumulation of sediment, trash, and improperly grown vegetation can affect the quality and performance of bioswales

3 Stormwater Tree Trenches



Description: Stormwater tree trenches/pits are similar to traditional tree pits but have greater capacity to retain stormwater runoff (EPA, 2016; City of Vancouver, 2019). Underground structural cells or structural soils (gravel and clay loam) provide support for the pavement above while allowing soils to remain uncompacted. This allows space for tree root growth and retention of stormwater runoff (EPA, 2016; City of Vancouver, 2019). Curb cuts are often used to divert runoff to the trenches. Stormwater tree trenches can be installed individually or together; the benefits are maximized with adjacent stormwater tree pits.

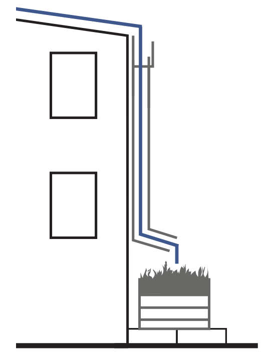
Pros:

- Reduced stormwater runoff flows to the drainage system
- Allows stormwater runoff to be used for plant uptake or groundwater recharge (City of Vancouver, 2019; GrowNYC, 2015)
- May improve tree growth due to sufficient space, regular irrigation, and improved drainage (Szota et al., 2019; EPA, 2016)
- Lower construction and maintenance costs compared to bioswales

Cons:

- Higher construction and maintenance costs compared to conventional street reconstruction (tree pit surrounded by compacted soils)

4 Downspout Planters



Description: This strategy involves placing one or more planters along or at the end of a downspout to capture rooftop runoff. The downspout planter allows rooftop runoff to contribute to outdoor irrigation of community planters.

Pros:

- Reduced stormwater runoff flows to the drainage system
- Easy to implement
- Minimal space requirement

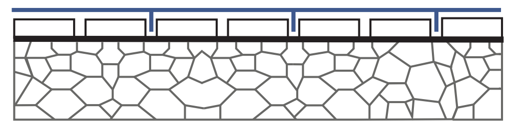
Cons:

- Could cause moisture problems if the overflow is not directed away from the building

Design Considerations:

- An overflow pipe should be installed to drain excess rainwater away from the building once the planter is full to drain excess water to a nearby rain garden or to an underground dry well. The dry well should have perforations so that the water can slowly be released into the surrounding soil (City of Vancouver, 2019)

5 Permeable Surfaces



Description: Urban development typically disrupts natural water cycles with impermeable surfaces on roads and buildings that generate stormwater runoff. Permeable surfaces include materials that allow stormwater to infiltrate through the pavement into the soil below (Grow NYC, 2016). This helps reduce stormwater runoff and replace the water in the region's underground aquifers instead of overwhelming the sewer and drainage systems. It also filters out suspended solids and pollutants, keeping them from waterways and streams (Grow NYC, 2016). Permeable surfaces can be constructed from a variety of materials, such as pervious concrete, porous asphalt, resin paving, and clay brick pavements.

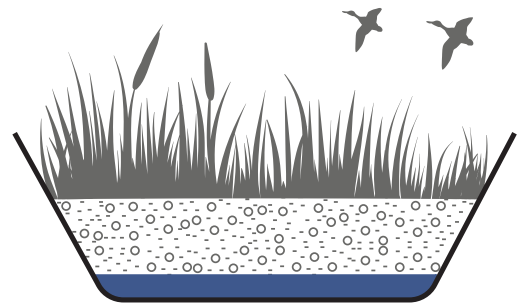
Pros:

- Reduces surface runoff
- Helps mitigate flooding, erosion, and siltation (i.e., water pollution cause by sand or soil)
- Controls pollutants by capturing them before going downstream, improving the quality of water systems
- Provides greater rooting space for urban trees, allowing more capacity to grow and establish healthier root systems

Cons:

- Can cost two to three times that of conventional asphalt paving (however, the trade-off may be saving costs in stormwater management during high precipitation events)
- At times, may be subject to more maintenance, as frequent use can wear down the function of the structure
- May also increase pollutant overload in areas of high pollution and should be implemented with caution for health measures
- Lastly, colder climates can bring forth challenges for permeable pavements such as conducting snow maintenance and the use of salt

6 Detention Basins & Engineered Wetlands



Description: Detention basins and wetlands are depressions designed to help reduce flooding risks during storm events by retaining water and releasing it in a gradual, controlled manner. Detention basins are landscaped depressions that are normally dry except during and immediately following storm events (CIRIA, 2015). When no water is present, detention basins are called 'dry' ponds and can be used for other functions such as recreational open space (Park et al., 2014). Wetlands consist of permanent pools of water that attenuate and treat surface water runoff. They support aquatic vegetation which enhances treatment processes and provides amenity and biodiversity benefits (CIRIA, 2015).

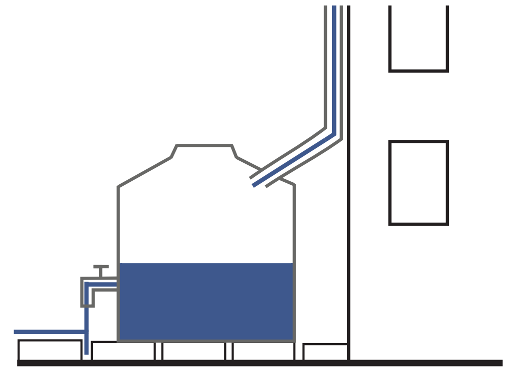
Pros:

- ✔ Prevents flooding by capturing large amounts of water during peak rainfall events
- ✔ Filters stormwater by retaining water so that sand and silt may settle, before the water is drained out
- ✔ Protects against erosion
- ✔ Promotes increased biodiversity and provides wildlife, amphibian, and fish habitat
- ✔ Can have a multi-purpose function by providing recreational open space

Cons:

- ✖ Requires maintenance
- ✖ If detention basins and wetlands are not monitored, they can become sites of still-water that can become vectors for disease

7 Rainwater Harvesting



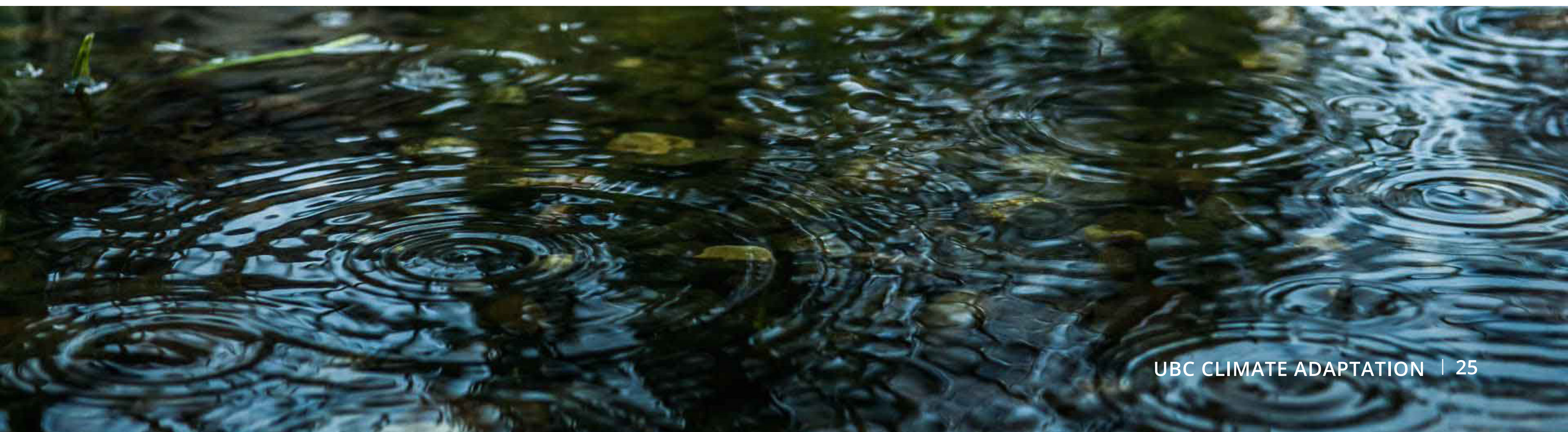
Description: Rainwater harvesting is the collection of rainwater runoff for use. Runoff can be collected from roofs and other impermeable areas, stored, and treated (where required); it can then act as a supply of water for various uses (CIRIA, 2015). Collecting and utilizing rainwater can be done through roof pitches, gutters and water tanks. If enough rainwater is properly stored and filtered, rainwater can be used for drinking water, cleaning, irrigation and even bathing.

Pros:

- Can provide water supply for a building and other uses
- Reduces the volume of runoff from a site
- Can provide emergency water supply during/after a disaster

Cons:

- Using rainwater to provide potable water for consumption or bathing would require specialised treatment and monitoring



CASE STUDY: CITY OF PORTLAND

The City of Portland, Oregon is found 500 kilometers south of the City of Vancouver and shares a similar climate. Well-known for its rain, the City of Portland receives an average of 37 inches of rain per year, with an expected increase in coming years due to climate change (City of Portland Environmental Services, 2020). The City is home to the north end of the Willamette River, and is a known leader in watershed and stormwater runoff management.

To improve the overall watershed health of the region, the City of Portland has commenced the Innovative Wet Weather Program. The Program supports projects that effectively manage stormwater as close to its source as possible (City of Portland, 2013). Interventions include green streets, pervious pavements, rain gardens, downspout planters and vegetated swales. These solutions use vegetation and natural hydrological systems to provide sustainable stormwater runoff strategies that meet regulatory compliance and resource protection.

Each project is publicly reported on, including statements about the project components, site selection criteria, benefits, costs, construction time, maintenance requirements, and lessons learned (City of Portland, 2013). Overall, the Innovative Wet Weather Program has helped support projects that have produced numerous benefits for the City, including reduced polluted stormwater entering Portland's rivers and streams, diverting stormwater from the sewer system, improving water quality, and enhancing watershed health.

Site Study: Irving K. Barber

To provide an example of how these recommended strategies could be implemented specifically at the UBC Vancouver campus, our team conducted a site study of the area surrounding Irving K. Barber (IKB).

Site Selection Process

Based on discussions with UBC Campus + Community Planning, our team compiled a list of potential sites for our site study (see Appendix A - Figure 7 for a map of all potential locations identified). We then developed a site selection criteria to help us select the most pertinent site for examining the applicability of our strategy recommendations. These criteria included:

- **Vulnerability to heat -** site characteristics include lack of canopy cover and shading, south and south-west facing exposures, presence of glass exteriors on buildings and reflections onto the nearby area, as well as the urban heat island effect
- **Vulnerability to high precipitation -** impervious surfaces, proximity to main stormwater channels (e.g. East Mall), in addition to historic flooding events
- **Potential impact on decision-making -** the potential for site redevelopment, the possibility of implementation of our interventions on a particular site, maximization of benefits and usefulness to our partner
- **Pedestrian traffic -** extent of use of the site by campus users

Using these site selection criteria, we assessed the strengths and weaknesses of each potential site for our study (see Appendix A - Table 1 for the site selection table). Where possible, we obtained site-specific information for each criteria by reviewing previous UBC SEEDS projects in the SEEDS Sustainability Library in addition to publicly available Campus + Community Planning reports (Fang, 2016; Luo, Lewis, Yuen, Fazel, & Lim, 2015; UBC, 2017). Our expert interviews and meetings with our project partner helped verify our research findings and provided additional information. Once our team completed the site selection process, we selected Irving K. Barber (IKB) as the location for our site study.

Site Description

The areas surrounding IKB are vulnerable to both high heat and high precipitation (see Figure 5). On the southwestern side of IKB, there is a large open space with a mixture of paved walkways and minimal canopy cover or shading. Furthermore, IKB has southwest-facing windows that have been noted to reflect sunlight onto the open space (D. Gregory, personal communication, November 26, 2019). As IKB is located on East Mall, a major channel for stormwater, there is also the risk of flooding on the eastern side of IKB during severe rain events (D. Doyle, personal communication, November 11, 2019). Additionally, the IKB site consists of paved walkways and roadways which also increases the risk of flooding in high precipitation events. Furthermore, IKB was suggested as a likely site for the implementation of future softscape climate adaptation interventions (D. Gregory, personal communication, November 26, 2019). The interviews also revealed that there would be a development site directly east of IKB in the future (D. Doyle, personal communication, November 11, 2019).

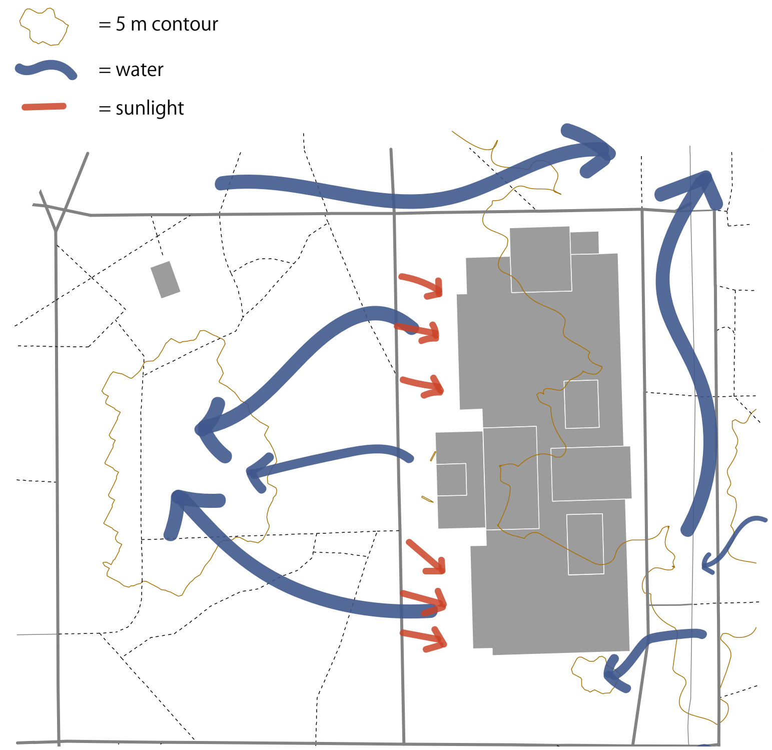


Figure 5. Irving K. Barber Climate Risks. This site drawing provides a high-level overview of the natural processes taking place on our site study. A 5-meter contour line shows the slight topographical range on the site, while the blue and orange arrows show the direction of water flow and sunlight in the area. East Mall is particularly prone to flooding due to being one of the major channels for stormwater management on campus. Additionally, the west-facing windows of IKB are known to absorb high solar radiation during the daytime which increases the overall heat of the building. Visualizing water flows and sun rays helps inform where and what strategies are most effective to implement on the site.

Site Areas

Given the large size of the Irving K. Barber site, our team divided the site into eight different areas (see Figure 6). In the next section of this report, we provide strategy recommendations for each area based on their vulnerability to certain risks.

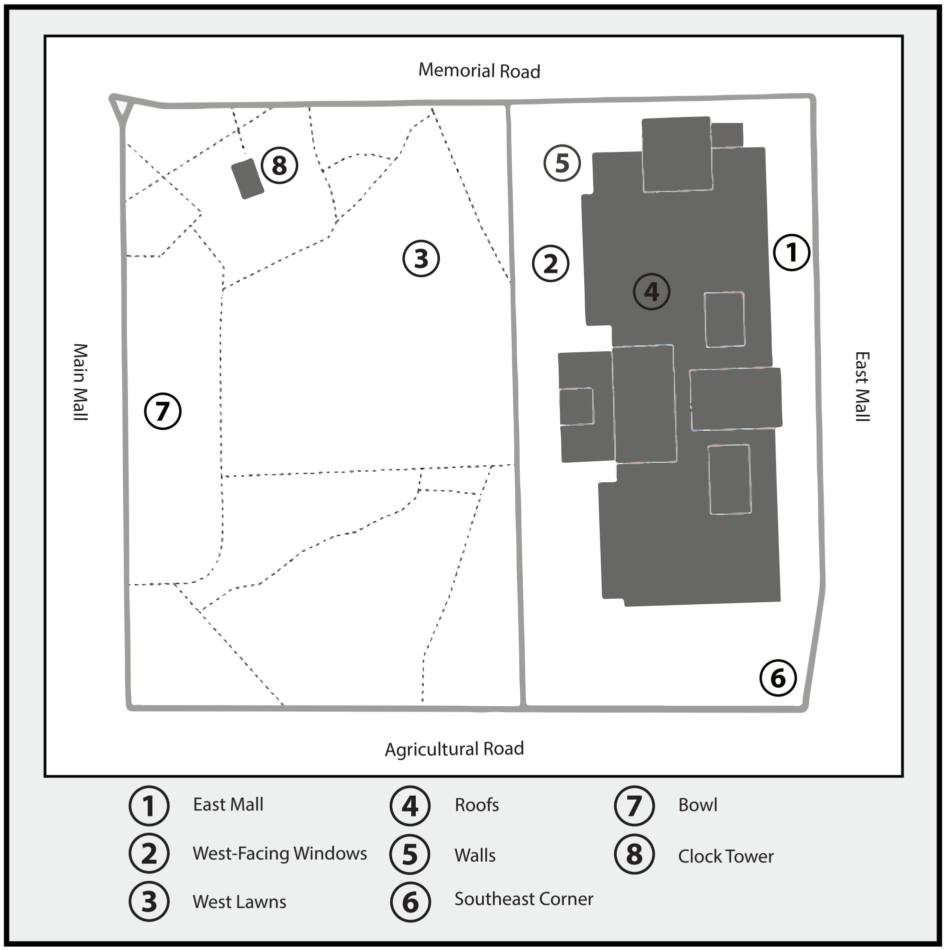
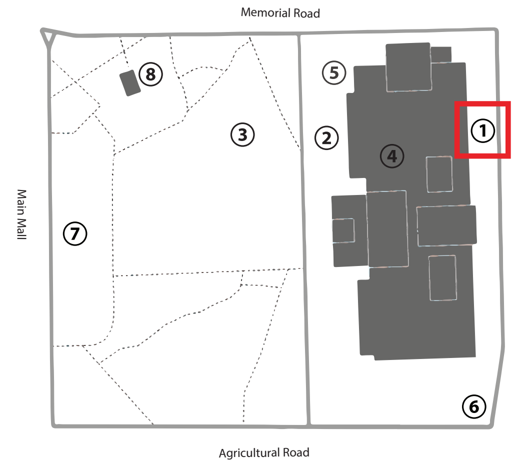


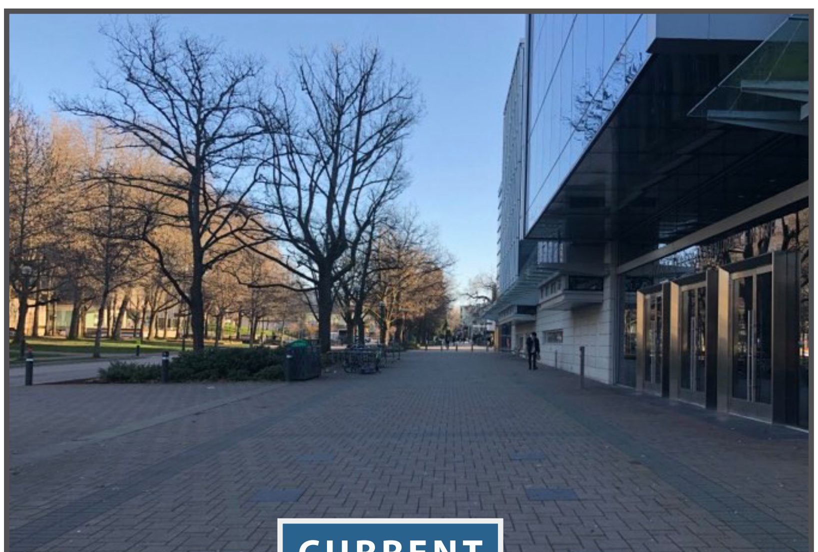
Figure 6. Map of Study Areas on Irving K. Barber site.

① East Mall

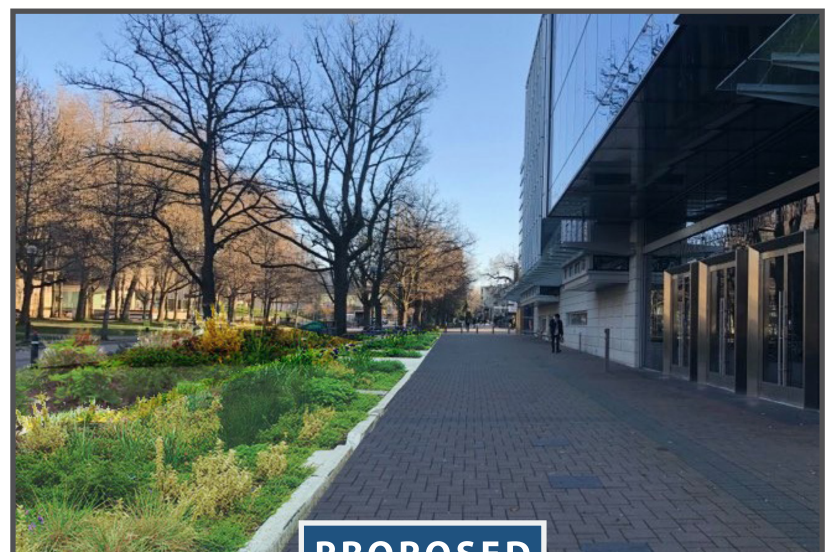


Description: East Mall along the IKB site study is a large impervious walkway for students to get to and from the library. Issues recognized in this area include: unused space, lack of vegetation, and a large impermeable surface. Additionally, East Mall is recognized as at risk to high precipitation due to the sewage configuration below campus grounds.

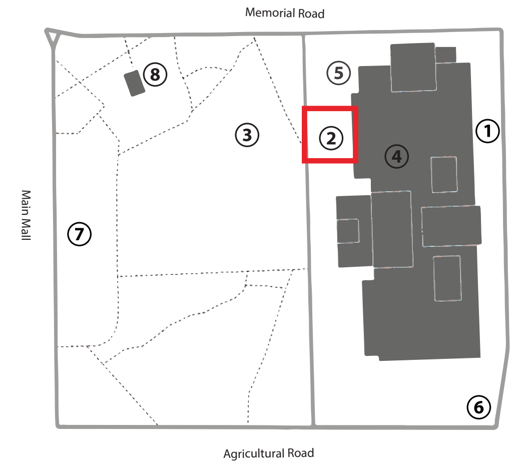
Strategy Recommendation: Solutions proposed for this area include **increased vegetation** or a **rain garden** along the walkway. Increasing the vegetation of this area can help soften the landscape and provide biomass for pollinators and birds. If more resources are available, a rain garden should be implemented not only to intercept, clean, and collect rainwater during peak flow, but to also direct rainwater to desired drainage sites. Considerations of these strategies include the pre-existing tree roots of the site as well as walkway designs for students to utilize the entire sidewalk more efficiently.



CURRENT



PROPOSED

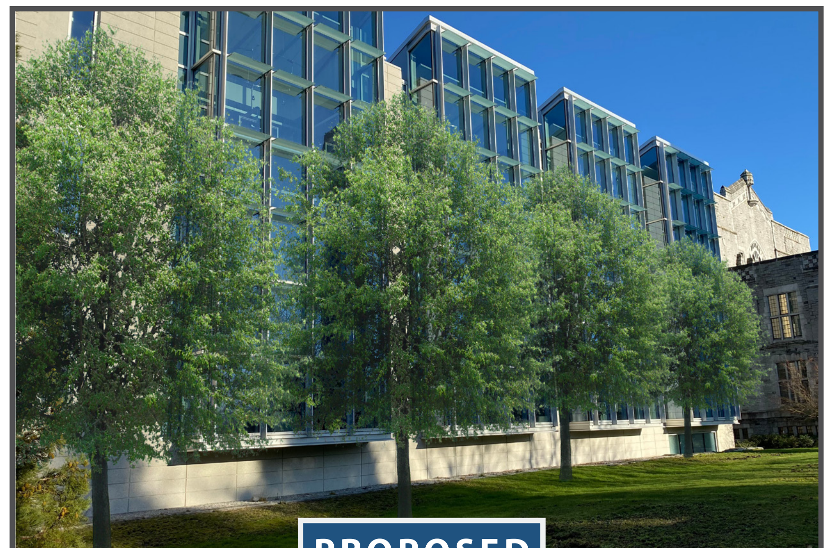


② West-Facing Windows

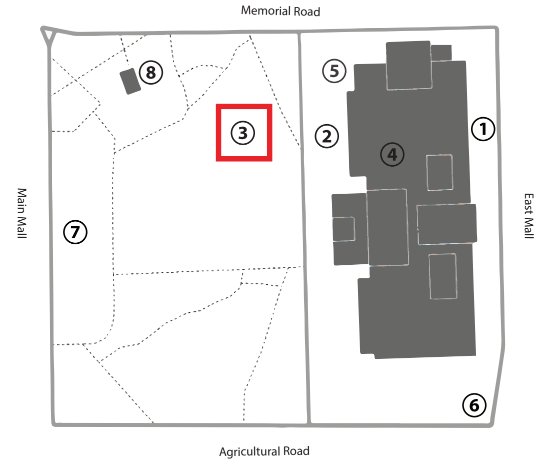
Description: The west side of IKB is recognized as a high heat hotspot. The west-facing windows of IKB is known to receive extended periods of sunlight during the day. This can produce a greenhouse effect within the library that can be distracting and uncomfortable for both students and staff while unnecessarily increasing cooling needs.

Strategy Recommendation: A proposed solution for this area is to **plant tall vegetation such as trees** along the edges of the IKB windows. This will reduce the overall solar radiation received by the building and help cool the building. Furthermore, native trees can contribute to ecosystem services by providing habitat for both local and migratory species.


CURRENT


PROPOSED

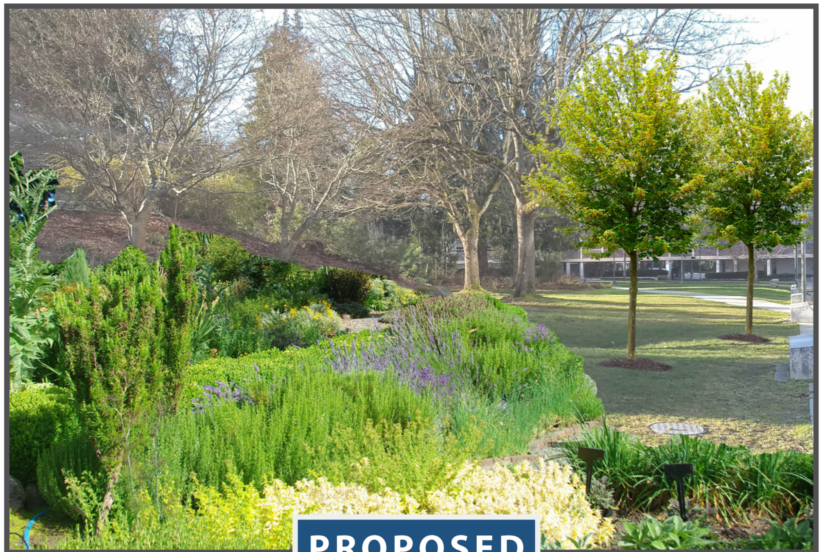
③ West Lawns



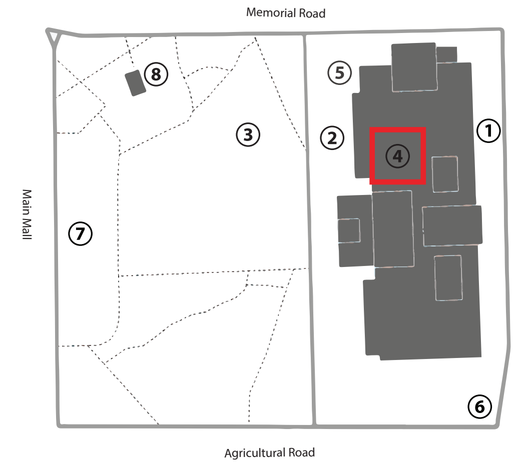
Description: The west side lawns of IKB is home to beautiful landscape designs that include many native trees and shrubs. However, some pockets of this area are left bare with only grass which provides limited ecological functions relative to other landscape designs.

Strategy Recommendation: A green infrastructure proposal for this area is to **supplement and extend the existing landscaping to IKB's west walkway**. **Increased vegetation** and soil can help absorb, filter and evapotranspirate water, as well as remove toxins from urban rainwater runoff. It also provides aesthetic value that invites students and staff into the landscape.

CURRENT



PROPOSED



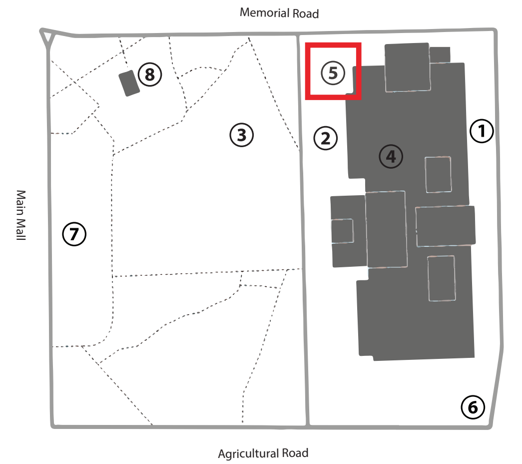
4 Roof

Description: When looking at the site from an aerial view, it is evident that there are missed opportunities along the rooftop of IKB. Due to its shape, form and surface area, IKB's roof has the potential to host many green infrastructure strategies.

Strategy Recommendation: The proposed strategy for this area is a **green roof**. Although green roofs require some maintenance, IKB's flat roof provides the optimal location for vegetation that may help in rainwater management, provide insulation for the building and reduce the overall heat island effect of the campus.

Site Study: Irving K. Barber

⑤ Walls

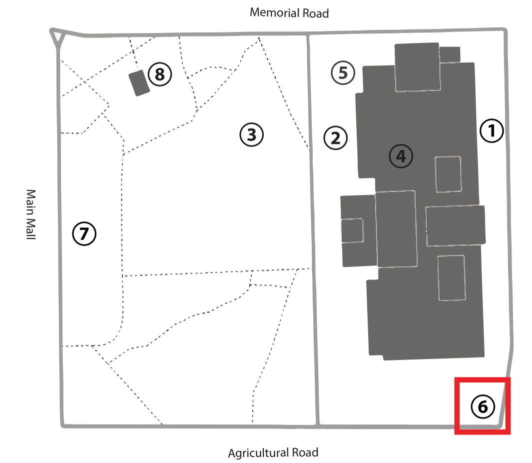


Description: IKB hosts many exposed exterior walls that can negatively contribute to heat island effect. Often overlooked, walls can become optimal spaces for green infrastructure and rainwater management.

Strategy Recommendation: A proposed design for this area is **green walls made of vines sitting on a cable structure**, which would have less maintenance requirements than an intensive green wall. Increasing vertical vegetation as such can help filter air pollution and provide food and habitat for pollinators. Additionally, it enhances the aesthetics of the building walls and can contribute to a greater sense of connectedness to nature among users in the space.

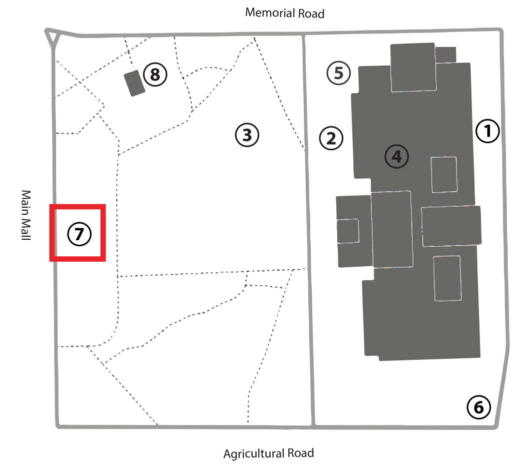
Site Study: Irving K. Barber

6 Southeast Corner



Description: Due to the flow and movement of heavy pedestrian traffic, a small section of the southeast corner has been recognized as an underutilized area with room for green infrastructure. This spot is found at the intersection of Agricultural Road, East Mall and a service laneway.

Strategy Recommendation: The proposed strategy for this site is a designed **rain garden** that attends to the empty pavement. Rain gardens help reduce runoff volume during extreme rainfall events which could help mitigate flooding along East Mall while providing other ecosystem benefits and aesthetic value.

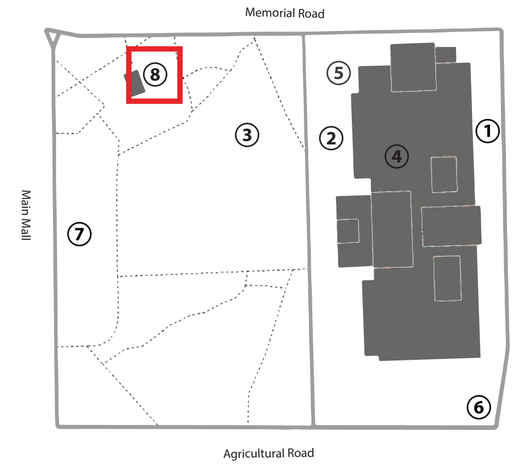


7 The Bowl

Description: A drastic slope is present from the library's west side down to the gardens. This area is known as 'The Bowl' and presently holds a water feature that is normally dry or filled with potable water in the summer.

Strategy Recommendation: In order to reduce the amount of resources used at this site, an **engineered wetland** can be built to replace the water feature. This would change the site from a hardscape to a softscape and work as a passive rainwater receptor. Engineered wetlands provide many ecological functions, increasing aquatic and terrestrial biodiversity as well as detaining and filtering rainwater through natural processes.

Site Study: Irving K. Barber



⑧ Clock Tower

Description: IKB's clocktower is an iconic image of UBC's campus. However, the area directly beneath the clocktower is largely underutilized and users rarely interact with the space.

Strategy Recommendation: In order to tackle issues of high heat as well as enhance social interaction in and around the library, **a gazebo or other shade structure can be implemented to provide shade for users of the space**. This strategy will not only engage campus users with UBC's landscape, but also provide a sitting area and refuge from the sunlight on hot days. The strategy can provide students and faculty a novel viewpoint of the site, while improving both mental and physical health.

Conclusion

With the acceleration of climate impacts, it is crucial that UBC address not only climate mitigation but also take further steps to increase its climate adaptability. This report provides a total of 12 adaptation strategy recommendations categorized by two major 2050 projected climate impacts: increased precipitation during the winter and increased heat during the summer. These recommendations take into account the findings from our literature review and expert interviews. Our site study of IKB visually demonstrated how adaptation strategies such as rain gardens, shade trees, and engineered wetlands can be implemented at the UBC Vancouver campus.

There are four key recommendations for next steps following the completion of this project:

1. **Formal Documentation and Identification of Relevant Hazards, Risks, and Vulnerabilities**

   We identified high-level climate risks at the UBC Vancouver campus including flooding, droughts, wildfires, and coastal erosion. We recommend that a more thorough risk and vulnerability analysis of the UBC Vancouver campus be conducted to identify other areas and sites of high priority for implementing climate adaptation strategies. We suggest developing a systems map with: the location of high heat areas; areas prone to flooding, coastal erosion, and wildfires; and areas with higher concentrations of vulnerable people (such as the elderly and children). This is expected to help form a more holistic understanding of climate adaptation needs and opportunities on UBC campus.

2. **Feasibility Analysis of Strategy Recommendations**

   A key barrier of implementing climate adaptation strategies is limited budgeting for operations and maintenance. However, considering the increasing climate risks and the many co-benefits of the strategies highlighted in this report, these strategies may prove to be cost-effective in the long-term. We recommend that a more comprehensive feasibility analysis of the recommended strategies be conducted for UBC, including the assessment of the costs for each strategy from installation to operation, maintenance, and monitoring over time.

3. **Conducting Additional Site Studies for Other Vulnerable Sites**

   Irving K. Barber was strategically chosen as the site study due to its central location and existing vulnerabilities to high precipitation and high heat. However, there are other vulnerable sites on UBC campus identified in this project (see Appendix A). Key themes and designs from the Irving K. Barber site study could also be applicable to other vulnerable sites. While we have provided a diverse range of climate adaptation strategies, it is imperative to note that not every strategy will be applicable for every site. Our site study of Irving K. Barber proved to be a helpful method of assessing which strategies could be effective at a particular site and visualizing how they might be implemented.

4. **Strategy Recommendations for Climate Adaptability for UBC Buildings**

   While the project scope deals primarily with the public realm and outdoor spaces, our interview findings also highlight the need for increasing the climate adaptability of UBC's buildings, particularly with regard to ensuring thermal comfort year-round. For UBC's next Climate Action Plan, it would be important to take into account the role of UBC Campus + Community Planning in both the public realm and indoor spaces.

Overall, we anticipate that our report findings and proposed design strategy recommendations will inspire and guide UBC stakeholders in planning future campus developments and redevelopments with climate adaptation as a key priority.

"We have time to get to 2050, and we have time to get to 2100.
But the fact is, we implement these things now
and every little step takes a chunk out of the problem.
So by the time the problem really shows up, we'll go,
'Oh, we don't have that much to do.'"

— Associate Director, Municipal Engineering at UBC Campus + Community Planning

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Appendix A

Figure 7. Potential Locations for Site Study on UBC Vancouver Campus

Table 1

Criteria Table for Potential Site Study Locations

	Vulnerable to High Heat	Vulnerable to High Precipitation	Potential Impact on Decision-making	Pedestrian Traffic
Agronomy Road	✕	✕	n/a	Medium
Armory	n/a	n/a	✔	Low
Brock	n/a	✔	✕	Medium
Irving K. Barber	✔	✔	✔	High
Orchard Commons	✔	n/a	n/a	High
Technology Enterprise Facility 4 (TEF4)	✔	✕	n/a	Medium
Totem Field	✔	✕	n/a	Low
Student Union Boulevard	✔	✕	n/a	High
University Commons Plaza	✔	✔	✕	High
Upper-West Precinct	✕	✕	✔	High

Note: "n/a" = information was unavailable for a particular site

Please see commentary on next page for more details about the table.

This site selection table (Table 1) is a qualitative assessment informed by the findings from our expert interviews and literature review.

Among the ten potential sites that were identified in our site selection process, only IKB fulfilled all components of the proposed criteria. Three other sites were shortlisted in addition to Irving K. Barber:

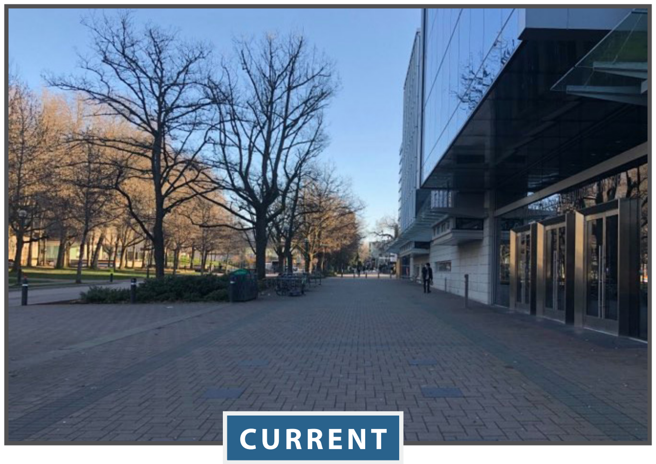
- **University Commons Plaza** – the site is described to have vulnerability to both heat and high precipitation based on our analysis and expert interviews, but there is extremely limited opportunity for future climate adaptation due to its recent redevelopment and designation as a large, open social space (D. Doyle, personal communication, November 11, 2019);

- **Brock Hall** – the site is expected to be climate vulnerable, but it was difficult to confirm as expert interviewees had not viewed the most recent updates on the site's redevelopment. The site is also already close to being finalized and our project would have limited impact on decision-making (D. Doyle, personal communication, November 11, 2019);

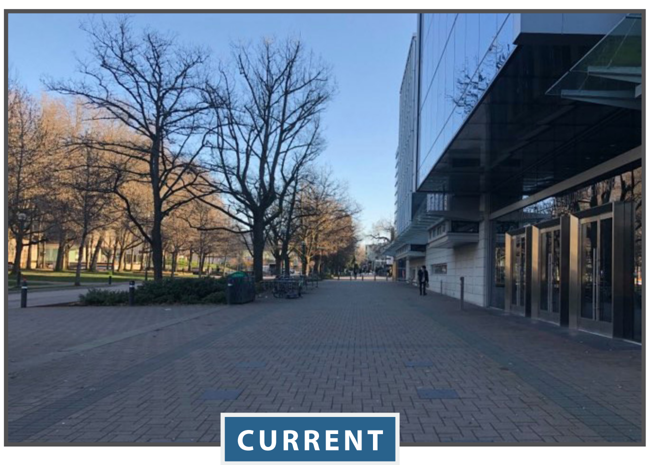
- **Armory** – an expert interviewee expressed a strong interest in redeveloping the site and believed it had immense potential for improvements from all perspectives; however, information on the climate vulnerability of the site is limited and very situational depending on future redevelopment outcomes (D. Doyle, personal communication, November 11, 2019).

Appendix B

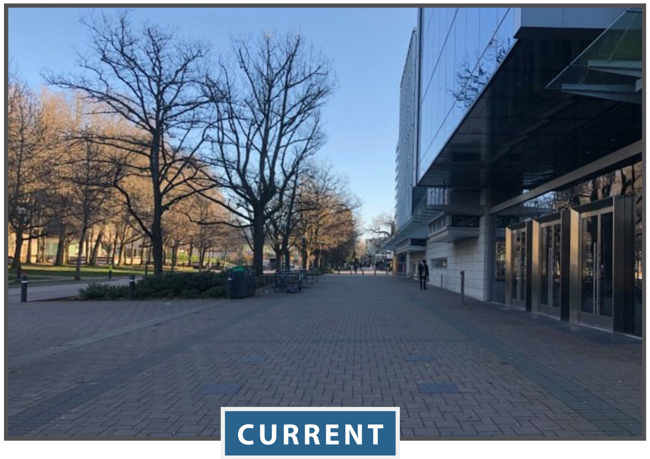
The following visuals are other design recommendations we considered and discussed with faculty and staff for our site study. A more thorough feasibility analysis for each design strategy would be needed to determine whether it would be beneficial to implement any of these strategies at IKB.



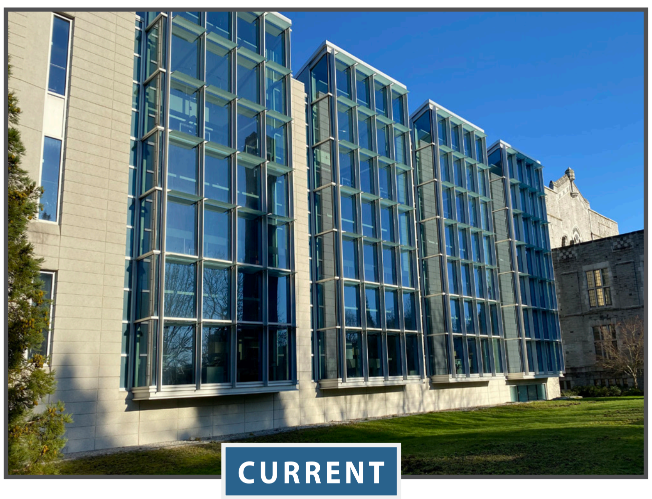
Area 1 - East Mall: Increased Vegetation



Area 1 - East Mall: Permeable Pavements

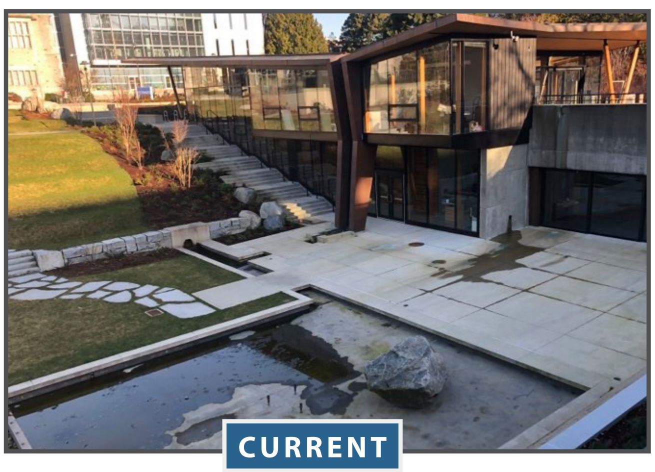


Area 1 - East Mall: Extended Coverage



Area 2 - West-Facing Windows: Increased Vegetation

Area 4 - Roofs: Cool Roof



Area 7 - The Bowl: Engineered Detention Pond (Gravel)

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