PROJECT MOTION: REVITALIZATION PROPOSAL

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University of British Columbia

CIVL 445

November 28, 2013

Letter of Transmittal

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November 28, 2013

Dr. Siegfried F. Stiemer, CIVL 445 Instructor
Department of Civil Engineering
The University of British Columbia
5000-2332 Main Mall
Vancouver BC V6T 1Z4

RE: Submission of UBC Garden Revitalization Proposal

Dear Dr. Stiemer:

We are pleased to present the enclosed term report entitled "UBC Botanical Garden Development Plan" as a part of the Civil 445 course requirement.

The report contains a concept to redevelop the UBC Botanical Garden with assessing environmental, hydro-technical, structural, and transportation engineering. We would like to express our appreciation for all the professional advice that has been generously offered to us for the formulation of this report. The entire process gave us an opportunity to derive a new design concept for a development project which will be invaluable for future professional practice.

We are available to answer any questions and can be contacted by email at: [redacted]

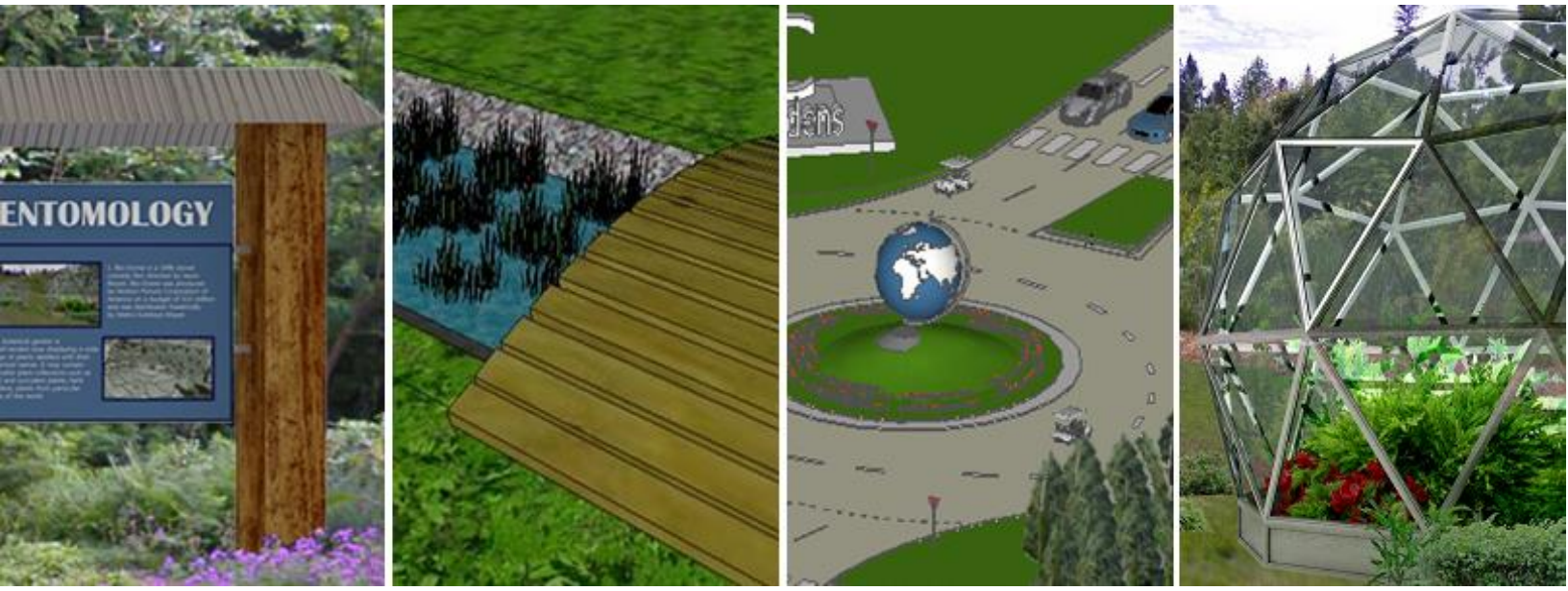
Kind regards,

The Project Motion Team: A. Schroeder, E. Yii, J.Gudsson, K.Kim, S. Blake, and S. Prasad

Enclosure

TEAM 8 / CIVL 445

PROJECT MOTION



ubcbotanicalgarden
& centre for plant research

REVITALIZATION PROPOSAL

NOVEMBER 28, 2013

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EXECUTIVE SUMMARY

The UBC Botanical Garden is a world renowned facility for plant research and a significant part of the university community. We propose a re-development of critical systems in and around the Garden to improve accessibility, sustainability, and educational aspects of the facility. Our goal is to create a more valuable experience for faculty, students, and the public.

Our focus was to add to and improve upon:

- **Transportation to, and within, the Garden.**
- **Structural attractions within the Garden.**
- **Hydrotechnical systems managing stormwater in the Garden.**

Currently, the entrance to the Garden is not visually impactful and there is no signage to indicate its location. The installation of a roundabout coupled with strategic placement of signs will draw attention to the Garden and facilitate access for potential patrons. With increased visitors, this project anticipates a need for additional parking spaces. We propose to increase capacity by relocating some parking to existing lots away from the Garden and providing a shuttle service.

Installation of major features to function as anchors will increase public interest in the Garden. A tour of six *BIO-DOMES* is proposed as a new attraction. This architectural feature doubles as a scientific facility, with each dome housing a unique self-sufficient ecosystem. Adjacent to the BIO-DOMEs, the *GlassHouse*, a sustainable multi-purpose space will allow the Garden to host private and public events such as environmental conferences, weddings, etc.

The current stormwater system in the Garden faces problems with erosion. By clever design of a new water diversion and filtration system, the team not only plans on addressing this problem, but aims to improve the quality of water, and improve sustainability of the entire system.

The project has a projected cost of $2 million in 2013 dollars for the implementation and completion of each component. The development and construction schedule is estimated to occur in three phases over the span of several year.

TABLE OF CONTENTS

LISTS OF FIGURES

LIST OF TABLES

1.0 PROJECT BACKGROUND

The UBC Botanical Garden hosts many world-class research biodiversity collections. Located on the UBC campus adjacent to Thunderbird stadium, the Botanical Garden includes various species of plants providing a vital research portal for researchers and students, and also acts as an educational facility for the community at large.

UBC has grown and evolved over the last few decades, with the exception of the UBC Botanical Garden, which has unjustly become an afterthought in annual budgeting. This may be partially due to the lack of awareness of the Garden's vital function within the fabric of the University. This problem is exacerbated by poor attendance figures for the Garden, particularly amongst non-membership holding visitors. The report will propose a substantial upgrade to enhance the Garden's significance as an important research, conservation, education, and community space. The design concept for re-development of the Garden will focus on transportation, structural, and hydro-technical engineering solutions that improve upon the current systems employed within the Garden and help re-establish the Garden as not only one of the most impressive features of the UBC campus, but as one of the top botanical garden facilities in the world, both academically and in terms of number of visitors.

Special care was taken in developing a plan that focused on sustainable systems and increased the significance and public visibility of the Garden without diminishing its educational value by introducing commercial interests or attractions that did not fit with the on-site botany. Consideration was also taken to ensure construction of these remediation systems would have minimal impact on the sensitive environment in and around the Botanical Garden.

2.0 TRANSPORTATION RECOMMENDATIONS

After consultation with Garden representatives, several issues with regards to the movement of people to, and within, the Garden were identified. Solutions to several of these transportation issues are outlined in this report.

2.1 ROUNDABOUT

Through use of a Decision Matrix (see Appendix A), installation of a roundabout at the intersection of SW Marine Drive and Stadium Road was deemed to be the most practical solution to slowing traffic at the Garden's entrance and improving safety for pedestrians crossing SW Marine Drive at Stadium Road.

2.1.1 PROBLEM DESCRIPTION

One of the main issues faced by the UBC Botanical Garden is the lack of visitor attendance. The Garden is struggling to attract interest from the general public and it is believed that part of the problem is its location. It is located on the very western side of the UBC campus at the intersection of Marine Drive and Stadium Road. This area has little human traffic as there are not many amenities compared to the eastern side of campus. For example, Westbrook Village, located on 16th and Westbrook Mall has many amenities, making it a central point for the public to convene. This allows businesses and facilities to benefit from the high levels of human traffic. The area surrounding the Garden is mainly occupied by residential developments. Because there is no central meeting point nearby, unplanned visits to the Garden are low.

Another problem that needs to be addressed is the high vehicle speeds along SW Marine Drive, which passes directly in front of the UBC Botanical Garden. The main issue with this is pedestrian safety. A pedestrian crosswalk is located in front of the Garden but is not combined with a speed deterrent. As Marine drive is 4 lanes, crossing the street can be a dangerous experience. Vehicles trying to access the Garden from stadium road face a similar problem.

The high speeds also pose a problem for motorists on SW Marine Drive. To enter the Garden, a sharp 90 degree turn has to be made; because speeds are high on this passage and signage of the Garden is poor, it becomes easy to overshoot the entrance. If the turnoff is missed there is no convenient location to turn back.

2.1.2 SOLUTION AND JUSTIFICATION

We propose that a roundabout be constructed on the intersection of SW Marine Drive and Stadium Road. We also recommend the addition of signs along SW Marine Drive leading up to the Garden in both directions to notify motorists of the approaching Garden.

The main benefit of the roundabout is that it will act as a speed deterrent along Marine Drive. Traffic will have to slow going into the roundabout while still allowing traffic flow to be fluid. This has the advantage over a traffic light in that it is a self-governing system, depending purely on the drivers' knowledge of how to navigate the roundabout. It does not have any mechanical or electronic parts that can malfunction. Apart from this, it also allows traffic to remain smooth in times of low traffic unlike traffic lights, where vehicles still have to stop even if there is no traffic coming the other way.

The roundabout will also address issues of pedestrian safety. Pedestrian crosswalks will be placed on all sides of the roundabout allowing easy access to the Garden and adjacent areas for pedestrians. Both of these solutions will allow for a safer and easier Garden experience. In addition to this, the roundabout will help to ease access into the Garden by slowing traffic and removing the 90 degree turn.

2.1.3 DESIGN OF ROUNDABOUT

The preliminary design of the roundabout was done using the BC Ministry of Transportation (British Columbia Ministry of Transportation, 2007) and Kansas Department of Transportation (Kansas Department of Transportation, 2003) roundabout design guide. It was designed under the urban double lane criteria. The design guide recommends an inscribed circle of 46m for this category. Having taken several factors into consideration, it was decided that an inscribed circle diameter of 42m was sufficient, preventing the need to expand existing roads. Design details and rules for the roundabout are summarized in Table 1 on the next page,

Table 1 - Roundabout Design Details and Rules (Kansas Department of Transportation, 2003)

Design Details	Rules
• 2 lanes on SW Marine Drive • 1 lane on Stadium Road • Lane size of 4.5m • Inscribed circle diameter of 42m • 1m clearance on interior/exterior of circle • 18m fully mountable central island • Crosswalks on all Sides	• Right hand lanes on double lane entries are expressly for the use of right turns • Traffic outside circle shall always yield to traffic within circle • Traffic shall always yield to pedestrians • Speed shall be reduced to 30km/hr in passage leading up to the circle, within circle, and exiting circle

and an overhead view of the proposed roundabout is shown in Figure 1 below, with SW Marine Drive running vertical, and the Garden entrance on the left of the image.

Figure 1 - Final Roundabout Design

2.2.3 Environmental Considerations

The main environmental impacts posed by the inclusion of the roundabout are contributed mostly from construction activities. As is, the roundabout can be constructed without much disturbance to the surrounding area. Likely disturbances are: ground vibration, dust dispersion, noise pollution, diesel leakage from equipment, material use. These are all minor impacts and will only be present during time of construction. This however, may cause slight disturbances to the local residents. As the roundabout will not be located in any sensitive areas, and the scale of the operation being relatively small, the environmental impact of inclusion of a roundabout is minimal.

Impact from sign installation is mainly from the production of the sign itself. The installation itself will prove to have little to no impact on the surrounding environment. As the material use and production of signs is outside the scope of this project, it will not be discussed in this report.

2.2 Signage Enhancement

It is recommended that signage be added around the roundabout, and on the approach to the Garden along SW Marine Drive to help motorists identify the Garden well before passing the Garden's entrance. Informative signage within the Garden can also be implemented to improve the overall experience for guests.

2.2.1 Road Signage

Signs will be placed on all entering lanes of the roundabout, indicating what each exit leads to. This has the potential of being very important for the Garden. The UBC Trek Program has found that a total of 41% of single occupancy vehicles and 32% of high occupancy vehicles travelling to UBC use SW Marine Drive, the most of any route. With these high traffic volumes, the addition of signs can draw a substantial amount of attention towards the Garden by alerting passing vehicles of its presence.

In addition to signs placed at the roundabout, we propose on installing signs along SW Marine Drive leading up to the Garden. We believe these can bring attention to the Garden and improve attendance numbers. Traffic signs placed at intersections can be very impactful and our proposal is to have signs erected at strategic intervals on SW Marine drive. Ideal locations would be at the intersections of SW

Marine Drive with 41st Street, 49th Street, 16th avenue, and Westbrook Mall. These locations are shown on a map in Figure 2 below.

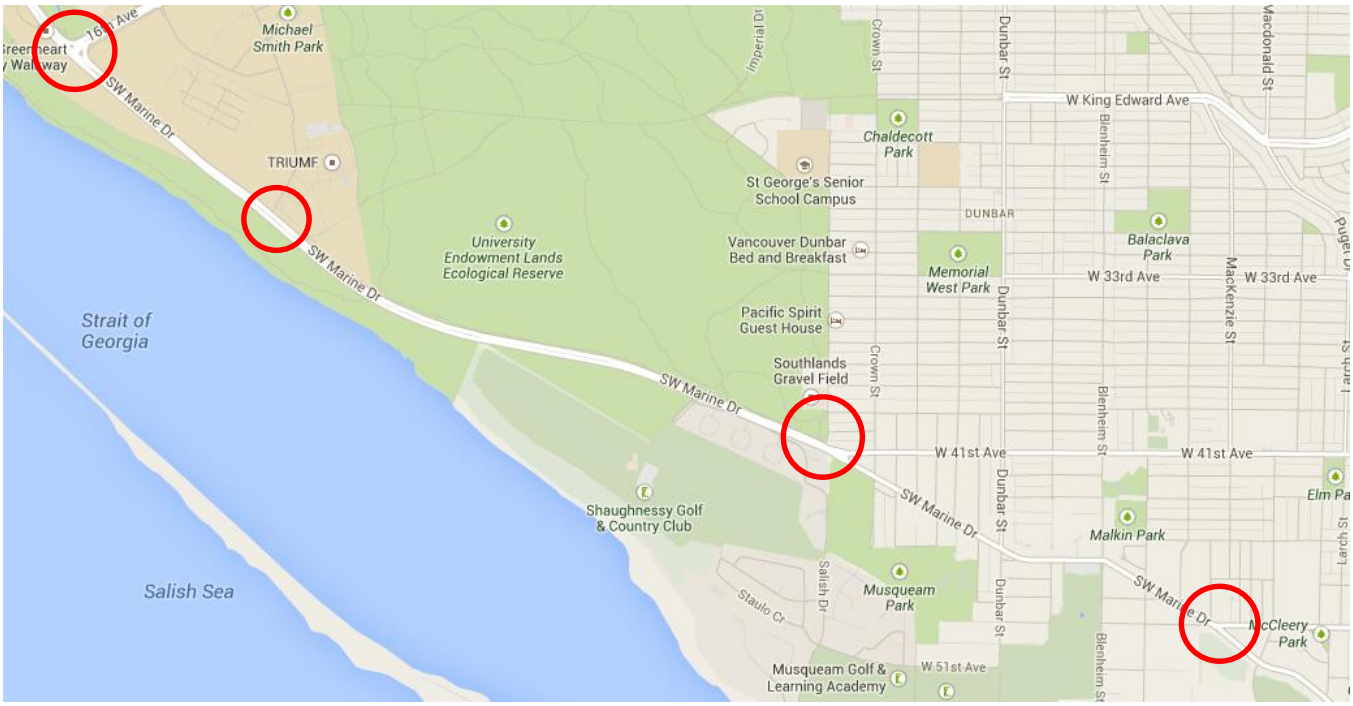

Figure 2 - Map of Sign Locations along SW Marine Drive

These roads have significant traffic flow and their major intersections with SW Marine Drive means that commuters to UBC will be alerted to location of the Garden. These will be coupled with indicator signs along the road to alert drivers of their distance in relation to the Garden.

2.2.2 PATH SIGNAGE

It is recommended that additional signage be installed within the Garden to act as anchor points along the Garden's nature trails, adding more educational context to the Garden and highlighting unique aspects of the site that would not be easily identifiable for most visitors. These signs would be mainly constructed out of timber in order to fit in with the surrounding environment, and would be located in along the nature trails near the Garden's entrance and gift shop to ensure visitors see them at the beginning of their visit. These signs would include: Garden history, ornithology (study of birds), entomology (study of insects), botany (study of plants), and trail maps. A rendering of two trail signs is shown in Figure 3 on the following page.

Figure 3 - Proposed Signage for Garden Paths

The signs will also display Quick Response (QR) codes, and be integrated with the QR code system already employed in the Garden to allow visitors to access additional information on their wireless devices. Providing extra information to guests allows for a more informative and enjoyable experience.

2.3 PARKING

A lack of parking both on-site and adjacent to the Garden creates problems, particularly during large events.

2.3.1 PROBLEM DESCRIPTION

The UBC Botanical Garden hosts various events throughout the year such as the Apple Festival, Magnolia day tours, weddings, school tours and much more. However, the Garden is unable to accommodate a large number of guests due to insufficient parking on-site. Compounding this problem is the lack of public transit routes that stop near the Garden's entrance, and high costs of renting shuttle service during large events – an expense that is a burden on the event organizer.

2.3.2 Solution and Justification

As a solution, our team has proposed to include two additional parking spaces during high traffic events. One is an overflow gravel lot just to the left of Stadium Road (Figure 4 below) and the other is the main parking lot at Thunderbird Stadium (Figure 5 below).

Figure 4 - Overflow Parking Lot, Stadium Rd.

Figure 5 - Thunderbird Stadium Parking Lot

Both of these parking lots have an approximate capacity of 100 cars, thereby significantly increasing the accessibility of the Garden when used in conjunction with the Shuttle Service proposed in Section 2.4 on the next page. One concern may be the availability of the Thunderbird Stadium's parking lot which can vary due to pre-scheduled UBC sporting events. Game schedules are released at the beginning of each school year so event conflicts can be avoided. However, in case of unavailability, an additional parking lot, located near the tennis courts on Thunderbird Boulevard can also be used as a secondary space. Access to these parking lots will be through a shuttle service, which will be discussed in the next section. In addition several staff members or volunteers will be needed for directing traffic during these events.

The purpose of the additional parking lots is to maximize Garden viewership and ease of traffic. By implementing this service, it not only increases Garden revenue but eliminates parking along SW Marine Drive, which can be a safety hazard.

2.3.3 Environmental Considerations

Parking lots in general do not generate significant amounts of environmental impacts. However the availability of them encourages people to drive which can increase CO_2 emissions and contributes to

greenhouse gas production. A possible mitigation strategy is to encourage car-pooling or transit use. Contaminant run-off due to the large number of parked cars could also be a problem during heavy rain periods. Metals and suspended sediments such as rock salts, oil and grease can seep through the surrounding soil and contaminate the groundwater. But the possibility of causing significant damage to the environment due to run-off is minimal and can be ignored.

2.4 EVENT SHUTTLE SERVICE

In order to take advantage of the additional parking outlined in Section 2.3, an affordable shuttle service will need to be implemented.

2.4.1 PROBLEM DESCRIPTION

Our team has recommended a shuttle service using golf carts as the primary option to get from the Garden to the parking lots and vice versa. Four eight-seat golf carts are considered to be the most efficient in terms of cost and gas usage. With the installation of the roundabout, specific lanes along Stadium Road should to be designated solely for the golf carts for ease of transportation. The maximum speed that the golf carts should be allowed to go up to, due to safety concerns, is 35km/h. Therefore a roundtrip, taking into account loading and unloading, will be approximately 15 minutes. The UBC Botanical Garden already has several small golf carts in their possession for regular Garden use, therefore additional usage of them contributes greatly in decreasing the number of roundtrips.

2.4.2 JUSTIFICATION

The purpose for the event shuttle service is to minimize viewer hardship and maximize Garden promotion. By implementing the service, the Botanical Garden will not only have more opportunities to host events throughout the year, but will increase its yearly revenue significantly. The proposed route system is shown in Figure 6 on the on the next page.

Figure 6 - Event Shuttle Route

2.4.3 ENVIRONMENTAL CONSIDERATIONS

Although the golf carts will only be used a limited number of times throughout the year, there's still a noticeable effect on the environment. Golf carts are powered by small gasoline engines that produce smog and greenhouse gas emissions, and cost more to operate. Gas powered golf carts are generally more popular because they're easier to operate and maintain than electric golf carts. However rising fuel prices and pollution levels have made electric powered golf carts a much more efficient alternative (Sustainable Technologies, n.d.).

3.0 STRUCTURAL SOLUTIONS

Lack of event space and attractions on-site limits the size and quality of events that can be hosted at the Botanical Garden. Several structural solutions are proposed which will enhance the profile of the Garden.

3.1 *GLASSHOUSE*

The *GlassHouse* is a multi-purpose event space. It is inspired by a glass-walled building that was previously proposed on-site; during a team site visit Garden representatives explained that previous efforts to build such a structure were withdrawn due to lack of funding.

3.1.1 PROBLEM DESCRIPTION

One problem facing the Botanical Garden is the lack of on-site infrastructure to adequately host large events. Currently, events held at the Garden require an exorbitant amount of time and energy put into the creation of sufficient event space, including the repurposing of the on-site parking lot into a paved event surface, and the erection of large, temporary tent structures around the Great Lawn. These particular activities propagate other pressing issues such as a lack of parking and the movement of people within the Garden. Additionally, current methods used in hosting events are non-ideal from a presentation standpoint; using the on-site parking lot as an event platform situates events too close to unsightly and noisy traffic, while temporary structures become dilapidated over time due to repeated construction and exposure to adverse weather.

The lack of indoor event space on-site also severely limits the type of event that can be hosted by the Botanical Garden. Of particular need is an impressive building able to seat a dinner service for large wedding receptions. Weddings at the Garden are extremely popular, with a full schedule of bookings every summer. While receptions can currently be held on-site at the Garden Reception Centre Building, located at the Garden's main entrance on the west-side of SW Marine Drive, it has a capacity of only 100 people and is located a considerable distance from the other event spaces that would be used for large weddings, namely the Roseline Sturdy Garden Amphitheatre and the Great Lawn.

3.1.2 SOLUTION AND JUSTIFICATION

In an effort to improve the Garden's ability to host special events, we propose the construction of the *GlassHouse*, a single-storey 4000 ft^2 glass-walled structure at the northern end of the Garden's Great Lawn, as shown in Figure 7 below.

Figure 7 - Approximate Location and Dimensions of *GlassHouse* on Great Lawn

A single-storey glass-walled structure would aesthetically fit in with the surrounding greenery without dominating the area. A conceptual rendering of the *GlassHouse* is shown in Figure 8 below.

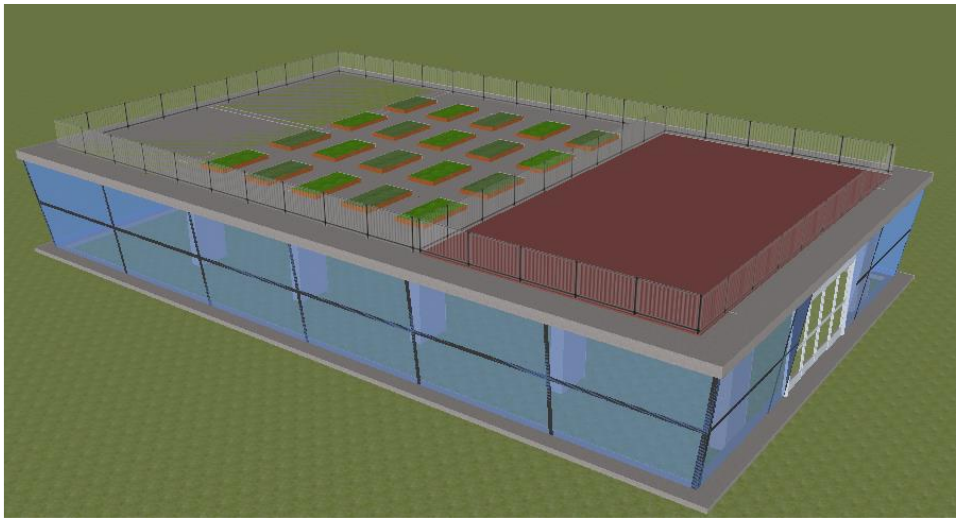

Figure 8 - Conceptual Rendering of *GlassHouse*

Situating the facility at the north end of the Great Lawn allows for events to be held more centrally within the park, within short walking distance to all areas, and enables additional access from Stadium Road through the Garden's service area. Moving events from the Garden Reception Centre, at the Garden's main entrance, to the *GlassHouse*, enables the Garden to host events without crowding the entrance area or trails on the western side of the Garden. This allows the Garden to host large events without affecting the experience of other Garden visitors using the trails, while enhancing improving privacy for the hosted events.

The key contribution of such a building would be drastically increasing the covered event space on-site, enabling the Garden to host larger weddings, presentations, and seminars and charge larger event fees to organizers. A modern facility in the heart of the Garden would allow customers to have the best of both worlds – state-of-the-art amenities in a natural setting. Additionally, construction of the *GlassHouse* has a positive impact on the other buildings in the Garden. Facilities such as the Garden Reception Centre and the Garden Pavilion can be at least partially repurposed as their need as multi-purpose event space will be greatly diminished. This creates several unique possibilities for the Garden, which can repurpose these spaces to possibly put in classrooms, research facilities, a small café, or a garden teahouse.

3.1.3 Environmental Considerations

Constructing a facility such as the *GlassHouse* in an area as sensitive as the Botanical Garden requires careful design. The Provincial Government of British Columbia requires that all publically-funded new construction projects achieve LEED Gold certification in order to ensure the province remains at the cutting-edge of green design (University of British Columbia, 2013). Furthermore, the university has additional requirements to ensure LEED certified design is optimized for the campus. Several systems can be implemented in order to reduce the environmental impact of constructing the *GlassHouse*, with the added benefit of achieving LEED Gold certification and meeting the universities specific criteria for green design. Reduction in environmental impact can be achieved by focusing on three areas: construction methods, energy usage in service, and water efficiency.

Environmental impact of the *GlassHouse* can be reduced by improving methods of construction. Use of sustainable materials, including recycled concrete and regional timber, in addition to proper waste disposal, helps reduce the building's carbon footprint. Additionally, effects caused by long-term use of the facility can be diminished by implementing systems which reduce the building's resource usage.

Systems which optimize the building's energy performance and reduce water waste would be required. Integration with the adjacent water management system in the marsh, as proposed in Section 4.2.2, would be one way of efficiently managing water concerns for the *GlassHouse*.

An extensive green roof would also be included as a low-maintenance means to reduce energy costs and water runoff, while earning LEED certification credits and government tax incentives.

3.2 *BIO-DOME* ATTRACTION

*BIO-DOME*s are our team's recommendation for a unique botany-themed attraction to add to the experience of guests at the Botanical Garden

3.2.1 PROBLEM DESCRIPTION

A primary concern expressed by Garden representatives was that the Garden was not attracting any new visitors. The majority of the Garden's current clientele consists of a small number of Gardening enthusiasts with membership passes who make a number of visits each year. Attractions that are able to appeal to both hobbyists and casual visitors are necessary to attract a wider demographic into the Garden, and as a result increase the total number of Garden visitors.

In an effort to revitalize the customer experience, we propose the development of an additional attraction which can attract a diverse clientele to the Garden, without compromising the Garden's purpose as a vessel for plant research, educational, and display. *BIO-DOMEs* are an exciting attraction which allows for powerful presentation of unique botany displays.

3.2.2 SOLUTION AND JUSTIFICATION

The proposed *BIO-DOMEs* are *Plexiglas*™-paneled geodesic dome displays with a diameter of 10 feet, which is large enough to allow for powerful displays but small enough that the structures do not aesthetically dominate the landscape. The *BIO-DOMEs* are inspired by sealed-bottle terrariums: completely self-sufficient micro-ecosystems that can live for decades and require no additional watering or pruning after sealing. These terrariums received significant interest in online forums and attention in media after it was discovered that a gentleman in England had been growing an impressive terrarium in a sealed 10-gallon jug since 1960 (Wilkes, 2013). In addition to being aesthetically impressive, these systems also act as an educational display of the systems within a functioning ecosystem. The only

external input is sunlight, which can be absorbed through the glass to allow the photosynthetic process to occur, allowing the plants to grow, and putting moisture back into the air in the form of condensation. As the condensation builds up on the inside of the glass, it 'rains' back down on the plant, starting the water cycle all over again. As leaves drop off the plant, the foliage decomposes which releases carbon dioxide which is also required in photosynthesis. This process is cyclical and occurs for many iterations.

The *BIO-DOME*s are uniquely enclosed spherical greenhouses which will allow for themed botany displays. Each dome will have a unique array of plants in it, representing a themed ecosystem. These ecosystem environments will vary from very dry desert displays to wet and lush rainforest type environments. The *BIO-DOME*s will be fitted with irrigation internal irrigation and lighting systems to allow the Garden's botanists to control the climate in each *BIO-DOME,* allowing for unique growing climates. Additionally, the *BIO-DOME*s will be fitted with hinged door systems to allow Garden staff to enter the system to troubleshoot any issues with the botany displays, as well as to clean the internal face of the *Plexiglas*™. Six of these *BIO-DOME*s are proposed to be strategically place around the Great Lawn event space, adding an impressive anchor point to the east side of the Garden, close to the proposed *GlassHouse* and . A rendering of the *BIO-DOME*s is shown in Figure 9, as well as an aerial photo outlining the proposed placement of the attractions around the Great Lawn in Figure 10 on the following page.

Figure 9 - Rendering of BIO-DOMEs

Figure 10 - Proposed Layout of *BIO-DOME*s

These *BIO-DOMEs* present unique opportunities for both the Botanical Garden and the paying public. For the Garden, having multiple climate controlled greenhouse structures allows for the study and display of plants that would be otherwise impossible to grow in the Lower Mainland. Expanding an already extensive botany display will further establish the Garden as a world famous botanical facility. The educational value of these displays will attract new visitors, particularly from school field trips to see these unique displays. The *BIO-DOMEs* will also provide gardeners who already frequently visit the Garden the opportunity to see new displays that are relative to their interests. This idea of creating a tour will be a fantastic anchor point for the Garden.

3.2.3 Environmental Considerations

Because of their small size, construction of the *BIO-DOMEs* will not have a huge impact on surrounding areas of the Garden. Structural components of the *BIO-DOMEs* can be assembled off-site to reduce noise and construction time on-site, while small foundations consisting of recycled concrete will have minimal impact on the surrounding environment. Running irrigation systems and lights to each *BIO-DOME* will require minimal excavation along the edge of the Great Lawn, and can have negligible impact on the Garden environment provided small excavation equipment is used. Bio-degradable cleaning agents will be used for cleaning the *Plexiglas*™ panels to ensure no toxic chemicals seep into the soil and cause grass death around the structures.

3.3 Garden Entrance

Improvements to the Garden entrance can be instituted as a means to make the Garden more eye-catching for traffic along SW Marine Drive.

3.3.1 Problem Description

As discussed in Sections 2.1 and 2.2, one of the main problems affecting Garden attendance is its lack of attention. The entranceway to the Garden is not visually impactful and does not draw attention from vehicles passing by. This can be seen in Figure 11 on the next page.

Figure 11 - UBC Botanical Garden Entrance

As can be seen in the Figure 8, there is little to signify the presence of the Garden from the road. The only item to do so is the Botanical Garden sign located in the right side of the picture, which is small and blends into the background.

3.3.2 Solution and Justification

We believe that a more visually impactful entranceway can benefit the Garden by drawing the attention of passersby. An attractive entranceway will make the Garden more appealing to the public and invoke interest.

Our proposal is to have the original UBC Botanical Garden sign removed and replaced with one that will be bigger and more contrasting to its surroundings. The new sign should be obvious and easy to notice by oncoming traffic. A possible alternative can be seen as in Figure 12 on the next page.

Figure 12 - Example of Entranceway Sign

The second part of the proposal is to landscape the surrounding area of the entrance. We plan to landscape and decorate the entrance with visually striking and appealing plants. The entrance to the Garden should be attractive and give an indication to potential visitors of the possible experience inside. A properly utilized entranceway has the potential to leave a lasting impression and set the tone of the visit.

3.3.3 Environmental Considerations

Environmental impacts will be mostly due to the construction of the sign and any entrance structures that may be erected. This may cause noise pollution and dust dispersion during the period of construction. As the Garden is located in a developed area, the addition of new plants at the entranceway will not affect any sensitive indigenous species native to the Garden.

4.0 HYDROTECHNICAL SOLUTIONS

Current water management systems employed at the Garden do not fit in with the sustainable image the university is trying to promote. A revitalization of the water systems on-site are proposed below in order to reduce environmental impact and bring the system up to the standards the university desires.

4.1 PROBLEM DESCRIPTION

In consultation with representatives of the Botanical Garden, we identified two key hydro-technical issues on-site: erosion due to stormwater flow, and the use of 100 percent potable water to maintain water levels in the on-site marsh and pond. Storm water flows have led to the erosion of Trail 7 Creek, as well as along the cliff face at Wreck Beach due to flows through the Trail 7 outfall. The Garden is also currently using 100 percent potable water to maintain flows in the existing marsh located near the great lawn and the existing pond located near the Garden entrance. These areas are shown below in Figure 13.

Figure 13 - Problematic Areas due to Poor Water Management

Erosion at the cliff face is a result of both human development and natural causes. Natural causes contributing to cliff erosion are shoreline erosion, uprooting of trees, weeping of groundwater through the cliff face, freeze thaw cycles, and wind and rain.

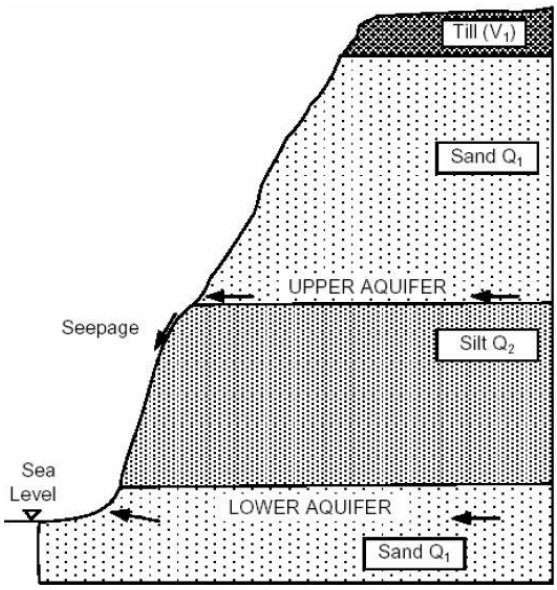

Figure 14 - Cliff Cross Section (Aplin & Martin Consultants et al., 2005)

The soil stratum at UBC consists of approximately 0.5m of organic topsoil underlain by roughly 30 metres of relatively impermeable glacial till. Below the glacial till is a layer of sand followed by a layer of impermeable silt. This layer of sand between the glacial till and silt composes the upper aquifer, which groundwater flows through and seeps off the cliff face causing the natural erosion of the cliff. As a result of this impermeable layer of glacial till at the surface, most of the groundwater flow in the upper aquifer originates east of the UBC Campus **(Aplin & Martin Consultants et al., 2005)**. A cross section of the soil strata is shown in Figure 14 (above right).

Development of the UBC campus has changed the natural hydrology of the land. As development of the campus has progressed, natural vegetated areas have been replaced by impervious surfaces such as pavement and rooftops. Vegetated areas allow the water to infiltrate into the soil reducing the volume and flow rate of the surface runoff. Vegetation further helps to reduce the volume and flow rate of runoff through evapotranspiration. Replacing these areas with impervious surfaces has resulted in higher runoff volumes and velocities as the water is no longer lost by infiltration and evapotranspiration. Runoff from the impervious surfaces is conveyed to the Trail 7 Creek and Trail 7 outfalls via subsurface drainage pipes and ditches. During storms the surface runoff is carried through these conveyance systems at higher volumes and velocities than it naturally would and is discharged through the creek and outfall. This is a major contributing factor to the accelerated rate of erosion of the creek and cliff face. The Trail 7 outfall is currently elevated several feet in the air due to erosion **(University of British Columbia et al., 2001)**. These increased flow rates and velocities also create a risk of flooding.

The decreased rate of infiltration into the soil as a result of increased impervious area also leads to various other problems such as groundwater depletion and water quality. Groundwater recharge helps to maintain base flows in streams and sustain vegetation and wildlife. Storm water contains contaminants such as

sediment, oils, and metals. Infiltration allows the soil to naturally treat contaminants found in stormwater. Directing the flow from impervious surfaces into the subsurface drainage system and ditches eliminates this natural filtration process as the water is no longer able to infiltrate into the soil. This creates pollution at the receiving body of water which has a detrimental effect on the environment and aquatic wildlife. Studies of the levels of contamination at the Trail 7 outfall have shown that the concentration of numerous metals exceed the BC Water Quality guidelines. The concentration of other contaminants such as oils and sediment were consistent with other areas of the lower mainland and below the BC Water Quality guidelines **(Aplin & Martin Consultants et al., 2005)**.

Additionally, the use of potable water to sustain flows in the marsh and pond is expensive and unsustainable. UBC currently consumes approximately 4 billion litres of water a year at a cost of $2.5 million per a year. Eliminating the need for potable water in these areas would help reduce the costs and consumption of water. Potable water contains chloramines which poses a risk to the aquatic life in the receiving body of water. The potable water from these areas is discharged into the storm system which has a detrimental effect on the environment **(Chieng, 2013)**.

During a site visit to the Botanical Garden on October 17, 2013, Garden Curator Douglas Justice indicated that the soils in the marsh area drain at a rapid rate and it is difficult to sustain flows in the marsh. He also indicated that the marsh is used for research purposes and it is difficult to access the central area of the marsh due to the steep and slippery slopes.

4.2 SOLUTION AND JUSTIFICATION

As a solution to the current problems faced by the Botanical Garden, we propose to divert the stormwater to the existing marsh and pond areas and construct retention and detention facilities. The purpose of this design is to reduce the need for potable water in the existing marsh and pond areas as well as achieve four main design criteria: flow volume reduction, flow rate control, water quality control, and flood conveyance. Achieving these goals will help to solve the problems associated with water management within the Garden and meet the objectives of UBC's Integrated Stormwater Management Plan. Improvement of the movement of water within the Garden also creates pleasurable creeks and marsh systems for guests to enjoy, while adding natural soothing sounds to the Garden environment.

4.2.1 Storm System Alterations

The UBC Campus consists of four catchment areas: the North Catchment, West (Trail 7) Catchment, 16th Avenue Catchment, and South Catchment. Each of these catchments has an outfall that leads to the ocean as shown in Figure 15 below.

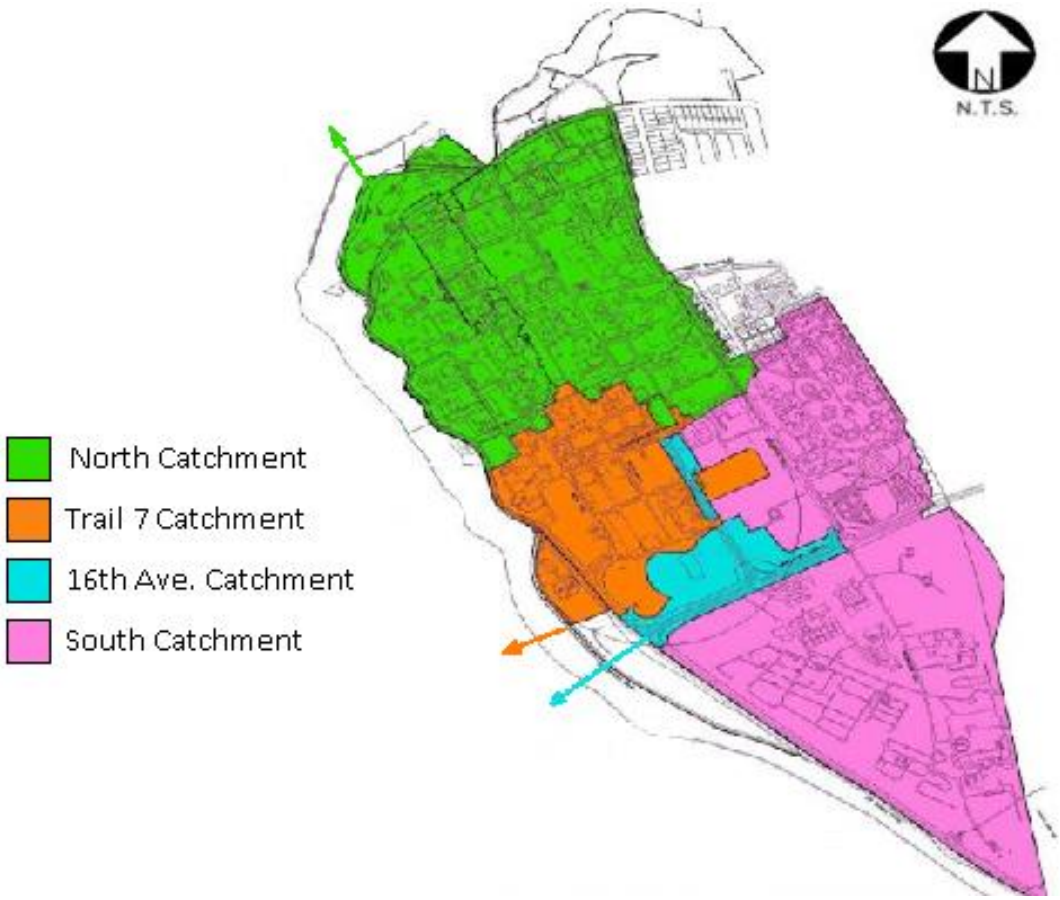

Figure 15 - Catchment Areas

The UBC Botanical Garden is within the boundary of the Trail 7 catchment. Since stormwater generated from the Garden is conveyed to the Trail 7 outfall, only improvements of the Trail 7 catchment are considered in this design.

The Trail 7 catchment has an existing storm system that conveys rainfall that is not absorbed by the soil towards the Trail 7 outfall. There is a storm sewer that conveys flows down Stadium Road and into the Garden running adjacent to the existing marsh. This flow then travels to the Trail 7 creek via a culvert underneath SW Marine Drive. Flows from the north-west corner of the Trail 7 catchment are conveyed through a storm system that travels into a ditch running along Old Marine Drive near the existing pond

at the Garden entrance **(GeoAdvice Engineering, 2012)**. With the existing stormwater network traveling in close proximity to the existing marsh and pond it is feasible to divert the flow to these areas. The proposed layout for the new storm system is shown in Figure 16 below.

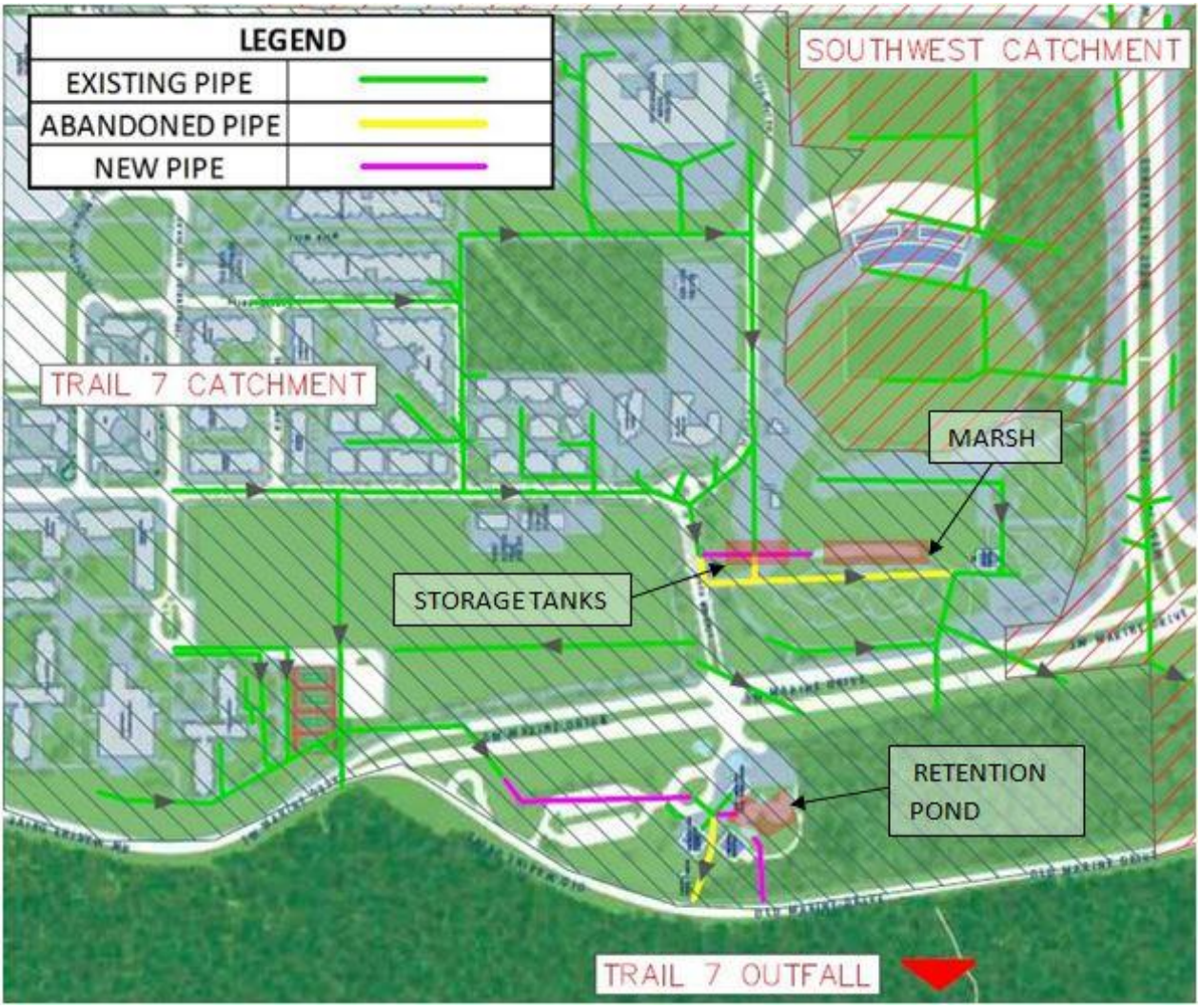

Figure 16 - Proposed Storm System

4.2.2 MARSH

The design of the marsh area consists of installing a new pipeline to direct flow towards the marsh and abandoning the existing storm pipe running adjacent to the marsh. To remove contaminants and oil a grit separator manhole should be installed at the tie in point on Stadium Road. Flow rates and volumes into

the marsh will need to be controlled to prevent flooding, erosion, and support plant growth. To achieve this, subsurface storage tanks will need to be installed with a flow control manhole at the outlet. Storm water will then flow out of the flow control manhole and into the marsh at a controlled rate. The proposed location of the storage facility is shown in Figure 16 above. Stormwater will then travel through the marsh and continues into the existing storm system, which then travels into the Trail 7 creek leading to the Trail 7 outfall.

By diverting flows towards the marsh, it will help to eliminate or reduce the need for potable water in the marsh. Depending on the flow volumes generated it also presents the opportunity to reuse the stormwater for irrigation purposes. The expected flow volumes will be calculated in the detailed design of the system at which point the feasibility of water re-use will be analyzed.

The marsh will also improve water quality and reduce flow volumes. Flow volumes will be reduced by increasing infiltration and evapotranspiration. Increased infiltration will help to recharge the groundwater and allow the soil to naturally treat the water. Additional treatment will be provided by the plants. Plants are an effective way of treating stormwater for metals, sediment, and nutrients **(Aplin & Martin Consultants et al., 2005)**. The marsh is currently lined with cat tails which would provide these treatment benefits. By diverting stormwater through the marsh area it presents the opportunity for the Garden to conduct research on the effectiveness of different plant species capabilities of treating stormwater. The design has also incorporated wooden bridges to provide better accessibility to the marsh for researches and improve the aesthetics of the area. A conceptual model showing the marsh area is shown in Figure 17 below.

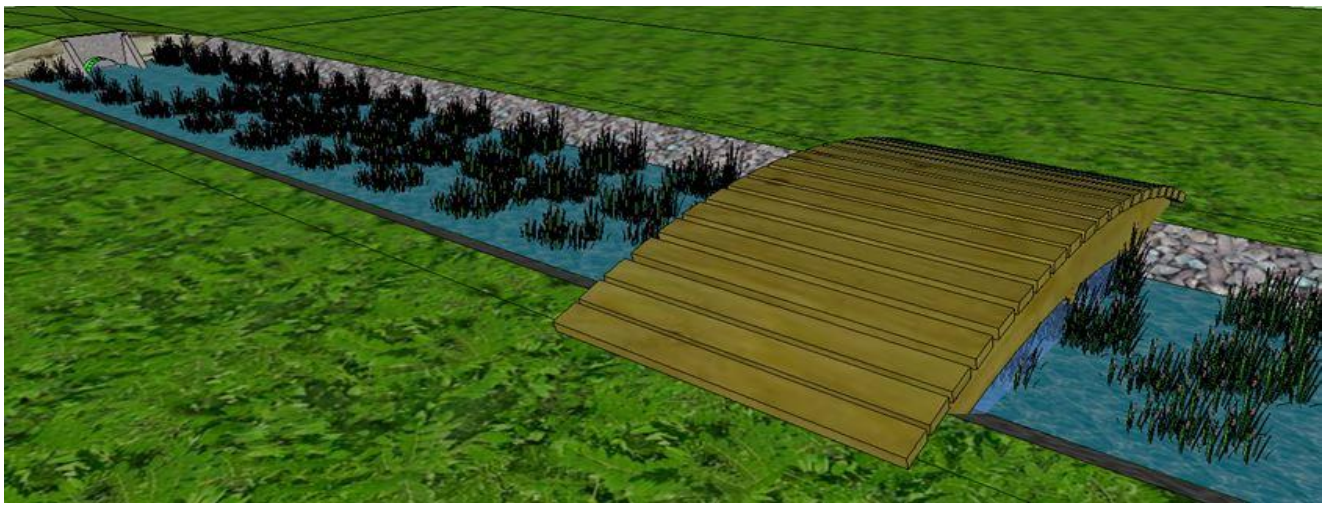

Figure 17 - Rendering of Marsh Revitalization

Patrick Lewis, the Director of the UBC Botanical Garden, indicated that the soils in the marsh are very permeable. Infiltration rates of soil depend on the soil type, soil structure, and soil compaction. A geotechnical study will need to be conducted to determine the current soil characteristics. Once the soil characteristics are known it will be possible to determine if the existing soil structure will need to be replaced with an imported soil to achieve the desired infiltration rates. Optimal infiltration rates to support plant growth are 2-3 inches/hour **(Urban, 2013)**.

Installation of the buried storage tanks will help to prevent erosion of the creek and banks by detaining the water during storm events and allowing it to dissipate into the receiving bodies of water at a controlled rate. It also adds additional capacity to the storm conveyance system which helps to reduce the risk of flooding.

4.2.3 POND

The design of the pond area consists of converting the existing pond into a retention pond. To maintain water levels in the pond a new pipeline will need to be installed to direct flow from the existing culvert travelling under SW Marine Drive located just north of the Garden entrance as shown in Figure 14. Currently stormwater is conveyed through this culvert and directed into a ditch on Old Marine Drive which then discharges through the Trail 7 outfall **(GeoAdvice Engineering, 2012)**.

Diverting stormwater flows into the existing pond will eliminate or reduce the need for potable water in the pond. Converting the pond into a retention pond will allow the water to infiltrate into the soil reducing runoff volumes and providing natural treatment through the soil. The water will infiltrate down to a layer of soil which has a perforated drain line. The perforated drain line is connected to an outfall, allowing the water to drain out if the water level rises to an undesirable level. There will also be a raised overflow to allow emergency drainage if the levels in the pond get too high.

Retention ponds are an effective way of removing contaminants such as sediment and oils **(Aplin & Martin Consultants et al., 2005)**. The retention pond also provides additional storage capacity which reduces the risk of flooding and erosion downstream at the outfall. The risk of erosion is reduced by reducing peak runoff volumes and velocities.

4.3 Environmental Considerations

Implementation of the proposed water management systems would require significant construction, particularly if geotechnical analysis determines that imported soil is required to achieve sufficient permeability in the marsh and pond. Ground vibration, dust dispersion, noise pollution, and diesel leakage also pose environmental risks during the construction process.

An erosion and sediment control plan, as required for construction projects by UBC bylaws, can by instituted to prevent turbidity in the sewer system. Our action plan considers silt fences, catch basin protection, and specialize wheel wash stations in order to control sediments and erosion.

Long-term environmental benefits of the proposed water management system, including a reduction in the erosion currently seen along the streams and banks of the area, far outweigh the detrimental effects of construction, particularly when mitigation techniques are implemented to prevent sedimentary particles created by the construction process from entering water systems.

5.0 Implementation of Design Components

Due to the sensitive nature of the Botanical Garden, the site cannot sustain multiple construction projects occurring simultaneously without significant impacts on both the Garden's distinct biology, as well as the experience of Garden patrons. Additionally, economic constraints and high development activity throughout the campus limits the amount of resources that can be dedicated to revitalizing the Garden at one time. Because of this, we propose this project be implemented in 3 phases, with a focus on first improving traffic flow systems to and within the Garden to bring more patrons.

5.1 Phase 1 – Event Shuttles

Phase 1 will consist of the university acquiring 4 specialty golf carts to be used as a shuttle service between the Garden and Thunderbird Stadium parking lot, as well as the gravel overflow parking lot on Stadium Road between West Mall and the Main Mall Greenway. The establishment of a shuttle service is the most pressing need for the Garden; parking at and adjacent to the Garden is extremely limited, particularly during large events when the on-site parking lot is used as a paved event space. These shuttles can be used throughout the campus when the Garden is not holding events, which can help the university to safely provide better access to amenities for students and staff with disabilities or other impairments, making them an attractive option for the university to implement as soon as possible. Rollout of the golf carts can precede installation of a specialty lane along Stadium Road or a roundabout at the intersection of SW Marine Drive and Stadium Road, provided appropriate safety measures are taken. Large path signage and enhancement of the current QR code system long the Garden's pathways will also be implemented during this phase.

5.2 Phase 2 – Advanced Transportation Management

Phase 2 will consist of redevelopment of transportation systems around the Garden, in an effort to slow bypassing traffic and attract more visitors. This redevelopment would involve the installation of signage along the SW Marine corridor in order to alert incoming motorists that the entrance to the Botanical Garden is approaching, and it would culminate in the installation of a roundabout at the intersection of SW Marine Drive and Stadium Road. The redevelopment also involves the beautification of the adjacent Garden entrance. These systems would provide easier and safer access to the Garden for both vehicles and pedestrians, and additionally attract more visitors into the Garden by creating a better roadside

appearance through improved signage and floral displays. Installation of a roundabout at this location is also preferable for the university as a whole, as it is the most efficient intersection management system for large traffic flows of single-occupancy vehicles during peak hours.

5.3 PHASE 3 – PATRON EXPERIENCE

Phase 3 will consist of implementation of systems to enhance the visitor's experience. While Phase 1 and Phase 2 both focused on improving access and increasing the flow of people into the Garden, Phase 3 will focus on improving the experience for the expected influx of new visitors to ensure they become repeat patrons. Phase 3 will involve the concurrent construction of both the *GlassHouse* event space and the stormwater management system in order to minimize the total time in which noise due to construction will be an issue on-site. Additionally, installation of the *BIO-DOME* attraction around the Great Lawn will occur throughout this phase.

7.0 SUMMARY

The following is a summarized list of key recommendations for the upgrade of the UBC Botanical Garden:

- Installation of roundabout on the intersection of SW Marine Drive and Stadium Road
- Signage and wayfinding on the roads leading to the Garden
- Alternative parking space and shuttle service with shuttles
- Multi-purpose *GlassHouse* and *BIO-DOME* architectural features
- Storm water and soil erosion management plan

Preliminary estimated costs to implement these features are summarized below in Table 2, with a more detailed summary cost estimate summary available in Appendix B.

Table 2 - Cost Estimate Summary

Component	Estimated Cost
Transportation Systems	$410,000
GlassHouse	$1,000,000
*BIO-DOME*s	$70,000
Hydrotechnical Systems	$420,000
TOTAL (with multipliers)	**$2,000,000**

7.1 ACKNOWLEDGEMENTS

Our group would like to thank Brook Robazza and Dr. Stiemer, Dr. Lo, Dr. Li, Dr. Chieng, Dr. Nesbit and all CIVL 445 presenters for their contributions to CIVL 445 and our project.

Special thanks goes out to Patrick Lewis and Douglas Justice of the UBC Botanical Garden for taking time out of their schedules to assist with our project by providing educational Garden tours. Without your help this proposal would not have been possible.

Additional details of this proposal are available upon request by contacting Project Motion Headquarters at [redacted]

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APPENDIX A – TRAFFIC MANAGEMENT SYSTEM DECISION MATRIX

A decision matrix is used for comparing and prioritizing a list of alternatives with respect to multiple criteria of importance. It's used here to analyze the different methods of improving transportation in front of the Garden. High vehicle speeds along SW Marine Drive is an issue for pedestrian crossing and a huge safety concern, therefore the construction of a roundabout was proposed. However alternative solutions include signalized intersection, four-way stop and a pedestrian overpass. The following decision matrix (Table 2) shows the best possible solution that can be constructed with respect to the Garden:

Table 3 - Ranking of Engineering Metrics

Very High	High	Medium	Poor	Very Poor
5	4	3	2	1

Table 4 - Decision Matrix

Engineering Metrics	Intersection Remediation Options				
	Pedestrian Overpass	Signalized Intersection	Four-way Stop	Roundabout	Do Nothing
Reliability	4	3	2	3	1
Safety	4	3	1	4	1
Cost of Implementation	5	2	1	3	0
Visual Appeal	4	3	2	4	2
Environmental Impact	5	2	1	3	1
Raw Score	***22***	13	7	17	5
Relative Rank	***1***	3	4	2	5

From the Decision Matrix, a pedestrian overpass was considered to be the best possible design in terms of safety and reliability. However, it is also the most difficult to implement and the most expensive. The Botanical Garden already has a relatively low budget, so the pedestrian overpass is not considered to be a feasible option. Therefore our team has alternatively suggested using a roundabout for a more cost effective design. The roundabout is also a self-governing system and does not have any mechanical or electronic parts that can malfunction, making it easier to operate than a signalized intersection. It also serves as a focal point for people who otherwise would have passed by the Garden due to minimal signage and obscure location.

APPENDIX B – PRELIMINARY COST ESTIMATE

Roundabout and Transportation (Kansas DoT, 2013) and (b2 Consultants).

Component	Quantity	Cost/per ($)	Cost ($)
Roundabout	1.00	375,000.00	375,000.00
48" x 24" Metal Sign	4.00	68.50	274.00
36" x 18" Metal Sign	4.00	42.50	170.00
10' Galvanized Sign Post	8.00	32.50	260.00
24" x 36" Wood Garden Signs	20.00	302.00	6,040.00
Golf Cart Shuttles	4.00	7,500.00	30,000.00
Total			***411,744.00***

GlassHouse (Reed Construction Data, 2013)*:*

Square Footage	Cost/per ($)	Cost ($)
4,000.00	250.00	***1,000,000.00***

BIO-DOME Attraction (b2 Consultants) *and (Estimates based on Engineering Experience):*

Component	Quantity	Cost/per ($)	Cost ($)
Plexiglas	80.00	10.24	819.20
Pipe	18.00	41.04	738.72
Labour			10,000.00
Total per Dome			***11,557.92***
Total for 6			***69,347.52***

Hydrotechnical Systems (Values based on Engineering Experience):

Component	Quantity	Cost/per ($)	Cost ($)
Grit & Oil Separator Manhole	1.00	5,000.00	5,000.00
Flow Control Manhole	2.00	5,000.00	10,000.00
PVC Storm Sewer	30.00	150.00	4,500.00
Concrete Storage Tanks	1.00	300,000.00	300,000.00
Retention Pond	1.00	100,000.00	100,000.00
Total			***419,500.00***

Project Total Preliminary Estimate (with 5% cost increase for construction on campus):	**$2,000,000.00**