Re-envisioning the UBC Botanical Garden Conceptual Design Report

Adrian Lee, Christan Hajen, Fangqing Chen, Jonathan Wong, Jordan Miller, Linus Yau

University of British Columbia

CIVL 445

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Siegfried F. Stiemer, Dr.-Ing. (Ph.D)
Professor of Civil Engineering
University of British Columbia
6250 Applied Science Lane
Vancouver BC, Canada V6T 1Z4

Dear Dr. Stiemer:

RE: CIVL 445 - Conceptual Design Report

Please find attached our report titled *Re-envisioning the UBC Botanical Garden*, as part of the CIVL 445 course deliverables.

The purpose of this report is to present a conceptual design for redeveloping the UBC Botanical Garden with a justification and in-depth analysis of each component. It also encompasses an estimated implementation plan and cost for the entire project.

We hope you find this report satisfactory.

Regards,

Group #15

Enclosures

(1) Copy of requested report, "*Re-envisioning the UBC Botanical Garden*"

Re-envisioning the UBC Botanical Garden

Conceptual Design Report

Prepared by: UBC CIVL 445 Group #15

Fangqing Chen
Christian Hajen
Adrian Lee
Jordan Miller
Jonathan Wong
Linus Yau

[redacted]

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EXECUTIVE SUMMARY

The UBC Botanical Garden & Centre for Plant Research occupies 78 acres of land situated on the southwest corner of the UBC campus. It is the home to a collection of over 12 000 plants, including numerous rare and endangered species, representing many regions around the world. This makes it the 2nd most diverse botanical garden in North America (UBC Botanical Garden and Centre for Plant Research, 2013b).

Improvement of the UBC Botanical Garden is required to increase the annual volume of visitors to a level that can provide funds to continue research and sustainability. To achieve this task, six different design components are proposed to be implemented over several phases. The six conceptual design components are as follows.

1. Directional and scientific cataloguing signage
2. Moon Tunnel interior upgrades
3. Rooftop rainwater collection and distribution system
4. Stormwater drainage system
5. Greenhouse-café bistro and lounge
6. Elevated pedestrian walkway

The first phase of the redevelopment plan will improve upon the visitor experience, and increase visitor engagement, by enhancing signage and aesthetics in the garden. The combination of thick foliage and low-strung signage in the west portion of the garden makes its trails challenging to navigate for visitors. Enhancing the directional signage and identifying garden landmarks will greatly contribute to the navigability of the garden. In addition, current plant signage only presents a taxonomical name, which has little meaning to most visitors. New scientific signage with improvements made to graphics and descriptions — with the possibility of interactive elements — would make the garden experience more educational and engaging for visitors.

The Moon Tunnel used to connect the east and west portions of the botanical garden is aesthetically displeasing when compared to the rest of the garden. Since the tunnel is unavoidable, due to the layout of the garden trail route, it is worthwhile to provide some upgrades. By simply covering the corrugated steel walls with wood, plants and signage, and by improving the interior lighting, the ambiance and safety within the tunnel can be greatly improved. These upgrades are inexpensive to implement and will improve the overall garden experience.

The stormwater drainage system in the botanical garden is currently inadequate to handle Vancouver's rainfall conditions. Thus, a new subsurface drainage system will be installed along with a new gutter system for the pathways in the garden. This system will use a series of catchment basins, perforated pipes, and concrete channels to redirect precipitation back to the existing stormwater drainage system. The stormwater drainage system may be retrofitted as a stormwater collection system in the future allowing the garden to reuse the water in its daily operations.

To address the current issue of excessive use of potable water in the botanical garden, a new rainwater collection system will be built to reduce the demand. The rainwater will be collected on the garden pavilion

roof next to the vegetable garden and stored in plastic drums adjacent to the building. This will allow for collected rainwater to be piped into the nearby vegetable garden for the plants. The cost of implementing a rainwater collection system is very low, and will yield huge benefits in addressing the sustainability of the garden.

The greenhouse-café bistro and lounge consists of several glass domes which, with their unique architecture, will be iconic to the botanical garden. The glass domes will serve the purpose of plant conservation, by creating a place to expand the floral collection with new species. It will also provide a place for visitors to relax and purchase coffee and snacks, with quiet study areas for students. Ultimately, the greenhouse-café will bring in more revenue for the garden to support its mission in scientific research. The establishment will provide a comfortable environment which will attract students from the nearby campus area and likely increase overall attendance.

A new elevated pedestrian walkway will create a dramatic change to the west side of the UBC campus, as well as address three major concerns: safety, accessibility, and publicity. The elevated pedestrian walkway will be a single span steel truss bridge which will be both functional and aesthetically pleasing. It will create a circular loop which completes the garden tour and provide a safer pathway to cross SW Marine Drive. The façade of the MSE wall will include a UBC logo and welcome message for visitors arriving to the UBC campus.

The six different design components will be implemented through various phases over 20 years. The work on the signage can commence immediately, as it is a simple upgrade. In the third year, upgrades to the tunnel can be undertaken, and by the fifth year, the rainwater collection and stormwater drainage systems can be implemented. After the more essential upgrades have been completed in the garden, work on building the greenhouse-café can begin around year 10. Lastly, construction of the elevated pedestrian walkway is planned for year 17, and expected to be completed by year 20.

Although the proposed plans to upgrade the botanical garden are ambitious, they are also financially feasible. The financial cost to implement all these conceptual design components range greatly. For example, the costs of upgrading the signage and Moon Tunnel, are relatively low as compared to large scale projects such as the greenhouse-café and elevated pedestrian walkway. The financial requirements of the projects are high, however, with proper planning, will be feasible procure.

Overall, the conceptual design to re-envision the UBC Botanical Garden addresses the issues of sustainability to promote further steady growth into the future, thus allowing the garden to expand and diversify its collection. Accessibility to the garden is improved and the visitor experience is enhanced to promote education in the garden. The proposed upgrades will establish the presence of the botanical garden on the UBC campus and provide a destination for the community.

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1 INTRODUCTION

1.1 Purpose

The purpose of this project is to redevelop the UBC Botanical Garden by implementing possible conceptual designs. These conceptual designs address current issues within the garden while staying true to the garden's mission of scientific research, conservation, display, and education. All of this together creates a sustainable future for the botanical garden.

In order for a business to be sustainable, a steady source of income must be available, which has been a challenge for the garden. Currently, the UBC Botanical Garden relies on a progressively shrinking annual allowance from the university to pay for staffing, and limited revenues from attendance are utilized to service the existing plants in the collection. The hope is that the proposed upgrades will also increase local interest in the garden and consequently attract more paying visitors so that extra revenue will be available for future development, collection expansion and additional staffing.

The conceptual design components introduced adhere to the mission of the re-envisioning project:

> To redevelop the UBC Botanical Garden to enhance the community's experience and education, promote sustainable research and conservation, and establish its presence on the campus.

1.2 Background

The UBC Botanical Garden was instated in 1916 as a living library of botanical species. As the first university botanical garden in Canada, it has gone from a small living library to one of the most highly regarded botanical garden in the world.

The garden formed as a result of an initiative in 1911 to document all native BC flora. The botanist, John Davidson, was tasked with compiling all species, and enlisted the assistance of local experts around the province. He set up the collection on a two acre plot at Colony Farm. When the First World War hit, economic depression forced the shutdown of the Provincial Botanical Office, and at the same time, Davidson's temporary garden was moved to UBC. The 25 000 plants of 900+ species were gradually transported to their new Point Grey home (UBC Botanical Garden and Centre for Plant Research, 2013a).

The new site was still in its natural state, covered in large trees, uneven ground, and large boulders. The land was cleared and graded until 85 acres of free space were finally completed. Most of this land ended up as the experimental farm (now UBC farm) but five acres were used for the UBC Botanical Garden, which became the new home of the Colony Farm when the 25 000 species were moved in the period from 1916 to 1917 (UBC Botanical Garden and Centre for Plant Research, 2013a)

When UBC moved to Point Grey in 1925, the garden finally became a component of the UBC campus, and with that move came further expansion to the garden including the installation of an alpine garden as well as subgrade drainage. At the start of the Great Depression in 1929, funding cuts interrupted development of the UBC Botanical Garden, but after numerous years of economic difficulty, the botanical garden had

numerous plant beds, tree nurseries, displays of native flora, a rock garden, an aquatic garden, and various other displays (UBC Botanical Garden and Centre for Plant Research, 2013a).

Today the UBC Botanical Garden has grown to 110 acres, a larger version to what it was in the late 1930s, with a variety of domestic and foreign species.

1.3 Description

The 110 acre garden is located on the west side of Point Grey, bordering the coastline and straddling SW Marine Drive on both sides. The east and west sides of the garden are joined by the Moon Tunnel, which allows passage of people under the four lanes of SW Marine Drive without interrupting the flow of traffic above. The garden is bordered on the southeast by 16th Avenue, on the northwest by Stadium Road, to the northeast by Thunderbird Stadium and to the southwest by Old Marine Drive (see Appendix B: Map of the UBC Botanical Garden).

Being so close to the ocean, the area experiences extensive moderation and heavy precipitation through much of the year. Point Grey is listed as a 7a Hardiness Zone- one of the most temperate areas in Canada (see Appendix C: Plant Hardiness Zones) (Agriculture and Agri-Food Canada, 2013).

Given the clearing of trees in plant bed areas, the area receives close to full sun, and receives ample water through a combination of rain during the wet season (October to June) and municipal tap water during the dry summer season (July to September).

1.4 Scope

1.4.1 Issues

Each conceptual design was developed to address a specific issue identified at the UBC Botanical Garden; these problems were identified through consulting garden representatives, along with several site visits to gain insight on existing conditions. At the conclusion of the brainstorming process, the following issues were chosen to be of highest importance:

- Plant species were not clearly identified
- Displeasing moon tunnel ambiance
- Excessive use of potable water
- Improper drainage of stormwater
- Low revenue and visitor attendance
- Relatively small presence on UBC campus

Having noted these issues as base for the designs, more in-depth assumptions would have to be made in order to tailor designs to better fit and mitigate these problems.

To tend to the low revenue and visitor attendance, it is reasonable to assume that revenue will have the same positive correlation to visitor attendance independent of time; therefore an increase in visitor attendance will generate an increase of revenue. Consequently, assumptions are made in light of increasing visitor attendance by mainly adding incentive for visitors to come and improving aesthetics in the area. The issue with aesthetics of the botanical garden were identified to be comprised of mainly the

lack of aesthetics in the moon tunnel, and the improper signage. It may be further assumed that with accessibility and aesthetics improved, the UBC Botanical Garden will have a larger presence in the UBC community.

Many members of the UBC Botanical Garden have mentioned that one of the more severe problems the garden is facing was the excessive use of potable water. Assuming that the expenses of potable water will also be a burden, decreasing usage of potable water will then help solve this problem. It is also assumed that the current issues the botanical garden is facing, namely pooling, flooding, soil erosion, and cliff erosion, are all caused by precipitation alone.

With these assumptions made, resolving these issues will provide UBC Botanical Garden with a more environmentally and economically sustainable agenda.

1.4.2 Limitations

One of the main restrictions of the design process was that there would be no numerical analyses on any sort of design. For example, the specific physical dimensions of all of the conceptual design components will not be taken into serious detailing as emphasis is placed on the roles that the designs will play in the UBC Botanical Garden community. Consequently, a detailed cost analysis is not performed due to the limited detail of the conceptual design components.

Other than not incorporating in-depth numerical analyses in all the proposed designs, there are other restrictions to how the designs will be incorporated. These limitations may be categorized into two types; the first type being limitations due to the assumptions, and the second type being the restrictions due to existing conditions of the garden. The assumptions made will limit the designs' validity to within the premises of the assumptions themselves (i.e. an increase in visitors will directly increase revenue). The second type of limitation, namely the in-situ restrictions, involves parameters that set the upper bound of the efficiencies in the designs. These restrictions include the size and constructability of the designs, and furthermore, UBC Botanical Garden's vision. Since the garden has limited space given that the collection of plants may not be removed in most situations, the designs, including their respective construction phases, will be tailor-made to fit into the garden physically without violating the UBC Botanical Garden's visions. Finally, the physical boundaries of the garden itself will provide a clear perimeter of where the designs may only be implemented and planned.

1.5 Stakeholders

The key stakeholders of this project have been identified in order to establish the most effective approach to deliver information about the proposed construction to all parties. Communication tools would include information packages that could be adapted for stakeholder websites, social media and channels or email/newsletters. Stakeholders are encouraged to share and discuss information with their networks.

Key stakeholders were classified into two categories based on the extent of the impact and their involvement in the project, termed as either "primary" or "secondary" stakeholders. Primary stakeholders are internal parties that engage in economic activities and construction guidelines. Secondary stakeholders are external parties that would be affected by or can affect the project.

Primary Stakeholders were determined to be the following:

- The University of British Columbia (UBC)
- Community Advisory Council of the University Endowment Land
- UBC Botanical Garden

Secondary Stakeholders were determined to be the following:

- UBC Students
- Residents (especially Hawthorn Place Strata Councils)
- UBC Faculty and Departments (especially The Faculty of Science)
- Student Housing and Hospitality Service (SHHS)
- UBC Centre for Plant Research
- Campus Volunteers
- UBC and Botanical Garden Staff

2 CONCEPTUAL DESIGN COMPONENTS

2.1 Directional and Scientific Cataloguing Signage

2.1.1 Design

New exhibit signage will present both the plant's layman and taxonomical names in addition to other important information. This will improve both ecological and environmental impact awareness. Revised signs will have a main section displaying distinguishing physical and chemical features of the plants and another section delineating the species' ecological characteristics and roles in the ecosystems in which they live. This will be followed by a final section explaining the plants' conservation status, including human activities which are having a negative impact on its survival in the wild. A QR code placed on the corner of the sign will link a visitor's electronic device to additional information online, with the possibility of unique website design on behalf of the UBC Botanical Garden to be incorporated into this design aspect. Figure 1 in Appendix A shows a conceptual sketch of the proposed scientific signage.

Re-vamped directional signage will be more colourful and prominent both inherently and by physical placement. The new signs will be higher off the ground and placed in high-visibility spots at garden trail intersections in order to be of the most benefit to visiting guests. Intersections may be given names which will be identifiable by use of the signage in reference to a potential new map system which will significantly improve the ability of newcomers to navigate the garden and visit the exhibits they are interested in.

2.1.2 Justification

New or modified signs can also be used effectively to improve the educational value of existing plant exhibit descriptors. In the few locations where existing plant captions are currently present, they generally contain minimal information, in some cases presenting only a taxonomical name which has little meaning to most visitors. The majority of these signs are also dishevelled and in need of maintenance, which makes replacements pragmatic. New signage with improvements made to graphics and scientific descriptions — with the possibility of interactive elements — would make the garden experience much more educational and engaging, especially for families with young children. This would broaden the visitor base in the Vancouver community and potentially serve as an inexpensive, short-term starting point for procuring additional revenues, which the UBC Botanical Garden could then use on other larger projects to upgrade the garden and create even more revenues.

The combination of thick foliage and low-strung signage in the South Garden portion of UBC Botanical Garden currently makes its trails and roads challenging to navigate for the visitor. These difficulties are complicated by the lack of available reference landmarks, as plant exhibits are infrequently and inconspicuously labelled. The patron experience is integral to attracting new guests and enticing the previous guests to return with others. An improved signage scheme will greatly contribute to the navigability and amenity of the garden while also serving it in its mission to be a scientific, educational institution.

Signs acting as way finding aids can be improved through increased prominence. Visibility is the main issue with the current navigation signs, as many are obscured by foliage, low to the ground, or poorly placed.

Signage usability can be significantly improved by either replacing the existing signs or by augmenting the existing set so as to address these physical features. Additionally, revisions to the garden map can be integrated with the signage network renovations to improve cross-referencing between the two tools so that guests can better find their way around.

2.2 Moon Tunnel Interior Upgrades

2.2.1 Design

Moon tunnel renovations will include efforts to cover the pavement bottom and two sides of the tunnel with wood panelling and grating, with the possibility for low light-requirement variants of ivy or other hanging species of plants to be placed on the wood. Installation of augmented tunnel interior lighting is also planned in order to improve safety and ambience of the tunnel, and to improve the aesthetic continuity of the garden so that visitors do not need to traverse a long section of corrugated steel pipe when passing from one area of the UBC Botanical Garden collection to the next. Other features which may be added in the future include exhibit or information signage on the walls within the tunnel with specific hanging plant species described. A conceptual sketch of the upgraded renovations are shown in Figure 2 in Appendix A.

2.2.2 Justification

The moon tunnel which connects the northern and southern portions of the garden is a project which was not completed to the full extent of its original design, and this is obvious when its crude aesthetics are juxtaposed with the features of other garden structures. Although there is limited available space for functional improvements within the tunnel, the overall quality of the garden experience can be refined by renovating or adorning the tunnel interior so as to conceal the presently exposed corrugated steel pipe surface.

Covering the steel with wood or plants will provide continuity in the garden atmosphere and maintain the venue's themes of biodiversity, naturalism and conservation throughout the visitor experience. A sharp break in the garden mood currently exists in the visitation circuit in the garden, as guests must walk through a long stretch of barren tunnel with no aesthetic or educational value in order to get from one side of the garden to the other. The tunnel represents a sizable portion of the garden path which is unavoidable for visitors who want to take the entire garden in during their excursion, and so it is worthwhile to complete inexpensive aesthetic improvements to the interior as a small step in improving the overall experience.

The placement of new material within the tunnel also presents opportunities to improve the poor interior lighting scheme. The tunnel is dim even in the daytime, and additional or more powerful lights mounted on the ceiling could greatly improve the safety of guests travelling through the tunnel, especially those with poor eyesight. The lights would also ostensibly be of benefit when garden attendance increases and there are larger simultaneous traffic volumes in opposing directions present in the tunnel.

2.3 Rooftop Rainwater Collection and Distribution System

2.3.1 Design

The rooftop water collection system uses the existing roof of the Garden Pavilion Building to store rainwater for future use. The building is located approximately 20m from the vegetable garden plots, tracts of soil which require large amounts of water during the summer growing season. Given the high annual rainfall on the west coast, the roof area will channel the water into large recycled plastic drums using a closed gutter system. The intake pipe is to be fitted with sieve-like screens to stop the ingress of both leaves and insects. A conceptual sketch of the proposed layout of the rainwater collection system is shown in Figure 3 and Figure 4 in Appendix A.

The closed pipe leading into the rain barrel allows the conservation of hydraulic head. In this case, the pressure difference from the gutter to the rain barrel's release valve provides the force necessary to distribute water laterally toward the vegetable garden. Using PVC piping, water can be directed manually or put on a timer to micro-irrigate vegetable plots during mornings of summer months.

By using one large rain barrel, footprint space and total costs are minimized, but the tremendous load from eight months of stored water could have structural effects on whichever surface the barrel rests on, including soil. If it is found through soil compaction studies that excess settlements are possible, a second barrel may be installed to distribute the dead load.

The outflow valve at the bottom of the rain barrel will feed a single transmission line, which will fork off at the vegetable garden into smaller distribution lines. This will maintain the efficiency of the system and will ensure sufficient flow during the morning watering period.

2.3.2 Justification

Given the vast fluctuations in rainfall throughout the year, vegetable cultivation without a reliable water source is a difficult prospect. Vancouver's five month growing period sees consistent moisture and sunlight for the early months of May to June, followed by periods of drought through the later months of July through September.

Without a system of water collection, the UBC Botanical Garden currently irrigates not only its vegetable garden, but everything including the ponds using potable tap water from Metro Vancouver. Relying on tap water brings two principal concerns. The first concern is soil salinization, a consequence of using salt-laden irrigation water, which deposits salts and eventually poisons soil over time. Unlike rainwater, even the clean tap water provided by Metro Vancouver has a salt content that has the potential to build up in soil over time. Secondly, leafy greens and most other vegetables require large quantities of water. Given the large area of the vegetable garden combined with botanical garden's overall, large water requirements cause a large strain on the municipal reservoirs during the dry summer months, and incur tremendous fees for the use of such vast quantities of water.

By collecting rain water in large barrels throughout the year, the botanical garden sees the following advantages:

- Utilization of natural rainfall to eliminate the salinization risk
- Reduction of surface runoff to ease burden on surface water drainage system
- Reduction of demand for potable tap water during drought periods
- Cost savings from both water use and runoff discharge
- Demonstration to public about the ease of implementing a rainwater collection system

Numerous guest speakers from the UBC Botanical Garden have noted the lack of funding available for project implementation. A water collection and distribution system is economical, with the only costs being those of the purchase of the rain barrel, a number of small valves, and small diameter rubber tubing to distribute to the vegetable garden. The components of the water collection and distribution system are easy to install, allowing the UBC Botanical Garden to cut installation costs by using volunteer labour. The plastic water storage tanks – the largest components of the system – are moveable between two people.

The location of the water collection and distribution system on the roof next to the vegetable garden is perfectly close to the main pedestrian loop, allowing easy access by the public and by botanical garden maintenance personnel for irrigation control during summer months. With no additional footprint required for the collection system, and only a series of small-diameter plastic lines running to the nearby vegetable garden, there will be no substantial effect on the environment on an ecological or aesthetic standpoint.

The UBC Botanical Garden's ultimate goal is to attract visitors. Dwindling numbers – especially during the fall and winter months – have prompted staff to seek economical ways to attract students as well as the general public to not only boost recognition of the botanical garden to more Vancouverites, but to generate the revenues necessary to maintain and improve the property. With the growth in popularity of balcony gardens and rooftop plots in densely populated urban areas such as downtown, the implementation of a space-efficient rainwater collection and irrigation system is an appealing option sure to explode in the near future.

By creating this innovative and sustainable feature, the rooftop water collection system complies with the mission to promote sustainability of the botanical garden, to draw more recognition and attendance from the public and to educate those visitors about simple ways to undertake sustainable practices.

2.4 Stormwater Drainage System

2.4.1 Design

A stormwater drainage system may be installed in the botanical garden by adding a network of pipes and collection systems. There will be two parts of the system, namely the surface collection and the sub-surface collection. The surface collection part of the system will ensure collection of precipitation, while the sub-surface collection will be installed to collect water that has percolated through the soil. Both parts of the design will be typical designs that may be implemented throughout various parts of the garden which have relatively higher elevations, to ensure enough water elevation head for the system to work completely under gravity. Figure 5 and Figure 6 in Appendix A show the typical the schematics of the conceptual surface collection and sub-surface drainage systems.

The surface drainage part will include the use of catchment pits and roadside gutters. The roadside gutters will direct surface runoff created by precipitation to catchment pits at lower elevations. This system will hence be a network of concrete channels connected to catchment pits. These catchment pits will then be connected to the existing main storm drain pipe. The roadside gutters will be covered with steel covers (with small openings for water to fall through) placed along the length of the channel to minimize clogging (i.e. fallen leaves that may pile up within the channel).

The sub-surface drainage part of the system will include the use of a series of perforated pipes, filter material, and a series of larger pipes. Since this drainage design will be underground, the perforated pipes will be responsible for draining the water that has percolated through the soil, while the filter material will surround perforated pipe in order to stop small particles (i.e. silt or clay) from entering the drainage system. These perforated pipes will then be collected via larger pipes and led to the existing main storm drain pipe.

Another option of this design may be to retrofit this entire system to allow for collection of stormwater by directing both subsystems in this design towards a stormwater detention/retention system instead of towards the main storm drain. This will also address the issue of sustainability as more stormwater may be reused rather than relying on potable water.

2.4.2 Justification

Prodigious amounts of rainfall in the Vancouver area may not be properly diverted through the existing drainage system at the UBC Botanical Garden. Proper drainage is crucial to preventing pooling and flooding on the grounds, and to maintaining quality of water sources. Excessive surface runoff can be mitigated through the use of surface and sub-surface drainage systems. The sub-surface drainage (SSD) system will involve using perforated plastic pipes, filter material, and a pipe main, and gravity. By implementing a good drainage system in the botanical garden, visitors will benefit from a better experience of their tour in and around the perimeter, along with protecting the garden from excessive runoff erosion causing drastic landscape changes.

The proposed surface drainage system will help account for surface runoff on impermeable surfaces like paved roads that will inhibit mud pits and puddles from forming. Muddy roads may be a heavily weighted factor for the visitor's decision upon coming to visit the garden, and the surface drainage system is a solution to this problem.

The idea of the SSD system was built on knowledge of environmental risks posed by poor sub-surface drainage on cultivable land. Salinization of soil will decrease its ability to yield crop, and is usually caused by a build-up of salt from irrigation water. Another potential threat of poor drainage in the area leads directly to the pools and ponds in the botanical garden; when surface runoff carrying agrochemicals, such as fertilizers, are transported into these bodies of water, they create a buildup of these chemicals, potentially causing eutrophication. As noted during the site visit to the botanical garden, the seepage into the ground seeps laterally after percolating through a certain depth of soil, and finally out onto the cliff face. This phenomenon is dangerous as it may lead to cliff instability through erosion of constant flow of

water, involving potential weathering problems. These environmental consequences may be taken care of by introducing the SSD system in areas with a lot of soil exposure.

By implementing the drainage system, UBC Botanical Garden will benefit from not only being able to provide a better environment for its users and visitors, but also being able to mitigate potential harm to the environment. If needed, this storm drainage system may be turned into a stormwater collection system by redirecting main drainage pipes to a storage tank. With this design, a more sustainable future may be developed for the botanical garden.

2.5 Greenhouse-Café Bistro and Lounge

2.5.1 Design

The café lounge will be a hybrid restaurant-greenhouse facility which will serve the functions of a café, bistro and study lounge, while simultaneously acting as a commercial prelude to showcase a small portion of the garden's collection in the interest of enticing people who are already in the area to visit the garden. The preliminary design involves a series of spherical glass structures joined in a diamond formation, with the whole establishment to be situated in the grass clearing just outside the UBC Botanical Garden's west entrance, next to the parking area off of SW Marine Drive. Implementation of the project may also include modifications to garden land use in the vegetable garden or near the entry area in order to grow some species of food or coffee which will be served in the café itself. A conceptual sketch of the layout of the proposed greenhouse-café is shown in Figure 7 in Appendix A.

The interior of the building is to be comfortably furnished in a heterogeneous manner. One portion of the building — near the food order area — will act as a compound restaurant and coffeehouse similar to a Tim Hortons restaurant and serve as the main eatery area. Other spaces will be fashioned to accommodate group or individual study with a lounge-style interior where people can stay for extended periods of time and over the course of their stay re-visit the café area for more coffee or snacks. Different plant species may be used for which a greenhouse atmosphere is appropriate and the structure may also have features to promote cooling in the summers and warmth in the winter in order to make interior conditions amenable to students and other visitors.

2.5.2 Justification

Introducing food or service businesses to the welcome area at the entrance of the UBC Botanical Garden could significantly benefit garden attendance by attracting more people to the general area. Location-wise it is evident that the garden is quite isolated, and currently offers few attractions to lure the UBC students who comprise the majority of nearby residents. But the garden's remoteness can have a place in the lives of university students if marketed correctly.

A project which targets student attendance is worthwhile because many live close to the university campus and it would be those people who would most readily make repeated trips to the garden. In addressing student needs, the two most prominent observations passersby on the UBC campus would make are those of students studying and of students lining up to buy coffee. There are people studying in every single building on campus no matter what their intended use, and the multiple coffee shops scattered over the

grounds are constantly filled with people. Additionally, the largest agglomerations of people are concentrated in areas where ample study space and good coffee-making intersect.

It is conceivable thus that a café-lounge situated in the grass clearing at the entrance of the botanical garden could serve as a major magnet for students to the UBC Botanical Garden area. Seclusion is a highly desirable feature of study space, and the garden could transform its apparent weakness into strength by marketing its café as an isolated but homey haven for the students to work while also satisfying their caffeine needs with quality coffee. With a well-designed building and a spacious and well-furnished interior, the garden café could likely serve the nearby student populations housed in the Totem and Marine Drive residences in a similar manner to that of the Beanery Café which services the Fairview Residences, an establishment which has a special and enduring place in the hearts of countless current students and UBC alumni alike.

Although the café would provide minimal educational features, it would allow the garden to better integrate itself into the UBC community fabric and strongly improve its financial and social standing. Ideally, UBC Botanical Garden would operate the café as an auxiliary but independent component of their organization, so that customers of the café would not necessarily have to enter the garden themselves, while the garden could still utilize the profits derived from the business. The increased traffic to the area could also potentially improve the garden's future pitches to UBC leadership for local transit configuration and parking improvements, which are a major limitation to its current bid for increased attendance. These types of upgrades would have a ripple effect that would ultimately increase the garden's capacity and value over time, and provide more revenues supporting its mission in scientific research.

2.6 Elevated Pedestrian Walkway

2.6.1 Design

For the final conceptual design component, construction of a new elevated pedestrian walkway is proposed over SW Marine Drive near the entrance to the UBC Botanical Garden. The walkway will be a single span steel Pratt truss bridge which will be both functional and aesthetically pleasing. The steel truss will be painted white for an elegant look, and create an airy and free environment. Along the eastern abutment of the bridge will be a mechanically stabilized earth (MSE) wall, where the façade of the MSE wall will include a welcome message and UBC logo. The functionality of the pedestrian walkway can be increased by allowing both the public and garden visitors to use the bridge. A ramp will be built along the MSE wall to the elevated entrance of the bridge for public access, as well as a one-way exit from the UBC Botanical Garden leading to the bridge. On the west side of the bridge will be a curving ramp returning to the parking area and entrance to the botanical garden.

The walkway will be constructed using wooden planks to present a natural surface motif. In addition, plants will be grown in planters along the edge of the walkway and climb up the barrier on either side to create a 'green walkway'. There is also potential for signage, which may provide a history of the UBC Botanical Garden, to be installed along the pedestrian barriers along the walkway. This would improve the educational value and entice pedestrians to enter the garden. Figure 8 through Figure 10 in Appendix A show various views of the elevated pedestrian walkway in its final alignment over SW Marine Drive.

2.6.2 Justification

A new elevated pedestrian walkway will create a dramatic change to the west side of the UBC campus, as well as address three major concerns: safety, accessibility, and publicity.

The current un-signalled crosswalk across SW Marine Drive poses a safety concern that the elevated pedestrian walkway will eliminate. Northbound traffic along SW Marine Drive is proceeding at a high rate of speed, and there is insufficient signage to warn drivers of the upcoming crosswalk. Although traffic volume is low, this risk of serious injury or death is still present. The elevated pedestrian walkway will create an elevated walkway to allow pedestrians to avoid this risk. Also, having a ramp on both ends of the elevated walkway will allow accessibility for bikes and wheelchairs as well.

Currently, access to the UBC Botanical Garden is an inconvenience to visitors arriving on foot. A new elevated pedestrian walkway will allow visitors from UBC to easily gain access to the garden entrance by creating a direct route to the entrance gate. In addition, due to the current layout of the botanical garden, there is only a single route between the west and east sides of the garden: the Moon Tunnel. This requires that visitors must return to the entrance along the same route. By implementing a one way exit gate at the east end of the elevated pedestrian walkway, visitors can forgo the need to return through the Moon Tunnel back to the entrance and parking area. In this way, the elevated pedestrian walkway creates a loop to complete the walking tour around the botanical garden.

Even though the botanical garden is located near the entrance to the UBC campus at SW Marine Drive, very few people know about the garden. The new proposed elevated pedestrian walkway will eliminate this problem by creating a landmark location for the botanical garden. Also, as the first elevated pedestrian walkway on campus, it will be a landmark for students and faculty. It will include a sign with the UBC logo along the MSE wall on the east side SW Marine Drive welcoming visitors to UBC and the botanical garden.

3 COSTS-BENEFIT ANALYSIS

3.1 Directional and Scientific Cataloguing Signage

3.1.1 Ecological

There are minimal environmental costs with the undertaking of new signage installation; indirect effects include the creation of waste in disposal of old signage and greenhouse gas emissions from the manufacture of new signs from durable synthetic materials. These material effects can be mitigated with sustainable design of the new signs, and by proper recycling or environment-friendly methods of material disposal.

The new signs themselves can add educational value by promoting conservational awareness for endangered species or by teaching visitors about crucial facets of plant ecology like the effects of invasive species and overuse of pesticides and herbicides. The signs with their QR codes are an educational tool that could potentially be used in several ways to teach concepts not just in botany and conservation, but also in plant-environmental impacts of human activities.

3.1.2 Social

Increased public awareness with respect to plant ecology can be invaluable in changing behaviours of people toward the natural environment, with effects not just in the vicinity of UBC but in national parks and forests all over British Columbia. The changes in attitudes of people spurred by the acquisition of new knowledge can also have positive effects on the UBC Botanical Garden's future bids for other engineering or development initiatives. The new features will increase popular interest and potentially provide the socio-political pressure which is required to compel projects that require a larger initial monetary investment.

It is also expected, in general, that the improvement of the overall quality of the garden by the presence of educational signage will serve to increase attendance to some degree due to word-of-mouth from new visitors after development takes place. The new signs could also provide concrete reasoning for environmental interest groups or school classes to visit the garden, as visits will be intellectually stimulating experiences.

3.1.3 Economic

A small initial monetary investment is associated with the detailed design, manufacturing and installation of new signage, including removal and disposal of the old signs. These would primarily cover material costs and web-facilities design as required by the inclusion of any smartphone-interactive features embedded in the new exhibit descriptions. Designs will be complete by the end of the proposal phase with the possibility for fine-tuning and adjustments remaining at proposed project start.

It is expected that new signage will play a role in enhancing the garden experience to the extent that more paying visitors will be attracted to the botanical garden, increasing its revenue stream. With more informative and aesthetically pleasing exhibit signs, patrons will realize they are paying to enter a carefully catalogued and cultivated collection of plants — almost like a museum — rather than a garden with

occasional wooden signs. The signs add value to the garden, which will likely increase the willingness of locals to pay to enter.

3.2 Moon Tunnel Interior Upgrades

3.2.1 Ecological

There are minor environmental impacts associated with the lighting system, as having new brighter lights within the tunnel will cause a higher total energy consumption for the garden for the sake of improved safety. However, the extra energy consumption can be mitigated through the use of low energy lighting such as LEDs lights. Wood paneling will most likely be purchased from a building materials depot, and could be treated with benign chemicals for enhancing its durability in the face of exposure to the elements. The benefits of the tunnel covering are mainly aesthetic in nature, but will help to preserve the overall natural motif of the garden within the tunnel to a greater degree than the original interior of corrugated steel pipe.

3.2.2 Social

Aesthetic improvement of the moon tunnel may have subtle social impacts in improving visitor outlook of the UBC Botanical Garden, which contributes to word of mouth effects in increasing the garden's renown in the local community. Improved safety lighting within the tunnel may also encourage parents to bring children or seniors for return trips to the garden as the lights may make the tunnel portion more welcoming and open.

3.2.3 Economic

The cost for this component will be rather small, consisting of materials costs for wood paneling, lighting and circuitry, and potentially installation workmanship. The endeavour would be a small step in the overall bid to improve the quality of the garden experience, in this specific instance by improving safety within the tunnel and maintaining thematic continuity in the conduit between the north and south garden areas. The upgrade may, in conjunction with other more significant upgrades, contribute to increased revenues through the effects of word of mouth.

3.3 Rooftop Rainwater Collection and Distribution System

3.3.1 Ecological

The environmental benefits of implementing the rooftop water collection and distribution system are significant. As with any form of irrigation with treated or surface water, salt deposits can accumulate over time, rendering soil unusable. Rainwater has the benefit that it is not contaminated by salts, and can be used indefinitely without salt buildup. Because there is already municipal water conveyance piping running to and from various installations (such as installed irrigation, ponds, etc.), the environmental cost to keep supplying them is minimal. However, by demonstrating the effectiveness of the rainwater system, the public and perhaps other small commercial garden operations will install a similar system, easing the municipal water demand and the need to excavate land to install waterworks infrastructure.

The environmental costs of such a system are negligible; especially given that the water tank can be made from 100% post-consumer plastic and that it contains no toxic chemicals and requires no soil excavations or the use of machinery to install. The risk of such a system is the potential for a stagnant breeding ground for mosquitos. Clean, oxygenated, stagnant water makes for an ideal environment for mosquitoes to deposit larvae, which can hatch in the thousands in the summer and lead to increased risk of West-Nile Virus (Centers for Disease Control and Prevention, 2013). To prevent such a risk, the collection barrel will be airtight, with water running through a sieve to prevent ingress or egress by mosquitos.

3.3.2 Social

As with many of the other improvement projects proposed for the UBC Botanical Garden, the rainwater system is intended to draw visitors to the area, ultimately generating funding to improve the quality, quantity and diversity of the botanical species at the UBC Botanical Garden. As an educational facility, the garden provide a community service, not only maintaining a living database of plant species, but by educating the public in water conservation methods, backyard farming methods, composting practices, and by feeding the homeless with vegetable crops. The rainwater system will allow the botanical garden to continue its principal mandate of building an inventory of as many native and non-native species as possible, while reaching its secondary goals of educating the public and feeding the homeless.

3.3.3 Economic

Like many retrofitting operations, the payoff period for the water collection and distribution system is quantifiable by direct cost savings over the existing condition, in which all rainwater is diverted to the storm drains. Because the use of municipal water is paid for per unit volume, a reduction of consumption by collecting rain water will reduce UBC's demand for and fees from the use of municipal water. In the 2011 water audit, UBC paid Metro Vancouver $2.5 million dollars for the 4 billion litres of water it consumed (The University of British Columbia, 2011). By implementing this rainwater system, and expanding the concept, visible savings will be experienced by UBC.

In addition, revenue is expected from the increase in paying visitors, who will be lured in part by the innovative system. The UBC Botanical Garden may choose to stock the plastic pipes, assembly and design guides, collection barrels and valves in the existing gift shop, further increasing both revenue and availability of supplies to the public.

The cost of implementing such a project is not significant due to the fact that a nearby slanted rooftop already exists, and that volunteer labour is readily available for installation of the design. The only installation costs are for the purchase of water reservoir tank, plastic distribution tubing, and a number of brass valves leading up to the vegetable garden. Due to the lack of moving parts and the longevity of the materials, minimal maintenance or parts replacement is expected, resulting in an initial capital cost, but negligible running costs.

3.4 Stormwater Drainage System

3.4.1 Ecological

The ecological issues at hand revolving around a poor or a lack of a drainage system range from losing cultivable soil, to causing a decrease in cliff stability. Without a proper drainage system, there may be a build-up of salt in the soil from any sort of irrigation (including precipitation), leading to a loss of cultivable land. On a more severe scale, loss of soil may also be observed as surface runoff may erode soil along its path of flow. Furthermore, if the percolation by rainwater into the upper aquifer that discharges off of the face of the adjacent cliff, the stability of the cliff will decrease over time due to erosion. With Vancouver's diurnal temperatures fluctuating around the freezing point of water, freeze-thaw weathering and salt growth weathering may be a problem, lowering the stability of the cliff itself.

The installation of the surface drainage system of at-grade channels will provide a path for surface runoff independent of any type of soil erosion, moreover providing an opportunity to store stormwater for future use. The system will decrease the amount of cliff erosion by redirecting a percentage of percolated precipitation that flushes out on the face of the cliff. Although the potential weathering problems may still be present, the drainage system will indirectly decrease its effect on cliff stability by reducing the amount of water discharging off the cliff. The collection and reuse of stormwater will lessen the stress on the shrinking supply of water in British Columbia.

As for the effects on existing flora and possible fauna, it may be considered negligible as neither of the systems, after installation, would alter the existing surface environment greatly. There is however an issue of laying out the sub surface drainage system with all the tree roots posing as a potential obstruction; this issue may be easily addressed during the actual implementation of the design with the contractor.

3.4.2 Social

The implementation of such a drainage design will portray the role of civil engineering in a community by being able to help tend to the potential problems at hand with technical knowledge of the geological and geographical conditions in the area. Should the design operate as planned and as foreseen, it would not only be a good opportunity for education in hydrology, but also a perfect precedent study for stormwater drainage design and its potential in stormwater collection. With the implementation of the stormwater drainage system, UBC Botanical Garden will have taken an incremental step towards becoming a more sustainable party under UBC's name. With proper negotiation, UBC Botanical Garden may be able to receive funding towards the research, development and implementation of future acts of sustainability similar to that of this stormwater drainage system. This will help UBC as an entire community by providing both education and job opportunities whilst achieving a more sustainable future financially and environmentally.

3.4.3 Economic

The major economic benefit of installing a stormwater drainage system is that the money spent on potable water will be decreased due to stormwater being available and ready for use (should the stormwater detention option be implemented). Although the capital cost of the system may be high depending on the

intended size of the drainage area, this long-term investment will be able to help the UBC Botanical Garden save substantial amounts of money on potable water. Operation costs would be negligible, containing only maintenance costs due to the entire system being able to operate with gravity alone.

The specific constituent areas that make up the capital costs would be the materials required for this system, and the work hours put into the project by contractors. This drainage system would definitely help alleviate a good percentage of the money spent by UBC on water consumption every year onwards, making the implementation a feasible method of saving money.

3.5 Greenhouse-Café Bistro and Lounge

3.5.1 Ecological

The carbon and land disturbance footprint of the proposed café will be minimized to the extent possible, and the building as whole will be designed in accordance with the highest standards of green building practice as per UBC's sustainability rating system for construction. It is not expected that construction of the building will require clear-cutting of trees in the area or excessive land disturbance, as the design goal is for the entire facility to fit in the existing clearing at the north entrance of the South Garden area. By exemplifying green building concepts in a manner similar to the CIRS building on the main UBC campus, the café will also serve as an iconic display of innovation in sustainability with positive effects on attitudes of engineering and science student visitors who will soon enter the workforce.

The business itself will be able to employ low-waste and low-carbon food service practices to further serve as a subtle example to visitors of innovation in sustainability. Such practices could include the utilization of reusable and biodegradable dishware and cutlery, as well as energy-saving food heaters which could use lost heat from the building itself. On-site sewage could also be utilized to further lower the environmental impacts of running the business. Many possibilities are available for sustainable operation of the building, and the extent to which green technologies are integrated into the building would depend on the budget which is ultimately available for the project. If a large sum of money is committed, significant design inspiration could be drawn from other innovative green buildings at UBC such as the CIRS and C. K. Choi buildings, or new techniques developed at the university.

3.5.2 Social

The presence of the café could serve as a major inroad for the UBC Botanical Garden to the UBC campus community by providing a gathering place for people to flock to or a place where individuals can go to seek an atmosphere of comfort. Providing a pragmatic reason for people to come to the garden area significantly mitigates against the garden's major limitation in its isolation and would increase its renown so that many people on campus actually know of its existence, which is the first step to further revenues down the road. Over time, the garden could gain a significant place in the lives of UBC students and become a memory-filled, irreplaceable component of the university landscape.

Becoming better known and valued around the campus also stands to have socio-political effects on the garden in its relationship with UBC leadership. The occurrence of increased traffic at the garden due to the presence of the café and more garden visitors could be used in the future as leverage in bargaining for

more ideal transit and parking arrangements, or more funds for additional infrastructure and novel developments in the UBC Botanical Garden to further refine the experience. With a higher demand for road use and parking, Translink may need to increase the size or frequency of the shuttles, which presently run every 20 minutes and have a capacity of only 24 passengers (Translink, 2013), which will improve accessibility to the area. If there is evidence which proves that the garden is important to people, the university will more readily comply with funding requests or proposals for new development.

3.5.3 Economic

Despite the large upfront investment cost for the café, coffee and food sales will provide a constant and substantial stream of revenue to the UBC Botanical Garden provided the venue is marketed correctly to locals. If many of the café visitors are students, it is likely that these individuals will stay for extended periods of time, steadily buying drinks and snacks while they study in the same way that they occupy the many coffee shops on the UBC campus. The facility's isolation can also play a role in augmenting food sales revenues, as people staying in the lounge who desire refreshments and food will have to obtain these from the café they are staying in due to the lack of other choices nearby.

In the future, the café may produce an economic ripple effect through the attraction of more guests and traffic to the garden area on campus, potentially providing economic incentive for food franchises to establish locations in the vicinity for which UBC Botanical Garden can charge occupational fees to further increase its passive revenues. The presence of more people nearby also increases the chance that individuals in the area will decide to visit the garden interior, as it is conveniently located right next to the café.

3.6 Elevated Pedestrian Walkway

3.6.1 Ecological

The ecological impacts of constructing a new elevated pedestrian walkway can be substantial. Considerations need to be made for land use, flora and fauna habitats, as well as soil and water disruptions. Land will have to be cleared to accommodate the new bridge on either side of SW Marine Drive. This impacts the local plant and animal habitats, as well as a portion of the UBC Botanical Garden's collection. However, by using the pre-existing elevation of the hill on the east abutment of the elevated pedestrian walkway, the amount of cut and fill is greatly reduced. In addition, on the west side of the bridge, a sweeping ramp will be used to bring the elevation down to the ground, thus bypassing the requirement to bring up the ground elevation. The only impact on the subgrade is the piles installed under the bridge.

Since the elevated walkway is being erected in the vicinity of the UBC Botanical Garden, the soil and water quality will need to be monitored during construction to ensure no contaminants or pollutants enter the ground. This can be easily managed by ensuring construction materials are stored properly, and runoff is collected or redirected and drained properly. Once in service, water runoff from the bridge will be collected on either one, or both sides of the walkway, and redirected into the stormwater drainage system. This runoff is not expected to have a significant impact on the stormwater drainage system since a portion of the runoff will be used to water the planters along the walkway of the bridge.

By choosing a steel truss and wooden walkway design, it is more environmentally friendly than using concrete as a building material, since the production of concrete is a major source of greenhouse gases. These materials are lighter and create an aesthetically pleasing bridge, thus making it more sustainable than alternatives designs. The planters along the 'green walkway' on the bridge also provide a place to grow plants or vines in order to improve the ecology of the area.

3.6.2 Social

Constructing a new elevated pedestrian walkway near the UBC campus has many social impacts. Firstly, a new bridge will greatly impact the local residents such as the nearby student residences, and Hawthorn Place homeowners. It may attract more pedestrian traffic to a quiet corner of the UBC campus, as well as changing the visual landscape of the area.

A large scale project will drastically change the landscape of the UBC campus. However, the social benefits of a new elevated pedestrian walkway are substantial. The bridge will create a visual landmark for the UBC campus and instill a sense of pride in the community. It will establish the location of the UBC Botanical Garden on the campus. It also benefits the society by improving safety for crossing SW Marine Drive. The elevated pedestrian walkway will create a path for fitness and recreation, such as walking, jogging, or cycling.

3.6.3 Economic

A brand new elevated pedestrian walkway comes at a huge cost and carries a large upfront investment. However, a large scale project will also create many jobs for the community, from design consulting to construction, and stimulate the local economy. Materials for the construction of the bridge can be sourced from local suppliers and fabricators, to keep costs low and put money back into the local economy. The design could be done by local engineering firms with local contractors for erection.

Another economic benefit to the university, is the pedestrian walkway could be implemented into student curriculums, such as those in Civil Engineering. Students could be required to complete thorough site analysis and structural design of the components. It would promote student involvement real engineering projects and bring more students into the program. The project, and pedestrian walkway will create visitor awareness of the botanical garden, and potentially attract more visitors to the garden.

A large structure such as an elevated pedestrian walkway will need to be maintained, and maintenance costs will need to be considered by the university and worked into the UBC Plant Operation's budget. With potential issues such as vandalism, this will be a significant consideration in the feasibility of the bridge.

4 IMPLEMENTATION PLAN

This proposal follows a 20 year plan before the final outcome is realized. Simple additions will be implemented with progressively increasing scope and complexity of components over time until the entire renewal of the botanical garden is completed. This section will outline the intended timeline for the renewal. Advancement is ambitious, but plausible if funding is achieved and work is efficient.

Work on the garden's signage can commence immediately. This simple upgrade will require a relatively small budget, yet will greatly enhance the visitors' experience. Visitors will be able to better navigate the paths and learn about the plant species with these upgrades. This will bring more traffic to the garden as the word is spread on the new intuitive experience the garden has to offer.

In the third year, upgrades to the tunnel can be undertaken. This project also has a small scope that does not require any significant engineering design. The current tunnel can be seen as a sore point in the garden and this upgrade will see to the overall beautification of the garden.

The improvement of the garden signage and Moon Tunnel is intended to increase annual number of visitors to the garden; which is a significant priority. Once this has been achieved, work on improving the garden's operation can be undertaken. This is intended to start by year five. The water collection and distribution system upgrades can be completed simultaneously with the improvement to the surface and sub-surface drainage. The two improvements will see to increase the overall sustainability and research capacity of the garden while reducing overall operating costs.

By year ten, it is intended that both the visitor experience and garden operations are improved. However, at this point, the garden visitors have not seen a significant change in years and annual attendance may begin to stagnate. This is when the proposed café is suggested to be built and put into operation. As discussed, this will achieve repeat trips of visitors to the garden. Attendance to the garden will flourish and profits will be seen. Due to the larger scale of this upgrade, significant funding will be required. This can be achieved through donations, grants or possible sponsorship from a private corporation. The benefits will outweigh the costs and this element will prove crucial to the garden's long term success.

After about seventeen years, the garden will now be seen as a significant destination for UBC students and residents of Vancouver. At this point, the final and most noteworthy portion of the plan will be implemented. The elevated pedestrian walkway will prove to significantly increase the safety of the garden's access for visitors crossing SW Marine Dr. Furthermore, this structure will become a landmark not only for the botanical garden, but for UBC as a whole. As with the café, this portion will also considerably depend on the availability of funding. However, UBC will be a stakeholder in this phase of the proposal because of the benefits the entire endowment lands will see.

At the beginning of the twentieth year, every aspect of this proposal will be completed. Visitor attendance will be at an all-time high, operation will be productive and research will be able to flourish for years to come.

5 IMPLEMENTATION COST

The several components of this re-envisioning plan will vary in costs significantly. From almost negligible costs of upgrading the signage in the garden to immense costs of designing and constructing an elevated pedestrian walkway, a reasonable plan must be in place in order for the goals to be achieved.

The costs of upgrading the signage in the garden will be minimal and can be worked into the current operational budget of the garden. A possible option to eliminate the cost of hiring a marketing firm to design the signage is to recruit a marketing class at UBC to complete the designs. Then staff at the botanical garden can use their expertise to complete the plant descriptions.

The cost of the tunnel will be minutely larger than the cost of enhancing the garden signage. This will require a few years budgeting in order to reach the small sum required for the improvement. The upgrade is intended to be economical and simple while still improving the tunnel's ambiance.

The upgrades to the water systems will require some planning and minor material costs. In the long term, the efforts will result in lower water bills, less maintenance and less damage during a catastrophic storm event. Therefore, the budget to complete the work can be seen as an investment. If the initial capital is not available and no other funding is possible, a loan at a low interest rate may still be a feasible option. A detailed cost analysis at the time of installation should be conducted to ensure that the savings overcome any interest rates.

The café and additional greenhouse will come at a high price initially, but as discussed, profits will begin to develop over time. The budget for the project can come from a variety of sources. A large portion could be backed by a private organization if they are given rights to name the café or exclusively sell their product. Additionally, the greenhouses that are built into the café's design will create substantial opportunity for new research. Therefore, research grants can be obtained to assist in the financial burden required to build the structure. Finally, philanthropic individuals may desire to donate sums of money in return for an area dedicated to their loved one. The large space created by the structure will also make this a viable option.

Finally, the pedestrian walkway will require great financial backing from a variety of sources. Funds raised from sales in the café can be saved and used towards this endeavor. Also, because UBC is intended to benefit considerably from its construction, it is foreseen that UBC will invest sufficient funds into the project. As discussed, the project will improve the overall look of the campus by providing a landmark and a grand entrance to visitors entering from SW Marine Drive. In addition, private individuals may also want to be a part of the project. By allowing plaques to be placed on parts of the bridge`s handrails, wealthy individuals can commemorate the lives of their loved ones. It is intended that this bridge will attract many individuals to want to be a part of it and willing to do so by providing funds to make its construction possible.

The plans to re-envision the UBC Botanical Garden is intended to be extravagant yet possible. The financial requirements of the projects will be aggressive to meet, however, with the proper planning, will be feasible.

6 CONCLUSIONSS & RECOMMENDATIONS

A number of changes to the UBC Botanical Garden have been proposed as a means to meet the mission of this re-envisioning plan:

> To redevelop the UBC Botanical Garden to enhance the community's experience and education, promote sustainable research and conservation, and establish its presence on the campus.

The recommendations were made keeping in mind the limited budget available to the UBC Botanical Garden. Projects were chosen using a cost-benefit analysis, noting that while implementation cost may be significant, the increase in visitation by paying entrants would produce a feasible outcome in the long term.

Initial upgrades to the garden's signage will immediately result in an intuitive experience to visitors while increasing educational value.

The Moon Tunnel upgrades will enhance safety and accessibility in the garden. A continuity between the north and south garden will be created to allow for a continuous positive feel along the garden's walking route.

The rooftop rainwater collection and distribution system eases the water consumption requirements, and at the same time reduces the amount of surface water runoff. The subgrade drainage system effectively conveys water at a shallow depth, allowing pools and floods to be prevented or dissipated quickly. As a result, educational value on the conservation of resources is gained by visitors. Additionally, the goals of maintaining the garden's sustainability and improving conservation for the future are met.

A glass domed café near the garden entrance will lure in visitors. The quiet atmosphere contrasted with the fresh greenhouses allow for a peaceful location for studying while permitting partial climate control to allow for the research of foreign plant species. This creates a communal location within the garden as well as enhanced abilities to research and conserve plant species.

To increase safety to pedestrians, the elevated pedestrian walkway crosses over SW Marine Drive. The bridge serves not only as a safety measure, but as an architectural masterpiece, welcoming guests to the UBC Botanical Garden. The presence of the garden is solidified among UBC and visitation will be a regular occurrence among students and faculty.

Over a timeline of 20 years, projects will be installed to fulfill the mission of this re-envisioning plan. Drastic improvement will be seen in the sustainability, accessibility, conservation, education and community feel of the UBC Botanical Garden.

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APPENDIX A: CONCEPTUAL DESIGN SKETCHES

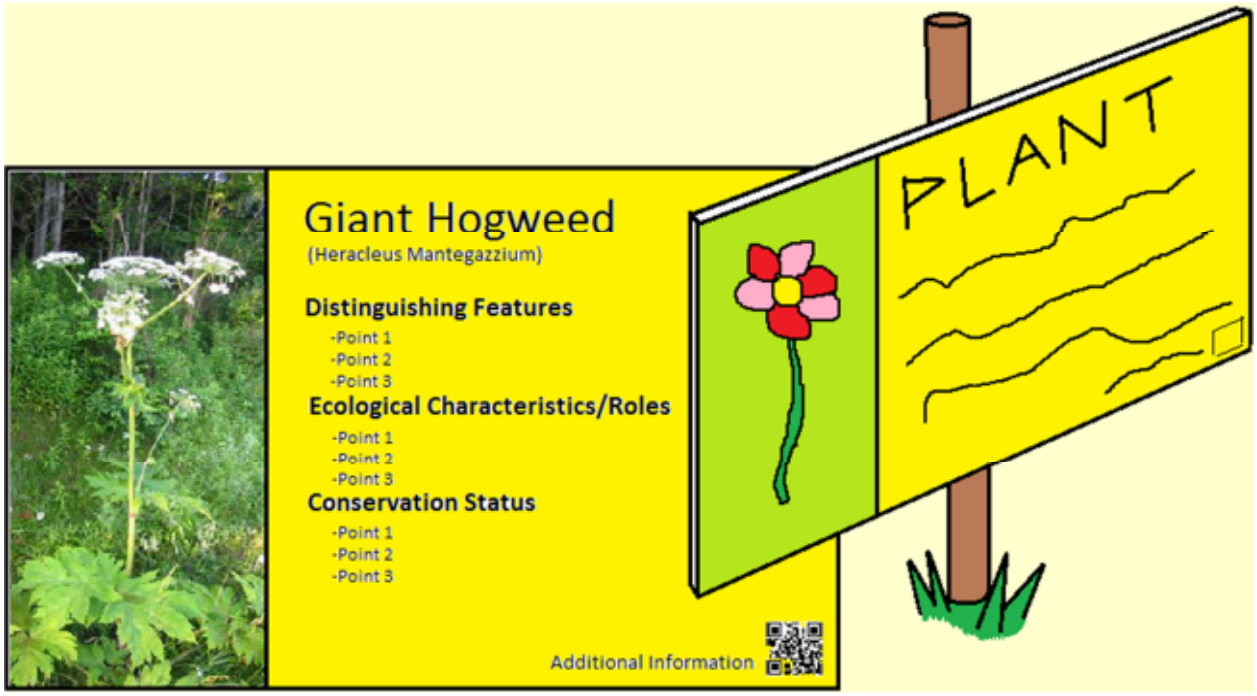

Figure 1: Conceptual sketch of scientific cataloguing signage.

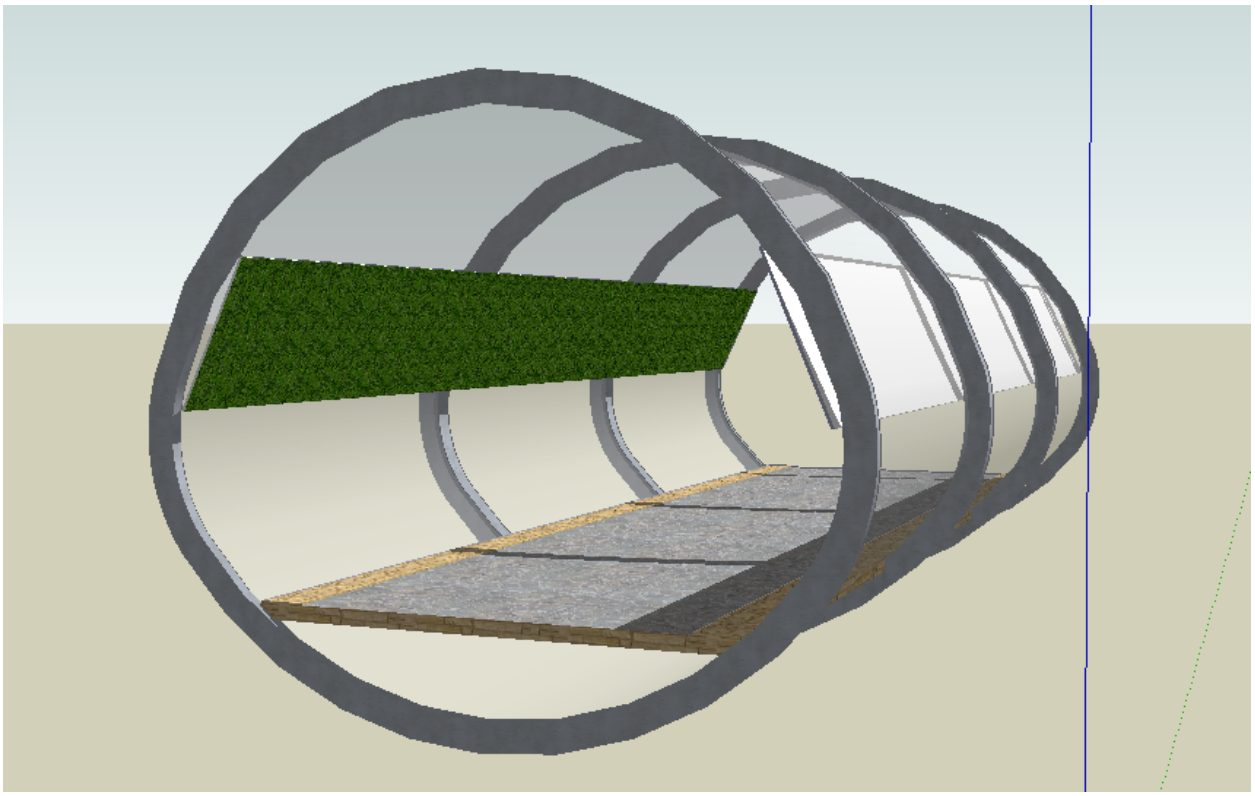

Figure 2: Conceptual sketch of Moon tunnel interior upgrades.

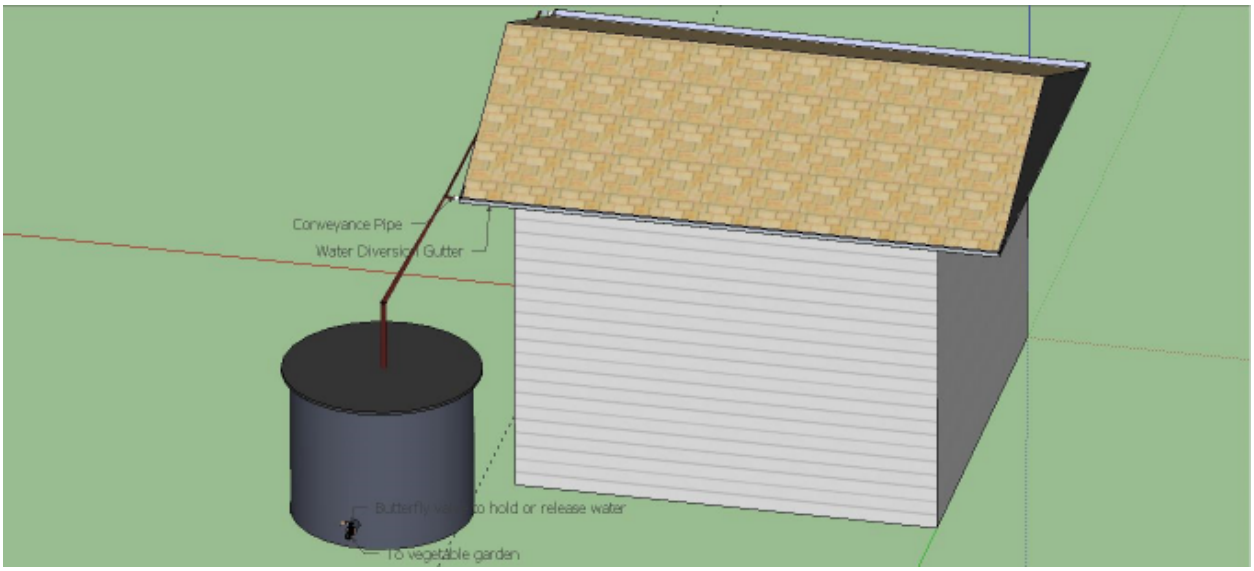

Figure 3: Conceptual sketch of rainwater collection and distribution system #1.

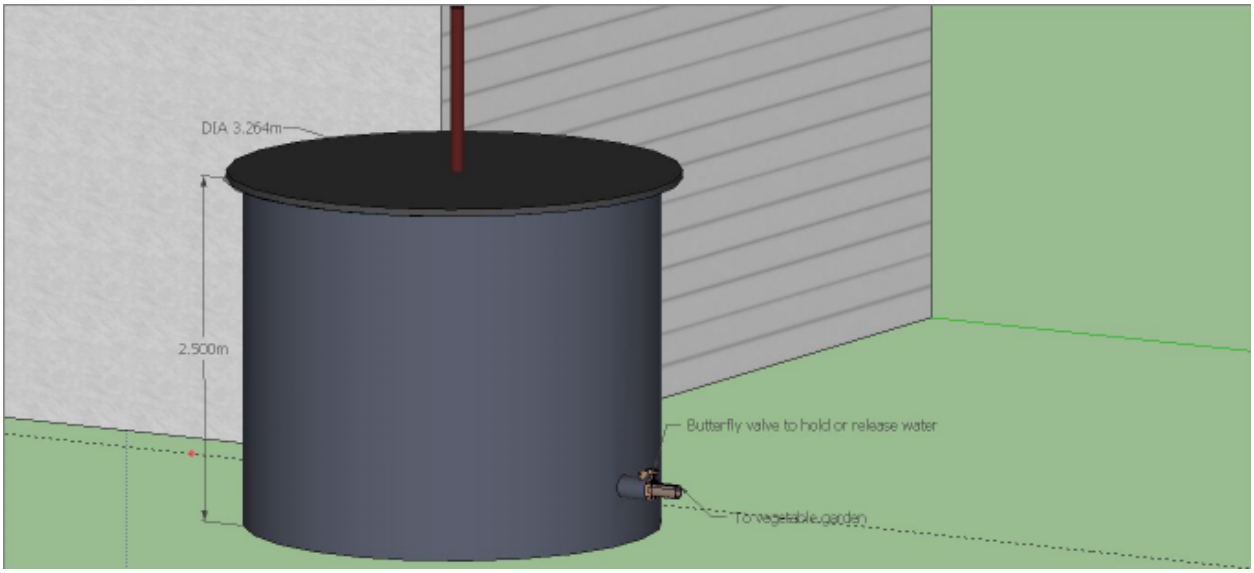

Figure 4: Conceptual sketch of rainwater collection and distribution system #2.

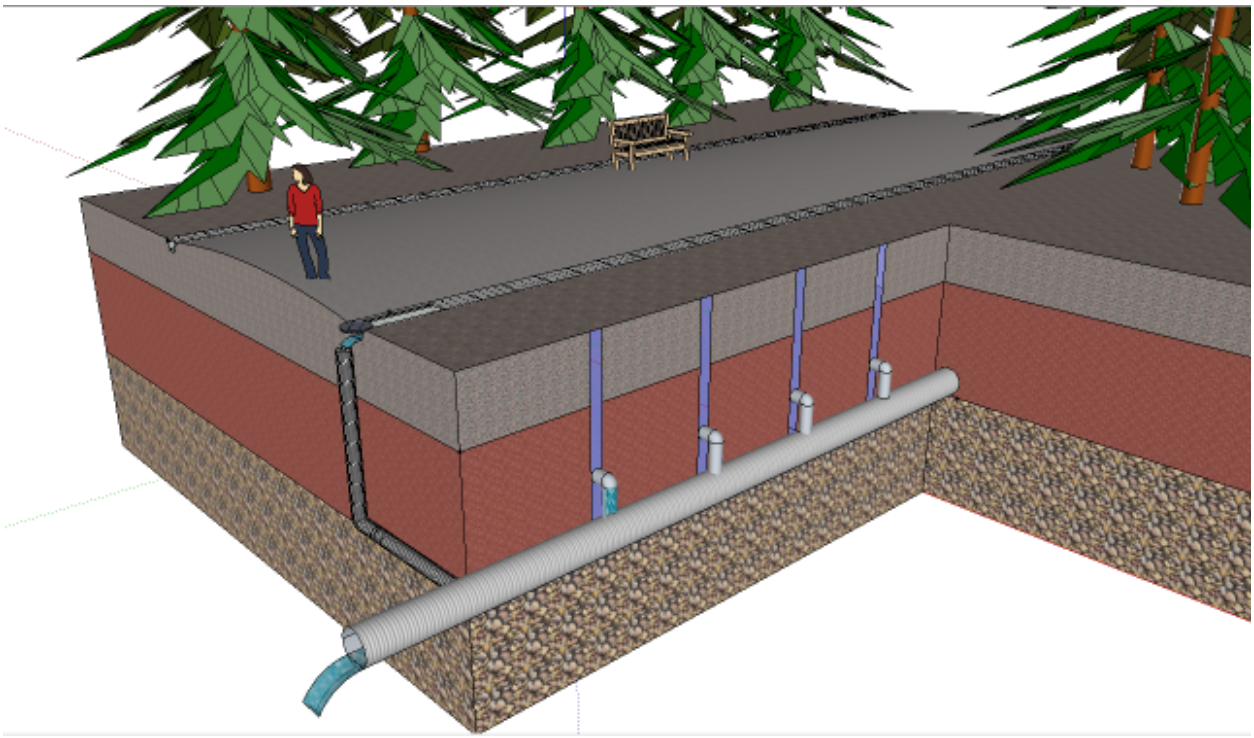

Figure 5: Conceptual sketch of stormwater drainage system #1.

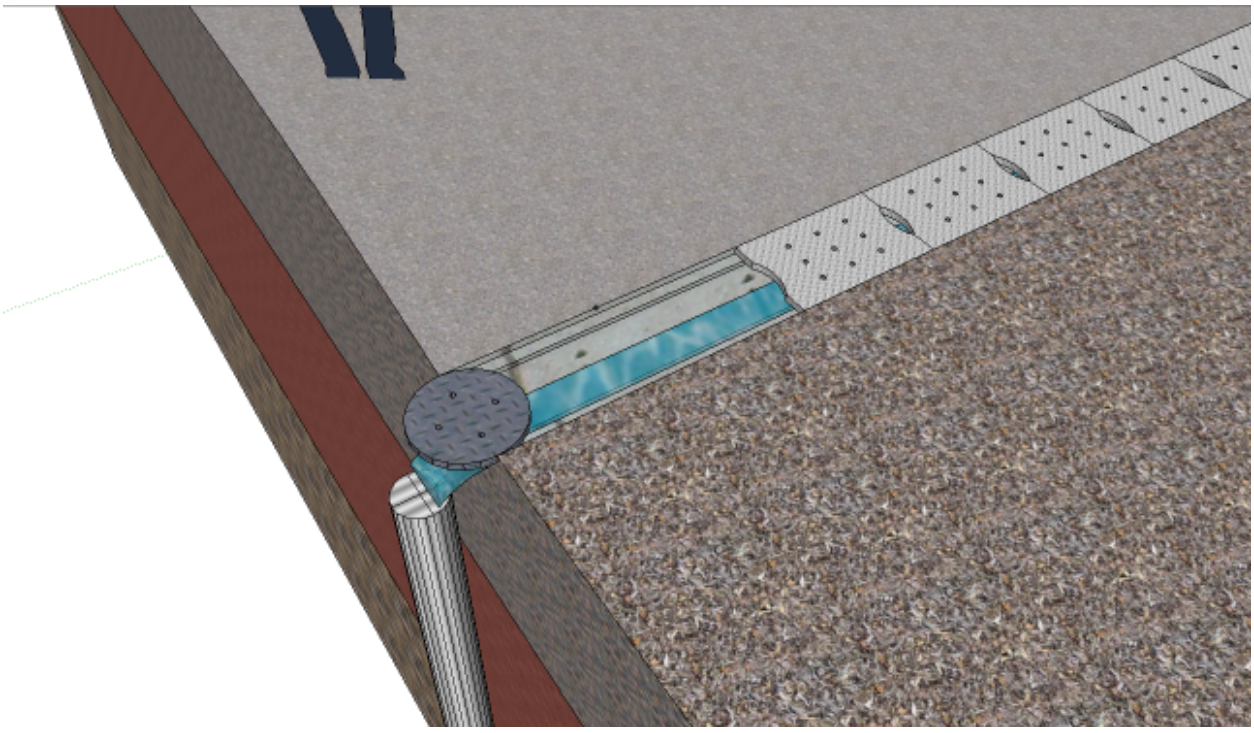

Figure 6: Conceptual sketch of stormwater drainage system #2.

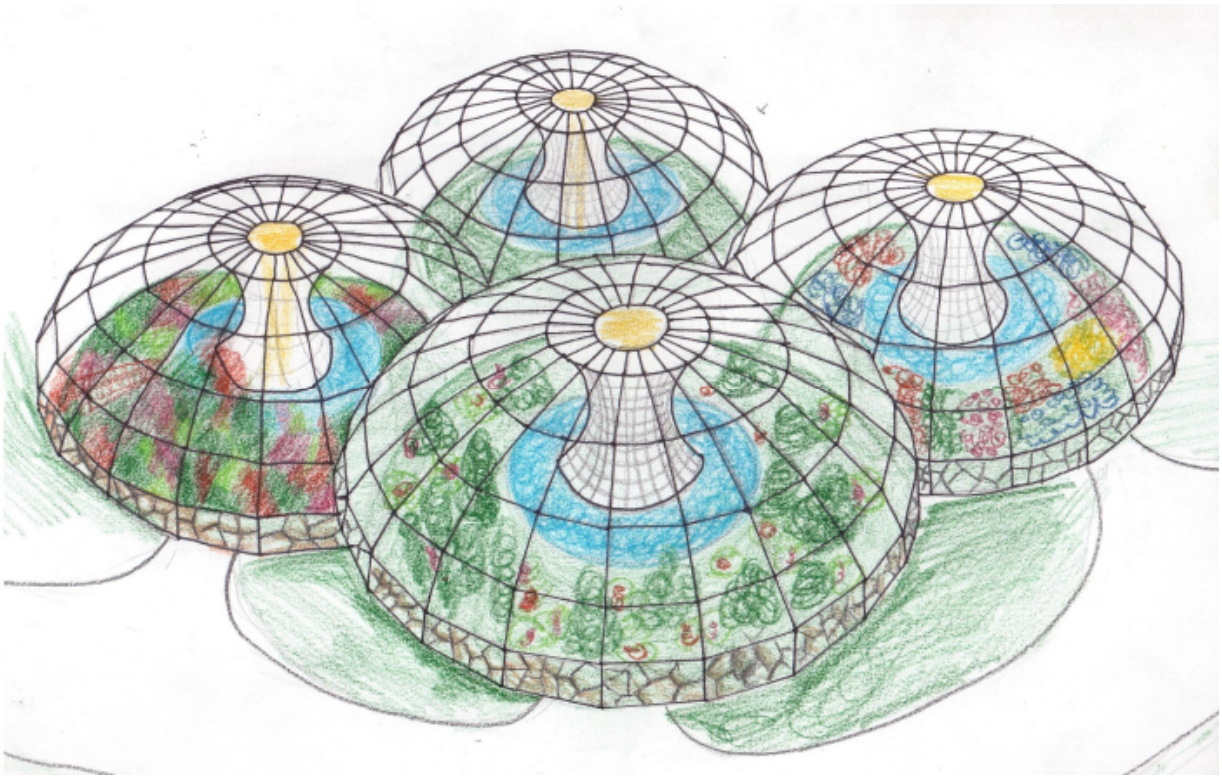

Figure 7: Conceptual sketch of greenhouse-café bistro and lounge.

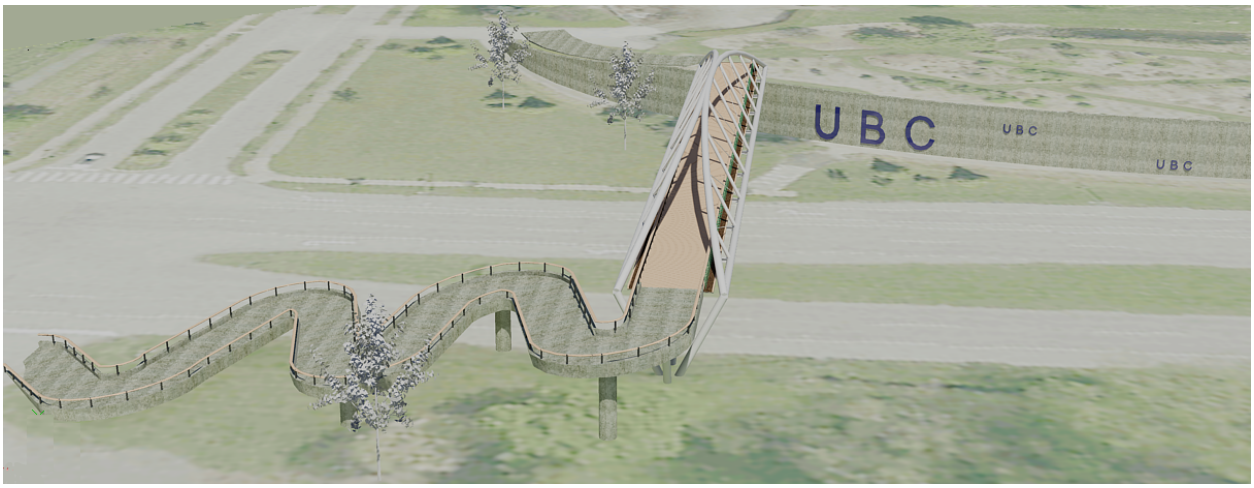

Figure 8: Conceptual sketch of elevated pedestrian walkway #1.

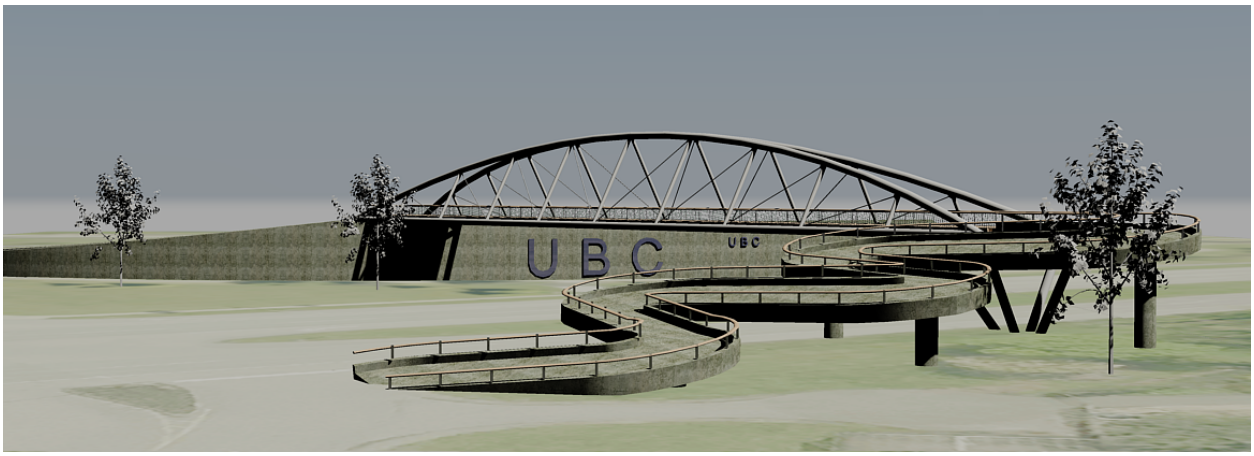

Figure 9: Conceptual sketch of elevated pedestrian walkway #2.

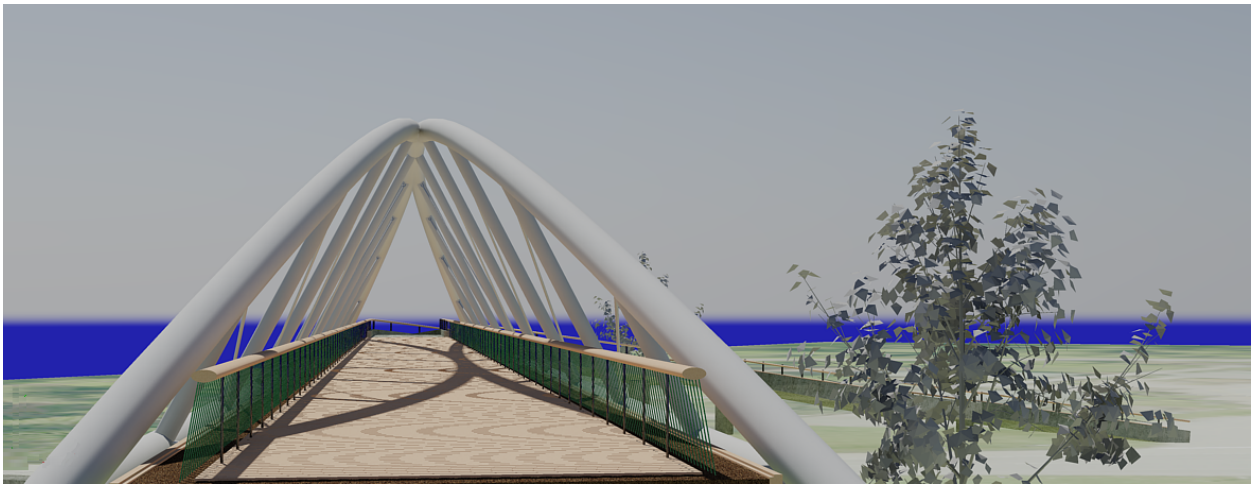

Figure 10: Conceptual sketch of elevated pedestrian walkway #2.

APPENDIX B: MAP OF THE UBC BOTANICAL GARDEN

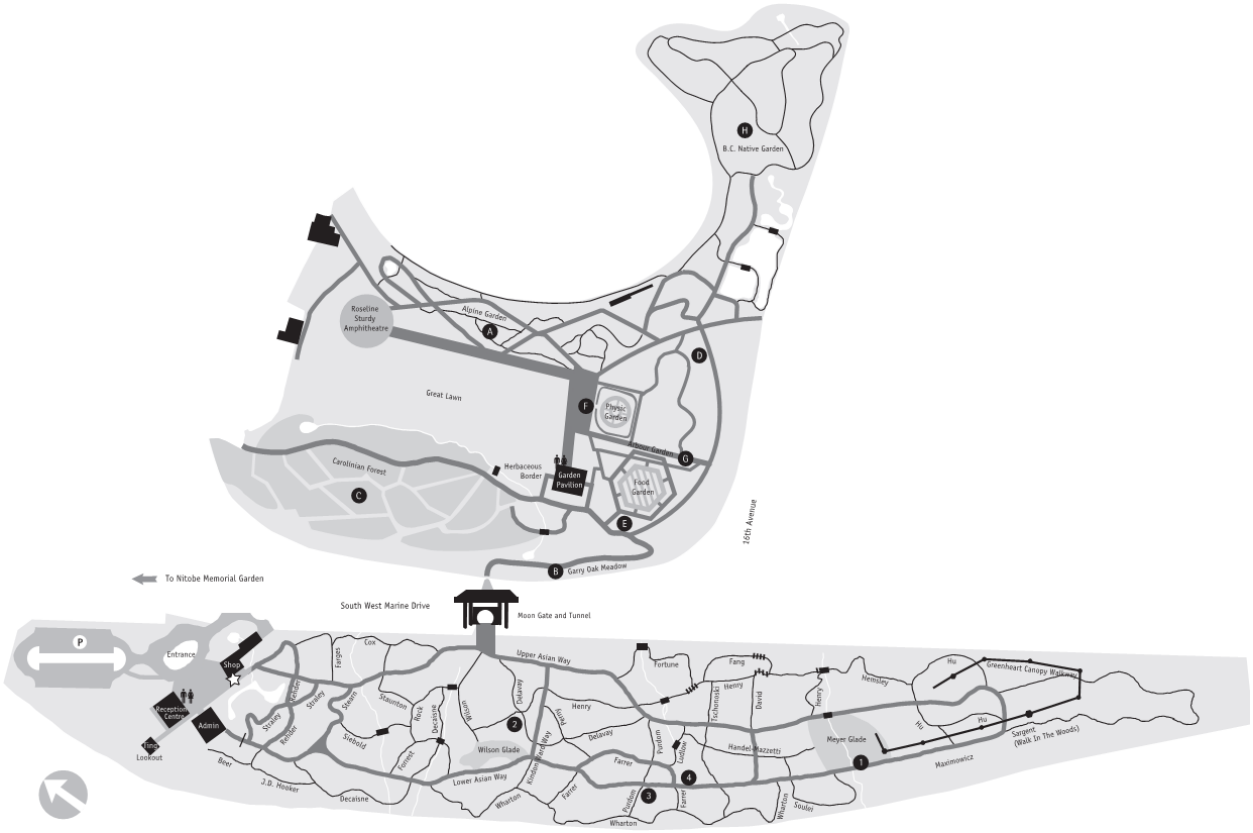

Figure 11: Map of the UBC Botanical Garden.

APPENDIX C: PLANT HARDINESS ZONES

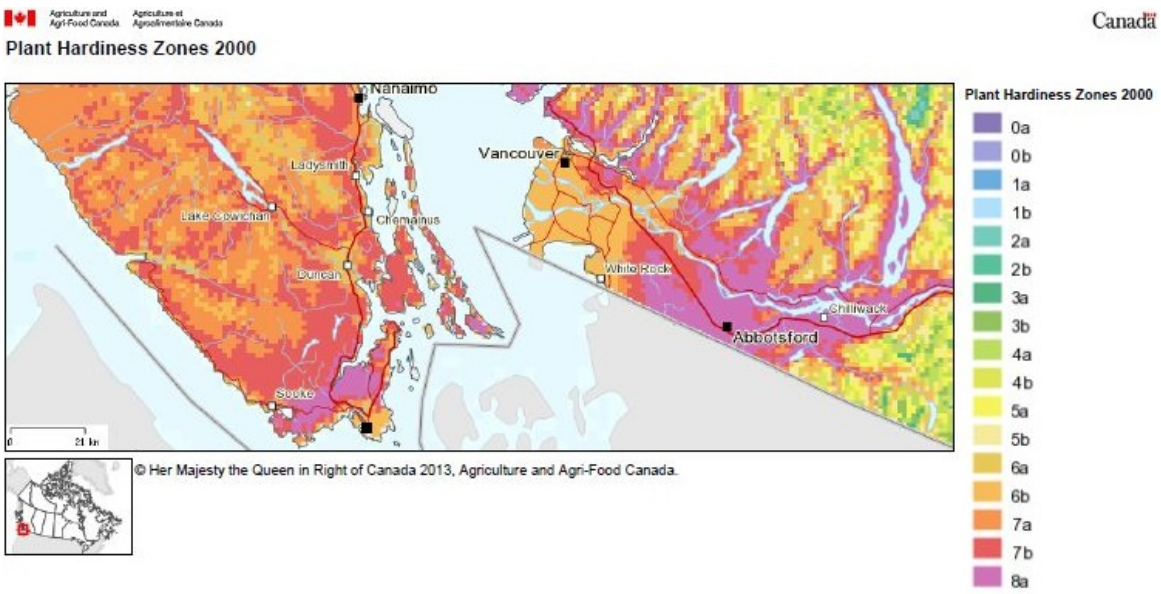

Figure 12: Plant hardiness zones in southwestern British Columbia.