

Technical Proposal UBC Botanical Gardens: Redefined

Colby Redekop, David Mollenbeck, Julian Cheung, Nick Richardson, Randy Chase, Wendy Xu

University of British Columbia

CIVL 445

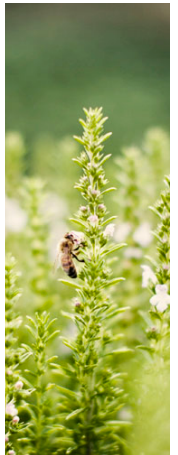
November 29, 2013

Disclaimer: "UBC SEEDS provides students with the opportunity to share the findings of their studies, as well as their opinions, conclusions and recommendations with the UBC community. The reader should bear in mind that this is a student project/report and is not an official document of UBC. Furthermore readers should bear in mind that these reports may not reflect the current status of activities at UBC. We urge you to contact the research persons mentioned in a report or the SEEDS Coordinator about the current status of the subject matter of a project/report".

CIVIL 445
NOVEMBER 27, 2013

Technical Proposal

UBC Botanical Gardens: Redefined



PREPARED BY

CIVGEN ENGINEERING INC.

**RANDY CHASE
JULIAN CHEUNG
DAVID MOLLENBECK
NICK RICHARDSON
COLBY REDEKOP
WENDY XU**



ubcbotanicalgarden
& centre for plant research



a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

EXECUTIVE SUMMARY

UBC Botanical Garden: Redefined

Early in September 2013 the UBC Botanical Garden put out a request for a proposal to improve their facility. The UBC Botanical Garden is Canada's oldest continually operated botanical garden situated on a university campus. The garden has occupied three locations throughout UBC and is currently situated on the south end of campus with two distinct areas of the garden separated by SW Marine Drive.

The open-ended request for proposal from UBC Botanical Garden was centered on two constraints: do not compromise the collections, and do not compromise the visitor experience. Additionally, it was required that the problem be considered from an engineering perspective which addresses issues such as visitor movement, garden access, lack of indoor spaces, and lack of water management practices. CivGen Consultants developed a positive mission statement to envelop the project constraints and turn them into a goal to focus the project.

Mission Statement

To harness sustainable engineering design practices to redefine the UBC Botanical Garden as a premier visitor experience

The goal of this proposal is to fulfill the mission statement above by proposing necessary and feasible ideas while still pushing boundaries that the client may not have explored in the past. All of the proposed designs were made specifically to fulfill UBC's goal of creating a campus that is also a living laboratory, with the goal of reducing greenhouse gas levels by 100% in 2050. In addition to being environmentally sustainable it was also important to consider the economic sustainability of projects within the UBC Botanical Garden. In order to be economically sustainable, all of the proposed ideas must either be revenue generators or funding magnets. Revenue generators will be able to draw in more visitors throughout the year, and encourage them to spend more money while at the garden. Funding magnets will be projects that align with UBC's goals of promoting sustainability, research and learning in order to acquire funds directly from UBC.

In order to address UBC Botanical Garden's request CivGen proposes the following engineering projects to redefine the garden.

Restaurant building with multipurpose space

- Situated on top of the bluff separating the garden from Thunderbird Stadium
- Provides panoramic views of garden
- Indoor multipurpose space for educational purposes
- Integration of green building principles including a rooftop garden, solar panels, naturally lit interior

Dome glasshouses

- Architecturally striking dome structure
- Situated adjacent to cattail pond in north garden
- Provides on-site nursery space, relocated from UBC Farm
- Provides a year round indoor anchor in the north garden

Upgraded visitor parking

- Allows for visitor access to north garden through existing parking lot at Thunderbird Stadium
- Expands capacity of existing parking lot by 150% to accommodate guests in high season
- Provides additional considerations for when traffic is changed on SW Marine Drive
- Reduced storm water runoff from tiled pavement surface

Integrated storm water management facilities

- Storage tanks to collect and distribute water throughout the year, reducing need for irrigation with potable water
- Construction of an aesthetic bio-swale to detain and attenuate peak flow leaving UBC through the Trail #7 outfall to mitigate erosion of the cliffs
- Ability to secure up to \$200,000 from UBC towards storm water management in the garden

New garden access and improved garden mobility

- Second access point located inside restaurant building
- New access trail from 16th Avenue to restaurant building will improve access to the garden through public transportation. Within short walking distance of the booming neighborhood of Wesbrook Village
- Meandering bridge through cattail pond will improve visitor mobility around the north garden and glass domes
- Staircase to shorten walk from tunnel up into north garden

These proposed ideas are necessary additions required by the UBC Botanical Garden in order to become one of the premier visitor destinations in Vancouver. The conceptual designs proposed will enhance and expand the already diverse plant collections at the garden. CivGen arrived at these ideas through a three month long process of attending information sessions, conducting site visits and holding bi-weekly planning meetings. Through this process CivGen was able to narrow down conceptual ideas and focus on the five designs presented above.

It was important to understand what had been proposed in the past, and why those proposals failed to be acted upon. By using multi criteria decision-making tools weighted towards the categories of sustainability, learning potential, economic feasibility, and year round increase in visitors, the five proposed ideas were chosen from a large list of ideas. By proposing conceptual designs that best fit UBC Botanical Garden's needs and means, it will be possible to redefine the UBC Botanical Garden as a premier visitor experience.

TABLE OF CONTENTS

1.0	SITE OVERVIEW	1
1.1	General	1
1.2	Site Description	1
1.3	Stakeholder Analysis	2
1.3.1	University of British Columbia Botanical Garden	2
1.3.2	University of British Columbia	2
1.3.3	Metro Vancouver	2
1.4	Project Limitations	2
2.0	PROJECT DESCRIPTION	3
2.1	Discussion	3
2.2	Conceptual Design Process	4
2.3	Decisions	5
2.4	Key Benefits.....	6
3.0	CONCEPTUAL DESIGN	7
3.1	Parking Lot	7
3.1.1	Description.....	7
3.2	Dome Glass House	10
3.2.1	Description.....	10
3.2.2	Dome Details	12
3.2.3	Schematic Sketches	14
3.3	Multipurpose Building	15
3.3.1	Description.....	15
3.4	New Access	19
3.4.1	Multipurpose Building Access	19
3.4.2	Garden Mobility Improvements	21
3.5	Stormwater Catchment.....	23
3.5.1	Description.....	23
3.5.2	Storm Water Capture	23
3.5.3	Erosion Mitigation	24
3.5.4	Storm Water Capture Conceptual Design	24
3.5.5	Erosion Control Conceptual Design	27
4.0	PROJECT IMPLEMENTATION	28
4.1	Environmental Impacts.....	28
4.2	Socio-economic Impacts	28
4.3	Priorities	29
5.0	ECONOMIC ANALYSIS	30
5.1	Potential Revenue	30
5.2	Sources of Capital.....	31
5.3	Construction Costs	31
5.4	Project Costs and Expenditures	32
6.0	CONCLUSION	33
7.0	REFERENCES	1

LIST OF FIGURES

Figure 1 - UBC Botanical Garden Map	1
Figure 2 - Initial Restaurant Renovation Design.....	5
Figure 3 – Thunderbird Stadium Parking Lot Proximity	8
Figure 4 – UBCBG Parking Lot Upgrade.....	9
Figure 5 - Concept Street Parking on SW Marine Drive	10
Figure 6 - ETFE Dual Layer Configuration	13
Figure 7 - ETFE Panels at Night	13
Figure 8 - Geodesic Dome Design	14
Figure 9 – General Building Overview	15
Figure 10 - Plan view of building location.....	16
Figure 11 - Upper Floor Restaurant Layout.....	17
Figure 12 - Rooftop Garden and Cafe Layout.....	18
Figure 13 - Key Features of Building.....	18
Figure 14 - Existing layout of Southeast corner of UBC Botanical Garden.....	20
Figure 15 - Proposed layout of UBC Botanical Garden Southeast corner access upgrades	20
Figure 16 - Trellised walkway connecting the Multipurpose Facility with T-bird Stadium Parking Lot.....	21
Figure 17 - Living Garden Sign	22
Figure 18 – North Tunnel Stone Stairway	22
Figure 19 - Stair Side Water Feature.....	22
Figure 20 - Cattail Pond Wooden Bridge.....	23
Figure 21 - Trail 7 Outfall Showing Extensive Erosion and Undercutting of Gully Wall.....	24
Figure 22 - South campus catchment areas and storm water outfalls	25
Figure 23 - Baffle tank to remove coarse sediments	26
Figure 24 - Ditch system along Old Marine Drive.....	27

LIST OF TABLES

Table 1 – Geodesic Glass Dome Specifications.....	12
Table 2 - Implementation priority rankings for different aspects of this proposal	29

1.0 SITE OVERVIEW

1.1 General

The primary purpose of the UBC Botanical Garden (UBCBG) is as a plant research centre. The UBC Botanical Garden is known for its diverse collection of rare and endangered plant species.

1.2 Site Description

The UBC Botanical Garden is located in the southwest corner of UBC. The garden is clearly divided into a west and east side by S.W. Marine Drive with a single tunnel connecting the two sides. The only entrance is located in the West side at the corner of S.W. Marine Drive and Stadium Road. The west side also contains the canopy walkway which is an elevated walkway through old growth trees and a main visitor attraction. Most of the west side is heavily forested and provides very limited opportunities for development.

The east side of the garden generally contains much smaller plants and more open space. It is bordered by West 16th Ave to the South, Thunderbird Stadium to the East, and Stadium Road to the North. The smaller, more transportable plants provide some flexibility in installing new facilities and modifying its location. See Figure 1 for the existing layout of the UBCBG.



Figure 1 - UBC Botanical Garden Map

1.3 Stakeholder Analysis

1.3.1 University of British Columbia Botanical Garden

The UBCBG is the main stakeholder in this project. Their current business model is unsustainable, and they recognize the need to evolve in order maintain its status as a valued member of UBC and the community. Although the collections are invaluable, significant issues in visitor attractions, garden access and water management jeopardize the long-term future of the UBCBG. The purpose of this report is to outline conceptual designs that will redefine the UBCBG for the better.

1.3.2 University of British Columbia

UBCBG is partially funded by UBC. The gardens value to the university lies in the diverse collections and unique botany research opportunities. UBCBG functions as a living laboratory and expanding the research available within the garden will impact the university. Alterations to the gardens could also aid in achieving UBC's aggressive sustainability goals. The botanical gardens are an important part of UBC and any changes will also affect the university.

1.3.3 Metro Vancouver

Metro Vancouver is responsible for providing storm water management for the Greater Vancouver Region. Although the University Endowment Lands operate independently, the systems are integrated and exert influences on each other. With respect to the UBCBG, two of the four UBC catchment areas drain through or near the garden. After crossing Old Southwest Marine DR, the storm water enters the Metro Vancouver system. Erosion of the UBC bluffs due to storm water outfalls is a severe and long running issue for Metro Vancouver. Any improvements in storm water management will affect Metro Vancouver's operation.

1.4 Project Limitations

UBCBG's primary purpose and true value is as a botanical research facility with diverse collections. It is vital that the collections are at least preserved in all design concepts and improving the visitor experience at the cost of the collections is simply not an option. Relocating large plants is also extremely expensive and must be considered when deciding where to locate new attractions in the garden. Many promising design concepts are simply not feasible for this project due to the absolute importance of the collections and research work at UBCBG. The garden also faces stringent budget restraints that limit major projects. To receive additional UBC funding, projects must prove their value to the university. Designs need to be economically efficient in addressing issues within the garden. Additionally, all concepts must fit with UBC's development plan and help to achieve the sustainability targets.

2.0 PROJECT DESCRIPTION

2.1 Discussion

To ensure that the proposed design to the UBC Botanical Garden is appropriate, it is important to consider and attempt to address all of the major issues. The first step in doing so is to gather information. Patrick Lewis, the director, and Douglas Justice, the associate director and curator, both gave informative presentations in regards to the background, purpose, and mission of the garden. They also discussed the potential improvements that could be made to the garden, and previous concepts that have not been followed up on. Following these vital presentations, a guided tour of the garden was held to gain a better understanding of the areas of failure and potential improvements around the garden. The guided tour was an important time to ask any questions and propose brainstormed ideas for some quick feedback.

The UBCBG expressed concerns about the public's lack of awareness of the garden. They claimed that this was largely due to a lack of signage around UBC, and a lack of captivating features throughout the extents of the gardens. Douglas Justice expressed concerns about the limited visitor demographics. The visitor demographics are mainly comprised of middle to old aged Caucasians. The garden receives funding from UBC which, when combined with garden revenue is just enough to keep the garden staffed and running. These low margins mean a lack of money to be invested in new capital projects. A large portion of the funding comes from donations of the deceased. Because of these issues, the garden's budget is very restricted. Large projects would need to be implemented in stages or be able to receive additional funding from UBC or outside sources.

Along with these challenges, clean potable water is used throughout the garden, for their water features and irrigation. This practice is not economically or environmentally sustainable and must be addressed. In addition, the UBCBG has poor water capturing systems and when it rains heavily, the ground becomes muddy and washed out. All this water is then carried towards the west bluffs and discharged over the cliffs causing serious cliff erosion. Another major issue is the insufficient gate incomes due to lack of public interest throughout the rainy and cold winter season. The garden is also lacking in useful space to conduct research as well as space for indoor, habitat sensitive, collections. Patrick Lewis also expressed that the capacity of parking lot is insufficient during peak seasons and special events like the Apple Festival. Finally, access to the garden, and similarly, flow of traffic throughout the garden has not been optimized and is detrimental to the visitor experience. There is a single entrance and exit to the garden, guests must traverse the entire garden and back to the entrance to depart to the parking lot. Hence, making the garden experience very inefficient and inconvenient.

All of the above issues were addressed in the conceptual design development process conducted by CivGen.

2.2 Conceptual Design Process

Following these informative sessions, CivGen Engineering Consultants developed a mission statement that fully encapsulates the Botanical Gardens' goals: "To harness sustainable engineering design practices to redefine the UBC Botanical Gardens as a premier visitor experience".

Once the mission statement had been established for the project, the next step is to prioritize the issues to be addressed. Using a system similar to a multi-criteria decision matrix, the importance of each "issue" is weighted so that proposed solutions can be ranked depending on the number and importance of the issues they address. The following issues were decided to be of the highest importance:

- Attracting visitors year round
- Proper management of water throughout gardens
- Improvement of visitor experience
- Improved access and flow throughout the gardens
- Proper dispersal of "anchor points" throughout the garden

After analyzing and evaluating of the issues and potential advancements of the gardens, CivGen began the process of brainstorming and researching potential solutions. This process included researching direct competitors of the UBCBG as a starting point for ideas. With some concepts in place CivGen facilitated a creative team environment, which allowed the creation of many conceptual design and solutions. A number of conceptual solutions were presented but the following solutions received the most consideration:

- Addition of a large tree house to the canopy walkway
- Periodic reptile and/or bird of prey shows
- Special events like Christmas and Halloween light displays
- Incorporation of a green restaurant
- A water treatment facility
- A living garden sign
- Parking lot upgrade
- Cattail pond bridge
- A second entrance area
- Addition of greenhouses

Although it was desired to address all concerns that the UBC Botanical Gardens had expressed, there was concern among CivGen Engineering Consultants that spreading the project into too many features would be not only unfeasible, but would likely end in many satisfactory conceptual solutions rather than fewer exceptional conceptual solutions.

2.3 Decisions

From the list of narrowed down solutions, CivGen examined the solutions that were being considered and determined the designs that would achieve the desired results.

The first concept to be re-evaluated and eliminated was the tree house. The issue was that the tree house would likely not work as a major visitor attraction as the tree house would just be an addition to the already existing canopy walk. The tree house would not bring guests to a new area of the garden, nor would it increase the access to the garden, it may bring more guests to the garden but not in a substantial way and for these reasons, the tree house option was determined not to be a feasible solution. The idea of having a reptile and/or birds of prey shows in the amphitheater was quickly abandoned due to the realization that a periodic special event was likely not enough to help the garden stay open year round. The final concept that was eliminated from the conceptual solution list was the idea of having Halloween and Christmas light displays at the garden. Although initially seeming like a good idea to bring in revenue through out the slow months, it was reasoned that there would be multiple challenges and factors working against this conceptual solution. The biggest issue with this concept would likely be the opposition from the garden to the hanging of Christmas lights all over their delicate collections. Even though the lights are not heavy, the installation and removal processes would likely cause some damage to the collections. Also, poor weather, which is often plaguing Vancouver from October to April, would be a large deterrent for potential visitors.

The remaining conceptual designs were also re-evaluated and found to be viable conceptual solutions for the UBC Botanical Gardens. The original design for the green restaurant had the restaurant being in an existing building near the parking lot that would be renovated to properly accommodate a new restaurant as Figure 2 shows below.

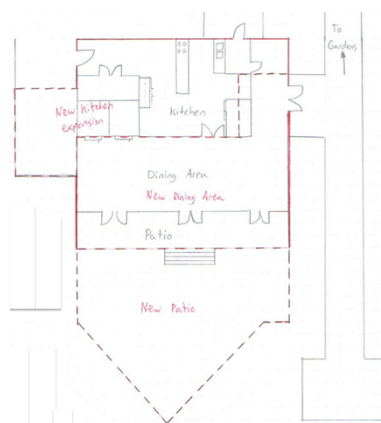


Figure 2 - Initial Restaurant Renovation Design

Although the original restaurant design would meet some of the design goals of the project, CivGen realized that if the restaurant was moved to a new location (where the current alpine garden is) it could be used as an east access point to the garden. With

the creation of a new building, instead of being just a restaurant, the building can be transformed into a multipurpose facility. Not only will it be able to function as a restaurant and a secondary access point, but also as a learning and teaching centre in the ground floor of the building. Other key features and justifications for the conceptual design of the multipurpose building can be found further ahead in section 3.2 Multipurpose Building.

2.4 Key Benefits

Each of the selected conceptual solutions will be presented in detail in the following section, along with their justifications for improvement of the UBC Botanical Garden. However, each feature also serves a major role in providing a solution to at least one of the issues deemed to be of high importance by CivGen to improve the gardens.

The multipurpose facility incorporated into the east access to the garden combines improved accessibility to the garden, but also encourages additional foot traffic to the garden from UBC students, perhaps stopping at the restaurant for some organic food before their walk. It also serves as an anchor to the eastern garden area and provides additional learning space to the gardens. It takes advantage of a rarely used parking lot at thunderbird stadium without the addition of any costs.

The glass domes bring a new anchor point to the north side of the garden, providing the opportunity to grow flora that survive only in delicate habitats, while providing a “wow” factor to the garden to aid in the improvement of the visitor experience. The water system and parking lot improvements take an existing part of the garden that is out of date and not sustainable and it revamps the system for a sustainable future.

CivGen Engineering Consultants determined that with the combination of a sustainable multipurpose facility, additional green house domes, an upgraded parking lot, secondary east access to the garden as well as sustainable water solutions, signage, access and flow improvements, the UBC Botanical Gardens can be redefined to a new and thriving business that not only creates a premier visitor experience but also teaches and provides research for scientists in the field of botany.

3.0 CONCEPTUAL DESIGN

3.1 Parking Lot

3.1.1 Description

In order to achieve the UBC Botanical Garden's "Master Plan" of being self-sustainable botanical garden, additional year round events will need to take place to increase visitor rate and generate sufficient revenue for future development and research. Some of the major setbacks are the insufficient parking and open space during events. For example, during Apple Festival in October, visitors must park at the UBC West Parkade and shuttle down to the Garden. Even during weekends on sunny weather days the existing lot is over capacity. The UBC botanical Garden has potential to host many outdoor events at various scales, however parking is the limiting factor in accommodating guests. By upgrading the parking through several phases the Garden will be able to further develop its mandate.

Phase 1 – Using the existing Thunderbird Stadium Parking

The existing Thunderbird Stadium parking lot is underutilized during non-event days. The close proximity of the parking lot to the UBC Botanical Garden makes it a potential expansion lot (refer to Figure 3). However, there is currently no access point into the Garden from the Thunderbird lot. In our proposal a new multipurpose / restaurant will act as a new access. Once this is in place the restaurant can run the new garden entrance. The only infrastructure required is signage to the parking lot and into the Garden. This is an excellent opportunity to align UBC parking regulations with the existing thunderbird lot. Visitors of the Garden can be reimbursed at the entrance.

Benefits:

- Low cost
- No additional land required
- Quick access to the East side of the Garden
- An additional 60 stalls to accommodate visitors to the garden

Disadvantages:

- Requires new access point (Such as the Multipurpose / Restaurant proposed)
- Installation of new parking meters at the existing parking lot
- Align parking regulations with main campus (use vehicle license to purchase time)
- UBC Botanical Garden visitors will need to be reimbursed

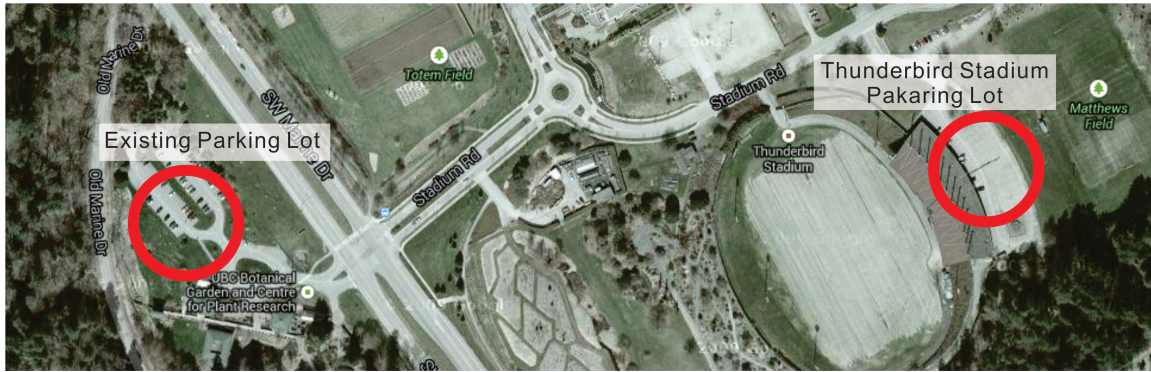


Figure 3 – Thunderbird Stadium Parking Lot Proximity

Phase 2 – Expansion of existing parking lot

The existing parking lot can only provide up to 80 stalls and during events the parking lot space is used up for event purpose and not parking. The expansion of the lot can service two purposes, increase parking capacity and provide additional open space. Two options are proposed depending on needs. Option 1 elongates the existing lot to the roundabout to provide an additional 48 stalls (Roess, Prassas, & McShane, 2004) as shown in Figure 4. The upgrade will provide the opportunity to convert the conventional parking lot into a sustainable lot by using tile green pavement to provide natural drainage and limit the effects of run-off (Ronca, 2008). Option 2 expands the lot further to the east, however UBC will need to collaborate with the Ministry of Transportation to discuss property rights and future reduction on SW Marine Drive.

Benefits:

- Relatively low cost
- Opportunity to build a sustainable parking lot
- Provide covered bike parking
- Can be completed regardless of phase 1’s status
- Additional stalls
 - Option 1: +40 Stalls
 - Option 2: +120 Stalls

Disadvantage:

- Requires land and potentially acquisition of land
- Reconfiguration of roundabout at the entrance

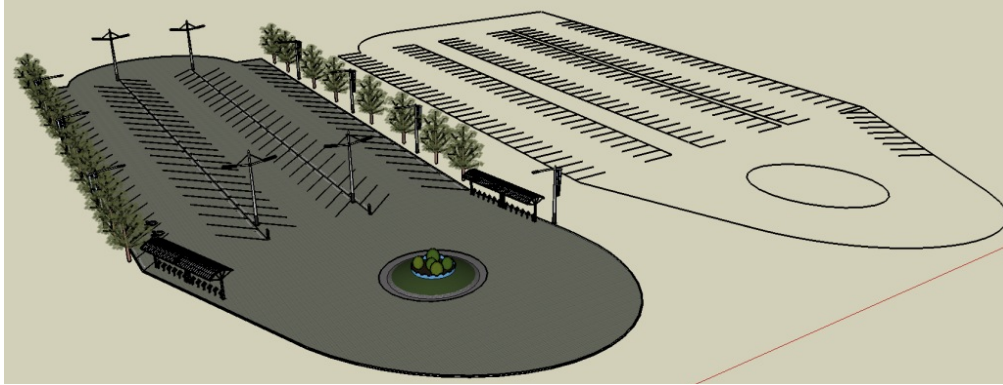


Figure 4 – UBCBG Parking Lot Upgrade

Phase 3 – Parking on Marine Drive

UBC has been in discussion with the Ministry of Transportation to construct a roundabout at Marine Drive and 16th Avenue (Short, 2013), and potential road diet north of 16th Avenue on SW Marine Drive from a 4 lane road to a 2 lane road. This would not only reduce the speed in the area but also increase the safety for pedestrians and cyclists travelling to the Gardens. It is vision that angle or parallel parking can be provided with the reduction in lanes. However, the jurisdiction of the parking rights will need to be addressed.

Benefits:

- Low cost to the Gardens
- Close to existing parking lot
- Increase safety of the overall area

Disadvantages:

- Low number of stalls
 - Angled layout: +40 stalls
 - Parallel layout: +15 stalls
- Requires discussion on jurisdiction and land rights

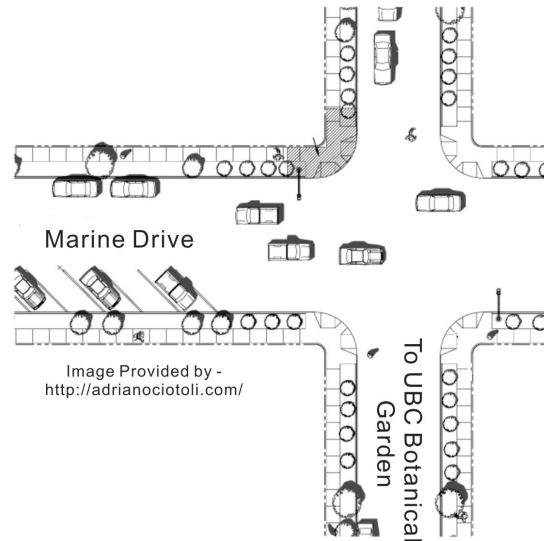


Figure 5 - Concept Street Parking on SW Marine Drive

Phase 4 – Future above grade parkade at UBC Thunderbird Stadium

Depending on future demand, it could be potentially feasible to construct an above grade parkade at the current UBC Thunderbird Stadium. However, this is highly dependent on the demand at the garden, Thunderbird Stadium and campus need. This report will not go into further details regarding the above grade parkade. As it this is too hard to predict and is highly unlikely to take place in the near future.

Benefits:

- Additional of +200 stalls depending on configuration on height
- Can be used for future development within nearby area

Disadvantage:

- High cost (Multimillion dollar facility at approximately \$30,000 per stall)
- Requires additional land (reduction on the adjacent open field)

3.2 Dome Glass House

3.2.1 Description

The UBC Botanical Garden currently lacks indoor exploration areas to facilitate and encourage visitors throughout winter months. In addition, UBC Botanical Garden’s greenhouse space is located offsite at the UBC farm. This inconvenience reduces productivity of garden volunteers, and fails to engage visitors in a full garden experience. A perfect way to solve this problem, while still promoting the mandate of the garden, is to construct a glasshouse. A glasshouse should be a large

open area to host plant collections, events and learning opportunities. Ideally a glass house would be large, well lit, and give visitors the same experience they would have outside minus the rain and cold. Many glasshouses tend to be basic rectangular buildings, with little to no aesthetic value to add to the garden around them. Their interior spaces are interrupted by series of columns, and light is blocked by the beams and girders overhead. For this reason CivGen is proposing a series of geodesic dome glasshouses, which can be constructed in stages as funds come available. The possibility of constructing multiple domes, either connected or spread throughout the garden, will give the UBC Botanical Garden an opportunity to create individual pods where specific plant collections, or biomes can be showcased. Visitors will be drawn in out of curiosity when they see the unique dome structures rising out of the garden area. At nighttime the domes will be lit up with different colours to attract they eye of potential visitors. The dome structures will provide large open spaces, with no interior supports, which will create a sense of being outdoors.

The dome glasshouses are an easily justifiable addition to the UBC Botanical Garden. The Dome Glass Houses will act as an anchor in the north garden throughout the year. Garden visitors will have the opportunity to explore and learn about plant collections while protected from the elements. Additionally, the dome glasshouses could be fitted with mobile greenhouse benches, which would allow some plants to be moved out of the domes during events like apple festival, or weddings. These educational buildings will enhance the efficiency of garden workers and volunteers, and help them share their horticultural expertise with the public. The energy efficient domes will require little energy input, and the energy required will easily be supplied by natural gas and electrical utilities located right beside the dome location in the north garden.

In order to promote UBC's commitment to sustainability the glasshouse must be energy efficient. Using a geodesic dome design will maximize the volume to surface area ratio. This means that the dome will have a large internal volume for growing plants, with the smallest surface area exposed to the environment. In addition to this the domes will be set 1m into the ground surface. This will reduce energy needs of the dome by insulating from the environment. Covering material, discussed below, will be chosen to be extremely energy efficient. The dome structures will transmit natural light to the plant collections and visitors within, and require little external energy to heat in winter months.

Conveniently, the geodesic domes can be located anywhere throughout the garden. It is recommended that a large (20m diameter) dome be placed in the Northeast side of the garden just to the south of the work yard on Stadium Road. The large dome will be connected to two other domes with diameters of 15m and 10m. Domes with diameters of 20m, 15m and 10m were chosen as the best options for UBC Botanical Garden. This is due to their ability to accommodate large crowds (up to 150 people each) for events like apple festival. Being on the smaller side of domes they will be light, cheap and easy to construct. Larger domes can be phased

in by UBCBG in the future. Smaller domes can be constructed using do-it-yourself kits purchased online and could simply be assembled by garden staff. During events mobile planters can be moved out of the domes to create room to accommodate hundreds of visitors in 570m² of floor area. Aside from events the main focus of the domes will be to showcase unique plant collections, and centralize UBCBG’s greenhouse space. Visitors can interactively learn from horticulture experts who are working in the glasshouses. Special exhibits can be prepared and showcased by the UBCBG. Additional 10m domes can be located on the corner of SW Marine and Stadium Road, and the corner of 16th Avenue and Southwest Marine Drive. These additional domes can shelter plants closer to the location they are needed. They will also be a visual draw to potential visitors outside the garden.

Table 1 – Geodesic Glass Dome Specifications

Dome Diameter (m)	Floor Area (m2)	Seating (ppl)	Dining (ppl)	Activity	Area/Person (m2/person)
5	20	30	20	Seating	0.65
10	79	121	79	Standing	0.5
15	177	272	177	Dining	1
20	314	483	314		
25	491	755	491		
30	707	1087	707		

3.2.2 Dome Details

The dome frame will be constructed from lightweight steel pipe. The frame of a 10m diameter dome will require 350 linear metres of pipe. The steel frame will be constructed on top of small foundations. These foundations will likely be square footings located at the base of each triangular portion of the dome to allow for the loads of the dome to be transmitted into the ground. Further design research is needed but one concern of note is the potential for extreme uplift forces on the dome during wind loading. This uplift could potentially justify switching from footing foundations to pile foundations. Each foundation will need to be set within competent soil (below topsoil). It is also important to ensure this is set below depth of frost penetration for Vancouver (0.5m).

Many different coverings are available for the domes but it is recommended that ETFE(ethylene tetrafluoroethylene) is used. This material has been used in other geodesic dome projects, including the Eden Project, and is chosen for its high strength, design life of 50 years, and insulation properties. The co-polymer can be arranged in multiple layers to enhance insulation values. The ETFE will be configured into triangular double layer panels, Figure 6 - ETFE Dual Layer Configuration (Mak Max, 2010), and will be supported by the steel frame. The dual layer ETFE film will encapsulate a layer of air, which will provide the insulation properties discussed above. These ETFE cushions have a higher insulation value than triple glazed glass.

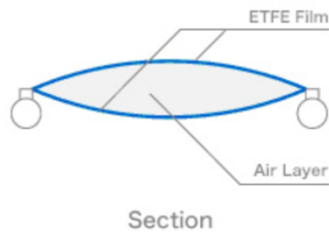


Figure 6 - ETFE Dual Layer Configuration (Mak Max, 2010)

The ETFE absorbs infrared radiation, which will help to warm the building, but allows UV to pass through which allows plants within the dome to thrive. This material is lightweight and will exert minimal force on the steel frame of the dome with a mass less than 1kg/m^2 (Mak Max, 2010). This lightweight characteristic will allow the amount of material in the steel frame to be minimized. An added benefit of ETFE panels is that they are aesthetically pleasing, and they can be illuminated with LED lighting at nighttime. This lighting will make the domes visually striking and will act as a draw for potential visitors who have never noticed the garden while driving or walking by before (Architen Landrell, 2013). LED lighting of ETFE panels has been used on many prestigious projects worldwide including the Beijing Aquatic Centre, the Eden Project, and Munich's Football stadium. An example of LED lit ETFE panels can be seen below in Figure 7.



Figure 7 - ETFE Panels at Night (FIXR, 2011)

3.2.3 Schematic Sketches

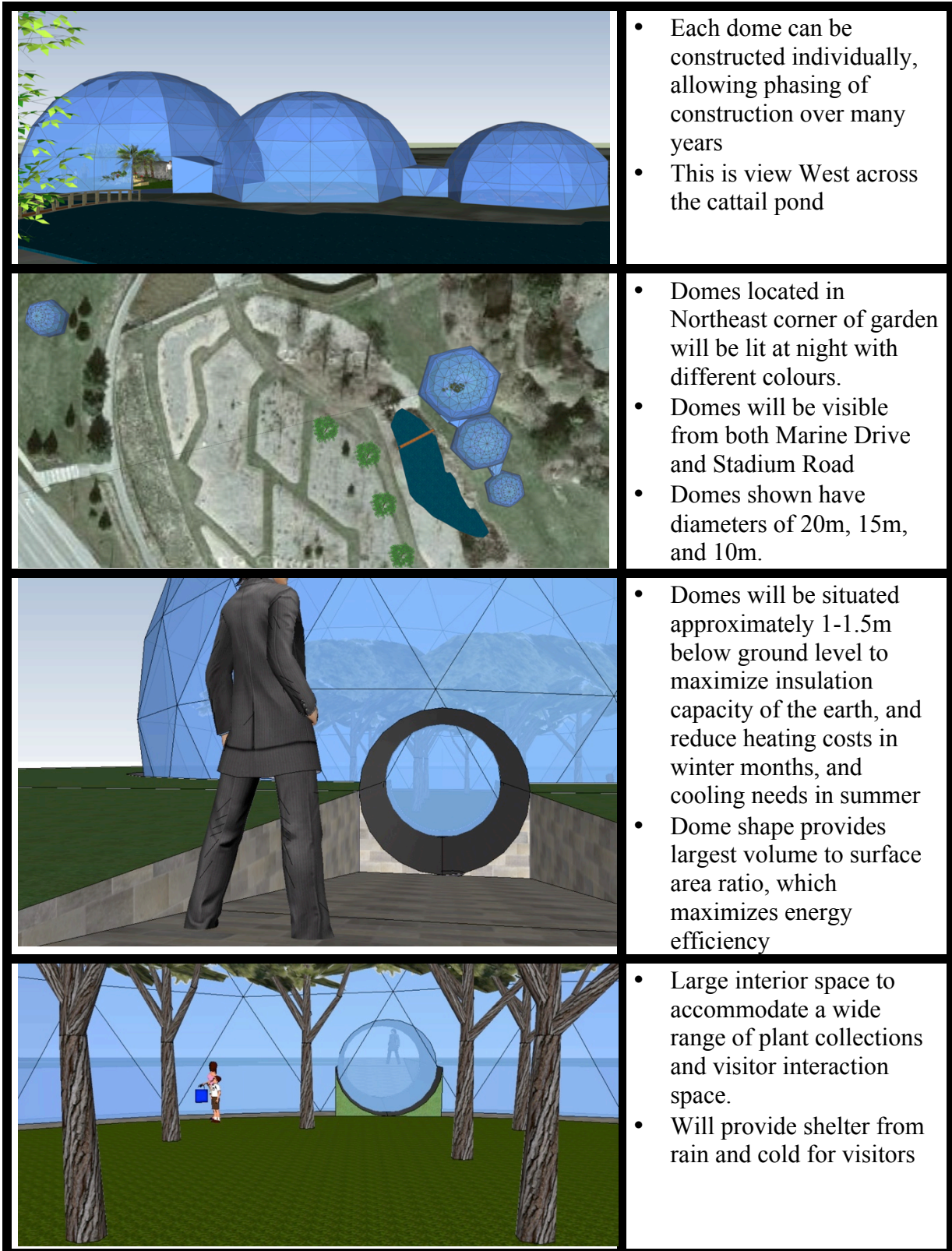


Figure 8 - Geodesic Dome Design

3.3 Multipurpose Building

3.3.1 Description

The UBC Botanical Garden, with an extensive collection of native and exotic plants, has been a valued element of the university and the community throughout the years. However, the garden struggles to sustain itself financially due these key issues: the lack of attractions to the garden, the limitation of year-round visits due to poor weather, and the narrow demographic of the visitors. In order to address these issues, a new multipurpose building is proposed. The general building overview is displayed in Figure 9 below. The main components of the building include:

- Culinary Studio
- Horticulture and research laboratory
- Interior plant collection space
- Study spaces
- Office and classrooms
- Restaurant and bar
- Rooftop garden and café



Figure 9 – General Building Overview

Inversion and invasion are the concepts used in the design of the building. In doing so, the relationship between the exterior and the confined interior are simply inverted and create a phenomenon known as a “green invasion”. To meet the sustainable goals of the university, sustainable features such as solar panels and natural lighting are incorporated into the building. The ground floor is mainly used for learning and working. The northwest end of the upper floor cantilevers out on three sides with full-length glass walls. The upper floor and roof ensembles the living and entertaining aspects of the campus plan.

Location

This multipurpose building is a 2-storey structure with a 50ft by 150ft long elevated ground floor, upper floor, and a rooftop garden and cafe. The total usable floor area of the building is 22,500sqft. The proposed location of the building will be on the top of the small plateau where the alpine garden is currently situated. Taking into consideration that the cactus collection can be easily relocated and no large trees are present in that area, this location will cause minimal disturbance to the garden. The front of the building faces southwest and it has a magnificent panoramic view of the garden. The back of the building overlooks the Thunderbird Stadium. With a sunny southern exposure and a million-dollar scenic view, it marks the best location within the garden for the multipurpose building.



Figure 10 - Plan view of building location

Ground Floor

The ground floor is designed to be a multipurpose facility that focuses on the enhancement of learning and working. There are two primary internal bearing walls dividing the ground floor into two main areas. On one side, there are a culinary studio, a horticulture and research laboratory, and an open classroom. The other side consists of separated workspaces and a large study space. The spaces on both sides of the building are partially partitioned to create privacy; however, the furniture and partition walls can be rearranged to dynamically adjust to evolving needs of the garden and its users.

The culinary studio can be utilized for cooking classes, which centralizes on the themes of organic cooking and sustainable eating. Fruits and vegetables from the rooftop garden and the food garden can be harvested and used. The fees of the cooking classes can be marketed and arranged with other attractions of the garden. For example, the purchase of five cooking classes will include a 10% discount at the restaurant and bar. The horticulture and research laboratory provides instruments and workbenches for research and experiments. The open classroom and the separate work and study spaces are used for teaching and studying.

Upper Floor

In a recent survey 74% of the students on campus feel that adding more shops and services is important in improving the quality of on-campus experience (UBC, 2013). To satisfy this demand, the restaurant and bar on the upper floor aims to provide top quality food and dining services for its guests. Restaurant guests may gain notice of the garden through the restaurant and bar. The new access road leads to the entrance of the upper floor. The kitchen, storage room, and dining area are setup at the front. The open concept bar area is perfect for interactions, and it is the ideal spot for watching the games at the Thunderbird Stadium. The cantilevered podium is equipped with full-length energy efficient windows. The stunning panoramic view of the garden and the stadium will redefine the guests' experience at the UBCBG. Figure 11 below shows the upper floor restaurant layout.

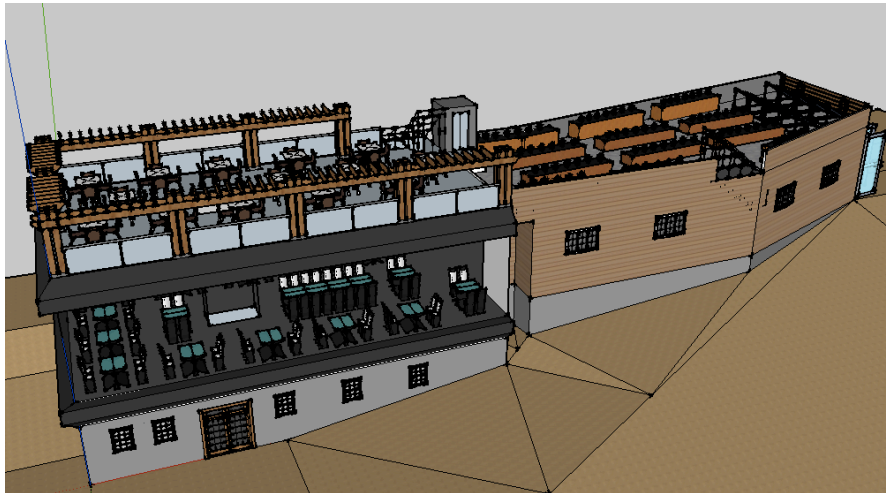


Figure 11 - Upper Floor Restaurant Layout

Rooftop garden + café

To fully utilize the natural sunlight, solar panels are installed at the southern end of the roof. The rooftop garden is separated from the café by wooden vine gates. Besides the decorative benefit of a rooftop garden, it also provides food for the restaurant and culinary studio. The café is organized around the exterior envelope of the rooftop. In the middle of the café, a skylight that extends from the roof to the ceiling of the ground floor. Therefore, natural lighting will be available on every floor of the building. The rooftop garden and café layout is presented in the figure below.

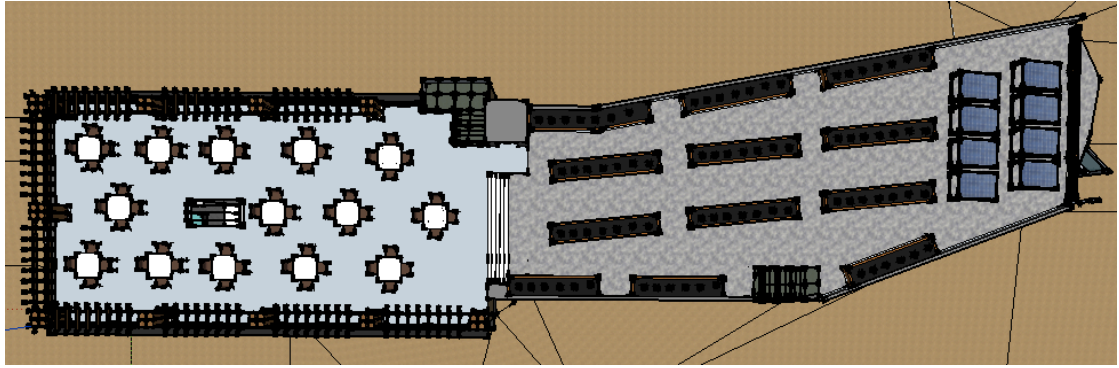


Figure 12 - Rooftop Garden and Cafe Layout

Key features of the building

The two main considerations of the design of this multi-purpose building are sustainability and functionality. The key features of the building includes:

- Solar panels
- SmartSun glass windows
- Skylight
- Natural ventilation system
- Green walls
- Storm water and grey water systems



Figure 13 - Key Features of Building (Poiraud & Weinmaster)

Energy efficiency of the building is achieved by the installation of solar panels, the natural lighting from the skylight, and a natural ventilation system. All of the windows in the building use a glass called SmartSun glass. The SmartSun glass lets sunshine in, but deflects unwanted solar heat and UV rays, which cuts down

on the heating and cooling costs (Andersen Corporation). Stormwater are collected and treated at the basement of the building. This will then be used to water the plants in the garden. Many of the walls within the building are green walls. Green walls are also known as vertical gardens because it is a wall covered with growing vegetation (Poiraud & Weinmaster). It functions as a passive air filter that purifies the air indoors. As mentioned above, the partition walls and fixtures of the building can be rearranged to better suit future needs of the garden. To accommodate people with disabilities, the entrances and exits are wheelchair accessible, and the elevator will transport guests between floors.

A signature attraction of the UBC Botanical Garden, the new multipurpose building will bring in a broader age demographic of year-round visitors even during the damp winter days. The building redefines the manner in which we learn, teach and interact. It seamlessly integrates with the environment of the garden and support the vision of a live-work-learn community at UBC.

3.4 New Access

3.4.1 Multipurpose Building Access

The current entrance to the UBC Botanical Garden is located in the northwest corner of the garden. It is isolated from UBC campus and any significant public transportation routes.

Improving garden access is a main benefit of the Multipurpose Building and Restaurant, as it will also function as a secondary garden entrance in the southeast corner. This is strategically located in the opposite corner of the current entrance. When the restaurant is open, the host will also function as a gatekeeper for the garden eliminating the need for additional staff.

In order for the restaurant to be successful, vehicle access must be provided directly to the building to maximize accessibility. Access from West 16th Ave was considered but it would require cutting a brand new driveway through the garden. This would entail replacing green space with asphalt while further fragmenting the garden with another road. New parking would also need to be created to coincide with access off of West 16th Ave. Vehicle access to the restaurant should utilize existing parking lots while minimizing reduction of green space within the garden. Figure 14 displays the current layout of the Southwest corner of the garden.



Figure 14 - Existing layout of Southeast corner of UBC Botanical Garden

The Thunderbird Stadium parking is approximately 200 metres from the restaurant entrance and underutilized aside from infrequent stadium events. It is sufficiently close to the restaurant as long as adequate vehicle access can be created closer to the entrance.

A utility road currently exists inside Thunderbird Stadium, connecting the parking lot with the south end of the field as shown in Figure 14. Modifying the existing road will efficiently connect the multipurpose facility to the parking lot without cutting a new route through the garden.

The proposed garden access upgrades are outlined in Figure 15. A small traffic roundabout will be constructed at the West end of the access round close to the restaurant entrance. This will provide customers the opportunity for drop off and pick up close to the entrance.



Figure 15 - Proposed layout of UBC Botanical Garden Southeast corner access upgrades

The fence will be moved to the North side of the road such that the upgraded road will now sit outside the stadium fence. This will maintain restricted stadium access while allowing the road to be modified. A gate at the base of the roundabout will maintain access to the field and allow the road to continue functioning as a utility road for the stadium.

A covered pedestrian walkway will run adjacent to the access road as shown in Figure 16. This will provide safe pedestrian access from the Thunderbird Stadium parking lot to the Multipurpose Facility while initiating visitors into the garden atmosphere. It will also function as a natural fence to separate the public from the garden.



Figure 16 - Trellised walkway connecting the Multipurpose Facility with T-bird Stadium Parking Lot

The new garden entrance will also improve public transportation access to UBCBG by connecting to the frequent bus service on West 16th Ave. A key component of the garden access upgrades is to connect the new entrance to west 16th Ave. A pedestrian pathway is proposed to run along the border between UBCBG and the UBC ropes course. This will connect the new entrance to the bus routes on West 16th Ave without fragmenting the garden.

The proposed UBCBG garden access improvements will create vehicle and pedestrian access directly to the second garden entrance at the Multipurpose Facility. No additional parking will need to be constructed and public transportation access will be significantly improved.

3.4.2 Garden Mobility Improvements

Some other small changes that could prove to be beneficial for the UBC Botanical Garden that we encourage be considered are: an increase in local area directional signage to get to the gardens, the incorporation of a stone stairway at the east end of the underground tunnel to streamline foot traffic that wants to go straight to the great lawn/pavilion area, as well as the addition of a wooden bridged walkway crossing the swamp from one side of the great lawn, to the other side of the

swamp. These smaller projects would come at a much lower cost, pre-construction time and construction time to accomplish and would make a great starting point while the other proposed projects are developed and fundraised.

There is a major lack of directional signage for customers en route to the botanical gardens. Whether coming along SW Marine Drive or down 16th Avenue, until you are right in front of the gardens entrance, there is very little to let you know that the garden is there. An increase in directional signage in the local area of UBC would help guide those who are coming to the garden and also increase the knowledge of the existence of the garden for people who commute through that area, as its existence is not well known locally. The main feature of this increased signage would be a living garden sign on the corner of SW Marine DR. and Stadium Road, that would include the UBC Botanical Garden's symbol as well as their name all made out of living plants. A 3D model of the proposed sign can be seen below in Figure 17.

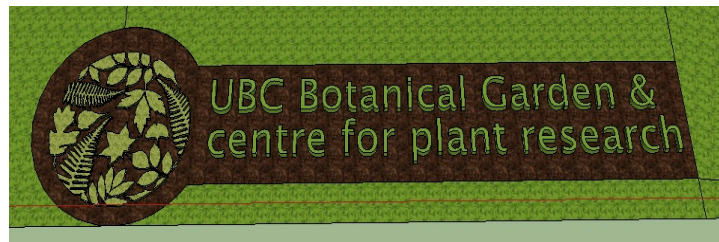


Figure 17 - Living Garden Sign

The incorporation of a stone stairway on the east end of the underground tunnel would not only streamline foot traffic, it would also give the opportunity to enhance the stream flowing right beside the proposed stair. This stream currently is unmaintained and not a visual draw. However, with the incorporation of a stone stairway, this stream could be re-landscaped to add in a small waterfall and really increase the aesthetics of the north tunnel area. Also, this newly landscaped stream and stone stairway would be visible from the adjacent SW Marine Drive and could bring in more customers. The proposed water feature and stone stairs proposed would be similar to those found in Figure 18 and Figure 19.



Figure 18 – North Tunnel Stone Stairway

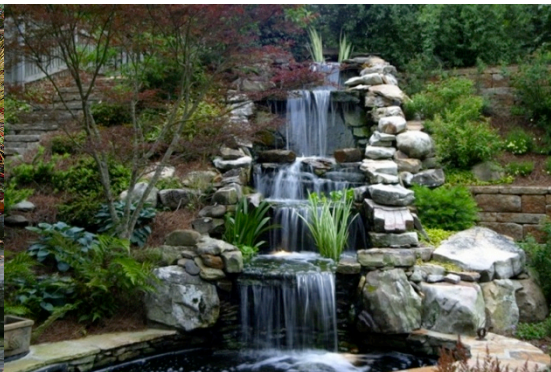


Figure 19 - Stair Side Water Feature

Lastly, another small change to the gardens that could make a big difference is the addition of a wooden bridge walkway over the cattail pond. A wooden bridge walkway would maintain the garden feel by having an aesthetically pleasing wooden structure that not only traverses the pond, but meanders across the pond providing a bit of a walkway. This walkway would provide access to the cattail pond ecosystem for visitors without them having to ruin the edges of the pond as they search for wildlife, as the garden often has to deal with. A 3D model of the proposed wooden bridge can be seen in Figure 19.

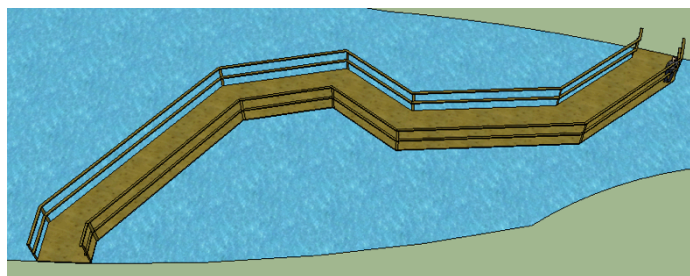


Figure 19 - Cattail Pond Wooden Bridge

3.5 Stormwater Catchment

3.5.1 Description

The UBCBG and surrounding south campus suffer from inadequate storm water management. The substantial rainfall in Vancouver creates an abundance of storm water. This abundance brings both challenges and opportunities. When the water comes, it surges, and has cut deep into the point grey cliffs wherever outfalls are present. But the water can be collected and used as a resource to reduce the reliance of the UBCBG on municipally treated potable water. The solutions to these problems must consider both the collection of storm water and the control of erosive peak flows.

3.5.2 Storm Water Capture

Excessive potable water usage at the UBCBG is an ongoing problem. The gardens rely solely on potable water for all of their water needs including plant irrigation and the maintenance of water features and a stream. In keeping with the sustainable vision of UBC a transition to alternative water sources is very desirable. A useful solution to this problem is the capture, storage and treatment of the plentiful rainwater UBC receives. Average annual rainfall over the UBC campus is approximately 1100mm per year (Lam et al, 2012). This quantity spread over the 16th avenue catchment area would provide more than an adequate supply.

Implementation of a storm water capture and detention system could be designed to provide a sustainable water source for the UBCBG. Storm water capture and retention has some very appealing benefits that fit nicely within the UBC botanical

garden's sustainability mandate. Some of the key benefits of storm water harvesting are:

- Minimize or eliminate use of municipal potable water
- Reduce downstream erosion on cliffs caused by uninhibited storm water outfall
- Improve overall sustainability of the UBCBG

3.5.3 Erosion Mitigation

Erosion at the UBC storm water outfalls is another ongoing problem that has been well known for some time. The heavy flows occurring during periods of rainfall have caused extensive erosion downstream of the culvert. Figure 20 clearly illustrates the erosive power of storm water at the trail 7 outfall. Trail 7 outfall is fed by a ditch system along Old Marine Drive which is in turn fed by multiple storm water pipes from UBC. In order to help deal with this issue we propose expanding the capacity of the ditches along Old Marine Drive. By expanding the ditches retention capacity can be created and the ditches can act as small linear storage basins. This additional storage area will help to reduce the peak flows at the Trail 7 outfall.



Figure 20 - Trail 7 Outfall Showing Extensive Erosion and Undercutting of Gully Wall

3.5.4 Storm Water Capture Conceptual Design

3.5.4.1 Storm Water Availability

The UBCBG's location is well suited for the collection of storm water run-off from the UBC campus. As shown in Figure 21, the 16th Avenue storm water line runs downgrade parallel to 16th avenue and right by the Multipurpose Facility.

Capturing water from this line should prove relatively easy and should avoid the need to pump the storm water to the detention facility. Storm water can be collected from the drainage pipes using a collection system that allows for the bypass of excess water in the event of the filling of the detention facility to capacity.

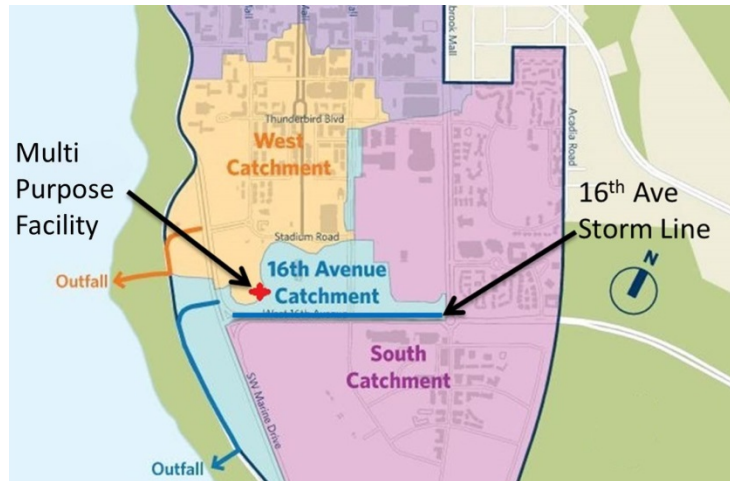


Figure 21 - South campus catchment areas and storm water outfalls (UBC, 2013)

3.5.4.2 Collection of Storm Water

Storm water collection for the storage scheme described above will be of the off-line type. That is, storm water should be diverted from storm water piping using a diversion weir that will allow water to enter the system while limiting the volume and bypassing heavier flows. At the point of entry into the storage system serviceable screens should be implemented to remove coarse aggregate and large organic materials such as leaves and sticks. By screening the incoming water some of the large solids may be removed from the flow.

3.5.4.3 Storm Water Storage

In order to best meet daily demands a storage tank should be large enough to hold a large volume of water inflow during rainy periods and retain it for dispersal during drier periods. However, the tank size will be constrained by the limited geographical area of the UBCBG and the high cost of installation inherent in installing a large tank. For this reason it is recommended that provisions for topping up the storage facility with potable water be made. Furthermore, an underground storage tank is recommended to eliminate the necessity of sacrificing valuable space in the garden. For these reasons it is recommended that the tank be installed underneath the proposed restaurant with access through the basement. Three cylindrical tanks approximately 12m in diameter and 6m deep. Three tanks are selected to best fit within the rectangular footprint of the multipurpose facility. This location was selected for a few important reasons, which are listed below:

- To limit additional disturbance to the garden by placing the tank within the restaurant footprint
- Eliminate any aesthetic issues pertaining to an above ground tank
- Lower temperatures below ground will inhibit the growth of deleterious microbes
- A lower elevation tank will allow better storm water inflow characteristics
- Will allow limited additional plumbing when implementing a potable water top-up scheme

3.5.4.4 Water Quality and Treatment

Water quality is an important aspect of assessing the usefulness of any water resource. When dealing with storm water, quality is an important consideration as there is ample opportunity for run-off water to pick up a variety of pollutants before entering the system. In a study conducted by UBC researchers the storm water output from campus was deemed to be of good quality relative to nearby municipalities (UBC, 2013). Regardless the water is likely to contain a fair amount of oil and heavy metals from road surface run off. For this reason it is recommended that a serviceable grease/oil separator be installed upstream of the storage tank.

In order to control sedimentation within the storage tank it is recommended that the system be installed with a sediment collecting baffle tank and provisions for routine tank flushing. A baffle tank system as shown in Figure 22 is commonly used for removing sediments for rainwater harvesting and will likely be an effective way to remove heavy sands and grit that infiltrate the system.

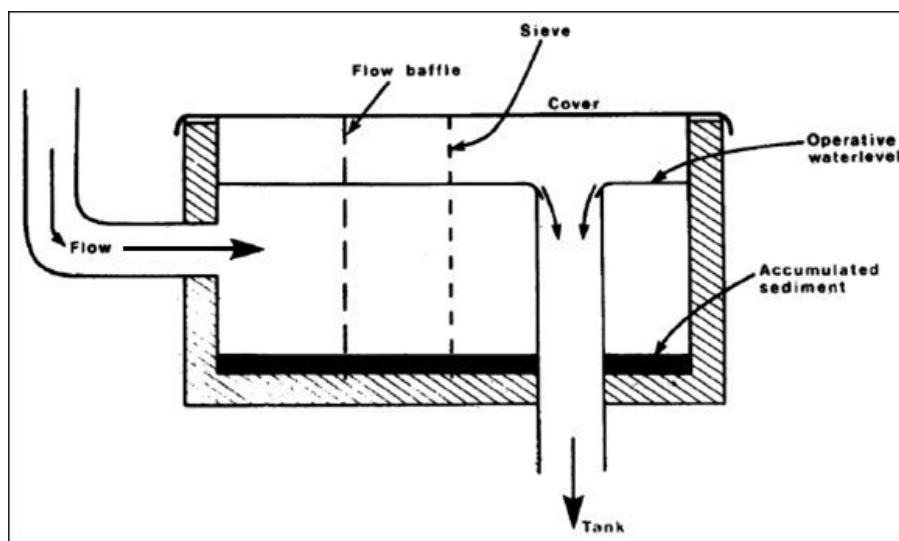


Figure 22 - Baffle tank to remove coarse sediments (Grant et al., 2002)

3.5.5 Erosion Control Conceptual Design

3.5.5.1 Storm Water Control

Storm water enters the ditch system west of the UBCBG at a few locations where the subterranean storm lines terminate. Figure 23 illustrates the location of the ditch and the 5 feeder ditches, which are in turn fed by storm lines. Adding capacity to this ditch system through a ditch expansion program can turn these ditches into a major obstacle for storm water heading to the outfall. The ditches should be expanded in depth and width wherever possible to create retention capacity.

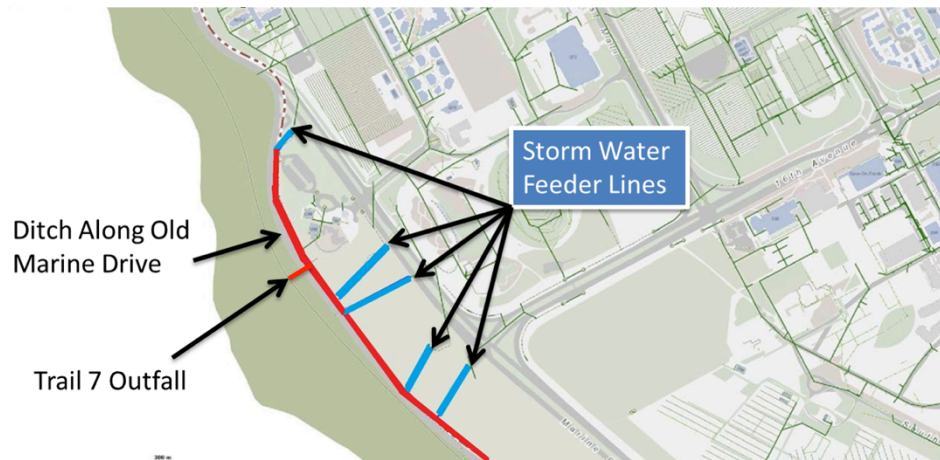


Figure 23 - Ditch system along Old Marine Drive (UBC, 2013)

3.5.5.2 Storm Water Control Benefits

The benefits to UBC from the improved control of erosion at the Trail 7 outfall are very important to this proposal. As shown in Figure 2 the erosion has become quite severe and although not pictured Trail 7 is immediately above and adjacent to this area of heavy erosion. This means the existence of Trail 7 is threatened by the erosive action of the outfall. By limiting this erosion UBC will reap the benefit of preventing or prolonging the need to perform maintenance on Trail 7. It will also limit the likelihood of a potentially dangerous and catastrophic collapse of the trail into the storm water flow.

3.5.5.3 Storm Water Control Limitations

Due to the small area available for ditch expansion along Old Marine Drive the impact of this ditch expansion would be limited. In order to take advantage of the roads inactive status consideration could be given to demolishing some portion of the road adjacent to the existing ditch line to allow a greater expansion in retention capacity. Because this area is mostly used by students for parking it could be considered worthwhile to sacrifice some vehicle storage capacity for improved water storage capacity.

4.0 PROJECT IMPLEMENTATION

4.1 Environmental Impacts

Sustainability is one of the guiding principles of this proposal and will thus yield many direct and indirect environmental benefits. By bringing in more visitors to the garden this plan will be expected to increase awareness and appreciation for the natural environment. The founding principles of the garden centre around the goal of protecting and displaying threatened species. That is why the glasshouse for example will be of great benefit in with its ability to harbour and show them. The following is a list of environmental benefits of implementing this project:

- Reduce garden's reliance on municipally treated potable water
- Protect Trail 7 and surrounding cliffs from erosion
- Increase awareness and appreciation for plant conservation
- Energy efficient building design with minimal to no net energy consumption
- Use of permeable pavement for parking lot will reduce run-off

Although the net environmental impacts of this project would certainly be positive there are some potentially negative impacts that must be considered. The following list describes some areas of concern for development in the garden:

- Damage to plants during construction phases
- Contamination of soils in garden from spills during construction phases
- Risk of damage to plants from increased visitor traffic

4.2 Socio-economic Impacts

This proposal aims to hold the health and wellbeing of the local community as a top priority. The potential benefits of a successful UBCBG are easy to see. Through the implementation of this proposal the attractive qualities' of UBCBG will be enhanced. This enhancement will bring in more visitors year round and ensure the relevance and longevity of the gardens. Ultimately the following benefits can be expected:

- Year round utilization of the gardens
- Improved the capability to handle visitor volumes during peak times
- Enhanced visitor experience through aesthetic and access improvements
- Create areas where more exotic species can be displayed
- Create a community inclusive learning space within the gardens
- Improve sustainability profile of the gardens
- Maintain and safeguard the existence of Trail 7
- Create jobs as gardens seek to expand operations

4.3 Priorities

When considering implementation of this proposal we advise that the project proceeds according to the following priority ranking table.

Table 2 - Implementation priority rankings for different aspects of this proposal

Aspect	Priority	Rationale
Restaurant building with multipurpose space	1	The restaurant/multipurpose facility is the cornerstone of this proposal. By providing a year round visitor draw and activity centre this facility will immediately improve the revenue generating potential of the gardens.
Storm water management plan	1	The storm water management plan will address some of the primary concerns of garden staff concerning the excessive use of potable water. This system, as proposed, must also be installed concurrently with the restaurant/multipurpose facility. The benefits to the UBC campus as a whole make this a strong selling point in the effort to gain investment funding from the university.
Upgraded visitor parking & new garden access	2	With the increase in visitors brought by the restaurant, expansion of visitor parking will be necessary to accommodate the new clientele. The new access point will also be necessary to facilitate the easy movement of supplies and visitors to the restaurant.
Dome glasshouses	3	After the restaurant has been established the domes will provide an additional boost the attractiveness of the gardens as a visitor destination. The domes will be prominent landmarks drawing attention the gardens. Additionally they will provide a unique structure for expansion of the plant collections and visitor exploration.
Improved garden mobility	4	The garden mobility project includes several small scale improvements to the overall garden experience. These improvements can be implemented slowly as funds become available. Once completed they will serve to further improve the ambiance and attractiveness of the natural garden setting.

5.0 ECONOMIC ANALYSIS

The economic analysis for the UBC Botanical Garden is broken down into 3 components: Potential Revenue, Source of Capital, and Preliminary cost estimates. The analysis is limited to high-level estimates due to large uncertainty in the conceptual design phases and limited information available.

5.1 Potential Revenue

The potential revenue activities for the UBC Botanical Garden are primarily based on visitor rates and ability to attract potential Garden visitors.

Access:

- The new access will provide a better visitor experience and increase awareness of the UBC Botanical Garden to by-passers on 16th Avenue. However, the access will not provide a direct source of revenue.

Parking:

- In order to protect the experience at the Botanical Gardens, visitor should not be charged for parking, since driving is the mainly mode of transportation to reach the Garden if you are not near UBC. Visitors will need to be reimbursed at the entrance
- Pay parking can be considered as a source to fund for the parking expansion. However, it should not be relied upon as a source of revenue.

Dome:

- The Dome will increase visitors as an attraction.
- The additional space can be used to host additional events.
- Third parties could be included to run events similar to the canopy walkway

Water Management:

- None

Multipurpose / Restaurant Facility:

- The restaurant will increase visitors to the Garden
- Classrooms can be to host public educational classes
- The new research facility can be used to obtain funding for research

Miscellaneous:

- The Garden sign will increase awareness of the UBC Botanical Garden to by-passers on SW Marine Drive

5.2 Sources of Capital

The following is a list of potential source of capital for the proposed components.

Component	Source of Capital
Access	None
Parking	UBC Parking – Phase 1 & 2 Ministry of Transportation – Phase 3
Dome	Third Party Funding
Water Management	\$200,000 SEEDS Program
Multipurpose / Restaurant Facility	Third Party Funding
Miscellaneous	None

5.3 Construction Costs

The construction cost of UBC Botanical Garden upgrades were calculated using RSMeans data adjusted for UBC and based on research of typical cost of similar projects. A breakdown of each component is provided below:

Access: \$200,000

- Covered Walkway: \$50,000
- Road Extension: \$120,000
- Fence and Stadium Gate: \$30,000

Parking: \$370,000

All parking cost estimates are taken from Traffic Engineering (Roess, Prassas, & McShane, 2004)

- Phase 1: Construction of way finding sign and repairs to Thunderbird Stadium parking
 - \$12,000 @ \$200 per stall
- Phase 2: Construction of new surface parking, installation of new features
 - Option 1: \$360,000 @ \$3,000 per stall
 - Option 2: \$600,000 @ \$3,000 per stall
- Phase 3: Construction of angled and parallel street parking on Marine Drive after installation of roundabout and road diet
 - Unknown cost due to property rights and jurisdiction of parking rights
- Phase 4: Construction of new above-grade parking at Thunderbird Stadium
 - \$5,000,000 @ \$25,000 per stall assuming 200 stall capacity

Dome: \$160,000

- Dome 1 (20m Diameter): \$87,000
- Dome 2 (15m Diameter): \$49,000
- Dome 3 (10m Diameter): \$22,000

Water Management: \$260,000

- Phase 1: Storm water storage and capture system
 - \$250,000
- Phase 2: Ditch expansion
 - \$10,000

Multipurpose / Restaurant Facility: \$6,750,000

- Cost per Square feet at \$300

Miscellaneous: \$40,000

- Bridge: \$5,000
- Garden Sign: \$15,000
- Stairs & Water feature: \$20,000

5.4 Project Costs and Expenditures

Total Project Construction Cost:

The total cost for construction was estimated to approximately \$13.2 million with a 20% contingency of \$2.2 million to account for the high amount of uncertainty at the conceptual level.

Annual Operational Cost:

These estimates may include the following: Supplies, Security, Utilities, Insurance, Routine Maintenance, Structural Maintenance, etc.

Component	Operational Cost
Access	\$2,000
Parking	\$2,000
Dome	\$5,000
Water Management	\$5,000
Multipurpose / Restaurant Facility	\$20,000
Miscellaneous	\$4,000
Total Annual Operational Cost:	\$38,000

6.0 CONCLUSION

The proposed report is intended to provide a collection of conceptual engineering designs and developments that will redefine the UBC Botanical Gardens as a premier visitor destination. The proposed designs addressed the four main issues: inadequacy of visitor attractions, inaccessibility, lack of water management, and the lack of indoor spaces. The following are the five major proposed engineering design projects:

- Multipurpose facility
- Dome glasshouse
- Visitor parking upgrade
- Storm water management facilities
- New garden access

The multipurpose facility and dome glasshouse serve as a visitor attraction, an educational centre, a collection exhibit, and a revenue generator. The UBCBG struggles to financially due to the lack of year-round visitors. Having these new indoor facilities will not only bring in visitors during the rainy season, but also broaden the age demographic of the visitors. Events such as weddings receptions and apple festival can be held inside these structures.

The parking lot upgrade and new garden access routes promote mobility inside the garden and increase the capacity of guests. The ease of access to and within the garden will attract more UBC campus staff and students to visit. Erosion of soil and poor drainage due to improper storm water management are a huge concern to UBC. Incorporating storm water collection systems within the garden can reduce portable water use for irrigation and aesthetic purposes. The construction of a bio-swale will detain and attenuate peak flow through the Trail #7 outfall, hence mitigating erosion of soil of the cliffs.

The implementation of sustainable design in all of the proposed developments supports UBC's goal in becoming the greenest university. Energy efficient features such as heat retaining glass, solar panels, and green roof and walls are included in the designs.

With cross-professional collaborations within the company, CivGen offers a broad range of engineering services. The final proposed designs incorporated the different disciplines and expertise which includes: transportation, structural, hydrological and geotechnical specialists and engineers. These designs facilitate the growth and continual evolution of the garden. The implementation of these five designs will reinforce the UBCBG as a key part of the university, and redefine it as a premier visitor experience.

7.0 REFERENCES

- Architen Landrell. (2013). *ETFE Foil: A Guide to Design*. Retrieved 10 20, 2013, from Architen Landrell: <http://www.architen.com/technical/articles/etfe-foil-a-guide-to-design>
- FIXR. (2011, 8 9). *10 Buildings Inspired by the Natural World*. Retrieved 11 5, 2013, from FIXR Visual Modelling: <http://www.visualremodeling.com/2009/11/08/10-buildings-inspired-by-the-natural-world/>
- Mak Max. (2010). *Membrane ETFE*. Retrieved 10 30, 2013, from MakMax: <http://www.makmax.com.au/membrane/etfe>
- Short, K. (2013, April 8). *Improving West 16th Avenue*. Retrieved October 29, 2013, from UBC (C+CP): <http://planning.ubc.ca/sites/planning.ubc.ca/files/attachments/W-16th-Improvements-Factsheet-in-Template-FINAL.pdf>
- Roess, R., Prassas, E., & McShane, W. (2004). *Traffic Engineering*. New Jersey: Pearson Prentice Hall.
- Ronca, D. (2008, May 28). *How Green Pavement Works*. Retrieved October 29, 2013, from HowStuffWorks: <http://science.howstuffworks.com/environmental/green-science/green-pavement2.htm>
- UBC, 2013., *Stormwater Quality at UBC*. Retrieved November 23, 2013, from <http://planning.ubc.ca/sites/planning.ubc.ca/files/documents/projects-consultations/consultations/Stormwater%20Quality%20at%20UBC%20Final%281%29.pdf>
- UBC, 2013., *Stormwater Management Infrastructure at UBC*, retrieved November 23, 2013, from <http://planning.ubc.ca/vancouver/projects-consultations/consultations-engagement/integrated-stormwater-management-plan>
- Lam, J., Chand, K., Shen, L., Mamorafshard, M., Hsieh, W., Lee, W., Wong, Y. (2012). *UBC Botanical Garden Stormwater Management Project*. Retrieved from <http://sustain.ubc.ca/courses-teaching/seeds/seeds-library>
- Grant, M., Hill, G., Holbrook, C., Lymburner, P., Mctavish, A., Sundby, A. (2002). *Water Management And Waste Water Treatment At The University of British Columbia: Study for Sustainable Alternatives*. Retrieved from <http://sustain.ubc.ca/courses-teaching/seeds/seeds-library>
- UBC, 2013., *Campus+Community Planning*. Retrieved November 23, 2013, from http://www.planning.ubc.ca/vancouver_home/plans_and_policies/campus_planning.php.
- Andersen Corporation. *Glass Provides Clear Views With Energy Efficiency*. Retrieved November 20, 2013, from <http://www.andersenwindows.com/media/smartsun-glass-provides-clear-views-with-energy-efficiency/>.
- Poiraud, Patrick, and Mike Weinmaster. *Green Wall Benefits*. Retrieved November 13, 2013, from <http://greenovergrey.com/green-wall-benefits/overview.php>.