UBC Social Ecological Economic Development Studies (SEEDS) Student Report

GROWING FORWARD AT THE UBC BOTANICAL GARDEN …and leaf-ing the past behind

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CIVL 445

November 28, 2013

GROWING FORWARD

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Executive Summary

This report proposes an initiative to redevelop and expand the UBC Botanical Garden (UBCBG). The mission statement and goals of the UBCBG were considered, and multiple site visits were conducted to explore the current state of the garden. The UBCBG was found to be lacking with respect to the overarching goals of the garden; research space is limited, integration with UBC is inadequate, parking is inadequate, sustainability considerations are lacking, the demographic appeal is constrained, and infrastructure is dated. This proposal seeks to address these concerns as economically as possible, in order to improve the experience for garden staff and visitors. The specific goals of this project are to attract new guests, increase revenue, improve access and integration, and facilitate research.

There were a multitude of possible solutions to these issues, and after careful analysis, several solutions were selected. The selection process considered the expected benefits, the cost, and the impact on the Botanical Garden. The solutions that were selected to be most effective are a multi-use building, signage improvements, transportation upgrades, as well as storm water collection, geothermal energy recovery, and an intensive green roof.

The multi-use building, the Innovative Research Institute for Sprouting (IRIS) Centre, will be located between the parking lot and the existing building and will house basement-level research labs, a café, a multi-purpose atrium, an information centre, a living learning centre, study space, hydroponic systems, and an aquaponic greenhouse. All of these features, and more, are detailed extensively in this report. These features culminate in a building that appeals to the staff, students, and visitors of all ages.

The environmental considerations will prove a sustainable step forward for the garden. It will retain storm water for irrigation use, recover geothermal energy for heating, mitigate erosion near the garden, and implement green roof technology. These developments will allow the garden to operate more efficiently; potable water use and heating cost will decrease substantially.

The transportation upgrades include creating better access by constructing a roundabout that will reduce traffic speeds while improving overall efficiency. Additionally, a pedestrian tunnel will be constructed to improve accessibility throughout the garden and a pedestrian bridge will improve access. By improving signage, the garden can be better identified and realize improved integration with the campus.

In conclusion, this report will identify a comprehensive plan to ensure a beneficial redevelopment of the UBC Botanical Garden that addresses the most urgent concerns facing it today. It is consistent with the mission statement of the Botanical Garden and will ensure that they continue to grow forward.

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1. Mission Statement of the Garden:

The mission of the UBC Botanical Garden (UBCBG) and Centre for Plant Research is to "assemble, curate and maintain a documented collection of temperate plants for the purposes of research, conservation, education, community and public display." The improvements to the UBCBG proposed in this report aim to better equip the UBCBG in achieving its mission. In order for the UBCBG to achieve its mission, it must have a healthy budget. Greater revenue for the garden can be achieved if it has a greater and more visible presence on campus, has attractions that draw in new patrons, and has facilities that can accommodate event rentals; all of which will be addressed by the improvements suggested in this proposal. Furthermore, the longevity of the UBCBG is better assured if it is viewed as an integral component of UBC by students, faculty, alumni, and residents. If the UBC community proudly considers the garden to be part of its DNA, it will contend to maintain and prosper the garden. The improvements proposed in this report also aim to foster a sense of ownership for the garden into the UBC community.

2. Basis for Redevelopment

The UBCBG has historically been a valuable part of the campus. In particular, the Nitobe Memorial Garden greets visitors from every walk of life on campus. Established in 1916, the UBCBG has expanded to an enormous collection of plant life. Researchers appreciate the breadth of diversity of the species grown here and the botanical garden has sought to integrate with the community. Events like the Apple Festival in the fall promote fun activities that can be enjoyed by all ages and accommodate high attendance. These features all contribute to the framework of the UBCBG.

It remains obscured from the common students' view. This can be attributed to a variety of effects, such as being isolated and having inconvenient pedestrian access. Specific examples of issues facing the garden are listed below.

- Primary garden is located west of Marine Drive, far from most classes and residencies.
- Old infrastructure has limited the aesthetic appeal.
- Highly seasonal interpretation of the UBCBG creates an issue where students do not see it as a destination during school year.
- There are few attractions that draw a variety of demographics.
- No circuit in the walking path through the garden.
- Limited indoor event space and event parking.
- Current research facility has room to grow forward.

Many of these issues can be addressed by engineering solutions. These solutions are detailed in this report. They have been thoughtfully considered to fulfill both the mission statement of this redevelopment and the mission statement and goals of the UBC botanical garden.

3. Vision for the Garden

An overview of the proposed strategies to better develop the UBC Botanical Garden is outlined below:

- The IRIS Centre will attract public attention through interactive learning activities and research lab, a venue of events at its high-ceiling atrium, or just simply a café to enjoy the beauty of the garden
- Signage improvement includes directions to the garden, as well as welcome signs
- Transportation upgrades include construction of roundabout on Marine Drive (between the two gardens) just by the main entrance of the UBC Botanical Garden, as well as a pedestrian tunnel for better circulation and a foot bridge to provide improved pedestrian safety
- Parking lot upgrade, to accommodate visitors for large events
- Bike parking facilities, to promote sustainability
- Look-out upgrade, to allow visitors to better see the ocean view

These proposed solutions will help the UBC Botanical Garden address the current issues by improving the local infrastructure, attracting more visitors, providing a complete walking circuit through the garden, while providing an indoor multipurpose atrium along with expansion of parking facilities.

4. IRIS Centre (Innovative Research Institute of Sprouting)

Currently the UBC Botanical Garden requires a significant source of income to help maintain operations, to fund expansion and to staff the garden. The design of this facility incorporates three major engineering disciplines: structural, geotechnical, and environmental. The site does not offer a place for visitors to eat during their tour of the garden. Furthermore, the current structures within the garden cannot accommodate desired research equipment to fulfill its mission statement as a leader in the botanical research and education field. The IRIS Centre was designed with these concerns in mind, and proposes a solution to a broader scope of issues.

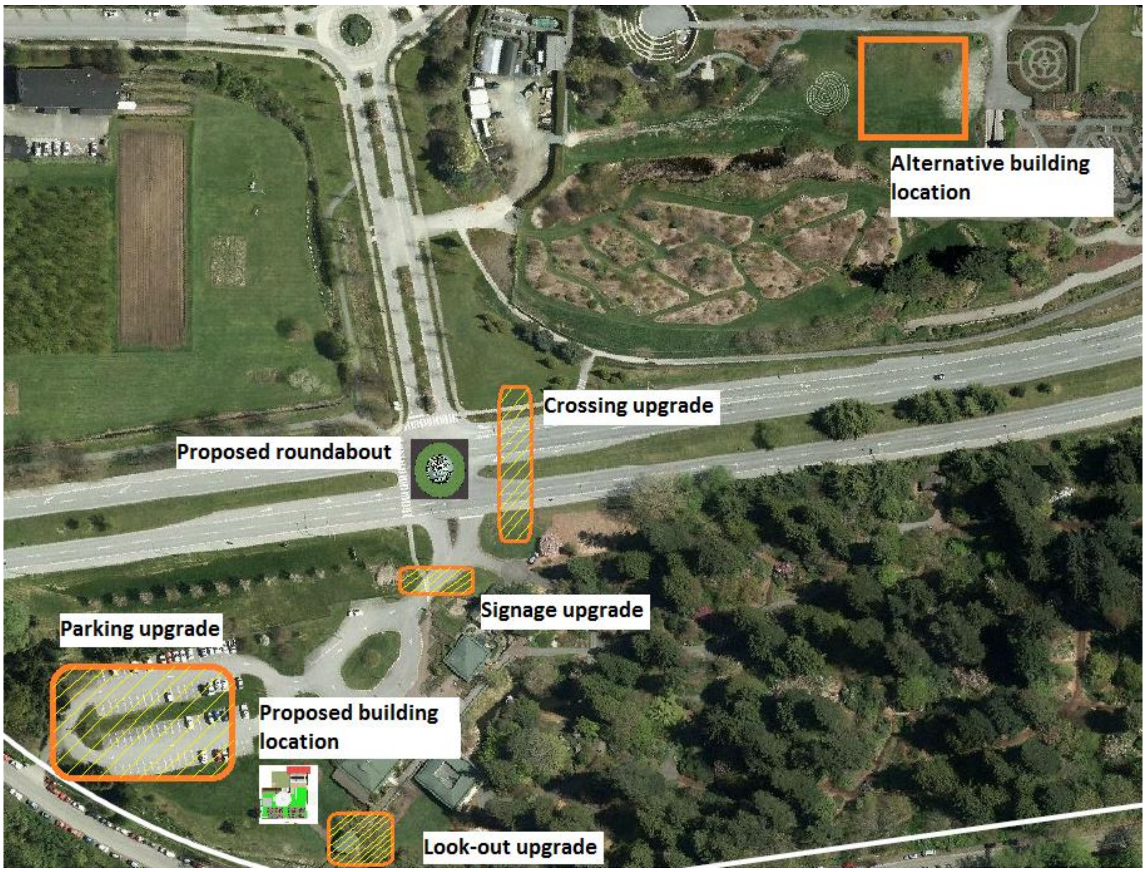


Figure 1 - Proposed Site Plan

4.1. Location of Multi-Purpose Building

There are two possible locations for the multi-purpose building. Location One is at the entrance of the garden, west of the parking lot, where there is currently unutilized space. Location Two is on the east portion of the garden, on the great lawn as shown in Figure 1.

Location One will allow the building to be more accessible for visitors. At this location, patrons can use facilities in the building, such as the café, classrooms, or exhibit space without paying admission. Several components of the building, such as the Information Centre and the interactive learning facility on the second floor, are best suited at the entrance of the garden. It is also beneficial to have the research space to be located near the existing research space at the entrance of the garden. The presence of a large building at the entrance will make the garden more noticeable for vehicles driving along on Marine Drive.

Location Two allows the open lawn adjacent to the parking lot to remain as is. This location is also beneficial in that it is further away from the cliffs and would likely be easier to construct due to better geotechnical conditions. Locating the building at the east portion of the garden will also serve to draw visitors into the garden.

Overall, Location One, at the entrance of the garden, has more benefits and better suites the function of the multi-purpose building, and is preferable over Location Two.

4.2. Main Floor

The ground level of the IRIS Centre focuses on improving the overall garden experience for visitors. Located on this level is the atrium, the Botanical Garden Café, the information centre with an interactive map and restroom facilities. The facilities on this level will serve to enhance visitors' garden experience, generate revenue for the garden and make the garden an integral component of UBC.

Botanical Garden Café

The Botanical Garden Café will be a regionally-recognized location that will allow customers to enjoy a classic, yet casual dining experience in an unforgettably picturesque setting. It will serve two main purposes: to provide a restful location for regular patrons to enjoy a meal before or after their visit and to serve as facility that will draw new patrons to the garden. The café will be set up in a self-serve manner, where customers will seat themselves, then order, pay for, and collect food and drinks at the main counter. The café will have regular menu items of gourmet salad bowls, paninis, sandwiches, light entrees, and desserts. The food in the café will be prepared with fresh herbs grown on the second floor of the buildings. In addition, the café will have seasonal items that use in-season ingredients grown in the UBCBG's food garden. The café will also have an espresso bar serving specialty drinks that patrons can enjoy in the café or while they experience the garden. The tableware used will reflect the classic dining experience that the café aims to provide. The café seating will be located on the perimeter of the building, which will have a glass curtain-wall. This will allow patrons to enjoy nature as they dine and provide ample natural light. The seating for the café will not be fixed, allowing the café to adapt to changing needs and growing demand. The café seating area will be decorated and organized in such a way that it creates a restaurant feeling. The Botanical Garden Café will enhance the UBCBG by being a regionally-recognized location serving gourmet food in a beautiful location, drawing new patrons into the garden.

Atrium

The atrium of the building will be a grand entrance to the building and a multi-purpose space. The double-height atrium will have a maximum amount of glass curtain-wall, allowing the occupants to enjoy the garden experience even while indoors. Exposed timber beams and columns and natural light will integrate the atrium into the surrounding garden. The surrounding garden will also be brought into the atrium with non-fixed planters throughout the space. Furthermore, the minimalistic design of the atrium will allow more flexibility in its use, such as weddings, lectures, events, art exhibits, and seasonal exhibits. The UBCBG is already a popular location to host weddings, and this multi-purpose atrium will create more opportunities to hold weddings and bring in revenue for the garden. The kitchen space in the adjacent café will help facilitate catered weddings and events. The atrium space will also be an ideal location for student exhibits, such as art displays or even chamber concerts. Using the atrium space for wedding, conferences, academic lectures and student exhibits will give more exposure to the garden and help the UBC community to see the UBCBG as an integral component of the university. When not used for events or exhibits, the atrium will be a place for patrons to relax and prepare for their trip to the garden.

Information Centre with Interactive Map

The UBCBG has a multitude of interesting features for visitors to experience; however, these features are difficult to accurately describe on a small map. The Information Centre on the main level of the multi-purpose building will have an interactive map to thoroughly represent all of the garden's features, as well as the features of the multi-purpose building. The interactive map system is also integrated into the second floor of the building in the interactive learning facility.

The garden portion of the interactive map will have visuals of all the features of the garden and will describe seasonal highlights of each area, allowing visitors to identify which parts of the garden to visit. Then to direct visitors to the parts of the garden they wish to see, the interactive map will have way-finding capabilities, incorporating Quick Response codes that allow patrons to download directions onto their mobile devices. Trails to take, weather predictions, walking time predictions and popular locations will be built in to the way-finding capabilities. The interactive map will also provide pre-set garden walking routes, which can be selected based on individual interests, as well as maps and information for events in the garden, such as the Apple Festival. Current and upcoming public events will be featured on the interactive map. Floor plans of the building, as well as way-finding capabilities for within the building, will allow visitors to enjoy all features of the building.

4.3. Living Learning Centre

The second level of the multipurpose building is an interactive learning space for visitors of all ages offering space for a range of educational and interactive activities. This learning centre will feature indoor garden technologies ranging from indoor greenhouses to modular hydroponic and Aquaponic systems. The intent of the space is to teach visitors about the UBC Botanical Garden collections, horticulture, the benefits of indoor planting, and developments in planting research.

Indoor Gardening and Building-integrated Agriculture

The intent of the second floor is to provide a space with Building-Integrated Agriculture through a series of recirculating hydroponic and Aquaponic projects and indoor gardens.

Benefits of Indoor Gardening

Plants are natural filters, absorbing chemicals from building materials, hydrocarbons, and filtering allergens. They can remove air toxins such as formaldehyde, xylene, benzene, acetone, chloroform, and trichloroethylene (Lawton, 2009). On top of physical benefits, the American Horticultural Association proved that therapeutic gardens reduce stress and lower blood pressure. Indoor plants raise humidity levels for a more oxygen rich environment and are proven to increase productivity in the work place. The incorporation of indoor gardens will enhance the visitor experience and create a comfortable environment by improving air quality and providing a visually inviting atmosphere. Indoor gardening also allows researchers and gardeners to garden year round in a controlled environment with fewer pests and weeds.

Basic Hydroponics and Aquaponics

The basic principle of agriculture is that plants need water, light, and nutrients to reach the roots. Hydroponics is a method of growing plants in water and nutrient solution without soil. This method allows you to grow plants, fruits, vegetables, herbs rapidly and effectively. Year round growing is also an option provided in an artificially lit environment. Growing with artificial lights is widely used and is a method to rapidly grow certain plants. By providing constant and readily available nutrients, hydroponic gardens grow up to 50% faster than they do in soil. Hydroponic systems can be constructed in a wide range of sizes from modular countertop units, to an expansive greenhouse. Compared to conventional agriculture, hydroponic gardens are more productive for their respective size. This system also results in a reduction of soil pests and diseases. In a temperature and carbon controlled environment, hydroponic systems can thrive; increased amounts of CO_2 levels boosts plant growth. Hydroponic systems that utilize artificial sunlight will produce a fair amount of heat that will need to be ventilated.

The most common types of growing lights are high intensity discharge (HID) and fluorescents. Fluorescent lights consume low amounts of electricity and are only useful for starting new plants in compact hydroponics. These weaker lights are more efficient when placed 1-4 inches from the plant. High intensity discharge lights are ideal for lighting indoor plants. At 150-1000 watts, a single fixture can cover a small self-contained hydroponic garden (20-40 s.f.) at a distance of 1-3 feet from the plant. HID lights generate a great deal of heat, which requires proper venting, ducting and fans (Salida Ltd., 2011).

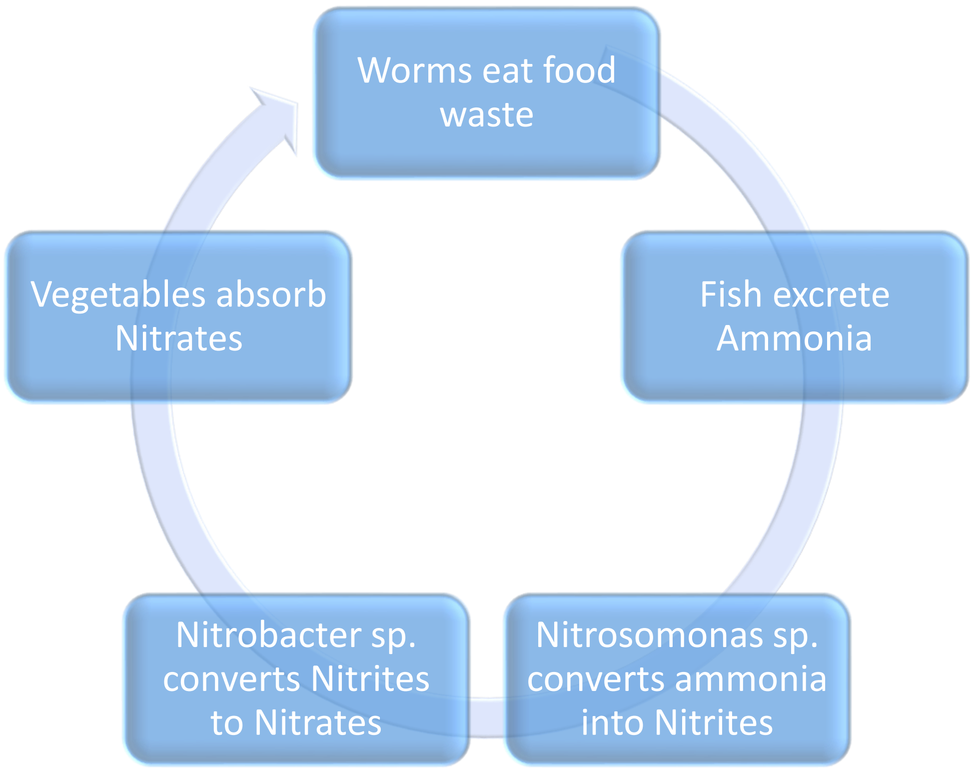


Figure 2 - Aquaponic Nitrogen Cycle

An Aquaponic system is a food production system for rearing aquatic animals with hydroponics. The basic operation of the system is a nitrogen cycle between the fish and the plants as shown in Figure 2. In regular aquaculture, animals being raised excrete waste that accumulates in the water thus increasing the toxicity of the water due to high concentrations of ammonia. This water is pumped through a hydroponic system where nitrification bacteria break down the waste into nitrates and nitrites. The resulting nutrients are pumped into the hydroponic system and utilized by the plants as nutrients. The water is then filtered and returned to the aquaculture with the ammonia removed (OKO Farms, 2012).

Environmental Advantages of Hydroponic and Aquponic Systems

Incorporating hydroponic and Aquaponic systems reduce transportation cost associated with conventional field agriculture and enhances food security and safety. These systems are more efficient than conventional farming and conserve water and reduce waste thus improving public health. Hydroponics use 10-20 times less land and 10 times less water while eliminating chemical pesticides, fertilizer runoff and carbon emissions from farm machinery and long distance transport (Wilson, 2009).

Building Integrated Agriculture (BIA): Recirculated Hydroponics

Building Integrated Agriculture is the practice of locating high performance hydroponic greenhouse farming systems on and in mixed use buildings to exploit synergies between the built environment and agriculture (Caplow & Nelkin, 2007). Typical installations include recirculating hydroponics, HVAC systems, and solar photovoltaic cells.

Featured Areas

The Living Learning Centre will feature the following areas that target indoor gardening research and public education space.

UBC Botanical Garden Murals

Enhancing the visitors' experience, the exposed walls on the second level will be a canvas for photographic artwork and LED displays featuring the various existing garden in the UBC Botanical Garden. The walls will function as a glimpse at what is hidden within the garden enticing the visitors of the building to also step into the garden and will be more effective in advertising the garden than the existing map. This display allows visitors to see the diversity and beauty of the garden all year round and will have the flexibility to change with the seasons, offering different moods to the building throughout the year. The walls are also a canvas for education on the grand history of the UBC Botanical Garden.

Nutrient Film Technique Hydroponic Garden Tower Stairwell

Entering the second floor of the IRIS Centre, the stairwell up from the main floor will feature a living wall that allows natural light to pass through. This full height feature, as well as the other living components of the Living Learning Centre, will be a part of UBC's first vertical hydroponic garden.

Nutrient Film Technique Hydroponics System

The Nutrient Film Technique (NFT) hydroponics is a hydroponic system where a steady shallow stream of water containing dissolved nutrients is re-circulated past the bare roots of the plant in sloping channels recommended at 1:30 or 1:40 to ensure ponding does not occur. The NFT gets its name from the amount of water that is required to run the system. The water running through the channels can be as shallow as a little more than a film of water flowing at a flow of 1-2 L/min (Wilson, 2009). Excess flow will cause nutritional problems and depressed growth rates. This will allow the roots to grow into a root mat at the bottom of the channel with an abundant supply of moist oxygen in the cavity above. As with any hydroponics system, soil is not necessary to aid the plant growth. The nutrient rich water passes through water tight channels (ie.

PVC pipes) and is re-circulated through a pumping system. Figure 3 illustrates a basic NFT cycle and how it can be integrated into a sloping tower formation. NFT hydroponics ensures that plants have a continuous and unlimited supply of water and nutrients and are most efficient in growing leafy plants.

Figure 3 - NFT Hydroponics System

Living Library and Study Space

The circular space with an overhead skylight provides a library and learning space for visitors, researchers, and staff members. Natural lighting from the overhead skylight, curved shelves along the windows with indoor plants creates a peaceful atmosphere to relax and learn from the library of plant research and the UBC Botanical Garden collections. Portable planters and vertical gardens provide partitions to the space as well as adding privacy. Visitors to the living library and study space will reap the benefits of being in an indoor garden environment.

Interactive Individual learning Centre

The individual learning centre will feature several interactive touchscreen platforms integrated with the way-finding system on the first floor. The aim of the learning centre is to allow visitors of all ages to be able to learn about the garden collections, horticulture and programs available. The platforms will be programmed with the details of the all the plants in the current collection and general facts about each species. Included in the learning centre is an electronic collection of past and present research papers for visitors who wish to research particular topics. Instructional videos for all ages will be featured in the learning centre to allow visitors to learn at their own pace without committing to a course or workshop. Registration and information for the Botanical Garden’s programs and workshops will also be available on this platform.

Interactive Learning Classroom Space

A large space on the second floor is allotted for classroom space. The space will help the UBC Botanical Garden run its programs and training courses. Similar to the atrium on the first floor, this multipurpose classroom space can also be rented out to generate revenue for the garden.

Aquaponic Greenhouse and Organic Herb Garden

The full height glass windows will feature a small greenhouse with an indoor Aquaponic system. The Aquaponic system will raise vegetables, herbs and even edible fish that can be harvested for the café and used to contribute to research on indoor Aquaponic gardening (Nelson & Pade, 2013).

Costs and Benefits

The estimated cost of the features on the second floor of the IRIS Centre excluding structural and architectural elements are outlined is estimated at $370,000. The NFT hydroponic system inclusive of coverings, cooling systems, air circulation, heaters, environmental support, growing supplies and growing equipment is estimated at $300,000. The modular hydroponic and Aquaponic systems enclosed in indoor greenhouse are estimated at $50,000. The 6 proposed units of the way-finding and interactive learning system platforms integrated on the first and second level is $36,000 (Crop King Inc., 2012). The capital costs of the features in this portion of the building is an investment for the IRIS Centre and has the potential to save the UBC Botanical Garden money as well as generate revenue. The benefits of integrating a way-finding and interactive learning platform are to advertise and educate visitors about the garden. This service can eliminate certain costs to the garden such as staff-led tours and educational courses. Many of the features on the second floor are implemented for educational or research purposes on top of generating an anchor for the garden. There are various applicable research and community learning program grants available to help subsidize a portion of the cost.

4.4. Basement: Botanical Research Facility

The objective of the research facility is to study the science of botany, to employ the conservation of earth's natural heritage and plant variety, as well as discover new valuable information that can be applied to horticulture, botany and agriculture. Through the understanding of various plant and tree species this space will contribute to botanical education and develop new ways to conserve botanical diversity. This research facility is needed to explore, identify and classify plants but also correlate human relationships with plants and how to preserve these species into the future (Durante Kreuk Ltd. & Catherine Berries Associates Inc., 2001).

Research Interests

Research interests of the plant research lab include:

- Plant biodiversity
- Plant molecular systematics, including deep plant phylogeny
- Plant evolutionary genomics
- Plant evolution and systematics
- Comparative plastid genomics
- Plant gene expression and alternative splicing, particularly in polyploids

(Mosquin, 2013)

Features of the Research Space

The new research space will need to integrate modern technology and robust design to create an easy to use, maintainable space with leading research equipment. The laboratory will be a sensitive, temperature dependent environment to allow for the growth of plant tissue, micro propagation and the study thereof. To deliver these requirements the research space will feature:

- Molecular lab with genomics, thermocyclers, gene sequencing and DNA splicing equipment
- Recycled grey water micro irrigation systems for indoor nurseries
- Climate, light and humidity controls to regulate the rate of evaporation simulating a natural environment
- Standard equipment such as autoclaves, pure water, centrifuges and refrigeration
- Greenhouse or nursery areas to protect sensitive plants
- An entrance from the garden to the research laboratory with a shower, boot washing area and racks for all garden clothing
- Concrete floors with a mud drain for easy cleanup of mess created by garden boots

(Royal Botanic Garden Edinburgh, 2013a, 2013b)

Costs and Benefits of Research Space

The total cost of the research facility equipment is estimated to be $280,000, which will be amortized over a ten-year period. The IRIS Centre is estimated on the basis of a College Laboratory, which already includes the cost of general laboratory equipment, the more specific research equipment not considered are covered within this cost. Initial funding will rely on research grants and government subsidies related to green building construction. The IRIS Centre will be eligible for grants and subsidies due to its LEED certification and modern research facility within a university setting.

The incorporated molecular lab allows for advances in organic compounds used to synthesize pharmaceuticals, pesticides, and antibiotics. Studying plants on a molecular level also allows for the reproduction of rare plants through the understanding of genomics, gene sequencing and DNA splicing.

The study of woody perennial crops allows for improvement in drainage and leaching of groundwater. Irrigation in agriculture and personal lawns consume a large portion of today's potable water. The demands for fresh water are increasing as the quality of resources decrease. All plant life requires adequate irrigation and an enhancement in the profitability, or quality of soil-water-nutrient interactions, would be internationally valuable.

If this research lab is constructed with contemporary equipment and facilities, it will attract prestigious, talented researchers— who in turn will earn grants and pay for their own salaries, equipment and aid. Having a plant research lab on campus will open doors for many students studying biology, forestry, land and foods systems, agriculture, and horticulture to carry out academic experiments. The research lab will adopt the NSERC program for students to fund independent research and also could offer internships for students who would like to pursue careers in botanical related fields.

Importance of Plant Research

Florae are the basis from which our agriculture, clothing and pharmaceuticals are constructed. There are many benefits of a deeper understanding of botanical topics. With more knowledge, society can enrich the nutritional value in many of the plants used for food. Furthermore, by studying the development of plants society can reduce the amount of pesticides and fertilizers required for agriculture.

Plant life is the foundation for which animals and humans exist — not only for food, clothing, and pharmaceuticals but also in order to generate a large portion of oxygen that allows life forms to respire. Plants also create photosynthesis, algae and bacteria, which use water and sunlight to create natural sugars, in turn feeding the micro-life of the food chain.

4.5. Environmental Considerations

The proposed project at the UBC Botanical Garden has the potential to have a large impact on the surrounding garden area and community. This proposal will minimize the impact by implementing several environmentally sustainable solutions to common facility issues. These solutions include, geothermal heating, stormwater management, and a green roof. The proposed facility strives for LEED Platinum certification, the highest level given by the United States Green Building Council as well as the highest level of sustainability as rated by UBC's internal review system. In the following sections of the report, each individual measure will be detailed to showcase how the technology will assist in meeting these high environmental standards.

Geothermal Energy

Geothermal heating is often considered to be a new technology; however, its use has been prevalent in North America since the 1970's. Our proposed system for the new facility will utilize heat exchangers, which will work on multiple systems to increase overall building efficiency.

The base of the geothermal system will be comprised of a vertical well geothermal closed loop network. The use of a closed loop system, despite the presence of a water table, is to ensure that the system will not affect the local water table. An example of a vertical loop system can be seen below in Figure 4.

The geothermal system will heat the entire facility, including the IRIS Centre as well as the existing buildings on the site. This use of geothermal heating will significantly reduce costs of Heating, Ventilation and Cooling (HVAC) of the IRIS Centre, as once the system is installed only a heat exchanger needs to be run as opposed to the costly units which are required to generate heat.

To increase efficiency of the geothermal system and to ensure that it is the most sustainable option, a heat exchanger will also process waste heat energy from the hot water piping and waste water piping within the building. To ensure that this is possible a larger heat exchanger will be installed resulting in a higher initial capital cost but a more efficient and cost effective HVAC system in the long term outlook.

The installation of such a large and complex system by a contractor would have a large cost which is why it is proposed that a partnership be created with the Clean Energy Research Centre (CERC) at UBC to allow for the system design to be completed in-house and modelled by students and professors within local faculties. In addition, by allowing UBC to work on the design of the geothermal system, a Social Ecological Economic Development Studies project (SEEDS) could possibly be utilized to focus resources within the university as well as deem the project a research endeavor, allowing for funding from multiple educational streams as opposed to merely green development grants (Lienau & Lunis, 1991).

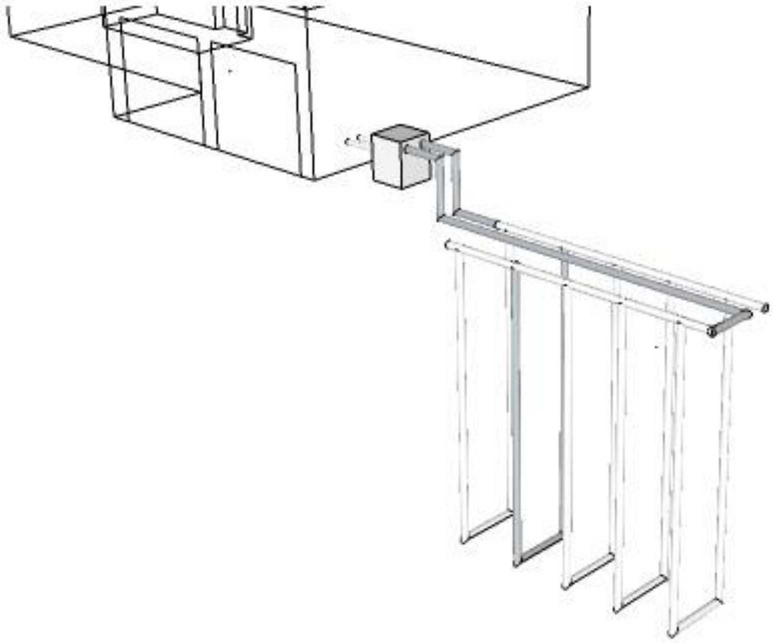


Figure 4 - Schematic of the well assembly of a vertical well closed loop geothermal system

Cost & Benefits of Geothermal Energy System

Geothermal energy systems have a relatively high cost of implementation due to the high cost of drilling holes for the geothermal circuit. In addition, the cost of plumbing the entire system can be less economical when compared to conventional heating systems; however, the longevity of the system helps to offset this large initial investment. A geothermal system also has a minimal environmental impact and results in very little greenhouse gas (GHG) emissions throughout its lifecycle. Geothermal energy is utilized through a heat exchanger which means that building floors and ceilings could be differentially heated and cooled. This balancing of heat allows for a smaller use of electricity and also does not result in the direct transfer of heat to air, which has a low thermal capacity. Instead it transfers heat through conductivity, which allows the process to be more energy efficient. Overall, the geothermal energy system will have multiple applications within the UBCBG, resulting in energy savings and lowered GHG emissions for years. The initial cost will be quickly being compensated by the reduced energy consumption due to the geothermal system.

The cost of an average geothermal system is around $13 000 for a 3 500 s.f. home in BC. Utilizing some cost data from companies across Canada, a finalized system cost of around $400 000 to $550 000 is expected. Although, these costs can be up to 30% higher than the installation of a typical natural gas or steam system, the savings over the long term are much greater. A geothermal system will, on average, reduce heating and cooling costs by up to 75% and will pay for itself quite quickly. In addition, the amount of GHG emissions saved by the use of a geothermal system is massive with an average reduction of GHG emissions by 81.5%. Tax credits are also offered by the government for geothermal systems, which makes the implementation of a system much more cost feasible. Therefore, the installation of a geothermal system is recommended for the IRIS Centre to help meet sustainability goals and reduce building operating costs (Gagnon Heating & Air Conditiong & Goodwin Well & Water Inc, 2009).

Stormwater Management

Currently the UBCBG utilizes fresh potable water for irrigation and all building operations while a large amount of stormwater is discharged unused off the banks of Wreck Beach. Although the source of potable water is not drastically limited, it is not sustainable or conservative to perform tasks requiring vast quantities, which could be achieved with water of a lesser quality.

Stormwater management is often considered to be a minor focus for most projects. Our project strives to make stormwater management an object of major forethought in the design process. To best manage storm water, multiple points of stormwater collection, and storage must be implemented to ensure that the resource is not wasted anywhere within the property.

Collection

Currently stormwater mains run under the UBCBG and are only daylighted near the edge of the gardens and flow at the most direct path out of the gardens. Our team proposes to redirect the water from these mains as well as the drainage ditch on the West side of the current parking lot into a set of massive tanks located underneath the new facility. The amount of water stored will be a function of the cost required to store it and the usage rates of the UBCBG. The facility will maximize storage capacity to allow the primary source for irrigation to be switched from potable water to stored stormwater. In addition the water within these tanks would be utilized to feed ponds and other water features located within the gardens. Furthermore, the water will be utilized for non-potable building operations ranging from toilet flushing to washing garden equipment.

A large collection point of on-site stormwater is the parking lot. Currently the parking lot is comprised of non-permeable pavement that is in good condition. The use of a curb and gutter assembly around the parking lot will channel stormwater runoff to the storage tanks, where it can be treated. Parking lot runoff water will tend to be significantly more contaminated than the typical stormwater due to the contaminants associated with cars such as oils and other road grit. To ensure that the stored water is not contaminated, parking lot runoff would first be filtered through a drainage ditch with vegetation similar to what is shown in Figure 5.

Figure 5 - Storm water collection ditch (Villarreal, Semadeni-Davies, & Bengtsson, 2004)

To further increase the filtration from parking lot runoff a drainage ditch structure as shown in Figure 6, could be implemented to reduce the level of sediment, metal and reactive contaminants by amounts of up to 90%. (Newberry & Yonge, 1996)

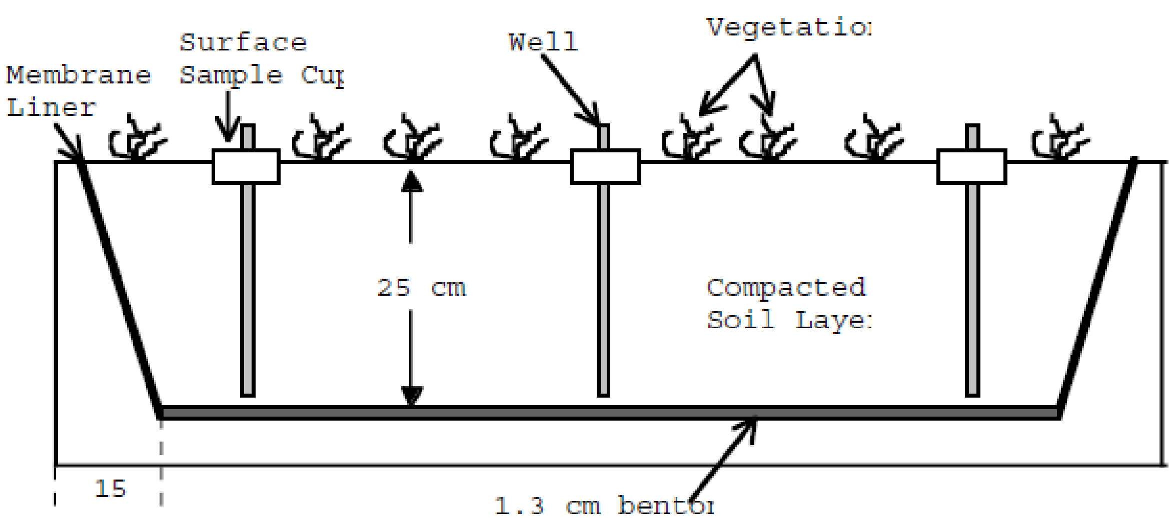


Figure 6 - Drainage ditch cross section with contaminant control measures (Newberry & Yonge, 1996)

Stormwater Utilization

In order to utilize the vast amounts of water collected, several systems within the UBCBG and the new facility need to be constructed. The most important conversion will be the use of stormwater within the gardens to meet irrigation requirements as well as to operate fountains and ponds. The main conversion to switch from potable irrigation to non-potable is the installation of a large pump to ensure that the head required for the current sprinkler system is provided. To assist with the head requirement, small storage tanks will be built throughout the garden to serve as points of static head. These tanks will also prevent damage to the pumps and sprinkler system from the entrapment of air or suction due to pressure fluctuation.

The use of stormwater would be acceptable for most plant research activities. Therefore, the lab facilities within the building would have an option provided to employ non-potable water. Should the UBCBG wish to meet the forefront of sustainability much like Metro Vancouver, the implementation of a sand filtration system could be used to treat some of the stormwater. This treated water could then be used for all of the buildings potable water needs such as drinking, pure water work within research, and at the café and for other uses requiring potable water.

A secondary use of the excess rainwater could be to supply fire protection for the gardens and the new facility. With the addition of a high pressure pump to bring the water up to the required firefighting pressure of around 520 kPa (75 psi). This would earn a new level of fire protection, which would most likely make UBCBG eligible for a lower fire insurance rate.

Excess stormwater would be discharged back into local streams to maintain adequate base flows without exceeding maximum velocities to prevent erosion and sediment deposit downstream. Should the local streams not require any further flow, excess water could be utilized to maintain the groundwater aquifer opposed to discharging directly into the Salish Sea.

Benefits of Stormwater Management

Stormwater is often seen as a problem within a city and even within communities such as UBC. This viewpoint is flawed, and the system which is to be implemented at the UBCBG aims to change this common view on stormwater. Although this system will also have a large initial investment, it brings fourth the opportunity to mitigate damage to the environment for generations. The aim of our design is to create a resource from what was once considered waste. Through the use of stormwater capture and storage and basic levels of treatment, the stormwater will be utilized as a resource to supply most of the water within the UBCBG. This water recycling will decrease the rate of bank erosion while also mitigating the excessive use of potable water for irrigation. Overall, stormwater management will not only make the garden more sustainable, but it will also help the garden decrease their water demand.

There are significant costs associated with stormwater management with little upfront benefit. The benefit of the large capital expenditures in stormwater management is in protecting the environment and eliminating damages due to erosion and depletion of natural habitats. The estimated cost of a stormwater storage reservoir, all related infrastructure, and stormwater management practices implemented at the project site totals around $1.2M (Lam et al., 2012).

Green Roofs

An integral part of this proposal's commitment to sustainability is the implementation of green roofs and green walls throughout the building. The main roof of the IRIS Centre will feature an intensive green roof, which showcases some of the species of the UBCBG. This allows garden patrons to go on a short walk through a small garden without having to leave the IRIS Centre. A schematic of an intensive green roof is below in Figure 7. Ease of access will allow garden patrons in wheel chairs to view a small and flat display of some of the unique species which the UBCBG has to offer without having to traverse the entire garden. In addition, the space will allow the collection to be showcased during the rainy season in Vancouver.

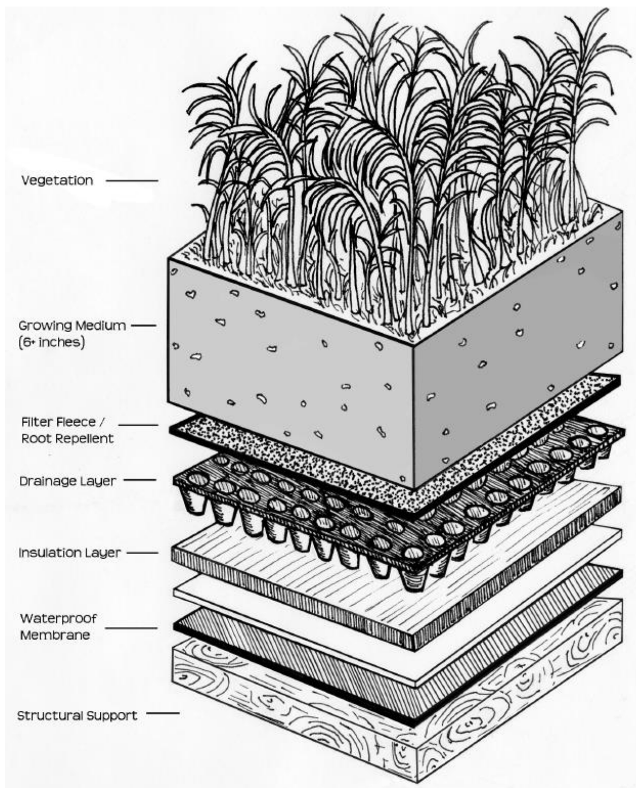


Figure 7 - Intensive Green Roof Profile (Green Roof Plan, 2012)

In addition to the proposed intensive roof garden on the IRIS Centre, other extensive gardens will be featured along the exterior of the building through methods such as green walls. Green walls will improve the aesthetics of the building, which would otherwise be cold and inorganic. These living walls will provide further space for the staff of the UBCBG to showcase the collection at the garden by providing added space which would normally not be utilized for any productive purposes.

A green wall can also be used in an active method which increases the oxygen levels within the building. As a result, the increased oxygen levels will make patrons and staff working in the building more alert while providing a more natural building and workspace that is better connected with the outdoors and its surroundings.

Benefits of Green Roofs

Green roofs have many benefits despite the higher cost due to the necessity for increased structural support. The addition of a green roof system helps to stabilize the temperature within the building and helps to reduce heating costs while also allowing the retention of stormwater. Overall, a green roof is worth the additional capital cost due to the positive benefits.

The costs of a rooftop garden can vary from $3 to $50 per s.f. The rooftop garden is an intensive system that increases the unit cost but also allows for a larger range of plants to be grown within the medium. In addition, roof drainage and geo-textiles will drive up the cost but will make the garden last much longer through the seasonal replanting. The overall cost for the rooftop garden as well as the living wall systems on the exterior of the building is estimated at $84,700. The additional cost due to increased structural requirements is taken into account within the building cost estimate (Low Impact Development Center Inc., 2012).

Costs and Benefits of Environmental Considerations

Each of the outlined systems, geothermal heating, stormwater management and green roofs, have a large capital cost when compared with traditional building methods. The traditional building is barren, non-integrated and an eye-sore when compared to the unique collection housed by the UBCBG. However, the benefits of these features cannot be quantified with a dollar value. Should there be a dollar value on integration, sustainability, building livability and minimized building impact, the benefits would outweigh the costs. Unfortunately, no such values exist and the intrinsic value of any of these systems are primarily shown through environmental gains. Long term benefits of a sustainable building are mitigating irreparable damage to the environment. In conclusion, the capital cost of implementing these environmental system measures is invaluable for the protection of the environment well into the future.

4.6. Feasibility and Applicable Grants

Green Building Grant: The multi-use event and research space is eligible for the government funded Green Building Grant. The mission statement of this funding claims it would like to support structures that "transform land use attitudes and practices through innovation, stewardship, and learning"(Real Estate Foundation of British Columbia, 2013). The mission statement requirements are reflected in the IRIS Centre in the following ways:

1.) Innovation: The botanical garden is an innovative place with unique plants from all over the world. Their research focuses on biodiversity, genomics, plant evolution, and molecular level DNA splicing which are all groundbreaking topics.
2.) Stewardship: The administrative board that manages the botanical garden is a self-sustained (under UBC's funding) non-government organization.
3.) Learning: The research facility also offers fully accredited university level apprenticeships to involve interested youth and up to date on the latest findings.

5. Improved Signage

Enhancing visualization of the entrance to the UBCBG is a method to draw more attention and improve visitors' experience at the garden. As more people are interested and visit the garden more revenue will be generated allowing for more public engagement. In short, the vision and mission of the garden are emphasized. Three proposed designs to improve the aesthetics of the UBCBG entrance are roundabout signage, steel truss at the entrance gate and wooden arch by the main visitor entrance as detailed below. Engineering disciplines involved in the signage upgrade include structural, environmental, and materials engineering.

5.1. Roundabout Signage

Increasing the signage on campus notifying drivers, pedestrians, and cyclists to the location of the garden, which will help further the integration of the botanical garden with the campus. These signs could take a variety of forms with regard to the roundabout. By notifying drivers well in advance of the garden as a destination the perceptibility increases. This works similarly for pedestrians and cyclists. Such signs are already present on campus for the Museum of Anthropology and the Beaty Biodiversity Museum. Some signs already exist but are often small and easily overlooked.

Additionally, using a centre monument in the middle of the roundabout, such as a spherical UBCBG logo, will do more to draw attention to the garden. This feature will also be required to avoid distracting drivers or otherwise inhibiting driver ability. A feature like this will draw more attention to the garden without being tacky or invasive. An example of this is shown in Figure 8. The diameter of roundabout metal sphere signage is 10 m with estimated cost of $160 000. The material used for the UBCBG's logo is a 1-inch thick A36 steel plate, whereas the bracings are ¼" x 3" alloy 4140 steel flat (Metals Depot International, 2013).

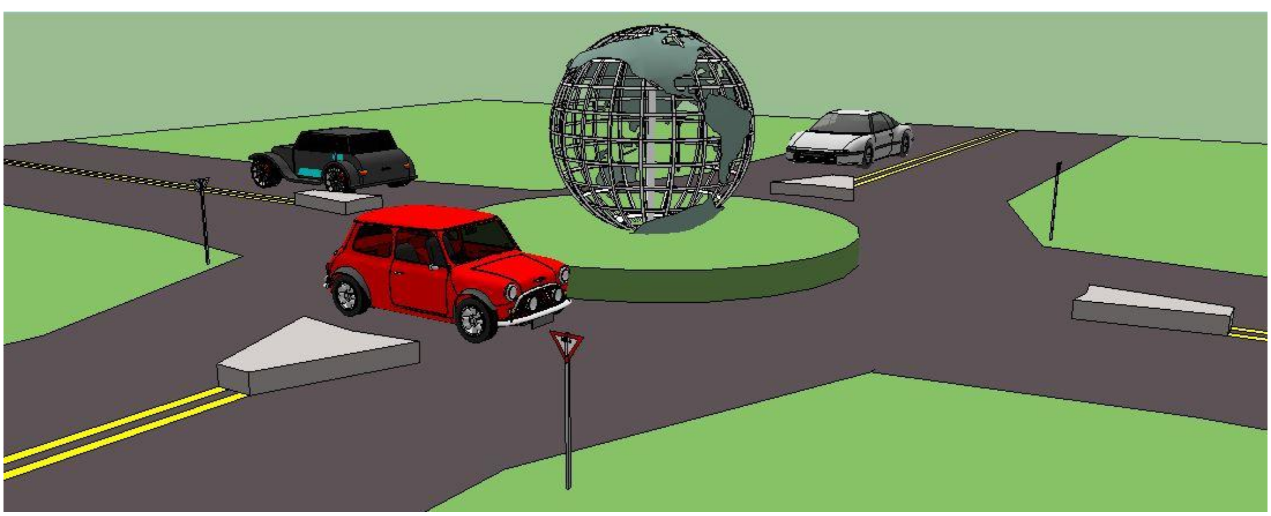


Figure 8 - Concept Roundabout with spherical sign.

5.2. Steel Truss Entrance Gate

A steel truss welcome sign covered by plants or flowers is proposed at the main entrance for vehicles of the botanical garden. A wooden board, reading "Welcome to UBC Botanical Garden" along with an embossed UBCBG logo, is attached to the top of the truss. A pair (or group) of totem poles placed side-by-side with the truss will also improve the UBCBG entrance to be more visible and attractive. The proposed truss dimension is about 6 m wide (of the arch span—to allow two-lane traffic flow), 5 m high, and 0.5 m thick. Total estimated cost of steel truss along with the wooden board, sticking plants, and labour cost is about $8 500 (Metals Depot International, 2013). In addition, the price of a pair of totem poles varies depending on the size and is started from $25 000 for the authentic full size hand-crafted totem poles (Native Online, 2013).

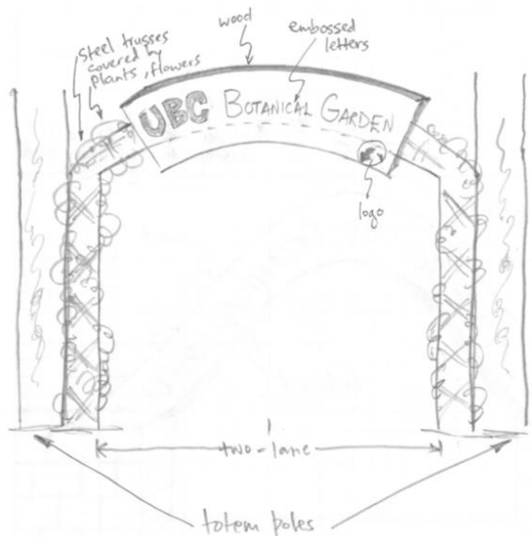
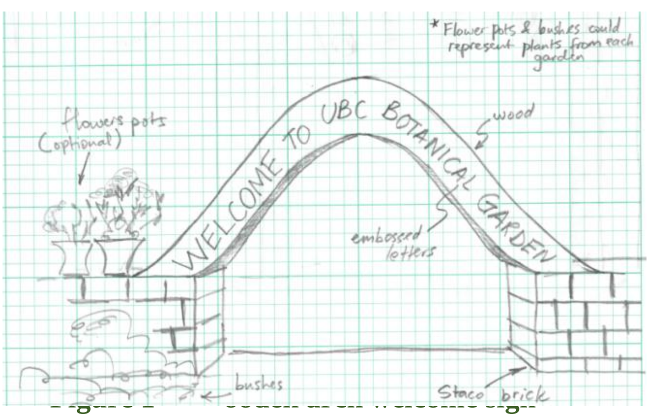


Figure 9 - Steel truss entrance gate

Even though steel is relatively more expensive than other materials such as timber or plastic, steel is a preferred material over others, as steel has longer durability, greater strength, fire resistant, and better aesthetic. See Figure 9.

5.3. Wooden Arch Welcome Sign



A half-oval wooden welcome sign is proposed at the main visitor entrance of the UBCBG. The wooden sign, reading "Welcome to UBC Botanical Garden" along with the embossed logo, is standing on a stucco brick wall. It will also be partially covered by some flowers and bushes to honour the botanical image. The sign will require carpentry expertise and significant labour-hours to expose its stunning details; as a return, it will enhance visitors' experience especially when entering the garden and will be a perfect spot for pictures. Estimated cost of the wooden arch welcome sign with 4 m span and 3 m height is $2 300 including labour costs (Goodreau Sawmill & Woodworking, 2013). Wood is the preferred material of the entrance sign because wood shows the natural sense of the garden and also is a renewable construction material; thus it promotes sustainability. See Figure 10.

6. Roundabout

Figure 11 - Route 92 (Washington) roundabout (Lake Stevens Washington, 2013)

The inclusion of a roundabout at the entrance to the UBCBG will assist with the goals of this broad redevelopment. This intersection will incorporate the entrance to UBCBG as well as Stadium Road and SW Marine Drive. By developing the intersection in a way similar to many others on the campus, the speed can be reduced, the safety increased, and the overall efficiency increased (De Winne, 2009). This change will provide an increase in all forms of traffic being directed to the area, from pedestrians with easier, safer access to vehicles going through the intersection. This section details the conceptual roundabout and the benefits of employing its use.

A roundabout will require more consideration from geotechnical and transportation engineering disciplines. Geotechnical concern will be necessary for the long-term sustainability of the intersection design. The road will need to support traffic loads without deforming for a significant period (ideally more than 20 years). A transportation engineer will be required to assess the traffic flows and verify the suitability of the roundabout for this application. Additionally, traffic analysis will be required to determine appropriate lane markings and slip lanes.

6.1. Cost

The roundabout is contained on land owned by the British Columbia Ministry of Transportation (MOT) and therefore the project will need their approval. The construction will likely be financed primarily through the UBCBG as a local improvement with the cost being added into the tax and amortized over a 10 to 20 year term.

The level of development can strongly affect the cost, with some features increasing the cost much more than others. In particular, artistic features, a truck apron, and active pedestrian safety devices can all dramatically increase the cost. Some of these features can be excluded from the initial development to reduce the cost but some are unavoidable. For example, MOT would likely dictate the necessity of a truck apron for the intersection. Pedestrian lights and a centerpiece could be left for future development. Typically, a roundabout on this scale would cost around $500 000 to $650 000.

6.2. Safety

Generally, car crashes are reduced in both frequency and severity when a roundabout is implemented. The pedestrian safety has historically suffered with improper safety mechanics or a driver population unused to roundabouts. Typically, though, as roundabouts become more frequent, the safety metrics prove more effective over signalized intersections. On this basis it makes sense to use a roundabout where speeding is already an issue and safety is compromised.

7. Pedestrian Tunnel

Another method considered to increase connectivity of the botanical garden is to integrate an additional pedestrian tunnel. This will ideally be done at the same time the intersection is upgraded and will be located under the intersection. The scale can vary significantly, from a box culvert similar in size to the existing tunnel, to a comprehensive concrete tunnel several meters wide. A tunnel will further benefit the pedestrian safety by eliminating any need to cross the driving area by foot or bike. Operating costs will be the electric lighting and maintenance requirements.

A pedestrian tunnel will require geotechnical investigation to determine the forces imposed onto the structure. Since it will be located under the intersection it will also be necessary to consider the traffic loads imposed on the structure. A structural engineer will be needed to consider the structural resistance of the tunnel.

7.1. Connectivity

The pedestrian tunnel, whether constructed with or without the roundabout, will increase the overall connectivity of the garden. Currently the existing tunnel is the only means by which visitors can access the portion of the garden on the east side of SW Marine Drive. By placing a new tunnel beneath the intersection of Stadium Road a pedestrian circuit can be made and allow a better experience for visitors to the UBCBG.

7.2. Incorporating Art

The existing tunnel interior is exposed corrugated steel and is somewhat unsightly. It is recommended to design this tunnel with artwork of some kind, such as a mural or aesthetic design inside the tunnel. The result takes an otherwise gloomy tunnel and turns it into a memorable feature. Incorporating artwork like this will help bolster the experience of visitors to the garden.

7.3. Cost

The cost of the pedestrian tunnel can range significantly. Tunnel width, depth, and total length underground are just some of the considerations that need to be made. Preliminary estimates can constrain the cost to as low as $650 000 or well into the millions. It is recommended to take a function-first approach and keep the cost of the tunnel as low as possible. Therefore, a preliminary cost estimate for the tunnel is $750 000.

8. Pedestrian Bridge

Another proposed component to the infrastructure upgrade includes the addition of a pedestrian bridge across SW Marine Drive. This will allow for a much safer alternative to existing crosswalks and even the alternative crosswalks integrated into the proposed roundabout. This option is inherently more expensive but also helps to serve the connectedness of the UBCBG. The bridge will need to achieve a significant height to allow trucks to travel along the roadway.

8.1. Benefits

A pedestrian bridge will provide a safer means of traversing SW Marine Drive than a surface crossing. It will also limit the requirement for lighting since it would be located in close proximity to the roadway. The addition of a bridge will also help with the goal of increasing the connectivity of the garden (not only internally but with the rest of campus). The addition of a pedestrian bridge will reduce access barriers, encouraging visitors to come to garden.

8.2. Safety

Pedestrian bridges are often used as alternatives to ground level crossings in many places. Commonly used for freeways and rivers, pedestrian bridges substantially increase the viability of crossing. When compared with ground level crossings they also increase the safety immensely and without affecting the traffic stream. For this reason, when considering the local traffic speeds and driver habits, it is recommended to construct a pedestrian bridge.

8.3. Cost

Pedestrian bridges can vary in price, similar to the previously mentioned pedestrian tunnel. The cost for a project of this scope will be roughly $500 000. The price can be increased significantly to account for more width to accommodate bikes or a roof structure to protect from rain.

9. Parking Lot Redevelopment

A parking lot redevelopment is another viable focus for redevelopment. The primary benefit is increasing the overall amount of parking, which is extremely beneficial in assisting the ease of access to the garden and promoting more tertiary visitors.

9.1. Cost

A parking lot redevelopment will be done quite cost effectively by repainting the lines. Alternative options, such as developing a multi-level parking structure will cost well into the millions of dollars but will not likely negatively affect the atmosphere of the UBCBG. In terms of getting the most value out of this development it will be recommended to expand the pavement to all areas where it is allowed and to include more spots for small cars.

9.2. Benefits

A parking lot will accommodate not only more visitors and staff of the UBCBG, but it will also increase parking facilities for other uses, such as events parking and student parking. This will generate more revenue for the garden through parking fees. Currently, parking is not generally an issue unless there are special events, such as the Apple Festival or weddings.

10. Covered Bike Parking Facilities

As part of the UBC Sustainability Campus Initiatives on transportation, the proposed building will feature covered bicycle parking to encourage cycling to the UBC Botanical Garden. Secure bicycle parking facilities will be located on the exterior side of the IRIS Centre underneath architectural overhang. The facility aims to provide secure bike parking sheltered from the elements for the duration of the visitors' trip to the garden. Bike parking facilities expand the potential of a different demographic of visitor to the garden and encourages sustainable transportation.

11. Mechanical Gates

The possibility of implementing mechanical gates throughout the garden was discussed to improve ease of access for workers within the garden. UBCBG representatives introduced this idea during a plenary session on September 30th; it was estimated that these gates would pay for themselves, in terms of saved time, within one year. The concept of installing mechanical gates was not continued due to the limited budget, the high initial cost (approximately $1900 for mechanism without installation), and the low long-term gain (Bezdan Ltd., 2013).

12. The Look-Over

The existing lookout at the UBCBG looks over the parking lot, Old SW Marine Drive, and the grass knoll. Over the years, the trees west of the garden have grown and obstructed the ocean view from the lookout. A proposed upgrade to the lookout will allow visitors to see the ocean through the window between the trees without too much intrusion onto the grass hills. The upgraded lookout will feature an elevated 360 degree covered balcony at an elevation high enough to look through the existing window between the trees as well as see the garden and the IRIS Centre. The pathway to the lookout will be elevated and steps installed to reach the higher view point.

13. Cost of Proposed Project

The estimated cost of the IRIS Centre, including construction equipment and site work, is $14.2M as outlined in Table 1. The cost of the IRIS Centre, not including the rooftop garden and major features, was assessed using the Square Foot Estimating Method (SFEM). The SFEM is a common method used by contractors to estimate the cost of large public structures such as classrooms, churches or laboratories. The Means Data Bank of Construction Costs is a database pertaining to certain building types that has been derived from over 11 500 similar construction projects in the U.S. to modify the cost of the building to be more reflective of modern construction in Canadian cities. The estimating method applied cost modifiers to account for inflation, location, size of footprint, and cost differences from the time the data was collected.

PROJECT	**Growing Forward**			
TITLE	IRIS Center Building Estimate		DATE	11/22/2013
NAME	Group 6		TIME	10:40 AM
1	**Base Cost (2010, US Average)**	60,000	$ 201.15	$ 12,069,000.00
2	**Cost (2010- size adjusted)**			
	Proposed building area	60,000		
	Typical Size	45,600		
	Area Conversion Scale	1.32		
	Cost Modifier	0.975		$ 11,767,275.00
3	**Cost (2010-Vancouver)**			
	Location Index US	100		
	Location index Vancouver	106.6		$ 12,543,915.15
4	**Cost (2013-Vancouver)**			
	Index 2010	4800		
	Index 2013	5226		$ 13,657,187.62
5	**Cost (April of 2014)**			
	assume inflation= 2.5%	0.025		
	n	1.5		
	Cost= C (1+ i)^n			$ 14,172,519.55
Total Cost for Basic University Laboratory, Engineering or Science Space				**$ 14,200,000.00**

Table 1 - Building Shell Cost Estimate

The following assumptions were made to conduct an accurate estimate:

- The basement and second floor are similar to a College (Science, Engineering, Laboratory)
- Estimates include costs for site work and equipment
- Construction would begin April 2014
- Inflation rate of 2.5%

The total cost of the IRIS Centre and all pertaining features including the environmental aspects, transportation improvements, signage upgrades, café, living lab, and research facility was estimated to be $19.6M as outlined in Table 2 below.

PROJECT	**Growing Forward**			
TITLE	IRIS Center Feature Estimate		DATE	11/22/2013
NAME	Group 6		T ME	10:39 AM
1	**Cost of College Engineering Laboratory Style Building**			$ 14,200,000.00
2	**Environmental Aspects**			$ 2,490,000.00
	Geothermal	$ 450,000.00		
	Stormwater Management	$ 1,200,000.00		
	Green Roof	$ 840,000.00		
3	**Transportation Upgrades**			$ 1,900,000.00
	Round-a-bout	$ 650,000.00		
	Pedestrian Bridge	$ 500,000.00		
	Pedestrian Tunnel	$ 750,000.00		
4	**Signage Upgrades**			$ 196,000.00
	Steel Truss upgrade	$ 8,500.00		
	Totel Poles	$ 25,000.00		
	Wooden Arch Welcome Sign	$ 2,500.00		
	Round-a-bout Signage	$ 160,000.00		
5	**Botanical Garden Café**			$ 150,000.00
6	**Living Lab**			$ 390,000.00
7	**Research Facility**			$ 280,000.00
	Total Cost for IRIS Center			**$ 19,606,000.00**

Table 2 - Building Feature Cost Breakdown

14. Implementation Plan

A well thought out plan will ensure that the redevelopment of the UBCBG results in as little disruption as possible. The phasing of the several phases of the project will be carefully planned with manufacturer's production schedules, class schedules on campus, and major events at the UBCBG taken into consideration.

The main phases of our project include the construction of the following:

- Roundabout
- Pedestrian tunnel
- Overhead walkway
- IRIS Centre
- Stormwater management
- Geothermal heating system
- Signage upgrades

Construction will start with the roundabout in April 2014, which will be after the coldest period of the winter and after student traffic has reduced along South-West Marine Drive (SWMD). Construction of this roundabout will follow a similar procedure to the roundabout recently completed at East Mall and West 16th Ave. This process ensured that there was traffic flow in all directions during a majority of the project. During the initial ground preparation phase of the roundabout construction the underground pedestrian tunnel will be installed section by section as each lane of traffic is taken out of service for the ground improvements and then subsequently reinstalled after the tunnel section and all ground improvements are completed. The entire intersection will be completed in this manner over a time period of 4 months with the landscaping of the roundabout and tunnel entrances to be completed in the following month.

IRIS Centre construction will begin in August 2014 with the exterior. The building construction will be phased in such a way that the interior building components can come online. The research facility will be brought online first to ensure that any funding due to grants can be received as soon as possible and that researchers can start their work at the world-class facility promptly. The café will be the next completed component to ensure that both the researchers and garden customers will have a space where they can relax and enjoy the garden while also allowing the garden to collect revenue from the café. Bringing the café online quickly will allow some revenue to be had from the construction workers as there is no other nearby coffee shop which would mean that most of the construction workers would frequent the local café on their coffee breaks. This would generate a positive revenue stream before the building was even completed which can also help to reassure investors. Both of these facilities will ideally be commissioned within 10 months of the start of construction. The next major portion of the building to be completed will be the living learning centre and the interactive maps, followed by the rooftop garden. It will be partly completed during the high tourist season which will allow visitors to get a look at what is coming to the garden for the fall. This will act as a form of free advertisement and also allow the patrons to see the great new facility which is being completed. The interactive maps will be completed by June 2015.

The overhead walkway will be started in April 2015 and completed by the end of August 2015 which is the time of lowest student traffic. In addition, this is well after the roundabout and pedestrian tunnel will have been completed and also after any major equipment will have left.

The rooftop garden construction will start in December 2015 and run through the winter to May 2016 to be finished in time for tourist season. As of that time, minor work will still be in progress on the building but it will be partly operational throughout the summer to allow for the revenue to be maximized.

Once work on the rooftop garden is complete all of the major construction traffic will be completed and enough consolidation time will have passed to allow the final top lift of asphalt to be paved on the roundabout.

The stormwater management construction will take place in August 2014 to allow installation of the storage tanks and collection facilities during excavation of the IRIS Centre. The stormwater facilities will be completed by March 2015.

Geothermal facilities will also be constructed at the same time as the stormwater management systems as they both require excavation and can be built simultaneously. The construction for geothermal is much shorter as it only requires the boring of holes and plumbing. This work is quicker compared to the tank and filtration system installation required for the stormwater management system.

Signage will be the last phase of the project to ensure that the custom designed signs have the proper amount of time to be crafted by local artists with the added benefit that a late installation date will ensure that any exposure due to construction traffic is minimized. The scheduled installation date is from January to March 2016.

Overall the complete project construction will take place between August 2014 and July 2016. The Gantt chart of the construction process can be seen below in Figure 12.

ID	Task Name	Start	Finish	Duration
1	Project Timeline	4/1/2014	7/28/2016	121.6w
2	**Building Construction**	**8/1/2014**	**7/28/2016**	**104w**
3	Building Shell	8/1/2014	7/28/2016	104w
4	Research Facility	2/2/2015	4/24/2015	12w
5	Cafe	2/2/2015	4/24/2015	12w
6	Living Learning Centre	4/27/2015	9/11/2015	20w
7	Interactive Maps	4/27/2015	6/5/2015	6w
8	Rooftop Gardens	12/1/2015	5/16/2016	24w
9	Roundabout	4/1/2014	8/18/2014	20w
10	Roundabout Top Coat	5/17/2016	5/30/2016	2w
11	Pedestrian Tunnel	4/21/2014	9/5/2014	20w
12	Overhead Walkway	4/1/2015	8/18/2015	20w
13	Storm water Management	8/1/2014	2/27/2015	30.2w
14	Geothermal Heating	8/1/2014	11/13/2014	15w
15	Signage	1/1/2016	3/10/2016	10w

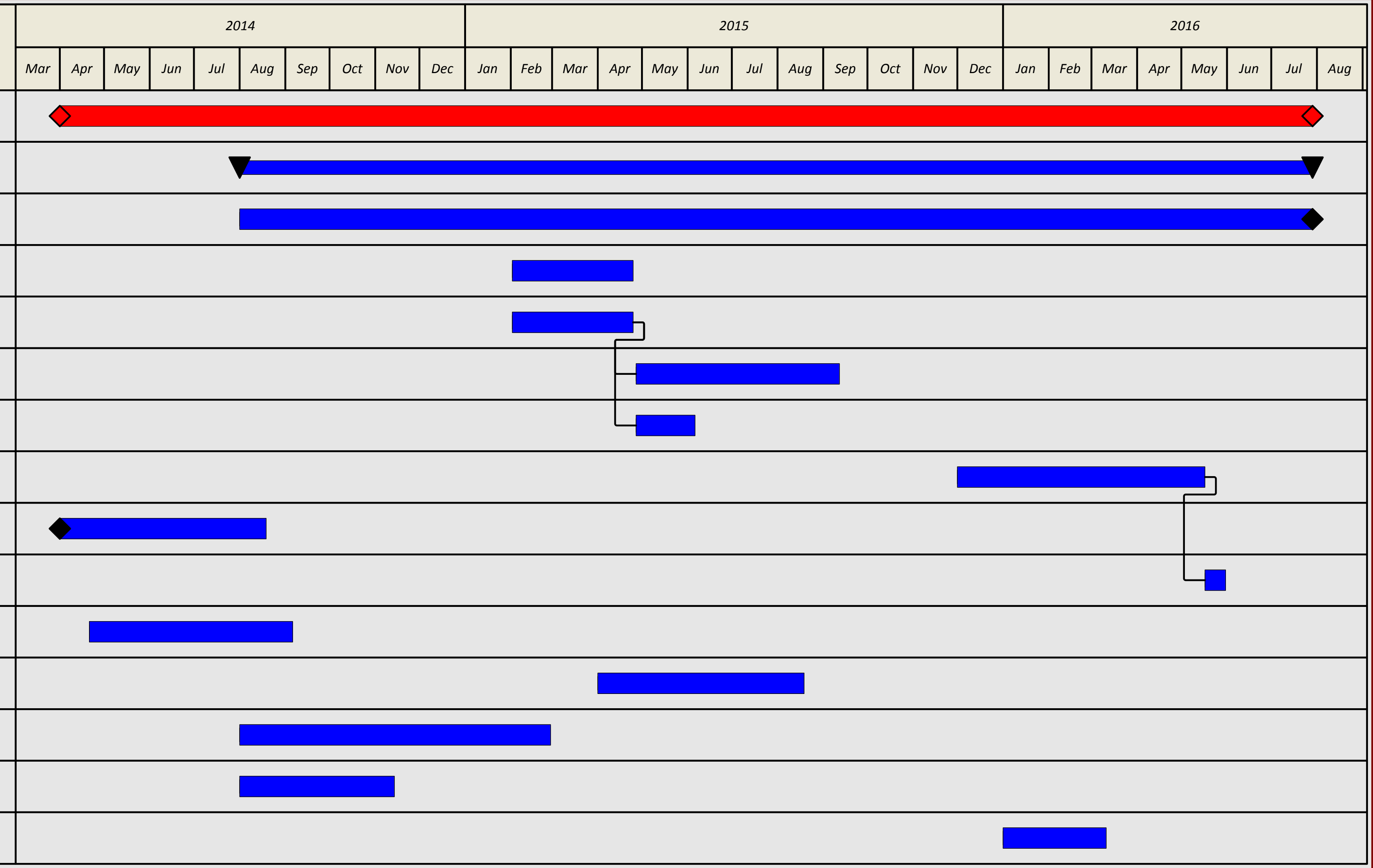


Figure 12: Proposed Project Timeline Breakdown

15. Conclusion

The Growing Forward redevelopment plan will improve the UBC botanical garden by allowing the garden to better achieve their mission statement. The IRIS Centre will have multipurpose event space, a café, interactive information maps, research and laboratory space, and a living learning centre. The features of this building will attract more visitors to the garden, increase revenue for the garden, facilitate botanical research, and educate the community. The IRIS Centre will also feature a geothermal heating system and a green roof, which will improve the building environment and make the IRIS Centre a leader in sustainability. A stormwater management system will be implemented throughout the garden to facilitate better use of stormwater. Improved signage for the gardens will make the garden easier to locate and increase public awareness of the garden. In order to improve the quality and safety of access to the garden, a traffic circle, pedestrian bridge, and underpass tunnel are proposed. The development of this plan took into consideration overall cost, goals of the garden, and the mission of the garden. In conclusion, this proposed improvements are a comprehensive plan to ensure a beneficial redevelopment of the UBC botanical garden that addresses the most urgent concerns facing it today. It is consistent with the mission statement of the UBCBG and will ensure that it continues to grow forward.

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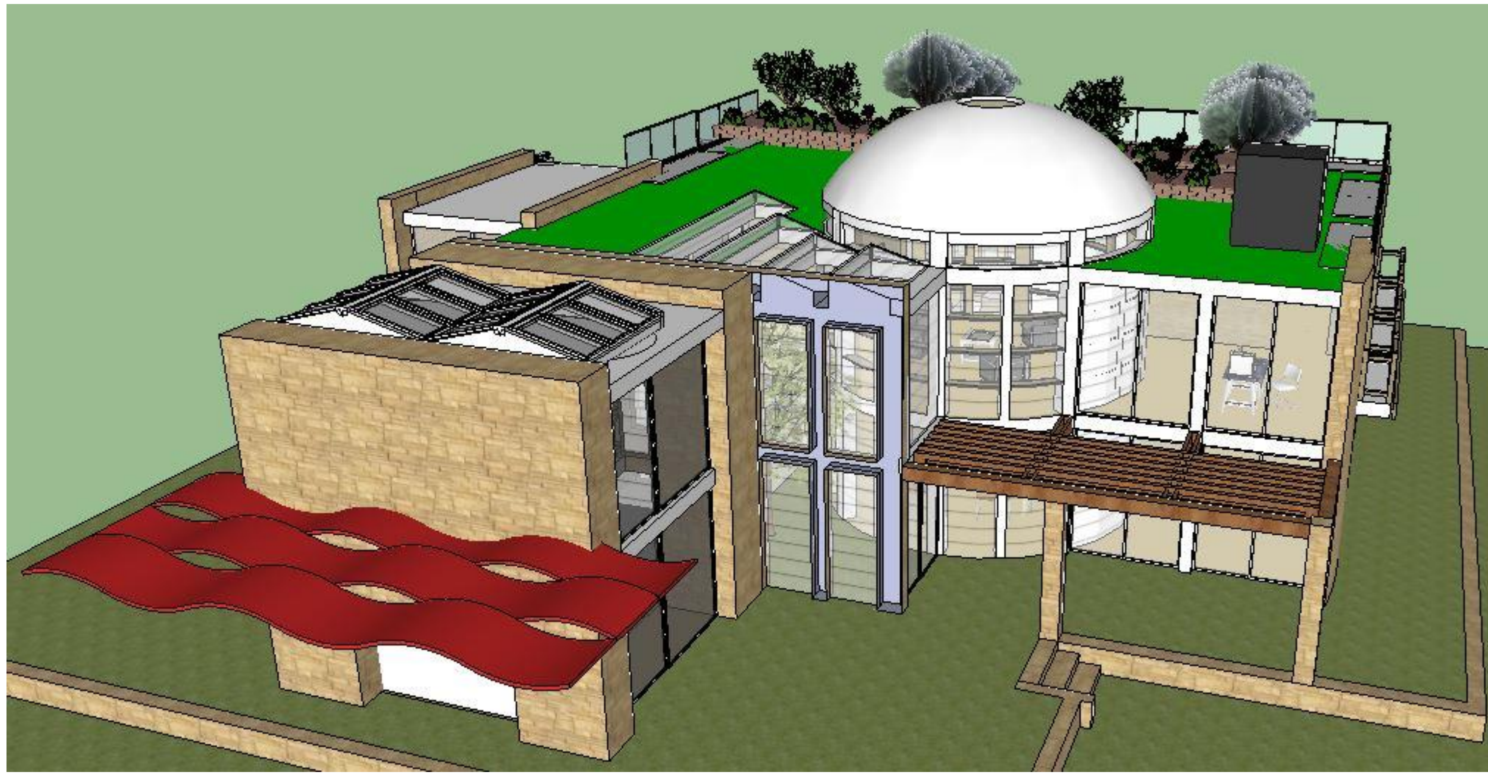
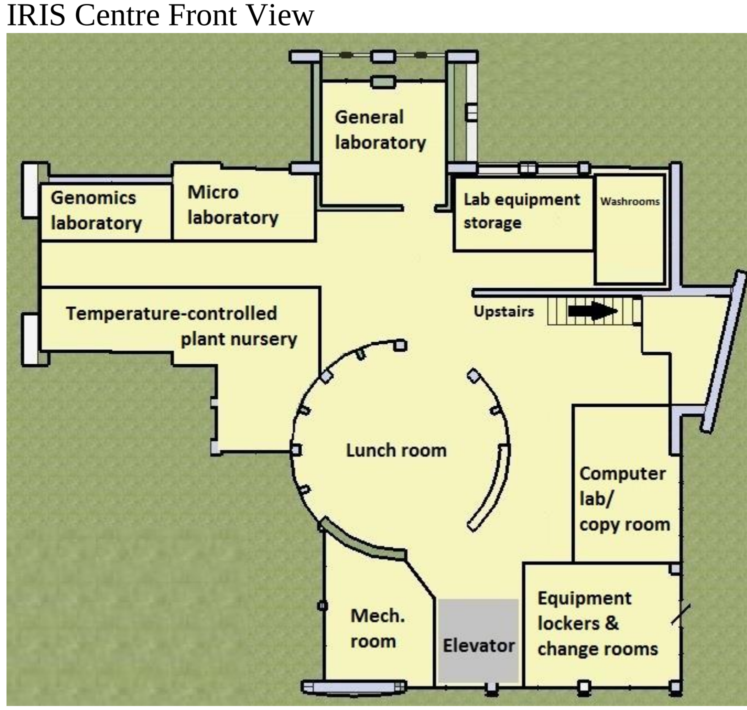
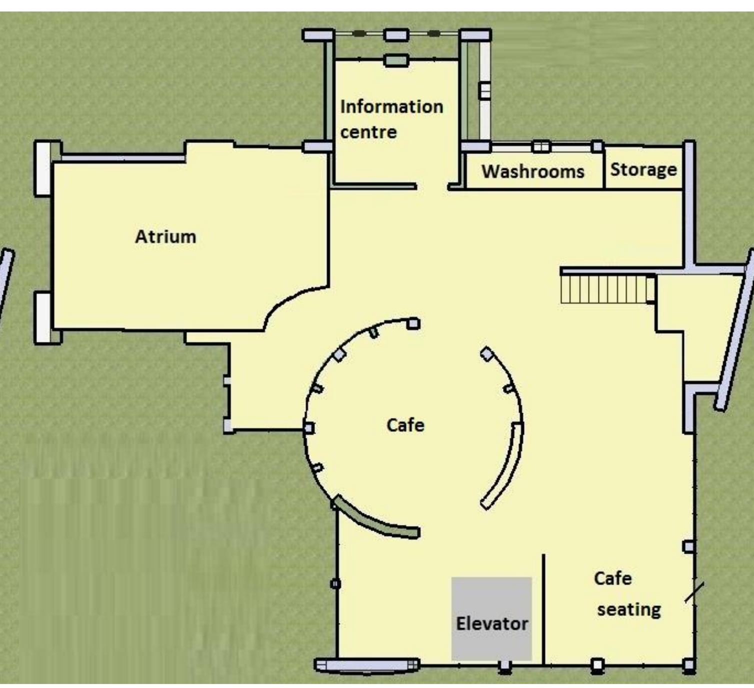
Appendix A: IRIS Centre Visualization


IRIS Centre Front View

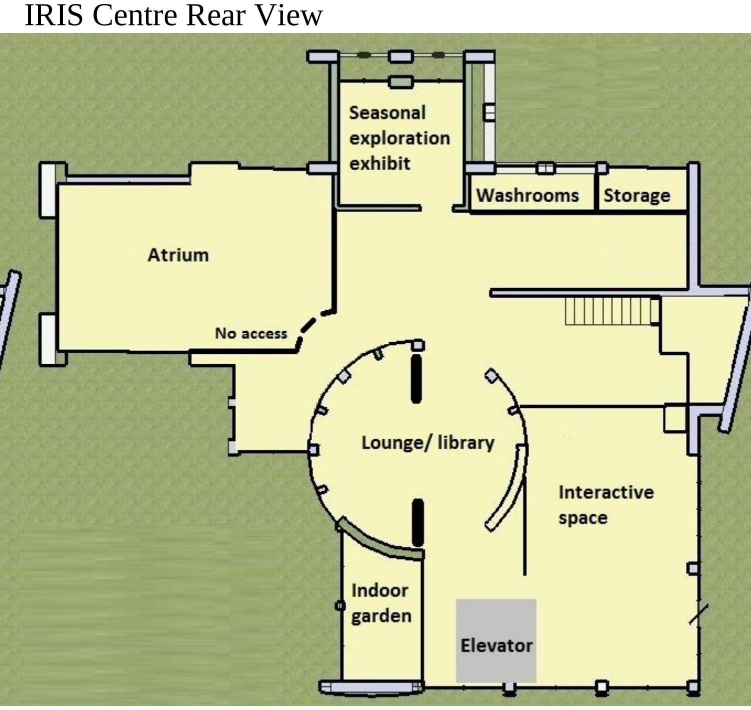

IRIS Centre Rear View



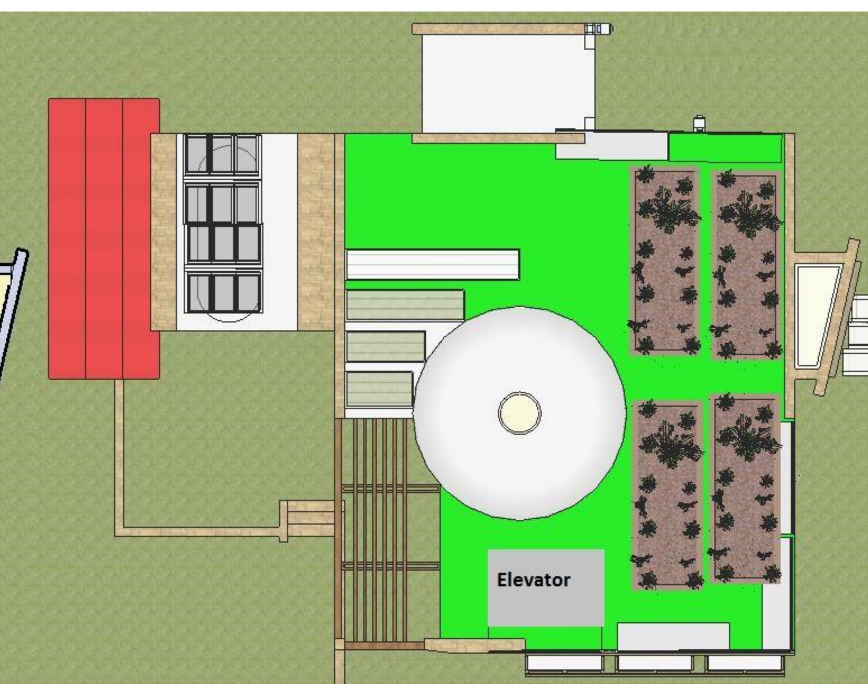
Basement Floor Plan



First Floor Plan



Second Floor Plan



Roof top