UBC Social Ecological Economic Development Studies (SEEDS) Student Report

UBC Botanical Garden
Development Plan

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UBC Botanical Garden Development Plan

CIVL 445 Engineering Design and Analysis I

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Executive Summary

West Coast Consulting has collaborated with the University of British Columbia and the UBC Botanical Garden to create a development plan that brings improvement to the garden and sustains the valuable asset that it is to the University.

Our vision for this development plan is to see the UBC Botanical Garden grow in its capacity to carry out its mission while undergoing incremental change to move towards fiscal sustainability. The UBC BG has been in deficit consistently in recent years, and requires infrastructural additions, new marketing strategies, and new direction to help it better fulfill its mission statement. However, these improvements must be accomplished while maintaining the identity of the UBC Botanical Garden as it currently stands.

The scope of this report is to present recommended conceptual improvements for the UBC Botanical Garden that attract a larger, more diverse demographic and make it a destination location. This will be accomplished through complimentary anchor points in multiple regions of the garden, enhancing visitor experience through improved accessibility and atmosphere, and by promoting interaction between community, research, horticulture, and education. This has come to fruition in the conceptual design of feasible, incremental improvements for the UBC BG that will be outlined in a three-phase development plan. The phases are as listed below:

Phase 1	*Phase 2*	*Phase 3*
Multipurpose Facility	Acer Fountain	Sound Walls
Pedestrian Crosswalk	Picnic Shelter	Improved Parking
Improved Signage		Pedestrian Overpass
		Observation Tower

The UBC Botanical Garden has several strengths; these include their research endeavors, collections, and educational programs, and the community involvement of a limited demographic. It also has several weaknesses that need to be addressed in order for the Garden to become more environmentally, economically, and socially sustainable. Our development plan is aimed at identifying and presenting feasible, practical solutions to these issues. The primary issues that have been identified include a lack of accessibility, infrastructure, atmosphere, marketing, and comprehensive community involvement. Of these, we will focus on accessibility, anchors, and atmosphere, as they are most aligned with the project's scope and will contribute to the fulfillment of our vision for the UBC Botanical Garden in a civil engineering context.

The projects that compose each phase were evaluated among multiple other projects based on a set of weighted criteria. A decision matrix was created and each idea given a rating that was used to place it in its appropriate phase. The components of these phases were chosen because they will improve the Garden's accessibility, infrastructure, and atmosphere, and set the UBC Botanical Garden on a path towards fiscal sustainability.

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1.0 INTRODUCTION

West Coast Consulting has created a Three-Phase Development Plan that targets three areas in which the UBC Botanical Garden requires growth to achieve fiscal sustainability. These facets of the Development Plan are Accessibility, Anchors, and Atmosphere. Each of these components is instrumental in achieving the vision that we have set forth for the Garden, and also in continuing to meet the UBC Botanical Garden's mandated mission statement. The graphic below displays how the chosen components of each phase will address the identified weaknesses of the Garden.

PHASE 1

1) Multipurpose Facility
2) Pedestrian Crosswalk
3) Improved Signage

PHASE 2

4) Acer Fountain
5) Picnic Shelter

PHASE 3

6) Sound Walls
7) Improved Parking
8) Observation Tower
9) Pedestrian Overpass

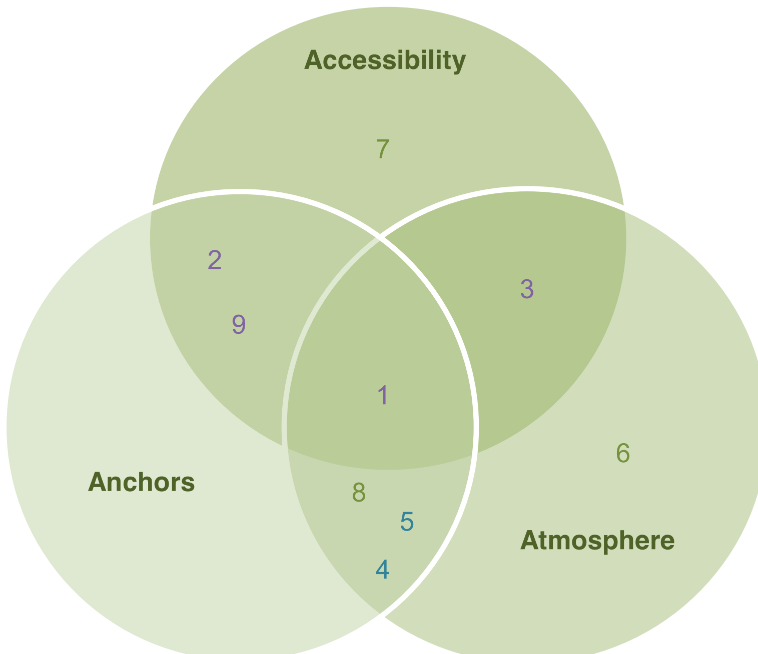

Figure 1: Phases and Components

1.1 Accessibility

Accessibility is a major concern that encompasses parking, garden access points, and travel between regions of the garden. This development plan proposes to reassess the garden's parking needs and proposes expansion of the existing parking lot. Currently, there is only one access point (entrance and exit) throughout the whole of the garden. This system has been re-evaluated to create a more visitor-friendly network into and throughout the garden. In addition, West Coast Consulting proposes installing an automated crosswalk across Southwest Marine Drive to address accessibility issues in Phase 1, and building a Pedestrian Overpass in Phase 3 to provide a more long-term solution for both internal and external accessibility.

1.2 Anchors

An important component of any park or garden is the distribution of anchors throughout the grounds to draw visitors to every region. The UBC BG lacks infrastructural anchors located in more remote regions of the garden. Each Phase contains one or two features that would serve as an anchor to draw visitors to currently unused regions. How each project will serve as an anchor will be discussed in detail throughout this development plan.

1.3 Atmosphere

The current atmosphere of the garden is not conducive to individual learning. Our proposal intends to develop an atmosphere that will encourage visitors to spend a whole day at the garden, by themselves or with their families, during which they can learn about the plant collections. Picnic shelters, food and beverage services, and better signage will enhance 'the garden experience' and encourage people to explore the whole of the gardens, ideally in all four seasons. Better site enclosure (i.e. sound walls) along the perimeter of the garden would also help promote the paradise atmosphere.

1.4 Phase Justification

Each Phase has been developed to address the areas that require improvement in a feasible, time-sensitive and cost-sensitive manner. Phase 1 targets all of the accessibility, infrastructure and atmosphere issues, and is financially viable. Phase 2 contains two anchors that will serve to draw more people to the garden once the accessibility issues have been addressed. Phase 3 will provide more permanent solutions to accessibility issues with parking improvement and a pedestrian overpass, and will subsequently focus on improving both the infrastructure and atmosphere of the garden with the addition of an observation tower. Together, these phases comprise a development plan that will draw more visitors to the garden and achieve the fiscal sustainability that is needed for this UBC treasure to grow and flourish.

2.0 BACKGROUND OF UBC BOTANICAL GARDEN

2.1 History

The UBC Botanical Garden & Centre for Plant Research has a very rich history spanning almost a century and is recognized as a world-leading research facility (UBC Botanical Garden and Centre of Plant Research, 2013). With an underlying commitment to promote biodiversity through education and research, it has continued to maintain a valuable component within the University and the community (UBC Botanical Garden and Centre of Plant Research, 2013).

The UBC Botanical Garden is Canada's oldest continuously operated university-based botanical garden with a footprint of approximately 78 acres (UBC Botanical Garden and Centre of Plant Research, 2013). It is made up of five major components: the Alpine, Asian, Food, Native, and Physic gardens. The garden was established in 1916 with only 900 species (Durante Kreuk Ltd, 2001).The garden's creator and first director was John Davidson (1878-1970) from Scotland, who was apprenticed to the university in 1893(Durante Kreuk Ltd, 2001). He was only given 0.8 hectares on the Colony Farm at Essondale in 1912, and acquired a collection of live native plants as a temporary botanical garden (UBC Botanical Garden a 1914, there were over 700 species in the temporary collection, and was later transferred to UBC in 1916 (UBC Botanical Garden and Centre of Plant Research, 2013). The whole relocation process took more than 6 months because of the garden's extensive collection (UBC Botanical Garden and Centre of Plant Research, 2013). More than 25,000 plants (about 900 species) were moved over 40 km from Essondale by trucks (UBC Botanical Garden and Centre of Plant Research, 2013). In 1925, the botanical garden became a significant teaching and research resource to the university, and further expansion were underway (Durante Kreuk Ltd, 2001). By the late 1930s, the garden consisted of the systematic beds, native arboretum, nursery, medical beds, rock garden, salicetum, various display areas and an aquatic garden (UBC Botanical Garden and Centre of Plant Research, 2013). Its collection includes British Columbia natives, willows, alpines, aquatics, and medicinal plants, as well as native and exotic trees in the campus arboretum (Durante Kreuk Ltd, 2001). In 1990, more major elements were added to the garden: the administration building, reception centre, shop, washrooms, lookout, and parking lot, which created the garden that you see today (Durante Kreuk Ltd, 2001).

Figure 2: UBC BG Logo

2.2 Issues Facing Botanical Gardens

Like all the other botanical gardens around the world, the UBC Botanical Garden is facing some serious challenges that may change its future landscape. The issues can be categorized into three different aspects: financial, operational, and physical. Table 1 below summarizes all the challenges into their respective category.

Financial	Operational	Physical
• Inadequate funding	• Insufficient staffing to maintain all garden areas	• Minimal on-site storage and treatment for storm water
• Lack of visitors	• Underutilizing university research and education programs	• Apparent sight and noise of traffic
• Inadequate donations	• Lack highlight and memorable experiences	• Entrance is highly visible
	• Lack of marketing staffs	• Poor pedestrian crossing of SW Marine Drive
	• Inefficient maintenance operation	• Poor signage for self-education
		• Limited parking space

Table 1: Challenges Facing the UBC Botanical Garden

3.0 DECISION PROCESS

The creation of this development plan and the stages within came about through a dynamic decision making process in which our team employed various strategies. The methodologies are explained below along with a detailed description of the most formal process used, a multi-criteria decision making matrix.

3.1 Methodology

The Methodologies employed by our team during the conceptual design process can be classified into four main categories: consensus building, command, consultation and voting.

A short description of the each of these methodologies is given below.

Consensus – talk until everyone agrees to one decision.
Command – decisions are made with no involvement.
Consult – invite input from others.
Vote – discuss options and then call for a vote.

The manner in which each of these 4 methodologies were employed will be explained below followed by a description of how the multi criteria decision making matrix helped to select the project components.

Consensus Building

Consensus was the primary methodology of decision-making used by the group. The two meetings during each week allowed for consensus to be reached for all major decisions. This proved to be very beneficial, as it allowed the team's diversity to be taken advantage of.

Commands

A commanding method was used in cases where an individual team member clearly had the strongest understanding of the topic at hand or when a task was delegated to a team member.

Consultation

In order to gain information and advice, our team consulted various internal and external professionals: client and owner representatives during the plenary sessions, and faculty of UBC department of Civil Engineering during the tutorials. The timeline of the consultation process resulted in modifications to the phasing order beyond what was establishing early on through the decision matrix.

Vote

Decisions that involve the most complicated matters were made through the use of multi-criteria decision-making matrix, a subtle type of voting method. Details of this matrix are presented below on page 6.

3.2 Decision Matrix

A multi criteria decision matrix was used in order to bring a degree of objectivity and simplification into the analysis and evaluation of the different ideas. First, a set of criteria for evaluation was generated followed by the relative weighting of each criterion. Next, each member of the team independently evaluated each idea and assigned a value of 0-5 for each criterion. The values were then discussed with a focus on outliers. Although over 15 ideas were evaluated, the decision matrix below shows only the top nine.

Criteria	Initial Cost	Ability to Construct	Feasibility	UBC Funding	Ability to Market	Vision & Scope	Net Profit
Weighting	*0.65*	*0.30*	*1.00*	*0.50*	*0.85*	*1.00*	*0.90*
Pedestrian Overpass	1.9	4.1	4.0	1.6	4.9	2.0	3.0
Lookout Tower	1.7	2.6	3.3	3.0	5.0	4.1	4.3
Multipurpose Facility	1.6	3.0	4.0	3.3	4.4	4.0	4.4
Fountain	3.6	3.4	4.1	2.4	4.1	3.5	3.0
Parking (Bike & Vehicle)	3.1	4.1	4.4	3.3	2.0	3.4	4.1
Crosswalk	4.7	4.9	4.5	3.4	2.3	4.0	3.0
Sound Walls	2.6	3.1	3.7	2.7	2.3	2.9	1.9
Signage	4.9	4.9	5.0	4.1	3.1	5.0	3.4
Picnic Shelter	3.7	4.4	3.9	2.9	2.0	2.0	1.7

Table 2: Decision Matrix

Results of the MCDM are summarized in Table 3.

Ranking	Final Score	Idea	Phase
1	22.4	Signage	1
2	19.4	Crosswalk	1
3	19.3	Multipurpose Facility	1
4	18.9	Lookout Tower	3
5	18.4	Fountain	2
6	18.2	Parking (bike & vehicle)	3
7	16.1	Pedestrian Overpass	3
8	14.3	Picnic Shelter	2
9	14.2	Sound Walls	3

Table 3: Summary of Decision Matrix Results

The priority with which each of the 9 components is implemented in the development plan generally follows the rankings generated through the decision matrix; however, there is some deviation. This deviation results from the order in which each method of decision-making was used. The decision matrix was employed during the initial stages of planning at which point the actual details of each idea had not been finalized. As the conceptual design neared completion, the consultation process finished up and a complete analysis of each idea was completed, the relative importance and benefit to the garden became clear. At this time, the final phases of the project were solidified.

4.0 THREE PHASE DEVELOPMENT PLAN

Applying the findings from the decision matrix, and fully complying with the scope and vision of this project, it has been determined that the most feasible approach would be to implement the development plan through three general phases.

A breakdown of the design components that have been assigned to each phase can be found in Table 4. In addition, the potential benefits and relevant civil engineering sub-disciplines associated with each design component are also shown in the table below.

Phase #	Proposed Design Component	Potential Benefits	Relevant Civil Engineering Sub-Discipline(s)
Phase 1	Multipurpose Facility	- Improved accessibility - Improved atmosphere - Acts as an anchor point - Can be used as a rental facility for additional revenue	- Structural Engineering - Project & Construction Management - Environmental Engineering
	Crosswalk/Pedestrian Overpass	- Improves accessibility by connecting the east and west portions of UBC Botanical Garden	- Transportation Engineering - Project & Construction Management
	Improved Signage	- Improves visitor experience by enabling self-directed learning and highlighting the garden's collections	N/A
Phase 2	Acer Fountain	- Acts as an anchor point that resembles one of UBC Botanical Garden's most valuable collections: the Acer Pentaphyllum - Improves UBC BG's marketability - Improves visitor experience by providing additional seats	- Hydrotechnical Engineering
	Picnic Shelter	- Improves visitor experience by providing additional seats - Acts as an anchor point in a less-traveled region - Can be used as a rental facility for additional revenue	- Structural Engineering - Geotechnical Engineering
Phase 3	Lookout Tower	- Acts as an anchor point - Improves UBC BG's marketability - Improves visitor experience by allowing visitors to view the gardens in a whole new way	- Structural Engineering - Geotechnical Engineering
	Parking Lot Improvements	- Improves accessibility - Enables UBC Botanical Garden to accommodate large events - Increases current parking capacity	- Transportation Engineering
	Sound Walls	- Improves visitor experience - Improves garden atmosphere	N/A

Table 4: Potential Benefits and Relevant Civil Engineering Disciplines

The following sections of this report provide an overview of the three-phase development plan, highlighting each component idea within the corresponding general phase.

4.1 Phase 1

Phase 1 of the conceptual development plan consists of three distinct yet complementary ideas: a multipurpose facility, a new crosswalk, and improved signage. An overview of the benefits of Phase 1 to the garden is given below.

Collectively, the three components of Phase 1 target the complete scope of the development plan: improving accessibility, adding anchors and improving atmosphere. The multipurpose facility is designed to improve accessibility, garden atmosphere and to act as an anchor. The improved crosswalk will mainly improve accessibility to the garden but will also be an anchor. The third component of Phase 1, improved signage, will improve visitor experience by enabling self-directed learning. A detailed description of each component of Phase 1 can be found in the following three subsections.

4.1.1 Multipurpose Facility

The development of a new multipurpose building was outlined to be one of the top priorities moving forward in the development of the UBC Botanical Gardens as it targets all three goals: improving accessibility, adding anchors, and improving atmosphere. The final building type, its features, and its location were chosen through a careful analysis of each possible use and impact on the community.

The site of the building is in the grassy field located next to the service yard. The features of the building are recommended to be: a new entrance and exit to the garden, a year-round café, a multipurpose room, and storage space.

Figure 3: Greenhouse, Café, Multipurpose Room and Storage Space

As shown above in Figure 3, the greenhouse extends into the service yard, cutting through the hedge surrounding the service yard. The greenhouse is also attached to the café showcasing a green roof. A detailed analysis of the building features and uses along with an analysis of the site selection are given below.

4.1.1.1 Scope

The UBC Botanical Gardens is a diverse and multidisciplinary entity, which serves many different purposes. Each of the many activities carried out at the Garden would benefit from having a dedicated space in the new multipurpose building. The most important possible uses of the building are described below and are as follows: New Entrance and Exit to the Garden, Café, Greenhouse, New Entrance/Exit, and Educational Facility.

New Entrance and Exit to the Garden

Accessibility to the Garden and its various features is a large problem with the current layout of the UBC Botanical Garden. The addition of a new entrance and exit point would encourage greater use of the garden. In particular, it provides a great opportunity to allow a looping experience for visitors of the Garden.

Café

The addition of a café to the features of the new multipurpose facility would serve multiple purposes. For instance, it would help offset the cost of additional staff required to regulate entering and exiting. In addition, the kitchen could be used by wedding caters to service weddings. More importantly, this café will attract new visitors to the Garden and help put the UBC Botanical Gardens on the map as an ideal place to visit.

Greenhouse

The proposed greenhouse could be either standalone or attached to the multipurpose space. Attaching the greenhouse to the multipurpose space would allow the public to view some of the rare plants with ease during the winter season.

Figure 4: Greenhouse

Educational Facility

A teaching space with sufficient seating capacity for between 30-60 students would be included in multipurpose facility either in the form of storable tables and chairs or in a permanent seating arrangement. The teacher or instructor would have a place to lead a lesson outside of the elements and then continue the lesson with a tour of the garden. The need for this space was identified through consultation with a UBC BG community and education outreach staff member.

4.1.1.2 Location

The selection of the site for the multipurpose facility involved the consideration of many different areas within the garden. The most important criteria in choosing an area for development was the potential impact of constructing the multipurpose facility on the existing garden space. Although many different sites were considered and analyzed, only the recommended site is described below.

The recommended location, which will hereby be referred to as the “grassy field”, borders Stadium Road, in the east section of the garden. It is located between the service yard and the access building dedicated for the Hospice Care Center across the street.

This location is recommended by West Coast Consulting because the development of the multipurpose facility at this location would involve minimal destruction or require minimal relocation of any valuable collections.

Service Yard Expansions
This empty field is a convenient location for any expansion of the service yard. This could be achieved by moving the existing greenhouse into the grassy field to allow for more space for operations. Alternatively, a new greenhouse could be added.

Tied into the Thunderbird Stadium
Since it will be located next to the Thunderbird Stadium, the development of the multipurpose facility would help to improve UBC Botanical Garden's marketability. It would be a convenient spot for athletes and spectators to grab a coffee or snack before or after games/events at the Thunderbird Stadium.

Benefits to Roseline Sturdy Amphitheater
The recommended site would encourage the use of the Roseline Sturdy amphitheatre due to its proximity. Space in the multipurpose building could be allocated for storage of equipment that will be used for events at the Amphitheatre. Consequently, the proposed multipurpose facility enables the amphitheatre to become a more attractive space to hold events.

Figure 5: St. John Hospice

Partnership with UBC St. John Hospice
The site located next to the new St. John Hospice would be a convenient location for the addition of extra space that can be included in the multipurpose facility.

4.1.1.3 Cost
RS Means Square Foot cost estimate data (published in 2010) was used to determine a cost estimate for the proposed multipurpose facility. In order to determine the total project cost per square foot that

corresponds to the actual sizes of the greenhouse and cafeteria, the RS Means cost per square foot (S.F.) must be adjusted based on the Cost Modifier curve shown in Appendix B. Upon determining the cost multiplier, the estimated total project cost per square foot can be calculated by multiplying the unadjusted median cost per S.F. by the corresponding cost multiplier. Finally, the total cost is adjusted with time and location factors. A breakdown of the cost estimate for the multipurpose facility can be found in Table 5.

Cost Estimate for Multipurpose Facility					
Component	**Median Cost per S.F. ($)**	**Cost Multiplier (based on RS Means Cost Modifier Curve)**	**Actual Area (S.F.)**	**Adjusted Cost per S.F. ($)**	**Cost**
Greenhouse	$198.00	1.10	1240	$217.80	$270,072.00
Cafeteria	$172.00	1.10	1510	$189.20	$285,692.00
Subtotal					$555,764.00
Contingency (15%)					$83,364.60
Total Cost (unadjusted)					$639,128.60
Time Factor (see Appendix A)					1.140
Location Factor					1.066
Total Cost (adjusted with Time and Location Factors)					**$776,694.64**

Table 5: Multipurpose Facility Cost Estimate Overview Table

4.1.2 Crosswalk

4.1.2.1 Crosswalk Upgrades

A feasible solution to improve the safety for pedestrians and cyclists crossing South West Marine Drive at Stadium Road would be an upgrade of the existing enhanced marked (Category C) crosswalk to an activated flashing (Category D) crosswalk, or even to a pedestrian signal (see Figure 6). The proposed upgrades must meet the crosswalk warrant criteria outlined within the Pedestrian Crossing Manual for British Columbia. Upgrades of the marked pedestrian crosswalks are warranted when certain thresholds are met (BC MoT, 1994). A brief overview of the BC crosswalk warrant procedure is provided in Appendix D.

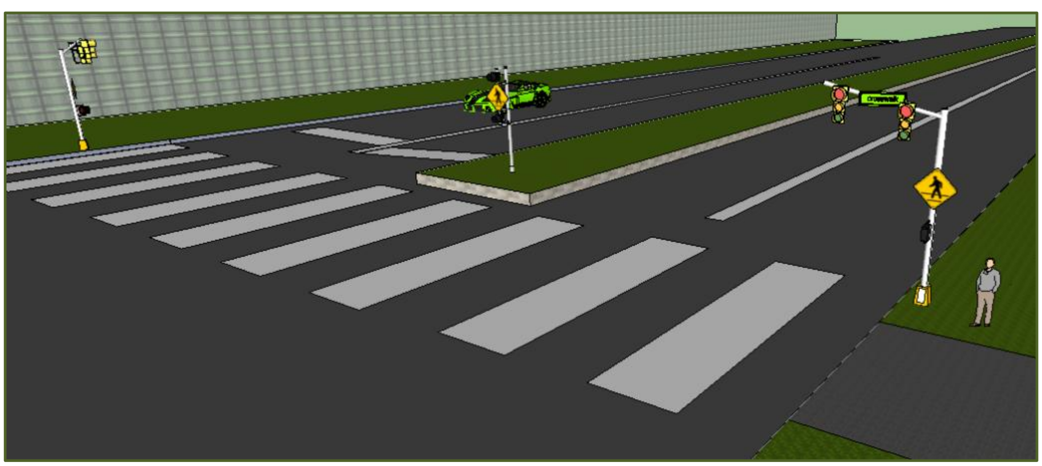

Figure 6: Conceptual Design of Pedestrian Crosswalk

The current vehicle and pedestrian traffic volume is insufficient to meet the required crosswalk warrant criteria for immediate upgrade of the existing marked pedestrian crosswalk to Category D, as explained in Appendix D. However, by incrementally implementing the projects included in this report, an increased visitor volume to the UBC Botanical Garden is anticipated. The resulting increase in attendance will increase both the pedestrian and vehicle traffic volume. With this in mind, it is projected that the required upgrade thresholds will be met in 3 to 6 years from the beginning of the first phase of this development plan. If the crosswalk upgrades are warranted, the BC Ministry of Transportation will be responsible for covering all expenses.

4.1.2.2 Aesthetical Features

Consideration of adding aesthetic pavement markings in the vicinity of the existing crosswalk on South West Marine Drive at Stadium Road would have significant marketing effects among all road users. The installation of such pavement markings is expected to be approved by the BC Ministry of Transportation, as long as the aesthetic features satisfy the crosswalk pavement markings criteria outlined in the Canadian Manual of Uniform Traffic Control Devices.

Highlighting the community characteristics by using visually appealing pavement markings has already been applied in several Lower Mainland locations as a very effective promotional and marketing method. One example is the rainbow crosswalk installed by the City of Vancouver at the intersection of Davie St. and Bute, Downtown Vancouver (Figure 7). Once this crosswalk has been painted, it became the main topic in both local and global news.

Figure 7: Rainbow Crosswalk - Davie at Bute Street, Downtown Vancouver

Similarly, painting visually appealing themes from the UBC BG on the pavement of SW Marine Dr. between Stadium Rd and Old Marine Dr. would have a significant marketing effect. The estimated cost for applying thermoplastic paint on the road is $10,000 to $20,000.

4.1.2.3 Pedestrian Overpass

Design of a new cycling and pedestrian overpass for crossing South West Marine Drive in the vicinity of the existing marked pedestrian crosswalk near Stadium Road would significantly improve the overall safety and accessibility of the Botanical Garden. Additionally, an architecturally well-designed overpass would have an efficient marketing effect by attracting the attention of all road users traveling along SW Marine Drive.

These types of overpasses promote the sustainable modes of transportation, cycling and walking, which fully complies with the UBC Transportation Planning Strategy (University of British Columbia, 2013). The Tynehead Cycling and Pedestrian Overpass in Surrey, British Columbia, is an example of successful promotion of cycling and walking modes of transport in the Fraser Heights area since 2011 (Figure 8).

Figure 8: Tynehead Overpass, Surrey, BC

Similar to the Surrey's Tynehead Regional Park in the period before 2011, South West Marine Drive in the vicinity of the UBC Botanical Garden is currently a dark and secluded area at night. As has already been implemented with the Tynehead Overpass, the entire area near the Garden's entrances can be converted into an enjoyable place during the nights by applying visually appealing effects from properly designed lighting along the new overpass (Figure 9).

Figure 9: Tynehead Overpass at Night

Estimated cost for cycling and pedestrian overpasses with a span of about 100 metres in British Columbia is within the range of \$1 to \$7 million (City of Surrey, 2010). However, typically the design and construction expenses for pedestrian overpasses are shared among several stakeholders. For instance, the total cost for Tynehead Cycling and Pedestrian Overpass was \$6.78 million, but was funded by one third of each of the three governmental partners – the Federal, the Provincial, and the Municipal Government (City of Surrey, 2011). Considering the complexity of the funding, design, and construction of overpasses, it is estimated that the completion of this project would take 5 to 10 years from the beginning of implementation of the projects suggested with this report.

The following figures illustrate a conceptual design of a pedestrian and cycling overpass designed for crossing South West Marine Drive:

Figure 10: Conceptual Design of the Overpass East View

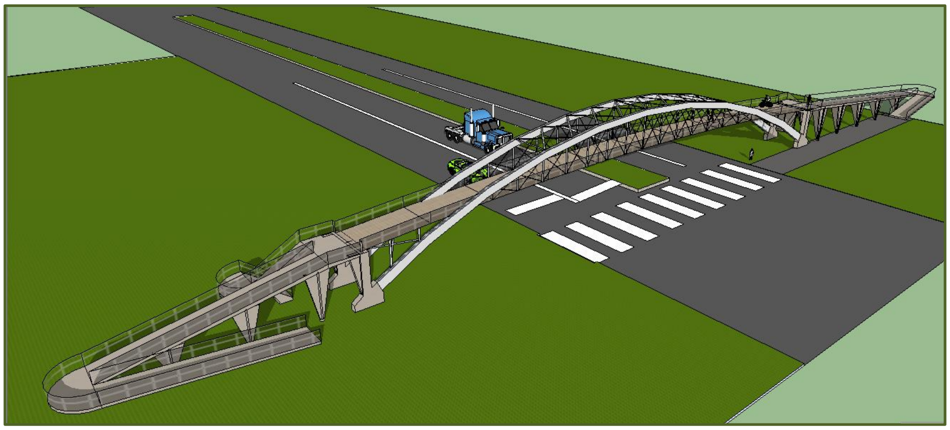

Figure 11: Conceptual Design of the Overpass West View

The overall cost of the proposed pedestrian overpass is estimated to be about $2,000,000.

4.1.3 Improved Signage

4.1.3.1 Scope and Vision

The identity of the UBC Botanical Garden as a global treasure is perhaps one of UBC's best-kept secrets, even when one is within the heart of this treasure itself. The UBC BG prides itself on its collections, and part of its mission statement is to maintain these for the purposes of education, community outreach and public display.

The greatest strength of the garden's collection is muted when not properly displayed. There is a severe lack of clear and informative signage within the garden that allows an average visitor to appreciate the rarity and beauty of the collections it holds. This inhibits the garden from fulfilling its missions of education and public display fully.

It is recommended that the current signage of the garden be augmented with improved, more substantial signage that will highlight the rare species and help patrons learn about the plants and collections without the need for a guided tour.

4.1.3.2 Current Signage

The current signs within the UBC Botanical Garden, where existent, include the following information about plants:

- Genus
- Species
- Family
- Common name
- Garden of origin
- Identification number

Figure 12: Current UBC BG Signage

These components, while important, do not catch the interest of the average person. They also do little to help a person understand the nature of each plant and why it might be found in a botanical garden. In addition, the existing signs are very small and can be difficult to locate due to inconsistent placement.

4.1.3.3 Recommendations

It is recommended that lecterns be placed along the pathway in regions with collections of a particularly rare or important nature. In order to maintain the aesthetics of the garden, these lecterns can be made of timber or recycled plastic with the appearance of wood. These recycled plastic lecterns (Figure 13) would align with UBC's vision of sustainability. Additional options would be to incorporate audio and digital/touchscreen technology into the new signage that would allow for the transfer of a greater quantity of information. These could be incorporated into the implementation of a self-guided tour.

Figure 13: Recycled Plastic Lectern

Characteristics to place on the new signs in addition to the existing information include:

- Level of endangerment
- Plant's native regions
- Life cycle information
  - Fruit/flower
  - Season(s) of growth
- Interesting/fun fact about the plant
- Preferred climate
- Method to identify the plant

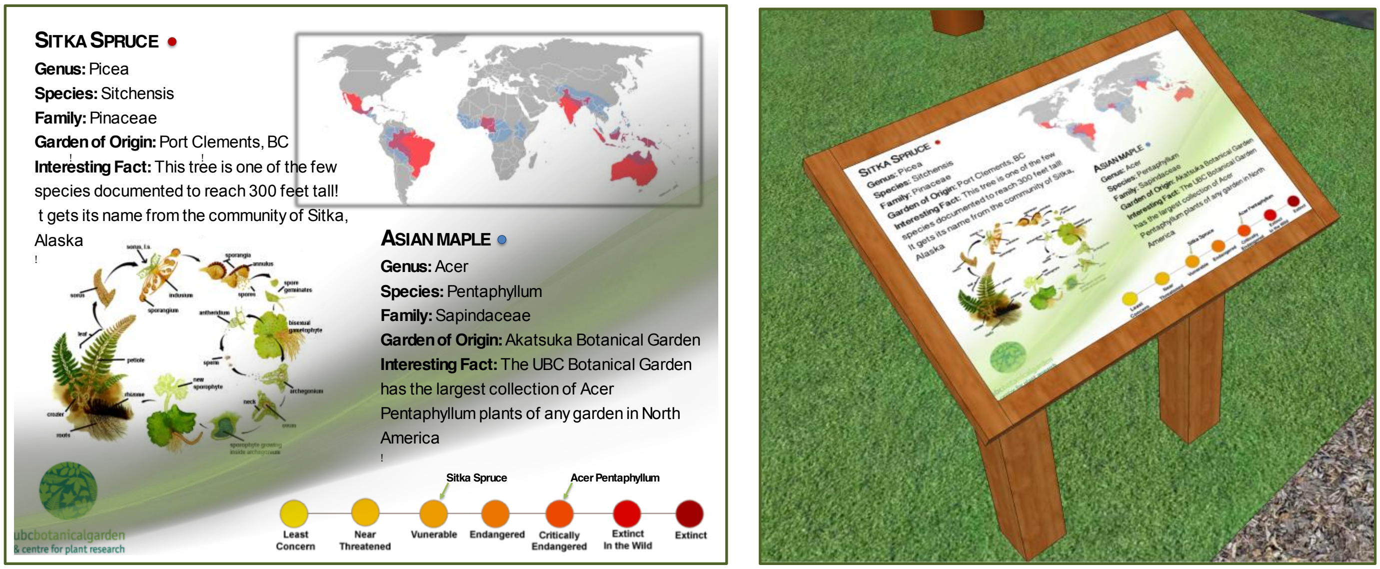

Figure 14: New Signage Design

4.1.3.4 Cost Analysis

The cost of lecterns (including installation and maintenance) varies widely, and depends on the inclusion of digital or audio components. An approximate initial cost analysis is provided below (Fitzpatrick Woolmer, 2010):

	Cost per unit	
Lectern	Lower Bound	Upper Bound
Wooden	$50.00	$200.00
Recycled Plastic	$500.00	$1,000.00
Audio-enabled	$800.00	$1,500.00
Digital	$1,000.00	$3,000.00

Table 6: Lecterns Cost Analysis Table

4.2 Phase 2

Phase two of the proposed development plan consists of two design components that aim to attract a more diverse audience by serving as complementary anchor points and improving visitor experience. The benefits, features, conceptual design, and recommended location for each design component are presented in the following sub-sections of the report.

4.2.1 Acer Fountain

4.2.1.1 Scope

The Acer Fountain is a water feature designed in the shape of a leaf from the Garden's rare Acer Pentaphyllum trees. It holds a two-fold purpose in its design – these are to serve as an anchor point in the northern half of the garden, and to highlight one of the Botanical Garden's most valuable collections. These will address the UBC BG's issues of atmosphere and, in a sense, signage, as the fountain will serve as an advertisement for the existence of the Acer collection.

If possible, the fountain will contain a plant of its namesake in its centre, gaining further exposure for this rare species. The individual parts of the leaf will also serve as a seating area and a location for congregation, eating, and events. A potential component to add into this project would be stormwater storage, as each of the petals could serve as basins if dug deeper below the fountain's base.

Figure 15: The Acer Fountain - Isometric View

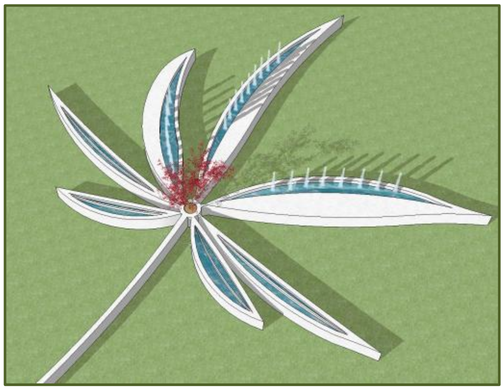

Figure 16: The Acer Fountain - Plan View

4.2.1.2 Location

Ideally, the fountain would be located in the northern half of the garden in the field adjacent to the Garden Pavilion. This is an empty area that is not utilized to its full capacity. There are existing water lines running through the space, and it would be a relatively simple matter to connect and supply the fountain with water.

This location would be advantageous because weddings are often hosted in the Garden Pavilion. The fountain would serve as further incentive to hold events in this area, since its aesthetically pleasing nature would be a central point for photos. Also, it would serve as a seating area for wedding guests and attendees of other events in the Pavilion.

4.2.1.3 Cost

Cost for the fountain from design to completion will likely range from $300,000 to $500,000, and will depend on final size, required earth and waterworks during construction, and the inclusion of additional features such as those found on the Martha Piper Plaza fountain (lights, signage, and seating).

4.2.2 Picnic Shelter

4.2.2.1 Scope

As part of our mission to attract a more diverse audience, the installation of a picnic shelter is an essential component of the proposed three-phase development plan that aims to improve visitor experience at the UBC Botanical Gardens. In addition to existing benches in the garden, the proposed sheltered picnic area offers an ideal location that could be used by visitors and large tour groups to take a break, stay dry during rainy days, and admire the beauty of the surrounding garden collections. Picnic shelters can also be used as rental space for families and companies. For instance, Metro Vancouver's picnic shelter in Belcarra Regional Park is considered to be suitable for family/corporate picnics and can be reserved for a rental fee of $65 on weekdays and $130 on weekends/holidays (Metro Vancouver, 2011). With this in mind, the proposed picnic shelter can serve the dual purpose of being a public area for improved visitor experience and being a rental space for additional revenue.

Figure 17: Metro Vancouver's Picnic Shelter in Belcarra Regional Park

4.2.2.2 Features

The proposed picnic shelter will consist of seven 6' X 5' tables and a 10' X 10' storage area. This facility will have a seating capacity of 42 people. The storage area can be used to store equipment such as garbage bags, charcoal, and barbecue grills. Consequently, this will provide UBC Botanical Gardens with the option of adding extra fees for usage of the storage area. A conceptual design of the picnic shelter is illustrated in Figure 18.

Figure 18: Proposed Picnic Shelter

4.2.2.3 Location

After evaluating the suitability of potential locations in the garden, West Coast Consulting's recommended location for the picnic shelter is the Meyer Glade. If the picnic shelter is built in the Meyer Glade, it can be used by visitors to take a break before or after tours of the Greenheart Canopy Walkway. More importantly, the Meyer Glade is one of the areas in the garden that can be developed without displacing valuable collections. Additionally, it will result in the addition of a rental outdoor facility in the east end of the botanical garden. The location of the proposed picnic shelter is illustrated in Figures 19 and 20.

Figure 19: Recommended Location of the Proposed Picnic Shelter

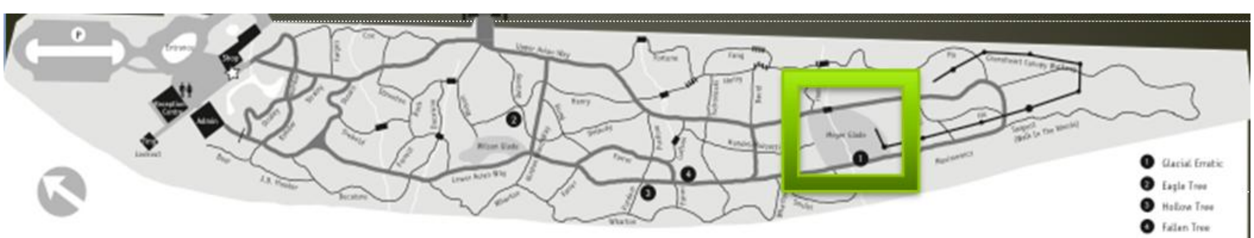

Figure 20: Recommended Location of the Proposed Picnic Shelter (Plan View)

4.2.2.4 Cost

Cost estimate data for similar picnic shelters that were built in the past is used to determine a cost estimate for the proposed picnic shelter. In addition to the constructing the picnic shelter, picnic tables and barbecue grills also need to be purchased. A breakdown of the cost estimate for the picnic shelter can be found in Table 7.

Item	Area S.F.	Quantity	Unit	Unit Cost	Cost
Picnic Shelter with Storage Area (25' X 40')	1000	1	each	$80,000.00	$80,000.00
Picnic Tables (5' X 6')	280	7	each	$500.00	$3,500.00
Barbecue Grills	N/A	7	each	$200.00	$1,400.00
Concrete Pavement for Shelter	1000	1000	S.F.	$4.00	$4,000.00
Subtotal					$88,900.00
Contingency (15%)					$13,335.00
Total Cost (unadjusted)					$102,235.00
Time Factor (see Appendix A)					1.140
Location Factor					1.066
Total Cost (adjusted with Time and Location Factors)					**$124,240.06**

Table 7: Cost Estimate for Proposed Picnic Shelter

4.3 Phase 3

Phase three of this development plan targets the three main goals of this development plan: creating innovative anchor points around the garden, improving accessibility to the garden, and improving the overall atmosphere of the garden. West Coast Consulting proposes the following three ideas to meet these goals.

4.3.1 Lookout Tower

To create an innovative anchor point for the UBC Botanical Garden, we propose to build a tree-based lookout tower in the eastern side of the garden.

4.3.1.1 Scope

In order to increase attendance and fully utilize the garden's resources, it is important to create anchor points throughout the UBC Botanical Garden. These anchor points will provide locations for visitors to travel to when visiting the garden and will direct them to different sections of the garden that they may not have discovered without the anchor point.

One of the main anchor points proposed in this report is a lookout tower that visitors can use to view the gardens in a whole new way. West Coast Consulting proposes to build the lookout tower three stories up in a tree. This will avoid the use of large metallic or concrete structures that would distract visitors from the garden. Constructing the lookout tower in a tree will provide a natural look for the structure that will blend into the garden's theme. A conceptual design of the lookout tower can be seen below.

Figure 21: Lookout Tower Conceptual Design

West Coast Consulting recommends the use of stand-in-place binoculars in the lookout tower to provide visitors with the chance to see the garden in a new way. We also recommend placing large map directories in the lookout tower to highlight sections of the garden for the visitors' benefit. In addition, the lookout tower can be used to attract UBC students into the garden. For example, art students could use this structure as a location for painting landscapes.

4.3.1.2 Location

The lookout tower will be situated in a tree on the west side of the gardens. It will overlook the food gardens and the lawns that host the wedding receptions. The exact location of the lookout tower can be seen below.

Figure 22: Lookout Tower Location

4.3.1.3 Cost

To estimate the cost of the lookout tower, we compared our design to previously completed projects. Tree Top Builders estimated a similar project to be between $35,000 and $55,000 US dollars (Wright, 2013). Considering our project will serve the public and require a higher level of detail than the estimate provided by Tree Top Builders we used the upper bound limit of $55,000. After converting this estimate to Canadian dollars ($58,000) we then multiplied it by three factors: a UBC/Botanical Garden factor (1.5), a height factor (1.5), and a size factor (1.5). A summary of our cost estimate can be seen below.

Cost Estimate				
Initial Cost Estimate	UBC/Botanical Garden Factor	Height Factor	Size Factor	Total Cost Estimate
$58,000	1.5	1.5	1.5	$200,000

Table 8: Lookout Tower Cost Estimate

The UBC/Botanical Garden factor exists because projects built on the UBC campus always require a higher estimate than other typical locations. This is partly due to it being more difficult to transport materials on the UBC campus (or specifically, the Botanical Garden) and the requirement that sections of the garden cannot be closed down to facilitate an easier construction. The height and size factors are used due to the fact that the proposed lookout tower will be placed higher up in a tree (three stories) and will be moderately larger than the Tree Top Builders project.

4.3.2 Parking Lot Improvements

With the anticipated increase in visitor attendance, the current parking capacity of 77 passenger car units (PCU) is anticipated to be insufficient. West Coast Consulting recommends redeveloping the existing parking lot to increase vehicle capacity and accessibility to the garden. Since one of UBC's policies opposes the development of new parking areas, the only feasible solution would be to increase the parking capacity of the current parking facility by modifying the existing configuration. Following the principle of incremental change, the required modifications are suggested to be performed in two stages. The design of the parking capacity improvements provided below has been created in compliance with the standards and requirements outlined by the Institute of Transportation Engineers (ITE) within the Traffic Engineering Handbook and the Manual of Transportation Engineering Studies. The construction process required for parking modifications would have negligible effects on the garden's operations – the proximity of the existing parking lot to the main arterial road provides convenient access for both the equipment and the labour, and no impact on the garden's collections is anticipated. The entire cost is evaluated to be about $30,000. After completion of both stages, the parking capacity will be over 150 PCUs.

4.3.2.1 Stage 1

Stage 1 would be implemented within the first 3 years of the project. This stage would involve removal of the existing median from the central location of the north parkade. Consequently, the area of the median can be converted into effective parking space. Also, the effective parking area can be maximized by modifying the current configuration of parking spots. For instance, one possible approach that would provide about 30 additional PCUs is designating parallel parking and one way traffic flow, as presented with Figure 23.

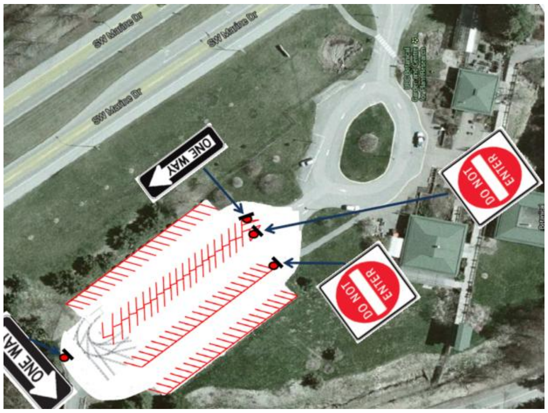

Figure 23: Parking Improvements - Stage 1

4.3.2.2 Stage 2

Stage 2 is to be implemented after the north improved parkade is found to be insufficient due to the increased number of visitors. It is projected that such circumstances would occur within the 3 to 6 years from the starting date of the Botanical Garden development plan. During this stage, the traffic circle located in the north parkade would be removed, and the entire south area would be converted into effective parking spots by increasing the parking capacity for additional 50 PCUs (Figure 24).

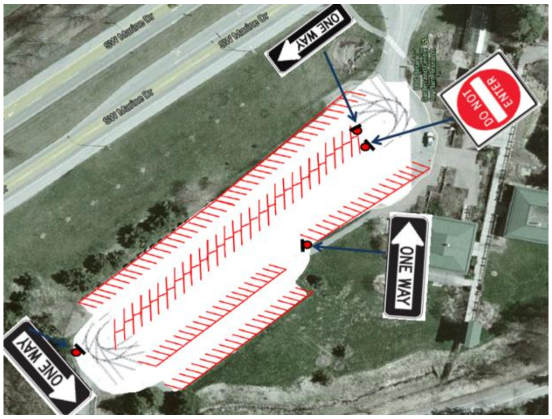

Figure 24: Parking Improvements - Stage 2

The figure below shows a conceptual design of the improved parking lot at the UBC Botanical Garden.

Figure 25: Conceptual Design of the Improved Parking Lot at the UBC BG

4.3.2.3 Biking Parking Improvement

An improvement on the current parking lot will help ease the inadequate parking space issues, but additional bike parking facilities are also needed to accommodate future rider demands. From observation, biking is the main alternative transportation method used on campus for most students and university staffs. Implementing extra bike parking around the garden can provide a secure and dry environment for daily visiting bikers and also further promote sustainable transportation. A conceptual design of the proposed bike shelter is shown in Figure 26.

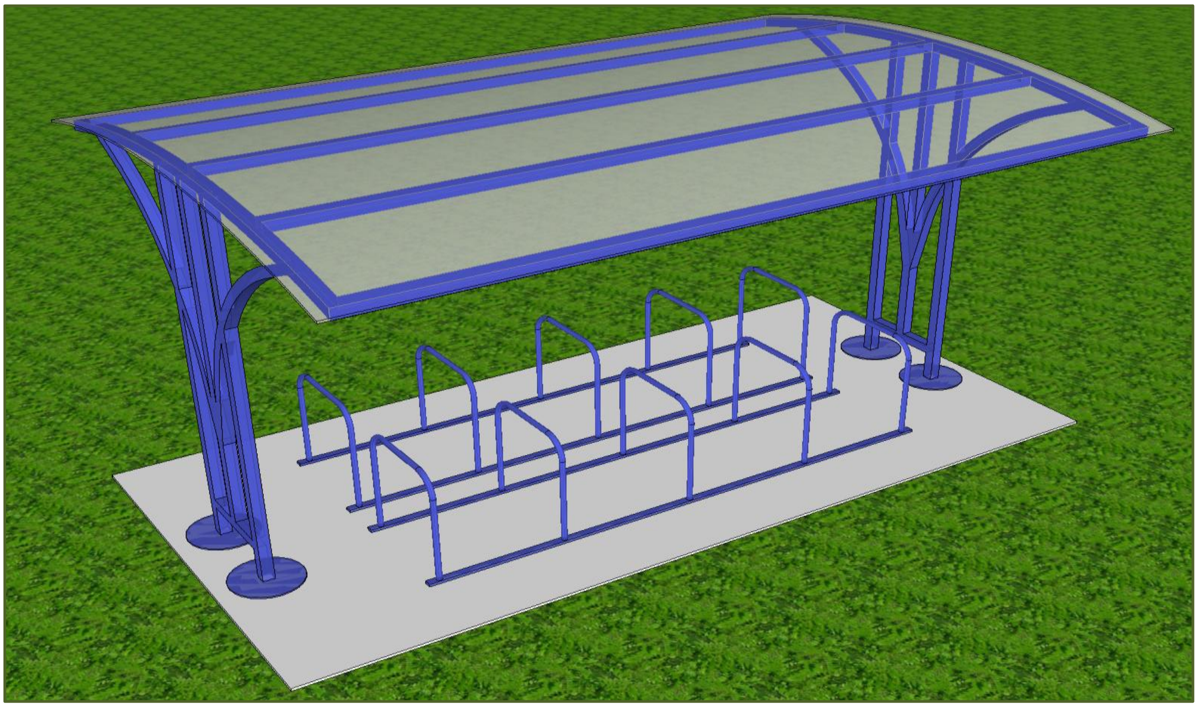

Figure 26: Conceptual Design of the Proposed Bike Shelter

The cost of the proposed bike shelter may vary depending on its size and preinstalled components. An initial cost estimate for different variations of bike parking is summarized below (Table 9):

Variations	Cost per unit
Durable Steel Bike Storage Shelter by Global Industry	$1500
Aero Cycle Shelter by Glasdon	$1700
Bi Store Cycle Shelter by Glasdon	$2500

Table 9: Bike Parking Improvement Cost Estimate

4.3.3 Sound Walls

West Coast Consulting proposes to construct sound walls around the UBC Botanical Garden to improve the atmosphere.

4.3.3.1 Scope

Enhancing the atmosphere of the UBC Botanical Garden is a top priority of our scope. To do so, we propose to build sound walls along the edges of the botanical garden that border South West Marine Drive. Sound walls will reduce the noise pollution from South West Marine Drive that distracts visitors as they tour the gardens.

Noise from traffic can be reduced by blocking the line of site from the receiver to the source with noise barriers (City of Vancouver, n.d.). Typical noise barriers consist of noise walls, berms, or a combination of berms and noise walls. The height of the sound barriers plays a key role in determining the amount of noise reduction a sound barrier is capable of. Whereas a major downside of sound walls is that they can rarely be built high enough for multi-storey buildings, sound walls would be perfect for a setting such as the botanical garden that doesn’t have any tall buildings. Sound walls built on the west side of South Marine Drive also benefit from the tall slopes that divide the botanical gardens from the road. Walls of roughly two meters in height would suffice to block the line of site from the gardens to the road. Sound would also be absorbed into the slope which will increase the effectiveness of the sound walls on the west side. Sound walls typically increase their effectiveness on long properties such as the UBC Botanical Garden (City of Vancouver, n.d.).

One downside of the sound walls that needs to be evaluated is the shade that is created from the walls. The shade created by tall noise barriers may impact the lawns and gardens nearby.

4.3.3.2 Design Recommendations

The sound walls that we recommend to use are the AcoustiGuard Sound Barrier Absorption Walls (Silent Protector). The Silent Protector walls consist of a PVC absorptive sound barrier wall system with acoustic mineral wool. The Silent Protector walls have received a Noise Reduction Coefficient (NRC) of 1.0 (AcoustiGuard, n.d.) on a scale of zero to one (one being the most absorptive material). The main ability of the Silent Protector walls is absorbing sound by reducing the sound energy that would typically bounce back towards the source.

One main advantage of the AcoustiGuard Sound Walls is their lightweight and easy to install designs. The walls are also impervious to rain, snow, ice and sleet which is a large contributing factor when designing sound walls in Vancouver. AcoustiGuard walls are also wind tested up to 140 mph and require no maintenance (AcoustiGuard, n.d.). Having durable sound walls is important to reduce maintenance costs that would otherwise be required in the future. The installation process can be seen in the figure below.

Figure 27: AcoustiGuard Sound Wall

4.3.3.3 Location

The sound walls will provide a barrier between the UBC Botanical Garden and South West Marine Drive. On the west end of the garden, the sound wall will wrap around the property starting on Stadium Rd, running along South West Marine Drive, and finishing on 16th Avenue. On the west side of the garden, the sound walls will stretch from Old Marine Drive to the 16th Avenue intersection. The exact location of the sound walls can be seen in the figure below.

Figure 28: Highlighted Location of Sound Walls

4.3.3.3 Cost Estimate

The cost estimate supplied by AcoustiGuard is summarized in the table below.

Cost Estimate per Section (2m high x 3m long)	
Vinyl Sound Wall	$1,072.00
Steel Post	$400.00
Installation	$390.00
Total Cost	$1862.00

Table 10: Sound Walls Cost Estimate

The required total length of the sound walls for the UBC Botanical Garden is roughly 1400 meters. This produces a total cost of roughly $870,000.00.

5.0 IMPLEMENTATION

The implementation of this development plan will take place over an extended period of time. We propose to implement this plan over the next ten years with each phase being constructed in roughly three year segments.

5.1 Sequence

We propose that the three phases of this project will be constructed sequentially in the order outlined in this development plan (starting with the multi-purpose facility and ending with the sound walls). The sequence proposed originated from the decision matrix summarized in Section 3.1 and 3.2.

The projects involved in this development plan are not constricted to any specific order. Since each individual project is designed as a stand-alone structure that does not depend on the other projects, the client may choose to construct these projects in a different sequence.

5.2 Cost Overview

Although this development plan is conceptual, it is important to operate with realistic cost expectations. The cost of each individual project will ultimately decide whether or not the project will be constructed. Keeping this in mind, the following table summarizes the cost estimates of each component of the proposed development plan.

Three Phase Development Plan - Cost Estimate	
Phase 1	
Multipurpose Facility	$776,695.00
Crosswalk	$20,000.00
Improved Signage	$20,000.00
Phase 1 Total	**$816,695.00**
Phase 2	
Acer Fountain	$500,000.00
Picnic Shelter	$124,240.00
Phase 2 Total	**$624,240.00**
Phase 3	
Lookout Tower	$200,000.00
Parking Upgrades	$37,500.00
Pedestrian Overpass	$2,000,000.00
Sound Walls	$870,000.00
Phase Three Total	**$3,107,500.00**
TOTAL PROJECT ESTIMATE	**$4,548,435.00**

Table 11: Total Project Cost Estimate

As shown in Table 13, the total cost estimates for Phase 1, Phase 2, and Phase 3 are roughly 0.8, 0.6, and 3.1 million dollars respectively. The total cost of our development plan is roughly 4.5 million dollars. We believe that these estimates lie within realistic cost parameters. Each phase can be implemented as financing for the development of the UBC Botanical Garden becomes available.

6.0 CONCLUSION

The three-phase development plan proposed by West Coast Consulting is compatible with UBC Botanical Garden's mission statement and enables UBC BG to attract a more diverse audience. Upon analyzing the existing garden functions and identifying areas that could potentially be improved, West Coast Consulting has determined that the development plan should primarily aim to address the issues generated by a lack of accessibility, infrastructure, atmosphere, marketing, and comprehensive community involvement. In order to address these issues effectively, the recommended design components of the proposed development plan are intended to incorporate complementary anchor points to the garden, improve accessibility, improve atmosphere, and enhance overall visitor experience.

After developing and analyzing various design components, a multi-criteria decision-making matrix (MCDM) has been prepared by West Coast Consulting in order to rank each project based on numerous criteria. Although the proposed sequence of the design components is not solely based on the results of the MCDM, the relative rankings suggested by the MCDM were used to assign each design component to a certain phase of the proposed development plan. Based on the economic analysis performed by West Coast Consulting, the design components of the proposed development plan can be implemented for an expected total cost of $4,548,435.00.

In conclusion, although the total costs of the entire development plan are quite high, the nature of the phasing, and the ability to separate components within a phase allow for a much more affordable approach to development, one which will allow the UBC Botanical Gardens to move towards improved fiscal sustainability.

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Appendix A: Calculation of Time Factor Associated with RS Means Data

Step 1: Solve for the escalation rate (r) using the equation shown below. Note the cost index for Jan. 2010 is used because the cost estimate is based on data obtained from RS Means 2010.

Given: m (from January 2010 to November 2013) = 47 months (inclusive)

Cost Index: I (Jan. 2010) = I_b = 8660

Cost Index: I (Nov. 2013) = I_c = 9666.46

$$r = [\ (\frac{I_c}{I_b})^{\frac{1}{m}} - 1\ ] * 100\% = [(\frac{9666.46}{8660})^{\frac{1}{47}} - 1\ ] * 100\%$$

➔ r = 0.234%

Step 2: Assume that construction will take place in July 2014. Solve for Cost Index in July 2013 (I_c) using the equation shown below.

Given: m (from Nov. 2013 to July 2014) = 9 months (inclusive)

Cost Index: I (Nov. 2013) = I_b = 9666.46

r = 0.234% (based on calculation in step 1)

$$r = [\ (\frac{I_c}{I_b})^{\frac{1}{m}} - 1\ ] * 100\%;\ 0.234 = (\ \frac{Ic}{9666.46}^{\frac{1}{9}} - 1\ ) * 100\%$$

➔ Cost Index in July 2014 (I_c) = 9872.13

Step 3: Solve for the Time Factor using the equation shown below.

Given: Cost Index in July 2014 = 9872.13

Cost Index in Jan. 2010 = 8660

$$\text{Time Factor} = \frac{\text{Cost Index in July 2014}}{\text{Cost Index in Jan. 2010}} = \frac{9872.13}{8660}$$

➔ Time Factor = 1.140

Appendix B: RS Means Square Foot Cost Estimate Data (2010)

Square Foot Costs | **RK1010-050 Project Size Modifier**

RK1010-050 Square Foot Project Size Modifier

One factor that affects the S.F. cost of a particular building is the size. In general, for buildings built to the same specifications in the same locality, the larger building will have the lower S.F. cost. This is due mainly to the decreasing contribution of the exterior walls plus the economy of scale usually achievable in larger buildings. The Area Conversion Scale shown below will give a factor to convert costs for the typical size building to an adjusted cost for the particular project.

The Square Foot Base Size lists the median costs, most typical project size in our accumulated data, and the range in size of the projects.

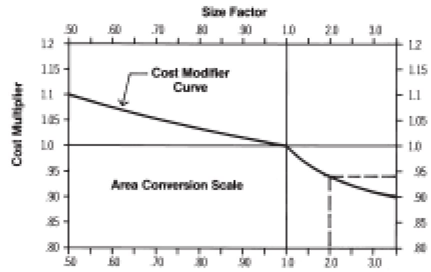
The Size Factor for your project is determined by dividing your project area in S.F. by the typical project size for the particular Building Type. With this factor, enter the Area Conversion Scale at the appropriate Size Factor and determine the appropriate cost multiplier for your building size.

Example: Determine the cost per S.F. for a 100,000 S.F. mid-rise apartment building.

$$\frac{\text{Proposed building area} = 100{,}000 \text{ S.F.}}{\text{Typical size from below} = 50{,}000 \text{ S.F.}} = 2.00$$

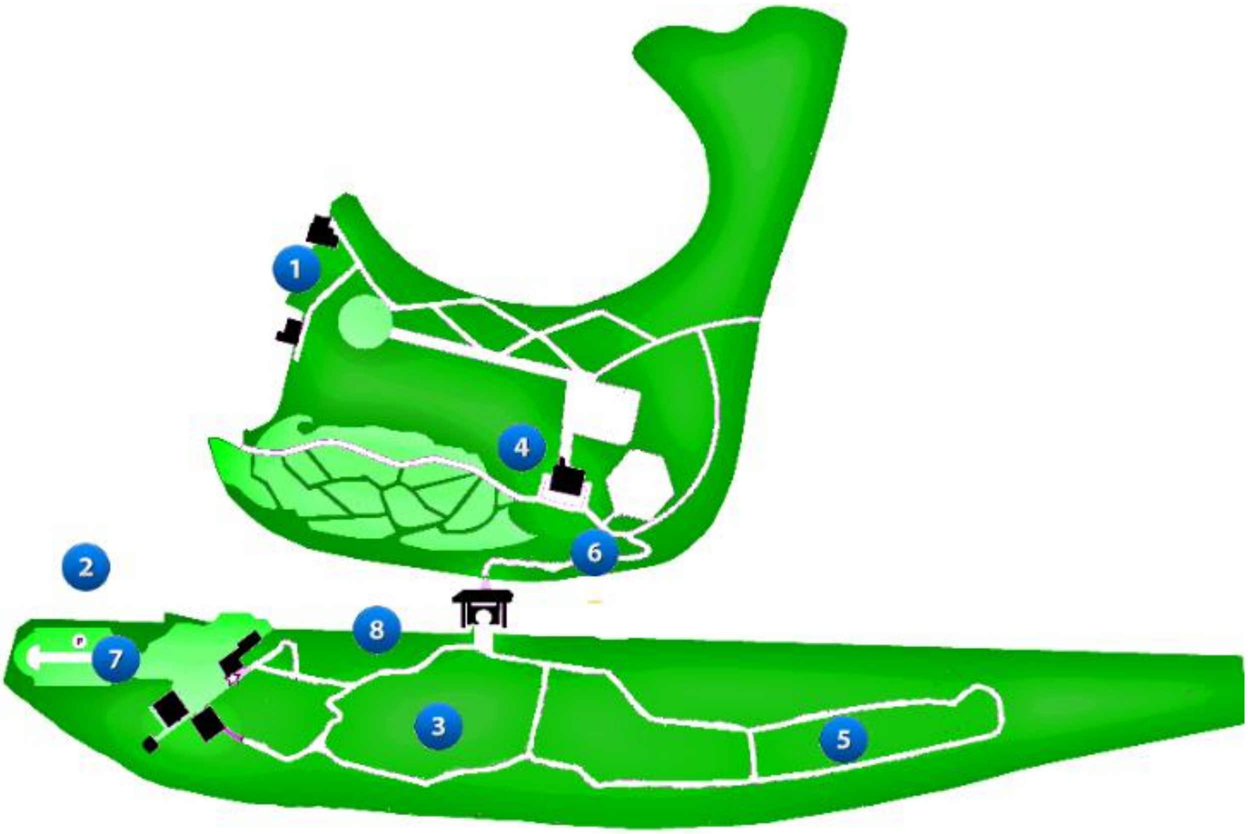
Enter Area Conversion scale at 2.0, intersect curve, read horizontally the appropriate cost multiplier of .94. Size adjusted cost becomes .94 x \$107.00 = \$101.00 based on national average costs.

Note: For Size Factors less than .50, the Cost Multiplier is 1.1
For Size Factors greater than 3.5, the Cost Multiplier is .90



Square Foot Base Size							
Building Type	**Median Cost per S.F.**	**Typical Size Gross S.F.**	**Typical Range Gross S.F.**	**Building Type**	**Median Cost per S.F.**	**Typical Size Gross S.F.**	**Typical Range Gross S.F.**
Apartments, Low-Rise	$ 84.50	21,000	9,700 - 37,200	Jails	$ 257.00	40,000	5,500 - 145,000
Apartments, Mid-Rise	107.00	50,000	32,000 - 100,000	Libraries	161.00	12,000	7,000 - 31,000
Apartments, High-Rise	116.00	145,000	95,000 - 600,000	Living, Assisted	137.00	32,300	23,500 - 50,300
Auditoriums	141.00	25,000	7,600 - 39,000	Medical Clinics	146.00	7,200	4,200 - 15,700
Auto Sales	105.00	20,000	10,800 - 28,600	Medical Offices	138.00	6,000	4,000 - 15,000
Banks	189.00	4,200	2,500 - 7,500	Motels	102.00	40,000	15,800 - 120,000
Churches	130.00	17,000	2,000 - 42,000	Nursing Homes	142.00	23,000	15,000 - 37,000
Clubs, Country	132.00	6,500	4,500 - 15,000	Offices, Low-Rise	120.00	20,000	5,000 - 80,000
Clubs, Social	126.00	10,000	6,000 - 13,500	Offices, Mid-Rise	119.00	120,000	20,000 - 300,000
Clubs, YMCA	143.00	28,300	12,800 - 39,400	Offices, High-Rise	152.00	260,000	120,000 - 800,000
Colleges (Class)	152.00	50,000	15,000 - 150,000	Police Stations	190.00	10,500	4,000 - 19,000
Colleges (Science Lab)	242.00	45,600	16,600 - 80,000	Post Offices	141.00	12,400	6,800 - 30,000
College (Student Union)	179.00	33,400	16,000 - 85,000	Power Plants	1000.00	7,500	1,000 - 20,000
Community Center	134.00	9,400	5,300 - 16,700	Religious Education	120.00	9,000	6,000 - 12,000
Courthouses	180.00	32,400	17,800 - 106,000	Research	198.00	19,000	6,300 - 45,000
Dept. Stores	78.50	90,000	44,000 - 122,000	Restaurants	172.00	4,400	2,800 - 6,000
Dormitories, Low-Rise	143.00	25,000	10,000 - 95,000	Retail Stores	84.00	7,200	4,000 - 17,600
Dormitories, Mid-Rise	176.00	85,000	20,000 - 200,000	Schools, Elementary	125.00	41,000	24,500 - 55,000
Factories	76.50	26,400	12,900 - 50,000	Schools, Jr. High	129.00	92,000	52,000 - 119,000
Fire Stations	139.00	5,800	4,000 - 8,700	Schools, Sr. High	133.00	101,000	50,500 - 175,000
Fraternity Houses	131.00	12,500	8,200 - 14,800	Schools, Vocational	128.00	37,000	20,500 - 82,000
Funeral Homes	146.00	10,000	4,000 - 20,000	Sports Arenas	103.00	15,000	5,000 - 40,000
Garages, Commercial	93.50	9,300	5,000 - 13,600	Supermarkets	83.00	44,000	12,000 - 60,000
Garages, Municipal	119.00	8,300	4,500 - 12,600	Swimming Pools	194.00	20,000	10,000 - 32,000
Garages, Parking	50.50	163,000	76,400 - 225,300	Telephone Exchange	225.00	4,500	1,200 - 10,600
Gymnasiums	129.00	19,200	11,600 - 41,000	Theaters	120.00	10,500	8,800 - 17,500
Hospitals	228.00	55,000	27,200 - 125,000	Town Halls	137.00	10,800	4,800 - 23,400
House (Elderly)	115.00	37,000	21,000 - 66,000	Warehouses	60.00	25,000	8,000 - 72,000
Housing (Public)	106.00	36,000	14,400 - 74,400	Warehouse & Office	66.00	25,000	8,000 - 72,000
Ice Rinks	153.00	29,000	27,200 - 33,600				

Appendix C: Location of Design Components



Designated Symbols for Design Components shown above:

#1 – Multipurpose Facility

#2 – Crosswalk Upgrades / Pedestrian Overpass

#3 - Signage

#4 – Acer Fountain

#5 – Picnic Shelter

#6 – Lookout Tower

#7 – Parking Improvements

#8 – Sound Walls

Appendix D: Crosswalk Warrant Procedure

Since the opposing traffic on SW Marine Dr. is divided by median, analysis for crossing 3 lanes per direction should be conducted. The empirically developed curves for Metro Vancouver area are used for evaluation of the number of crossing opportunities per hour, from the two way traffic volume (Figure D-1).

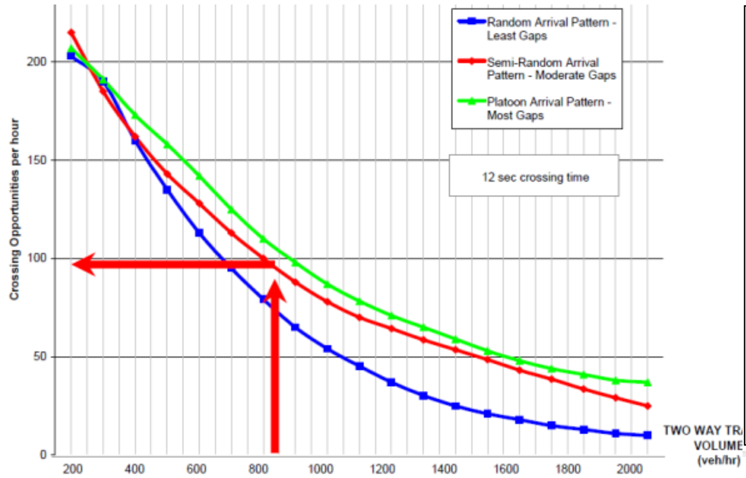


Figure D-1: Metro Vancouver Empirical Curves

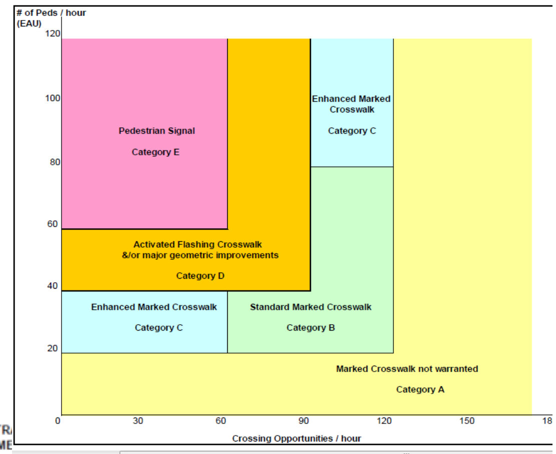


Figure D-2: Crossing Opportunities vs. EAUs

During the busiest hour, 40 to 60 equivalent to adult units (EAUs) pedestrians need to attempt crossing South West Marine Drive. The number of EAUs is combined with previously determined number of crossing opportunities per hour, and from the plot shown on Figure D-2 is determined the warranted crosswalk category. It should be noted that if the number of EAUs per hour exceeds 60, then installation of a pedestrian signal is warranted (Figure 6).