East Mall Redesign between Agronomy Road and W16th Avenue

Prepared by: Deepinder Bajwa, Ray Han, Johnson Hu, Thomson Mai, Bastien Moy, Kyle Tam

Prepared for:

Course Code: CIVL 446

University of British Columbia

Date: 16 April 2021

Disclaimer: “UBC SEEDS Sustainability Program 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 research project 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 Sustainability Program representative about the current status of the subject matter of a report.”
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EXECUTIVE SUMMARY

Our team has been retained by UBC Social Economic Development Studies (UBC SEEDS) to redesign East Mall between Stadium Road and Agronomy Road in attempt to better accommodate sustainable transportation modes. The corridor’s current conditions do not accommodate the high amount of pick-up/drop-off traffic during the evenings, and do not promote sustainable modes of transportation.

This report will provide and in-depth review for the detailed design of the transportation, structural, municipal, and environmental disciplines. Our recommended concept involves shifting the existing median East to separate vehicle travel lanes and bike lanes, reconfiguring the intersection of Thunderbird Boulevard and East Mall and upgrading the existing signal, and widening the segment from Thunderbird Boulevard to Agronomy Road to accommodate a new bi-directional bike lane. This design will improve the safety of cyclists, provide an abundance of green space for pedestrians, and reduce conflicts between vehicles and cyclists at drop-off pick-up zones while retaining parking for residents and users of the nearby facilities.

An assessment of the existing utilities was conducted to identify impacts on the existing utility networks. The proposed reconfiguration is not expected to affect the system demands the water distribution and sanitary sewer systems. A stormwater management strategy has been developed on site, and the final corridor reduces the captured stormwater volumes within the project area. Specifications for the new permeable concrete cycling lanes and sidewalks have been developed, including an aggregate reservoir base to detain major storm flows for natural infiltration into the subgrade.

The new pedestrian canopy consists of W200x31 section profiles for the columns and cantilevers with tempered glass panels mounted as the decking. The structure is 66.86-metres in length and will be constructed along the South side of Agronomy Road.

The greenspace consists of the plantation of several new tree species to further improve the aesthetic of the corridor. Additionally, the greenspace has a community garden composed of various flowers to encourage people to gather and enjoy the surrounding landscape hence building the community.

Estimated budget for the proposed solution will be $5,163,449 which includes labour, materials, operation & maintenance and a 15% contingency. Construction work will begin on May 2021 with a completion date of December 2021 with a duration of around 9 months.
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1. **INTRODUCTION**

Our team has been retained by UBC Social Ecological Economic Development Studies (SEEDS) to redesign East Mall between Stadium Road and Agronomy Road. This section will introduce the project site and the project scope. Our team member contributions are provided below.

*Table 1: Team member contributions to the Design Report*

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Contributions To</th>
<th>Review and Edited By</th>
</tr>
</thead>
</table>
| Johnson Hu       | • Report formatter and editor  
• Detailed design and analysis of pedestrian canopy  
• Canopy drawings  
• Canopy construction specifications | • Final Design Report  
• Municipal design and calculations  
• Cost estimate and schedule  
• Greenspace design |
| Bastien Moy      | • Design Objectives and Key Issues  
• Road Configuration  
• Roadway design  
• Signage plan | • Final Design Report  
• Risk analysis  
• Existing and future traffic condition analysis  
• Greenway design |
| Ray Han          | • Utilities review  
• Utilities design and calculations  
• Drawing formatting  
• Utilities drawings  
• Service life maintenance plan  
• Cross-section drawings | • Final Design Report  
• Detailed design and analysis of pedestrian canopy  
• Cost estimate and schedule  
• Road configuration |
| Kyle Tam         | • Cost estimate & schedule  
• Risk Analysis  
• Revised plan view drawings  
• Traffic Management Plan Drawings  
• Plan view details | • Final Design Report  
• Utilities design  
• Synchro modelling  
• Stakeholder engagement |
| Deepinder Bajwa  | • Stakeholder engagement  
• Service life maintenance plan  
• Greenway design | • Final Design Report  
• Canopy site preparation requirements  
• Construction sequencing  
• Traffic management plan |
| Thomson Mai      | • Existing traffic condition analysis  
• Future traffic volume growths  
• Synchro modelling  
• Greenway design | • Final Design Report  
• Final drawing package  
• Signage plan  
• Service life maintenance plan |
1.1. **SITE OVERVIEW**

Located on the University Endowment Lands, East Mall runs parallel to Westbrook Mall and is an important point of access for the UBC campus and bears a high volume of traffic on a day-to-day basis. It is a wide road with a large median strip separating single travel lanes. From 16th Avenue to Agronomy Road, East Mall contains two shuttle bus stops, a street bike lane, and a generous amount of curb side parking that also serves as a pick-up/drop-off zone to numerous sports fields and recreation centres. The current design poses several issues including speeding, cyclist safety, overdemand for curb side parking, pedestrian crossing safety, and lack of usable green space. Figure 1 and Figure 2 below show the current conditions and project site location.

![Figure 1: East Mall](image1)
![Figure 2: Project Location](image2)

1.2. **PROJECT SCOPE**

The scope of work for this project consists of client required objectives as identified below. This report will address each objective and provide some insight on the design process, including calculations, technical drawings, and construction specifications. A summary of the major components of this project are:

1. Upgrade the existing East Mall corridor to promote sustainable modes of transportation and incorporate traffic calming measures to reduce travel speeds

2. Improve liveability along the corridor by reducing the possibility of vehicle conflicts with pick-up/drop-offs, pedestrians, and cyclists

3. Minimize impacts to the existing utility networks and prepare a stormwater management strategy aligned with UBC’s sustainability initiatives
4. Incorporate a pedestrian canopy along Agronomy Road that prioritizes comfort, safety, campus aesthetics, and cost

5. Prepare a Class A cost estimate and detailed construction schedule

1.3. **STAKEHOLDER MANAGEMENT**

A stakeholder study has been completed to ensure the project accounts for all requirements. Our team identified the relevant stakeholders, developing a consulting plan, and reviewing feedback. Table 2 outlines the relevant stakeholders and their importance to the project.

*Table 2: Stakeholder Identification*

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Association to the project</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBC Social, Ecological, Economic Development</td>
<td>The client</td>
</tr>
<tr>
<td>Studies (SEEDS)</td>
<td></td>
</tr>
<tr>
<td>UBC Students, Faculty, and Staff</td>
<td>Primary users of the corridor and pedestrian canopy</td>
</tr>
<tr>
<td>Ministry of Transportation and Infrastructure</td>
<td>Governs transportation policies within BC</td>
</tr>
<tr>
<td>TransLink</td>
<td>Provides transit services along and nearby the corridor</td>
</tr>
<tr>
<td>UBC Water &amp; Energy Services</td>
<td>Major utility owners within the corridor</td>
</tr>
<tr>
<td>Musqueam First Nations</td>
<td>Are the traditional, ancestral habitants of the territory</td>
</tr>
<tr>
<td>UBC Neighbourhood Association</td>
<td>Residents that live near the construction project</td>
</tr>
<tr>
<td>UBC Properties Trust</td>
<td>Manage the lands adjacent to the corridor</td>
</tr>
</tbody>
</table>

The feedback provided by the stakeholders was critical to establishing an effective final design. Contact has been established with each of the stakeholder to gather information regarding their issues and concerns.

Based on the feedback our team received from stakeholders, our team is confident that the project will receive full support during construction. We will continue to reach out to our identified stakeholders before, during and after construction and address any issues that arise.
2. **KEY DESIGN COMPONENTS**

During the design phase of this project, our team utilized a number of engineering standards, specifications, and software. The table below outlines them organized by project discipline.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Standard / Code Used</th>
<th>Software Packages Used</th>
</tr>
</thead>
</table>
| **Transportation** | • BC Active Transportation Design Guide  
 • TAC Geometric Design Guide for Canadian Roads  
 • City of Vancouver Engineering Design Manual | • Synchro 10  
 • AutoCAD  
 • Civil 3D |
| **Structural**  | • CSA A23.3-14  
 • CSA S16-19  
 • NBC 2015 | • S-Frame  
 • S-Steel  
 • AutoCAD |
| **Utilities**   | • City of Vancouver Engineering Design Manual  
 • City of Surrey Design  
 • UBC Integrated Stormwater Management Plan  
 • UBC Utilities Technical Guidelines  
 • UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds | • Civil 3D |
| **Greenspace**  | • UBC Exterior Improvements Technical Guidelines | • Bluebeam Revu |
| **Construction** | • BC Traffic Management Manual for Work on Roadways 2015 | • AutoCAD  
 • Bluebeam Revu |

2.1. **DESIGN CONCEPT**

*Figure 3: Streetmix cross section of our East Mall Design*
Our redesign of East Mall features a full reconstruction of the boulevard. The main feature of this configuration is the shifting of the existing median to the east side of East Mall and moving all the vehicle travel lanes to the west side. Additionally, new traffic calming measures will also be implemented along East Mall to reduce the speed of traffic. This new location of the median will improve the safety of pedestrians and cyclists as it creates a natural separation from the vehicular traffic. Improved access to this area also adds a variety of land use options, and will function as a greenspace featuring new landscaping and space for community garden boxes or public art. A new pedestrian canopy will also be constructed along Agronomy Road and provide shelter for bystanders. A stormwater management strategy has also been prepared centred around the use of permeable pavement for new cycling paths and sidewalks.

Table 4: Summary of design objectives and features

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Design Objective</th>
<th>Design Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>• Encourage use of active transportation modes</td>
<td>• New 4.0m bi-directional greenway</td>
</tr>
<tr>
<td></td>
<td>• Reduce speeding along East Mall</td>
<td>• Reduced travel lane widths</td>
</tr>
<tr>
<td></td>
<td>• Reduce vehicle – cyclist conflicts at pick-up drop – off zones</td>
<td>• Dedicated drop off pick zones with no parking at any time</td>
</tr>
<tr>
<td></td>
<td>• Retain ease of access for current residents</td>
<td>• Retains parking on both sides of the road</td>
</tr>
<tr>
<td>Structural</td>
<td>• Encourage walking along Agronomy Rd. by implementing a pedestrian canopy</td>
<td>• Spans the full width of sidewalk</td>
</tr>
<tr>
<td></td>
<td>• Comfortable and safe to use</td>
<td>• Design was inspired from existing UBC bus loop to fit campus architecture</td>
</tr>
<tr>
<td></td>
<td>• Cost considerations</td>
<td>• All structural components are the same size and thickness in order to save cost</td>
</tr>
<tr>
<td></td>
<td>• Fit with campus architecture</td>
<td></td>
</tr>
<tr>
<td>Utilities</td>
<td>• Ensure post-development demands on UBC utility networks are within pre-developement levels</td>
<td>• Reduce travel lane widths and introduce permeable concrete sidewalks and cycling lanes</td>
</tr>
<tr>
<td></td>
<td>• Capture and keep stormwater on-site wherever possible</td>
<td>• Provide stormwater detention reservoir in aggregate base of permeable concrete</td>
</tr>
<tr>
<td>Greenspace</td>
<td>• Encourages active modes of transportation</td>
<td>• Planation of new tree species long median</td>
</tr>
<tr>
<td></td>
<td>• Creates a barrier from vehicle traffic increasing safety of users</td>
<td>• Community gardens at various points throughout median</td>
</tr>
<tr>
<td></td>
<td>• Minimize demand on UBC distribution networks and capture stormwater on-site</td>
<td>• Use absorbent topsoil in landscaped areas to promote infiltration</td>
</tr>
<tr>
<td>Construction</td>
<td>• Minimize disturbances to surrounding residents</td>
<td>• Existing utilities will remain in place and in-service during construction</td>
</tr>
</tbody>
</table>
3. **TRANSPORTATION DESIGN**

This section will describe the design considerations relating to the roadway including roadway dimensions, intersections upgrades, and signage plans.

3.1. **ROADWAY DESIGN**

Roadway design was done in accordance with the Geometric Design Guide for Canadian Roads, written by the Transportation Association of Canada (TAC), Engineering Design Manual from the City of Vancouver, as well as the British Columbia Active Transportation Design Guide. Key requirements include: all roadways to have a minimum crossfall of 2.0%, minimum vehicle travel lane width must be 3.25m or greater, grade of proposed alignment must not exceed 10%, and minimum sidewalk widths of 1.8m. Other factors considered in the detailed design include sightline requirements, driver comfort for sag and crest curves, as well as signal timing plans for the proposed signal upgrades at the intersection of East Mall and Thunderbird Boulevard. Software packages utilized in roadway design include AutoCAD and Civil 3D, and intersection analysis and timing plans were done with the aid of Synchro 6. Traffic signs were designed in accordance to the Manual of Traffic Signs and Pavement Markings from the British Columbia Ministry of Transportation and Highways.

3.1.1. **ROADWAY CROSS SECTIONS**

Roadway cross sections for the newly designed East Mall segment must meet the requirements set out in section 410 in the TAC Geometric Design Guide for Canadian roads. In the proposed design, travel lane widths are set to be 3.30m wide, which satisfies the 3.25m minimum lane width for road segments with a design speed between 50km/h to 70km/h. Roadway crossfall in the design is 2.5%, which satisfies the TAC requirement of having a crossfall of 2% or greater, which is needed in order to provide adequate drainage for the road surface. 2.5% crossfall was chosen in consideration with the climate of the area which experiences high amounts of annual precipitation, and the higher crossfall will assist in facilitating drainage. Existing parking is retained in the new design with 2.4m parking lanes on both sides of the road. 2.4m was chosen to balance the goal of keeping vehicle speeds down on the segment by reducing the amount of space available to drivers, while providing enough room for parked vehicles. Sidewalk widths for the new segment are designed to be a minimum of 1.8m throughout the segment. 1.8m provides enough space for pedestrians to feel comfortable, safe, and allows for movement in both directions. A good sidewalk network is vital in encouraging more users to choose active transportation modes such as walking or cycling. Lastly, the multi-
use pathway in the design is 4.0m, surpassing the required 2.7m as required by the British Columbia Active Transportation Guide (BCATG). A wide facility provides users more space to travel on the corridor and encourages more users to make trips with modes like cycling, walking, skateboarding, and rollerblading safely and comfortably. Having good a greenway network is also beneficial for the UBC campus as it allows for better accessibility for the future Stadium development, which is projected to add thousands of units of occupancy.

Table 5: TAC Geometric Design Guide – Roadway Width Requirements

<table>
<thead>
<tr>
<th>Design Speed (km/h)</th>
<th>Lane Width (m)</th>
<th>Unpaved (m)</th>
<th>Normal X-Fall (m/m)</th>
<th>Fill Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADTT&gt;15(3)</td>
<td>ADTT&lt;15(3)</td>
<td>Shoulder</td>
<td></td>
</tr>
<tr>
<td>80 - 90</td>
<td>3.6</td>
<td>3.5</td>
<td>0.5</td>
<td>0.02</td>
</tr>
<tr>
<td>50 - 60 - 70(5)</td>
<td>3.5</td>
<td>3.25(4)</td>
<td>0.5</td>
<td>0.02</td>
</tr>
<tr>
<td>30 - 40(5)</td>
<td>3.25(4)</td>
<td>3.25(4)</td>
<td>0.5</td>
<td>0.02</td>
</tr>
</tbody>
</table>

3.1.2. ROADWAY PROFILE

The roadway profile was also designed to meet the requirements set out in the TAC Geometric Design Guide. Key requirements for the profile of the roadway include grade requirements and sightline requirements. The roadway profile primarily depends on the existing natural topography of the area, which is mostly flat. Hence the proposed roadway will largely overlap with the existing roadway profile and does not contain large elevation changes, with the biggest grade change at 4%, which is below the 10% maximum grade requirement outlined in the TAC Geometric Design Guide. When designing the roadway profile, sightline distances were also taken into consideration in order to satisfy the 65m sight distance for a roadway with a design speed of 50km/h. The length of the crests and sags were also calculated in accordance with best practices currently used in North America. Crest and sag lengths are important to rider comfort as well as stopping distances. Sample calculations can be found in the attached Appendix C. The figure below showcases the roadway profile of the proposed design.
3.2. **THUNDERBIRD BOULEVARD AND EAST MALL**

East Mall runs parallel to Westbrook Mall and Marine Drive and is one of the few roads that run North-South on the UBC Campus, providing key connections to locations such as the Health Sciences Parkade and Thunderbird Stadium. A traffic analysis on the intersection of Thunderbird Boulevard and East Mall will be provided in detail throughout this section.

3.2.1. **EXISTING CONDITIONS AND ISSUES**

Currently, the intersection of Thunderbird Boulevard and East Mall is controlled by an existing pre-timed signal. The intersection services around 800 vehicles in the AM peak period and around 1150 vehicles in the PM peak. A majority of the vehicle traffic in the AM period are vehicles heading northbound into the campus, while in the PM period most vehicles are heading south and leaving the campus. The existing configuration is as follows: The South, West, and North approaches all have one receiving and departing lane, while the East approach has one receiving lane and two departing lanes, one dedicated to a left turn movement and the other for through and right movements. The intersection also sees high pedestrian volumes, with around 300 crossings in both the AM peak and PM peak periods. Cyclist volumes should also be accounted, as there are
around 130 cyclists in both the AM and PM peak periods. The following figure shows the vehicle volumes serviced by the intersection:

![Vehicle Volumes Diagram](image)

*Figure 5: Existing Vehicle Volumes at intersection of Thunderbird Boulevard and East Mall*

As shown in Figure 5, there are many vehicles making the westbound-left movement in the PM peak period, and the current traffic signal is not capable of providing a protected left turn movement for those motorists and is a bottleneck in the system.

### 3.2.2. Proposed Design Changes at Thunderbird Blvd and East Mall

To better facilitate pedestrian and cyclist movements, it is proposed that vehicle travel lanes on the North approach to be moved to the west side of East Mall, allowing the existing northbound lane to be converted into a dedicated bi-direction bicycle lane with bollards acting as a barrier to vehicle traffic. The goal behind this design is to prioritize active transportation modes and provide additional capacity for cyclists and pedestrians. Having dedicated conflict paint will provide users of the greenway a safer experience crossing the intersection by making drivers more aware. A bi-directional bicycle lane makes full use of the existing road space and encourages drivers to slow down due to having less buffer space. The proposed design also includes a full
signal upgrade on the intersection to allow for protected westbound left turn movements in the PM peak period to alleviate total intersection delays. To accommodate this, induction loops are to be installed on the westbound left turning bay on the East approach. Section 3.2.3 will discuss the rationale behind this upgrade and provide additional analysis and justification. The figure below highlights the proposed changes to the intersection.

![Figure 6: Proposed Design at Thunderbird Boulevard and East Mall](image)

### 3.2.3. Synchro Analysis

Intersection performance analysis at Thunderbird Boulevard and East Mall was performed using Synchro. The performance of the intersection with the addition of a protected westbound left movement was compared to the existing conditions. The results from the Synchro model showed that in the AM peak period, having a protected westbound left phase decreased the performance of the intersection due to the low volumes. Therefore, it is recommended that the AM peak period retain its current timing configuration. However, in the PM peak period, having a dedicated phase for vehicles making the westbound left movement decreases the delay from an estimated 43 seconds to 22 seconds while maintaining the same overall intersection delay. The
results from the Synchro analysis are shown in the table below. A sample Synchro report can be found in Appendix I.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Intersection LOS</th>
<th>Intersection Delays</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing Signal</td>
<td>Upgraded Signal</td>
</tr>
<tr>
<td></td>
<td>AM</td>
<td>PM</td>
</tr>
<tr>
<td>EBL</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>EBT</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>EBR</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>WBL</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>WBT</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>WBR</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>NBL</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>NBT</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>NBR</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>SBL</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>SBT</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>SBR</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>Overall</td>
<td>B</td>
<td>C</td>
</tr>
</tbody>
</table>

3.3. **Agronomy Road and East Mall**

The intersection of Agronomy Road and East Mall is north of Thunderbird Boulevard and is the next intersection for users heading north on East Mall after passing Thunderbird Boulevard. This section will highlight the challenges currently posed on the intersection and the proposed changes to tackle these challenges.

3.3.1. **Existing Conditions**

Unlike the intersection at Thunderbird Boulevard, the intersection of Agronomy Road is much narrower and supports larger volumes of pedestrian activity due to its proximity to the UBC Centre for Advance Wood Processing and nearby businesses such as the Starbucks at the southeast corner of the intersection. For this report, vehicle volumes on the intersection are assumed to be lower than the intersection of Thunderbird Boulevard due to pedestrian activity as count data was not available at the time of the study.

3.3.2. **Proposed Changes**

Sticking with the goal of improving active transportation along the corridor, improvements at the intersection of Agronomy Road and East Mall include installing conflict paint and elephant’s feet to help facilitate crossing of cyclists and continuing the bi-directional protected bicycle lane originating from Thunderbird Boulevard. The bi-directional bicycle lane is set to terminate at the Agronomy, but the conflict paint markings will allow cyclists...
to continue northbound on East Mall and provide southbound cyclists a safe connection onto the greenway.

The figure below shows the proposed changes at the intersection.

![Proposed Changes at the Intersection of Agronomy Road and East Mall](image)

**Figure 7: Proposed Changes at the Intersection of Agronomy Road and East Mall**

### 3.4. **SIGNAGE PLAN**

The signage plan was designed in accordance with the Manual of Standard Traffic Signs & Pavement Markings from the British Columbia Ministry of Transportation and Highways. Many of the new proposed traffic signs are due to the greenway shifting the travel lanes to the east side of the boulevard. Due to the future Stadium Neighbourhood changes, two zebra crosswalks will be added to facilitate anticipated foot traffic growth on the south end. Additional time-limited parking spots will follow the current design, indicated by white paint. The proposed signage plan can be found in Appendix A.
4. **Structural Canopy Design**

The detailed structural design and analysis of the proposed pedestrian canopy is outlined in this section. The canopy structure will be made up of wide flange steel beams and columns with tempered glass panels. The structure will be constructed on the south side of Agronomy Road, due to the existing awnings and trees/shrubs on the north side that would obstruct the proposed canopy. As shown in Figure 8 below, the canopy will have one 12.73-metre section and one 54.13-metre section separated by the parking lot driveway. The total length of the structure will be 66.86-metres.

![Figure 8: Pedestrian canopy plan](image)

The detailed design process consists of sizing the main structural members, designing the connections, and sizing the foundations. Technical drawings and specifications for the canopy can be found in Appendix A.

4.1. **Design Loadings**

The loading on the structure was determined in accordance with NBC 2015 and consists of dead, snow, and wind loads. Live loads and earthquake loads were not included in this analysis. The considered loads will determine the member sizes and connection detail based on Ultimate Limit States or Serviceability Limit States. Since the canopy structure will not have live loading, the design of the members and connections will be governed by serviceability requirements. A summary of loads is given below:
Table 7: Summary of load combinations used for analysis

<table>
<thead>
<tr>
<th>Case</th>
<th>NBC 2015 Load Combination</th>
<th>Load on Cantilever [kN/m]</th>
<th>Load on Column [kN]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.4D</td>
<td>1.06</td>
<td>5.85</td>
</tr>
<tr>
<td>2</td>
<td>1.25D + 1.0S or 0.4W</td>
<td>2.42</td>
<td>10.54</td>
</tr>
<tr>
<td>3</td>
<td>1.25D + 1.5S + 0.4W</td>
<td>3.59</td>
<td>14.75</td>
</tr>
<tr>
<td>4</td>
<td>1.25D + 1.4W + 0.5S</td>
<td>3.19</td>
<td>13.31</td>
</tr>
<tr>
<td>Serv.</td>
<td>1.0D + 1.0S + 1.0W</td>
<td>3.31</td>
<td>13.37</td>
</tr>
</tbody>
</table>

4.1.1. **SNOW LOAD**

Snow loading for the structure were determined in accordance with NBC 2015 Clause 4.1.6. NBC specified a 1.8-kPa 1-in-50-year ground snow load for the Vancouver City Hall region. The importance factor for this structure was assumed to be 1.0. The final snow load to be used for analysis was 1.64-kPa. Further detailed calculations can be found in Appendix D.

4.1.2. **WIND LOAD**

Wind loading for the structure was determined in accordance with NBC 2015 Clause 4.1.7. The external and internal pressure cases were calculated, and both resulted in a wind uplift of 1.20kPa. The reference velocity pressure used was 0.45-kPa for the Vancouver City Hall region and the assumed importance factor was 1.0. Further detailed calculations can be found in Appendix D.

4.2. **STRUCTURAL ANALYSIS**

The analysis completed on the structure consisted of a typical section (ie. cantilever and column) with fixed joints and supports. Loads from the previous section were applied as shown in Figure 8 below. The snow load was applied with global projected coordinate system, wind load was applied in the local coordinate system, and dead load was applied with global coordinate system. The analysis model is shown in Figure 9.
All ultimate limit states requirements as specified by NBC 2015 were met. See Appendix D for the code checks from S-Frame. The wide flange section that resulted from serviceability limit states was a W200x31 section profile. The deflection at the outer edge of the cantilever beam due to the serviceability load combinations was 33mm. A L/120 deflection requirement results in a maximum displacement of 30mm. As a result, a standard 10-millimetre thick, 100-millimetre-high stiffener plate will be added on both sides of the top and bottom connection. See Appendix A for detail drawings.

### 4.3. CONNECTION DESIGN

The top and bottom connections as identified in Figure 9 above will be a fixed moment end plate design with similar hex bolt layouts. The end plates will be welded to the column using a fillet weld 6-millimetres thick all around the wide flange section. Three checks on the connection capacities due to internal bending transfers were completed. The prying force on the end plate, yielding of the end plate, and strength of the welds were all passed for both connections. See Appendix A for connection details and Appendix D for calculations.

### 4.4. FOOTING DESIGN

The plan dimensions of the footing were initially determined based on the soil type obtained from the Piteau Geotechnical Report. The specified soil type was dense sand with a soil bearing capacity of 150-kPa (based on NBC 2015 Table 9.4.4.1). The resulting plan dimensions are 0.7-meters wide by 1.2-meters long. The depth of the footing was found based on the required overturning resistance of the canopy loads. A depth of
1.3-meters was found to be sufficient to resist the overturning moment. See Appendix A for connection details and Appendix D for calculations.

4.5. CONSTRUCTION CONSIDERATIONS
A construction plan was developed in accordance with NBC 2015. Since the location of the pedestrian canopy will be in a relatively high traffic area, construction fencing, and barricades will adhere to Clause 8.2.1 of NBC 2015 during weekdays. Construction of the canopy shall occur inside an enclosed area with at least 2.0-meters of distance between any adjacent pedestrian areas. Additionally, excavations for the canopy footing shall be kept clear of water to prevent soil and water contamination, and necessary shoring or bracing shall be installed. Proper pedestrian and vehicular traffic management should be implemented as necessary and construction waste materials should be disposed of appropriately.
5. **Utilities Design**

The following section details the municipal utilities engineering design including the water, sanitary, and stormwater network components.

5.1. **Existing Utilities**

An initial assessment of the existing utilities has been conducted, based on information provided by the client. While a PDF displaying a plan view of the underground utilities was provided by UBC Seeds, titled UtilityMasterMap2019, it is not up to date nor high enough resolution to determine accurate alignments and dimensions. As-built drawings for the project area were not available, and so no detailed location and depth information could be found. Figure 11 below shows a snippet of the master utility map. Utility relocations and diversions do not fall under the original scope, and so were not considered for this project. Further, certain utilities are likely to fall under different ownership groups such as FortisBC, and the decision to conduct realignment ultimately does not fall under the project teams’ control. The proposed design is generally limited to the road surface and does not introduce any major underground elements that would require the current alignments to be moved. However, an analysis of the water, sanitary, and stormwater systems was conducted to determine if upsizing will be required and can be found in the subsequent report sections.

![Figure 11: Existing underground utilities](image)

5.1.1. **Utilities Design**

The following table summarizes the existing utilities identified based on available resources, as well as approximate dimensions, typical depths of cover, and key comments:
Table 8: Existing Utility Summary

<table>
<thead>
<tr>
<th>Utility</th>
<th>Dimensions (mm)</th>
<th>Typical Depth of Cover (mm)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td>400 x 600</td>
<td>600</td>
<td>• Not shown on master utilities plan, but identified by UBC SEEDS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Likely third-party owned</td>
</tr>
<tr>
<td>Electrical</td>
<td>400 x 600</td>
<td>600</td>
<td>• Not shown on master utilities plan, but identified by UBC SEEDS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Likely third-party owned</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Ø 50 to Ø 100</td>
<td>600</td>
<td>• Service connections not shown</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Likely third-party owned</td>
</tr>
<tr>
<td>Water</td>
<td>Ø 200 to Ø 250</td>
<td>900</td>
<td>• Likely to be small diameter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Service connections not shown</td>
</tr>
<tr>
<td>District Energy</td>
<td>Unknown</td>
<td>Unknown</td>
<td>• Not shown on master utilities plan, but identified on UBC Energy publications</td>
</tr>
<tr>
<td>(Water)</td>
<td></td>
<td></td>
<td>• Located along Thunderbird Boulevard</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• High-temperature pressurized main</td>
</tr>
<tr>
<td>Sanitary</td>
<td>Ø 200 to Ø 450</td>
<td>1500 to 3000</td>
<td>• Manholes, service connections, and cleanout information not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• No distinction made between gravity and pressurized mains</td>
</tr>
<tr>
<td>Storm</td>
<td>Ø 300 to Ø 900</td>
<td>1500 to 3000</td>
<td>• Likely to be large diameter mains along East Mall</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Manhole and service connection information not available</td>
</tr>
</tbody>
</table>

While the communications and electrical duct banks were not shown on the plan view sheet, typical construction practice is to install close to the surface and underneath the main roadway or sidewalk. Based on an inspection of the project area, most buildings directly facing East Mall are only reachable by mains along the corridor and so must have service connections not shown in the mastery utility map. Service connections are generally installed perpendicular to the main utility with less depth of cover. Other major infrastructure components like manholes are visibly present in the project area, though they are not indicated in the utility map.

5.1.2. CONSTRUCTION CONSIDERATIONS

Based on the City of Vancouver’s Engineering Design Guides, the geotechnical requirements for bus lanes call for a minimum of 50mm of surface mix, 180mm of base of mix, 150mm of 19mm crushed granular base, and 300mm of 17mm crushed granular base for a total excavation depth of 680mm beneath the road surface. Communications, electrical, and natural gas conduits will fall directly in the excavation zone and water mains...
are likely to be encountered where over excavation is required. Information on the district energy system is not available but is likely to have similar specifications as the water mains. Based on the estimated depth of cover, sanitary and storm mains are unlikely to be encountered during construction. However, service connections to adjacent properties are generally found at shallower depths and could be located in the excavation area. Sanitary and storm sewer manholes also fall within the reconfiguration area, though are identifiable prior to construction. As such, safety during construction is the primary concern, and our team has outlined considerations in the General Notes of the drawing package and the Construction Specifications including the following key requirements:

- The Contractor will perform a detailed utility locate to confirm the alignments and depths of existing utilities prior to commencing construction
- Hand excavation will be required within 300mm of any pressurized utilities
- The Consultant will be contacted prior to any construction work requiring the removal or shutdown of an existing utility
5.2. **WATER AND SANITARY**

UBC owns and operates both the water distribution and sanitary sewer networks on campus. Both have been identified within the East Mall corridor, as well as the Academic District Energy System which intersects along Thunderbird Boulevard. Sheets W101 and S101 in the drawing package provide plan-view drawings of these systems, as well as construction comments and notes. The focus of this project is a road reconfiguration for East Mall and does not introduce any new developments to the project area that need to be serviced by the existing water or sanitary networks. As such, the post-development demands on these underground utilities will be unchanged from the pre-development demand. A survey of the existing hydrants was conducted, and no relocation will be required for the final design. No improvements will be required, and thus the emphasis will be to maintain service and minimize disturbances during the construction phase.

*Figure 12: Water Utilities Map at Thunderbird Blvd. and East Mall*

In addition to the previously identified construction considerations, stub lengths and pipe loops have also been identified in the water distribution system. Flow can often become stagnant in these areas, and potentially lead to health concerns if the system is not adequately maintained. UBC will be contacted to determine if these sections should be removed or grouted. Hydrants, manholes, and other ground-level infrastructure
should remain in place during construction. Service should not be stopped without first getting approval from both the Consultant as well as UBC. Without further information, the sanitary and district energy mains should both be considered to be pressurized and treated as high-risk. Excavation should be done by hand around the mains to avoid potentially damaging them.

5.3. **STORMWATER**

Ensuring that UBC’s sustainability initiatives were met was one of the main design objectives, and proper stormwater management plays a critical role in this. The existing corridor has a paved roadway with a shared bicycle lane and an adjacent sidewalk drained through catch basins along the curb line. Rainfall is then directed into the stormwater sewer system, which is owned and operated by UBC. From Thunderbird Blvd. to Agronomy, runoff is directed into the University’s Western catchment and out through a creek adjacent to Wreck Beach. South of Thunderbird, runoff is directed along into the University’s 16th Avenue Catchment area and the majority drains out within Pacific Spirit Park. While a detailed control plan is not required based on UBC’s technical guidelines, the following section outlines the management philosophy for the site.

5.3.1. **MANAGEMENT**

Throughout the design process, our team minimized runoff and the amount of impermeable area introduced wherever possible. Decreasing the travel lane widths and specifying permeable pavement for the new sidewalks and bicycle paths are two key features of the new corridor that reduces the impermeable area. These impermeable surfaces are associated with the fast runoff response in the system and reducing the tributary area that drains into pipe network reduces the total runoff volume and by extension reduces the peak flow entering the system. The capture method for the roadway has remained the same as before, with both directions sloped towards the adjacent gutter line. According to the City of Surrey’s Design criteria, catch basins should serve a maximum catchment area of 500m². With a typical road width of 12.2m, catch basins will be spaced every 35m including a factor of safety. However, this spacing is actually less than what is currently being provided by the existing catch basins. Furthermore, as the stormwater main does not need to be upsized, removing the existing basin leads then installing new ones is redundant and adds unnecessary construction complexity. As a result, catch basins on the roadway will be relocated to follow the new curb line and the leads will be adjusted to suit. Existing basins should be reused wherever possible as long as they are in adequate condition to reduce construction waste.
Landscaped areas like the greenway do not drain into UBC’s system, and precipitation is expected to percolate into the groundwater. In accordance with UBC’s technical guidelines, the greenspace will also feature a 450mm layer of absorbent topsoil to promote infiltration. More extensive gardening and planting on the proposed greenspace helps to improve stormwater quality by acting as a filter prior to percolation. Similarly, the permeable concrete also allows stormwater to be kept on site instead of captured into the sewer system and conveyed away. From the Integrated Stormwater Management Plan, UBC’s preferred implementation strategy is to use detention to capture flooding. As such, the permeable concrete was also designed to have a base aggregate reservoir capable of storing a major storm event. Drawing D101 shows a plan view of the stormwater utilities in the project area, including landscaped and permeable areas.

5.3.2. PERMEABLE CONCRETE

Permeable concrete is still a relatively developing field, and there are currently no widely accepted standards. The design for the permeable concrete was developed based on best practices and guidelines from the City of Vancouver, National Ready Mixed Concrete Association, UNH Stormwater Centre, and Flood Testing Labs. Layer depths were determined based on the capacity required to store a 10-year 24-hour duration intensity storm, assuming no infiltration into the subgrade. The final design offers 95.2mm of storage compared to an expected 67.2mm of precipitation. This contingency can help to detain excess rainfall from the adjacent landscaped areas and prevent ponding in extreme events. Detailed calculations are available in Appendix E.
Table 9 summarizes the target construction specifications for the permeable concrete, and Figure 14 below illustrates the required layers for construction:

### Table 9: Permeable Concrete Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 Day Compressive Strength</td>
<td>20 MPa</td>
</tr>
<tr>
<td>Infiltration Rate</td>
<td>8600 mm/hr</td>
</tr>
<tr>
<td>Void Space</td>
<td>15%</td>
</tr>
<tr>
<td>Unit Weight</td>
<td>1500 kg/m³ to 2000 kg/m³</td>
</tr>
<tr>
<td>Slump</td>
<td>15cm to 18cm</td>
</tr>
</tbody>
</table>

![Figure 14: Required permeable concrete layers](image)

A detailed mix design was considered to be outside of the scope of the project, and the Contractor will be expected to develop a final mix design meeting the above specifications. Due to differences in load response, permeable concrete requires slightly different procedures than conventional concrete. Detailed specifications are provided in the Construction Specifications, but the following key points are identified:

- Conventional strength tests are not recommended as compaction is highly variable in cylinder tests for permeable concrete. Instead, a void-density curve should be established for the final mix-design and used for quality assurance during construction.
- Concrete should be moistened then covered for curing within 20 minutes of initial placement and compaction.
• A minimum of two panel tests should be conducted on site according to ACI 522.1-13 to establish acceptable ranges for hardened concrete.

• Three cores will be tested every 75 m³ poured to verify infiltration rate, dimensions, and average hardened density are within values obtained from the test panels in accordance with ASTM C1754.
6. GREENSPACE

The final design includes a multi-purpose green space separating the travel lanes and the cycling path. One of the primary objectives is to encourage use of active and sustainable modes of transportation. This new greenspace encourages people to gather and enjoy the surrounding landscape, thereby improving the sense of community and health of residents. The landscape architecture design for this area was based on UBC’s sustainability recommendations and past examples of integrated spaces like the Arbutus Greenway.

The final greenspace design involves the transplanting of the existing maple trees and the planting of 4 new trees at each crossing to further improve on the aesthetic of the corridor. The four new trees to be planted are the Saucer Magnolia, Weeping Cherry, Eastern Redbud, and Red Oak. Additionally, the greenspace features a community garden consisting of several different species of plants at various locations of the median. A summary of the plants utilized in the final design is summarized in the figures below.

![Figure 15: Hydrangeas (gardeningknowhow.com)](image1)

![Figure 16: Rudbeckia (oscseeds.com)](image2)
The overall layout and locations of the various components of the greenspace is shown in Figure 20 and 21 below. Figure 20 displays the greenspace plan from Thunderbird Blvd to Eagles Dr, and Figure 21 displays Eagles Dr. to Stadium Rd.
Construction requirements for the greenspace include the following:

Construction for the greenspace is expected to be done in accordance with the UBC Exterior Improvements Technical Guidelines. In conjunction with current best practices the following key requirements have been identified:

- Where possible, existing trees along the current median are expected to be transplanted to their new proposed locations
- Newly planted and transplanted trees must be spaced apart according to their mature canopy spread
- Erosion control devices such as silt fencing shall be installed to prevent siltation and/or erosion within the tree protection zone
- Ensure that soil texture, fertility and drainage at the new planting site by laying composted bark mulch and absorbent topsoil
- Soil should be tested prior to installation to ensure acidity and nutrient composition is adequate for the specified plants
7. **CONSTRUCTION MANAGEMENT**

This section will provide information regarding construction sequencing, anticipated issues during construction, the construction schedule, and our traffic management plan.

7.1. **SEQUENCING**

To mitigate disruptions to the overall network, construction activity has been sequenced into five sections, each relating to a specific portion of East Mall. The bulk of the work has also been further divided into three phases. Figure 22 details the scope of each specific sequence. For full breakdown of tasks and timelines, refer to Section 7.3. Materials and equipment rentals will be procured at the start of each section. Reviews will be undertaken at the end of each activity, with an audit at project turnover.

![Figure 22: Construction phases and sequencing](image)

7.2. **ANTICIPATED ISSUES**

A detailed risk assessment was conducted to outline potential setbacks during construction. Table 10 provided below presents several key hazards identified, along with their likelihood of occurrence and impact to the project. A more detailed description of the hazards is also provided in this section. Refer to Appendix H for the risk register in its entirety.

*Table 10: Risk analysis of construction method*

<table>
<thead>
<tr>
<th>Risk</th>
<th>Likelihood</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design changes</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>On-site incidents</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Interrupting Buried Utilities</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Traffic Delays</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Damage during tree transplant</td>
<td>Moderate</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Design changes**

Due to continuous stakeholder engagement, there is potential for varying magnitudes of design changes. Unforeseen site conditions might also require change orders during construction. A substantial change could greatly impact the traffic and stormwater analysis, resulting in schedule delays and cost revisions. To mitigate
this, site constraints will be clearly communicated to stakeholders and contractors. Our team will also address issues case by case to mitigate design changes.

**On site incidents**
This hazard includes both worker and pedestrian accidents on site. Due to the sheer number of days worked, it was deemed a moderately probable occurrence. Impacts would vary depending on the incident. To mitigate this, procedures will be developed with worker safety at the forefront. A daily hazard assessment of the site must be conducted prior to start of work by the supervisor. Routine site inspections will be conducted to ensure WorkSafeBC compliance. Equipment will only be operated by qualified personnel. Adequate signage and fencing will block off public spaces and minimize contact with pedestrians.

**Interrupting Buried Utilities**
Due to the limited information regarding buried utilities, there is potential for accidental contact during construction work. Depending on the affected system, the impact can range from moderate to high. Mitigation will require detailed confirmation of pipe depths at areas with substantial earthwork. Amount of excavation has also been optimized in the design. Hand digging will also be done when in proximity to known utility locations. Given the new development proposed at Stadium Road, it is likely utility owners may already have upgrade works planned. In this case, construction could be coordinated so that the upgrade works can happen in conjunction with the road reconstruction to minimize disruption to the community.

**Traffic Delays**
Congestion induced by site work will limit access and result in project delays. As such, the East Mall corridor must be able to shoulder a majority of the usual volumes despite construction. Traffic delays were classified as a moderate probability; it will be lowered through the phasing of construction work. Mitigation will consist of the provided Traffic Management Plan and ensuring clear communication with contractors. A bulk of the work is also schedule for the summer with lower volumes. Equipment transport will also occur outside of peak hours when possible.

**Damage to trees**
With 47 existing trees requiring uplift, there is a moderate probability of damage during the process. To mitigate this, work will be done in accordance with the Tree Protection Guidelines outlined in the UBC Vancouver Campus Plan Part 3: Design Guidelines (2014).
7.3. **Construction Schedule**

Commencing May 3rd, 2021, construction duration was estimated at around nine months, completing on December 16th, 2021. Workdays were taken as Monday to Friday, eight-hour days with statutory holidays off. A schedule summary is provided in Table 11. For a full task breakdown and Gantt chart, refer to Appendix G.

*Table 11: Key construction dates*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Start (2021)</th>
<th>End (2021)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Preparation</td>
<td>May 3rd</td>
<td>May 7th</td>
</tr>
<tr>
<td>Phase 1 Construction</td>
<td>May 10th</td>
<td>June 11th</td>
</tr>
<tr>
<td>Canopy Installation</td>
<td>June 14th</td>
<td>July 23rd</td>
</tr>
<tr>
<td>Phase 2 Construction</td>
<td>June 14th</td>
<td>September 2nd</td>
</tr>
<tr>
<td>Phase 3 Construction</td>
<td>September 2nd</td>
<td>December 6th</td>
</tr>
<tr>
<td>Site Clean-up</td>
<td>December 7th</td>
<td>December 16th</td>
</tr>
</tbody>
</table>

To prevent congestion along East Mall, construction was sectioned into chronological phases. Figure 23 below presents the scope for each phase. Phase one includes the Thunderbird & East Mall intersection upgrades along with roadwork north to Agronomy Road and the pedestrian canopy. Canopy installation will begin mid-June with to minimize roadway disruption. The structure will be complete and inspected by August, allow for immediate use during the fall months. The remaining work along East Mall is divided into two phases. Phase two details the median removal while phase three is dedicated to the new median and greenspace installation. Dividing the work allows traffic to be shifted onto the open lane with capacity for two lane flow. Meeting the usual capacity is essential as phase three will extend into the 2021 winter semester. Temporary parking and traffic control measures will be required.

![Figure 23: Construction phases](image)

7.4. **Traffic Management Plan**

Under project classifications set out by the Ministry of Transportation and Infrastructure, the redesign falls under Category 2: moderate impacts on the travelling public and involves some complexity. As such, a full
traffic control plan will be required. The figures below provide our management plan for all phases of the project. Temporary signage codes are derived from the BC Traffic Management Manual for Work on Roadways (2016)

7.4.1. **Phase 1**

Work zones will be divided into halves of road. The first half will require the closing of the southbound lane. While work is in progress, the adjacent lane will allow for two-way traffic flow, with a total width of 18ft. Traffic flow operators and temporary 15 mph speed limit signs will be posted at appropriate intervals to regulate traffic. Figure 17 details the first half of phase one and the required signage and personal on site.

Occurring synchronously with phase 1 is the construction of the pedestrian canopy. To prevent congestion, equipment and operational vehicles will detour down Agronomy and Health Science Mal into the highlighted alleyway. The southern sidewalk of Agronomy will be closed with pedestrian demand relocated to the north.

![Figure 17: Phase 1 traffic management plan](image)

7.4.2. **Phase 2**

Existing median removal headlines phase two which will require work on the southbound lane of East Mall. The wide roadway easily allows for two-way traffic flows on the adjacent lane. Parking will be restricted to meet demands. Adequate signage and pylons will be placed alongside traffic flow operators. Figure 18 below
details the phase two configuration. A temporary 15 mph vehicle speed limit will be imposed for pedestrian and worker safety.

![Figure 25: Phase 2 traffic management plan](image)

### 7.4.3. **Phase 3**

Phase three will require the closing of the northbound lane, with the volume shifted on the finished southbound lane. Similar to phase two, a temporary no parking limit on the southbound lane will be enacted to meet capacity. A 15-mph vehicle speed limited will also be imposed for worker and pedestrian safety.

![Figure 26: Phase 3 traffic management plan](image)
8. Cost Estimate

The total project is estimated to cost $5,163,449, with an annual operations & maintenance cost of $23,500. A high-level cost breakdown is provided in Table 12. To account for potential uncertainty during construction, a 15% contingency has been assigned to overall costs. For the full detailed Class A Cost Estimate, refer to Appendix F. Unit cost for specific materials has been derived from cost guides from different locales and times. As such, RSMeans Cost Indices were used to normalize costs when applicable.

<table>
<thead>
<tr>
<th>Table 12: Cost Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
</tr>
<tr>
<td>Development</td>
</tr>
<tr>
<td><strong>Construction</strong></td>
</tr>
<tr>
<td>General Permitting</td>
</tr>
<tr>
<td>On-Site Personnel</td>
</tr>
<tr>
<td>General Construction</td>
</tr>
<tr>
<td>Site Preparation</td>
</tr>
<tr>
<td>Road Replacement</td>
</tr>
<tr>
<td>Median Installation</td>
</tr>
<tr>
<td>Bike Lanes &amp; Sidewalks</td>
</tr>
<tr>
<td>Stormwater Facilities</td>
</tr>
<tr>
<td>Greenspace</td>
</tr>
<tr>
<td>Permanent Traffic Controls</td>
</tr>
<tr>
<td>Structural</td>
</tr>
<tr>
<td>End of Construction</td>
</tr>
<tr>
<td><strong>Maintenance &amp; Operations</strong></td>
</tr>
<tr>
<td><strong>Contingency (15%)</strong></td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
</tr>
<tr>
<td><strong>PST (7%)</strong></td>
</tr>
<tr>
<td><strong>GST (5%)</strong></td>
</tr>
<tr>
<td><strong>Total Cost + Tax</strong></td>
</tr>
</tbody>
</table>
9. **SERVICE LIFE MAINTENANCE PLAN**

This section will outline the potential maintenance concerns associated with the new roadway, canopy, utility, and greenspace upgrades. The items below are only common issues and therefore not exhaustive. Additional issues may arise throughout the lifecycle of the project.

9.1. **TRANSPORTATION**

The main component of the road requiring maintenance is the asphalt. The asphalt road in our final design has a design life of 18 years, after which the road will require repaving. However, to achieve this design life maintaining the driving surface and other roadside upkeep is required. The road maintenance plan consists of the following:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Maintenance Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack sealing</td>
<td>As required with annual inspections</td>
</tr>
<tr>
<td>Snow and ice control</td>
<td>As required seasonally</td>
</tr>
<tr>
<td>Pothole patching</td>
<td>As required with annual inspections</td>
</tr>
<tr>
<td>Signage repair</td>
<td>As required with annual inspections</td>
</tr>
<tr>
<td>Pavement marking repair</td>
<td>As required with annual inspections</td>
</tr>
</tbody>
</table>

Effective road maintenance addresses damage early. Preventive maintenance for the road will be performance based. This approach maximizes the service life and reduces long term costs of the project.

9.2. **STRUCTURAL**

The hot dip galvanized steel canopy has a design life of 70 years. Hot dip galvanized steel structures provide long-term durability. The main concern for the steel canopy is corrosion due to it being located outdoors in a wet climate. That is why a zinc coating was selected since it would be able to provide the proper protection. A Hot Dip Galvanized coating is known for its durability and low maintenance; therefore, the maintenance plan is not overly involved and consists of the following:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspect and repair damaged welds</td>
<td>As required with annual inspections</td>
</tr>
<tr>
<td>Repair corrosion on the steel by brushing off any rust with a hard plastic bristle brush and repainting with Zingalu spray</td>
<td>As required with semi-annual inspections</td>
</tr>
</tbody>
</table>
9.3. **UTILITIES**

No new utility mains are installed as part of this project, and so the service life of the existing mains should be unchanged. New catch basins are specified to replace the existing, and the lifespan of a typical precast concrete catch basin including its service lead is estimated to be around 75 years. The on-site utilities do not require any special servicing plans, and the following suggestions are made on the basis of UBC’s Technical Guidelines to preserve utility lifespan:

*Table 15: Maintenance summary and frequency for utilities*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Maintenance Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCTV inspection of underground utility services shall be conducted every 5 years to identify potential leaks, root intrusion, among other damage in accordance with UBC Technical Guidelines Section 33 82 01</td>
<td>Once every 5 years</td>
</tr>
<tr>
<td>Sewers should be flushed in accordance with UBC Technical Guidelines Section 33 01 30.41</td>
<td>Yearly</td>
</tr>
<tr>
<td>Clear out catch basin sumps and surrounding grate area</td>
<td>Twice a year or whenever ponding is observed</td>
</tr>
<tr>
<td>Vacuum permeable concrete areas with regenerative vacuum sweeper</td>
<td>Yearly or whenever ponding is observed</td>
</tr>
</tbody>
</table>

9.4. **GREENSPACE**

The greenspace including its plants and trees all have an indefinite design life and should not require replacement as long proper care and maintenance is provided. Maintenance services are necessary to ensure that the landscape is healthy and looking good. The maintenance plan for the greenspace is the most intensive and consists of the following:

*Table 16: Maintenance summary and frequency for greenspace*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Maintenance Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard lawn care of the land surrounding the garden including lawn mowing and other techniques to maintain the overall appearance of the garden itself</td>
<td>Bi-weekly during necessary seasons</td>
</tr>
<tr>
<td>Watering of all trees and plants along the greenspace</td>
<td>Daily</td>
</tr>
<tr>
<td>Renewing mulch to protect roots and soil moisture</td>
<td>Bi-weekly</td>
</tr>
<tr>
<td>Lawn fertilization and pest control</td>
<td>Annually</td>
</tr>
<tr>
<td>Tree and shrub insect treatments</td>
<td>As required with annual inspections</td>
</tr>
<tr>
<td>Leaf removal and trimming</td>
<td>Annually</td>
</tr>
<tr>
<td>Aeration and over seeding of the grass</td>
<td>Annually</td>
</tr>
</tbody>
</table>
10. REFERENCES

Documents and Articles


The University of British Columbia. "Guidelines by Division Specification" http://www.technicalguidelines.ubc.ca/technical/divisional_specs.html#Div03


EAST MALL
RECONFIGURATION
UBC ENDOWMENT LANDS
VANCOUVER BC
ISSUED FOR CONSTRUCTION

DRAWING INDEX:

GENERAL:
G101 Existing Site Overview
G102 Notes

TRANSPORTATION:
R101 Roadway Plan View (Sheet 1 of 3)
R102 Roadway Plan View (Sheet 2 of 3)
R103 Roadway Plan View (Sheet 3 of 3)
R104 Roadway Cross-Section (Sheet 1 of 3)
R105 Roadway Cross-Section (Sheet 2 of 3)
R106 Roadway Cross-Section (Sheet 3 of 3)
R107 Roadway Profile
R108 Roadway Details
R109 Signage Plan (Sheet 1 of 2)
R110 Signage Plan (Sheet 2 of 2)

STRUCTURAL:
C101 Canopy Plan View
C102 Canopy Typical Cross-Section
C103 Canopy Connection Details (Sheet 1 of 2)
C104 Canopy Connection Details (Sheet 2 of 2)

UTILITIES:
W101 Utilities Plan - Water
S101 Utilities Plan - Sanitary
D101 Utilities Plan - Stormwater
D102 Stormwater Details
U101 Utilities Cross-Sections (Sheet 1 of 2)
U102 Utilities Cross-Sections (Sheet 2 of 2)
NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS STATED OTHERWISE
2. FOR ROADWAY CROSS-SECTIONS, REFER TO DRAWINGS R104-105
3. FOR ROADWAY PROFILES, REFER TO DRAWINGS R106-107
4. FOR TYPICAL MEDIAN CURB RAMP AND RAISED CROSSWALK DETAILS, REFER TO DRAWING R-108
5. EXISTING SIDEWALKS DENOTED BY DASHED LINE, TO BE LEFT AS IS UNLESS STATED OTHERWISE
NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS STATED OTHERWISE
2. FOR ROADWAY CROSS-SECTIONS, REFER TO DRAWINGS R104-105
3. FOR ROADWAY PROFILES, REFER TO DRAWINGS R106-107
4. FOR TYPICAL MEDIAN CURB RAMP AND RAISED CROSSWALK DETAILS, REFER TO DRAWING R-108
5. EXISTING SIDEWALKS DENOTED BY DASHED LINE, TO BE LEFT AS IS UNLESS STATED OTHERWISE

EMERGENCY VEHICLE ZONE
NO STOPPING OR PARKING AT ANY TIME

RAISED CROSSWALK DETAIL

PICK UP DROP OFF ZONE

KNOCKDOWN BOLLARDS FOR EMERGENCY ACCESS

3m REDUCTION TO EXISTING CURB

EMERGENCY VEHICLE ZONE
NO STOPPING OR PARKING AT ANY TIME

EXISTING EMERGENCY VEHICLE ACCESS ROAD

CONCRETE ISLAND FOR BUS STOP TRANSITION

MEDIAN CURB RAMP DETAIL

12m BUS ZONE NO PARKING OR STOPPING AT ANY TIME EXISTING BUS STOPS TO BE REINSTATED

EXISTING BUS STOPS TO BE REINSTATED

EMERGENCY ACCESS DRIVEWAY DETAIL
NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS STATED OTHERWISE
2. FOR ROADWAY CROSS-SECTIONS, REFER TO DRAWINGS R104-105
3. FOR ROADWAY PROFILES, REFER TO DRAWINGS R106-107
4. FOR TYPICAL MEDIAN CURB RAMP AND RAISED CROSSWALK DETAILS, REFER TO DRAWING R-108
5. FOR TO DRAWINGS C101-C104 FOR CANOPY DRAWINGS
6. EXISTING SIDEWALKS DENOTED BY DASHED LINE, TO BE LEFT AS IS UNLESS STATED OTHERWISE
EXISTING MEDIAN TO BE REMOVED.
EXISTING NORTHBOUND LANES TO BE REMOVED. NEW DRIVING AND BIKE LANES TO BE CONSTRUCTED AS SHOWN.

NEW LIGHT POLES TO BE INSTALLED PARALLEL TO SIDEWALKS AND BIKE LAKES. LIGHTING DUCTS TO BE DETERMINED BY ELECTRICAL CONSULTANT.

NEW GREENSPACE AREA TO ACCOMMODATE FUTURE COMMUNITY GARDENS AND PUBLIC ART PROJECTS.

EXISTING SIDEWALK TO REMAIN. ESTIMATED DIMENSIONS.

TYPE A CURB & GUTTER, TYP.

50mm SUPERPAVE SURFACE MIX AS PER CoV DESIGN GUIDELINES SECTION 32 1217.

180mm SUPERPAVE BASE MIX TO BE DONE IN 2 Lifts OF 90mm AS PER CoV DESIGN GUIDELINES SECTION 32 12 17.

150mm MINUS CRUSHED 19mm GRANULAR BASE AS PER CoV DESIGN GUIDELINES SECTION 32 11 23.

300mm MINUS CRUSHED 17mm GRANULAR BASE AS PER CoV DESIGN GUIDELINES SECTION 32 11 16.1.

TYPICAL CROSS-SECTION A.

PERMEABLE CONCRETE SEE SHEET D102 FOR DETAIL.
The University of British Columbia

EAST MALL REDESIGN

Roadway Cross-Sections (Sheet 2 of 3)

BUS STOP AND GREENWAY CROSSING
CROSS-SECTION B

- NEW PEDESTRIAN CROSSING TO BE CONSTRUCTED ACROSS NEW GREENSPACE. SEE PLAN VIEW FOR DETAILS
- EXISTING BUS STOPS @ EAGLE DR. TO BE REINSTALLED
- TYPE A CURB & GUTTER, TYP.
- SOUTHBOUND BUS STOP TO BE IDENTICAL TO NORTHBOUND
- EXISTING SIDEWALK TO REMAIN, ESTIMATED DIMENSIONS
- 50mm SUPERPAVE SURFACE MIX AS PER CoV DESIGN GUIDELINES SECTION 32 1217
- 180mm SUPERPAVE BASE MIX TO BE DONE IN 2 LIFTS OF 90mm AS PER CoV DESIGN GUIDELINES SECTION 32 12 17
- 150mm MINUS CRUSHED 19mm GRANULAR BASE AS PER CoV DESIGN GUIDELINES SECTION 32 11 23
- 300mm MINUS CRUSHED 17mm GRANULAR BASE AS PER CoV DESIGN GUIDELINES SECTION 32 11 61
- BUS STOP TO FEATURE NEW SAFEWALK UNIT AND LIGHT POLE FOR SAFETY
- NEW LIGHT POLES TO BE INSTALLED PARALLEL CROSSING. LIGHTING DUCTS TO BE DETERMINED BY ELECTRICAL CONSULTANT

EXISTING SIDEWALK TO REMAIN, ESTIMATED DIMENSIONS

2021/04/16
EXISTING LANDSCAPE
4m (ESTIMATED)

SOUTHBOUND DRIVING
3.3m

NORTHBOUND DRIVING
3.3m

SOUTHBOUND CYCLING
1.5m

NORTHBOUND CYCLING
1.5m

EXISTING LANDSCAPE
7.87m (ESTIMATED)

THUNDERBIRD TO AGRONOMY
CROSS-SECTION C

EXISTING SIDEWALK TO REMAIN, ESTIMATED DIMENSIONS

EXISTING LANDSCAPED AREA AND TREES TO REMAIN

50mm SUPERPAVE SURFACE MIX AS PER CoV DESIGN GUIDELINES SECTION 32 12T

180mm SUPERPAVE BASE MIX TO BE DONE IN 2 LIFTS OF 90mm AS PER CoV DESIGN GUIDELINES SECTION 32 12 17

150mm MINUS CRUSHED 19mm GRANULAR BASE AS PER CoV DESIGN GUIDELINES SECTION 32 11 23

300mm MINUS CRUSHED 17mm GRANULAR BASE AS PER CoV DESIGN GUIDELINES SECTION 32 11 16.1

EXISTING SOUTHBOUND BICYCLE LANE TO BE MOVED FROM WEST SIDE OF STREET TO EAST

EAST SIDE OF STREET TO BE WIDENED AS SHOWN TO ACCOMMODATE NEW ON-STREET BIKE LANES

EXISTING LIGHT POLES AND SIDEWALK TO REMAIN, ESTIMATED DIMENSIONS

EXISTING LANDSCAPED AREA

EXISTING LIGHT POLES

EXISTING LANDSCAPED AREA AND TREES TO REMAIN

EXISTING LANDSCAPED AREA

EXISTING SIDEWALK TO REMAIN, ESTIMATED DIMENSIONS

EXISTING LANDSCAPED AREA

EXISTING SIDEWALK TO REMAIN, ESTIMATED DIMENSIONS

EXISTING LANDSCAPED AREA

EXISTING LANDSCAPED AREA

EXISTING LANDSCAPED AREA
NOTES:
1. ALL DIMENSIONS ARE IN METERS UNLESS STATED OTHERWISE
2. REFER TO DRAWING R101-103 FOR GENERAL PLAN VIEW
3. REFER TO DRAWING D102 FOR DETAILED SUBGRADE MATERIAL
4. REFER TO CoV CONSTRUCTION SPECIFICATIONS FOR FULL DETAILS
5. CONTRACTOR TO CONFIRM CROSSING LAYOUT IS APPROVED BY CITY INSPECTORS PRIOR TO POURING
The University of British Columbia
EAST MALL REDESIGN
Signage Plan (1 of 2)

EAST MALL
GREENWAY

BM

Ken Woods Field

Warren Field

300mm 2EBRA CROSSWALK (TYPICAL)

100mm YELLOW SOLID LINE

WHITE BICYCLE STENCIL (TYPICAL)

100mm WHITE SOLID LINE

DETAIL A
NOTES:

1. REFER TO DRAWING R109 FOR DETAIL A
2. REFER TO DRAWING C101 FOR CANOPY DETAILS

REDESIGNED MEDIAN, 419m TOTAL LENGTH

UBC Tennis Bubble

Thunderbird Boulevard

Sopron Lane

Agronomy Road

Centre for Advanced Wood Processing

EAST MALL

DETAIL A

4 WAY SEAL

100mm WHITE SOLID LINE

WHITE BICYCLE STENCIL (TYPICAL)

GREEN MMA SKID RESISTANT PAINT (TYP.)

3.0m TOTAL WIDTH

TWO LANE ROAD, 6.6m TOTAL WIDTH

DELINEATOR POSTS TO SEPARATE CYCLIST AND VEHICLE LANES

NO STOPPING ZONE

4.6m TOTAL WIDTH

300mm WHITE STOP BAR (TYPICAL)

300mm ZEBRA CROSSWALK (TYPICAL)
Agronomy Road

PARKING LOT DRIVEWAY

FOOTING OUTLINE
SEE DRAWING C104

CANOPY PLACED ALONG SOUTH SIDE OF AGRONOMY ROAD FROM EAST MALL TO HEALTH SCIENCES MALL

12.73
3.56
1.80
54.13

1:100

PRODUCED BY AN AUTODESK STUDENT VERSION
2.8m WIDE SIDEWALK
32MPa CONCRETE

CONCRETE FOUNDATION
SEE DRAWING C104 FOR DETAILS

SEE DRAWING C104 FOR BASE PLATE DETAIL
700x700x100mm CONCRETE TOPPING 32MPa CONCRETE

100mm DEPTH MINUS CRUSHED GRANULAR BASE 95% MPD

2550

PLAN VIEW TYPICAL SECTION

1800x1800mm TEMPERED GLASS PANEL

GLASS PANEL BREAK SEAL WITH RUBBER GASKET

SEE DRAWING C103 FOR CONNECTION DETAIL

The University of British Columbia
6250 Applied Science Ln
Vancouver, BC V6T 1Z4

2021/04/16

The University of British Columbia
6250 Applied Science Ln
Vancouver, BC V6T 1Z4

2021/04/16

CANOPY TYPICAL CROSS-SECTION

0 0.5 1

METRE

0 1

METRE

CANOPY TYPICAL CROSS SECTION - FOR CONSTRUCTION

PRODUCED BY AN AUTODESK STUDENT VERSION
COLUMN BASEPLATE 500x127x20mm

2X4 14mm BOLTS, A325
WELD TO COLUMN WITH
FULL PENETRATION BUTT WELD

WEB STIFFENERS (BOTH SIDES)
THICKNESS 10mm - FILLET WELD
6mm ALL AROUND

1800x1800mm TEMPERED
GLASS PANEL

COLUMN TO BEAM
CONNECTION DETAIL 1:5

58Ø WALL TO GLASS GLASS PANEL
MOUNT FROM JRE HARDWARE
OR APPROVED EQUIVALENT (TYP.)

BASEPLATE STIFFENERS 10mm THICK,
FILLET WELD TO BASEPLATE
ALL AROUND, HEIGHT 100mm

COLUMN END PLATE
DETAIL 1:2

GLASS PANEL BREAK
SEAL WITH RUBBER GASKET

500x127x20mm COLUMN BASEPLATE

W200x31 STEEL BEAM

W200x31 STEEL COLUMN

COLUMN BASEPLATE 500x127x20mm
2X4 14mm BOLTS, A325
WELD TO COLUMN WITH
FULL PENETRATION BUTT WELD

WEB STIFFENERS (BOTH SIDES)
THICKNESS 10mm - FILLET WELD
6mm ALL AROUND

1800x1800mm TEMPERED
GLASS PANEL

COLUMN TO BEAM
CONNECTION DETAIL 1:5

58Ø WALL TO GLASS GLASS PANEL
MOUNT FROM JRE HARDWARE
OR APPROVED EQUIVALENT (TYP.)

BASEPLATE STIFFENERS 10mm THICK,
FILLET WELD TO BASEPLATE
ALL AROUND, HEIGHT 100mm

COLUMN END PLATE
DETAIL 1:2

GLASS PANEL BREAK
SEAL WITH RUBBER GASKET

500x127x20mm COLUMN BASEPLATE

W200x31 STEEL BEAM

W200x31 STEEL COLUMN

COLUMN BASEPLATE 500x127x20mm
2X4 14mm BOLTS, A325
WELD TO COLUMN WITH
FULL PENETRATION BUTT WELD

WEB STIFFENERS (BOTH SIDES)
THICKNESS 10mm - FILLET WELD
6mm ALL AROUND

1800x1800mm TEMPERED
GLASS PANEL

COLUMN TO BEAM
CONNECTION DETAIL 1:5

58Ø WALL TO GLASS GLASS PANEL
MOUNT FROM JRE HARDWARE
OR APPROVED EQUIVALENT (TYP.)

BASEPLATE STIFFENERS 10mm THICK,
FILLET WELD TO BASEPLATE
ALL AROUND, HEIGHT 100mm

COLUMN END PLATE
DETAIL 1:2

GLASS PANEL BREAK
SEAL WITH RUBBER GASKET

500x127x20mm COLUMN BASEPLATE

W200x31 STEEL BEAM

W200x31 STEEL COLUMN

COLUMN BASEPLATE 500x127x20mm
2X4 14mm BOLTS, A325
WELD TO COLUMN WITH
FULL PENETRATION BUTT WELD

WEB STIFFENERS (BOTH SIDES)
THICKNESS 10mm - FILLET WELD
6mm ALL AROUND

1800x1800mm TEMPERED
GLASS PANEL

COLUMN TO BEAM
CONNECTION DETAIL 1:5

58Ø WALL TO GLASS GLASS PANEL
MOUNT FROM JRE HARDWARE
OR APPROVED EQUIVALENT (TYP.)

BASEPLATE STIFFENERS 10mm THICK,
FILLET WELD TO BASEPLATE
ALL AROUND, HEIGHT 100mm

COLUMN END PLATE
DETAIL 1:2

GLASS PANEL BREAK
SEAL WITH RUBBER GASKET

500x127x20mm COLUMN BASEPLATE

W200x31 STEEL BEAM

W200x31 STEEL COLUMN

COLUMN BASEPLATE 500x127x20mm
2X4 14mm BOLTS, A325
WELD TO COLUMN WITH
FULL PENETRATION BUTT WELD

WEB STIFFENERS (BOTH SIDES)
THICKNESS 10mm - FILLET WELD
6mm ALL AROUND

1800x1800mm TEMPERED
GLASS PANEL

COLUMN TO BEAM
CONNECTION DETAIL 1:5

58Ø WALL TO GLASS GLASS PANEL
MOUNT FROM JRE HARDWARE
OR APPROVED EQUIVALENT (TYP.)

BASEPLATE STIFFENERS 10mm THICK,
FILLET WELD TO BASEPLATE
ALL AROUND, HEIGHT 100mm

COLUMN END PLATE
DETAIL 1:2

GLASS PANEL BREAK
SEAL WITH RUBBER GASKET

500x127x20mm COLUMN BASEPLATE

W200x31 STEEL BEAM

W200x31 STEEL COLUMN

COLUMN BASEPLATE 500x127x20mm
2X4 14mm BOLTS, A325
WELD TO COLUMN WITH
FULL PENETRATION BUTT WELD

WEB STIFFENERS (BOTH SIDES)
THICKNESS 10mm - FILLET WELD
6mm ALL AROUND

1800x1800mm TEMPERED
GLASS PANEL
M20x610 ANCHOR BOLTS

500x300x20mm BASEPLATE

FILLET WELD 6mm
THICK ALL AROUND

GROUN DLEVEL

BASEPLATE STIFFENERS 10mm THICK,
FILLET WELD TO BASEPLATE
ALL AROUND, HEIGHT 100mm

M20x610 ANCHOR BOLTS

COLUMN TO FOOTING
CONNECTION DETAIL 1:5

COLUMNS BASEPLATE
DETAIL 1:5

500x300x20mm BASEPLATE

FILLET WELD 6mm
THICK ALL AROUND

COLUMN BASEPLATE
DETAIL 1:5

METRES

0 0.5 1

0 1200

0 700

0 1300

0 72
EXISTING HYDRANTS TO REMAIN IN PLACE DURING CONSTRUCTION, VERIFY WITH CONSULTANT PRIOR TO REMOVAL IF REQUIRED

CLOSE HYDRANT VALVES PRIOR TO REMOVING HYDRANTS, IF REQUIRED

EXISTING WATER MAIN TO REMAIN DURING CONSTRUCTION, TYP.

VERIFY DEPTH OF EXISTING WATER MAIN PRIOR TO CONSTRUCTION

EXISTING DISTRICT ENERGY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

VERIFY DEPTH OF EXISTING DISTRICT ENERGY MAIN PRIOR TO CONSTRUCTION

COORDINATE WITH UBC TO DETERMINE IF STUBS SHOULD BE REMOVED DURING CONSTRUCTION

COORDINATE WITH UBC TO DETERMINE IF CLOSED LOOP SHOULD BE REMOVED DURING CONSTRUCTION

COORDINATE WITH UBC TO DETERMINE IF STUBS SHOULD BE REMOVED DURING CONSTRUCTION

COORDINATE WITH UBC TO DETERMINE IF STUBS SHOULD BE REMOVED DURING CONSTRUCTION

COORDINATE WITH UBC TO DETERMINE IF STUBS SHOULD BE REMOVED DURING CONSTRUCTION

COORDINATE WITH UBC TO DETERMINE IF STUBS SHOULD BE REMOVED DURING CONSTRUCTION

LEGEND:
- EXISTING WATER MAINS
- EXISTING DISTRICT ENERGY MAINS
- EXISTING HYDRANTS
- EXISTING VALVES

NOTES:
1. ALIGNMENTS AND LOCATIONS SHOWN ARE APPROXIMATE, ESTIMATED BASED ON MASTER UTILITY MAP PROVIDED BY UBC
2. CONTRACTOR TO PERFORM UTILITY LOCATES PRIOR TO CONSTRUCTION
3. PERFORM HAND-DIGGING METHODS WHEN EXCAVATING CLOSE TO UTILITIES
4. SERVICE SHOULD BE MAINTAINED THROUGHOUT CONSTRUCTION
NOTES:
1. ALIGNMENTS AND LOCATIONS SHOWN ARE APPROXIMATE, ESTIMATED BASED ON MASTER UTILITY MAP PROVIDED BY UBC
2. CONTRACTOR TO PERFORM UTILITY LOCATES PRIOR TO CONSTRUCTION
3. PERFORM HAND-DIGGING METHODS WHEN EXCAVATING CLOSE TO UTILITIES
4. SERVICE SHOULD BE MAINTAINED THROUGHOUT CONSTRUCTION

LEGAL DESCRIPTION
SURVEY BENCHMARK

EAST MALL REDESIGN
Utilities Plan - Sanitary

The University of British Columbia
5000 Applied Science Ln
Vancouver, BC V6T 1Z4

Utilities Plan - Sanitary

LEGEND:
EXISTING SANITARY MAINS

EX. SAN

EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

SERVICE CONNECTION LOCATIONS NOT PROVIDED, EXERCISE CAUTION PRIOR TO MECHANICAL EXCAVATION

MANHOLE AND CLEAN OUT INFORMATION NOT PROVIDED. EXISTING INFRASTRUCTURE SHOULD REMAIN IN-PLACE DURING CONSTRUCTION

VERIFY DEPTH AND LOCATION OF EXISTING SANITARY MAIN PRIOR TO CONSTRUCTION

NO SANITARY MAINS IDENTIFIED AT INTERSECTION FROM INFORMATION PROVIDED. DETAILED LOCATES SHOULD BE PERFORMED PRIOR TO CONSTRUCTION TO VERIFY

VERIFY DEPTH AND LOCATION OF EXISTING SANITARY MAIN PRIOR TO CONSTRUCTION

CONTINUES OUTSIDE PROJECT BOUNDARY

VERIFY DEPTH AND LOCATION OF EXISTING SANITARY MAIN PRIOR TO CONSTRUCTION

EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

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EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

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EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.

EXISTING SANITARY MAIN TO REMAIN DURING CONSTRUCTION, TYP.
1. Alignments and locations shown are approximate, estimated based on Master Utility Map provided by UBC.
2. Contractor to perform utility locates prior to construction.
3. Perform hand-digging methods when excavating close to utilities.
4. Service should be maintained throughout construction.
PERMEABLE PAVEMENT DETAIL

1. REFER TO CONSTRUCTION SPECIFICATIONS FOR COMPREHENSIVE INSTALLATION AND TESTING
   REQUIREMENTS
2. PERMEABLE CONCRETE MIX SHALL BE TESTED DAILY BEFORE FIRST POUR TO VERIFY SLUMP IS
   WITHIN 15cm TO 18cm AND FRESH UNIT WEIGHT IS WITHIN 80kg/m^3 OF TARGET
3. ENSURE 95% PROCTOR COMPACTION WITHIN SUBBASE AND ADEQUATE MOISTURE PRIOR TO
   POURING PERMEABLE SURFACE MIX
4. PERMEABLE CONCRETE SURFACE TO BE CONSOLIDATED USING STEEL ROLLER
5. FINISHED SURFACE TO BE MISTED AND COVERED WITH PLASTIC SHEET FOR MINIMUM OF 7 DAYS
   WITHIN 20 MINUTES OF PLACEMENT

PERMEABLE CONCRETE SPECIFICATIONS
1. 18MPa 28-DAY COMPRESSIVE STRENGTH
2. 8600mm/hr INfiltration RATE
3. 15cm TO 18cm SLUMP
4. VOID-DENSITY CURVE TO BE PREDETERMINED THROUGH LAB TESTING

TYPICAL CATCHBASIN DETAIL

1. REFER TO CoV STANDARD CONSTRUCTION DOCUMENTS FOR DETAILED INSTALLATION
   REQUIREMENTS
2. ALTERNATIVE PRECAST CONCRETE CATCHBASIN MEETING MMCD REQUIREMENTS MAY BE USED IF
   PRE-APPROVED BY DESIGN ENGINEER
3. TRAPPING HOOD CAN BE PURCHASED AND INSTALLED SEPARATELY
4. EXISTING CATCH BASINS FROM ROAD RESTORATION TO BE REUSED WHEREVER POSSIBLE
5. ENSURE GRATE IS ALIGNED WITH FLOW DIRECTION
EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX WATER MAIN,
ASSUMED 250mm DIA,
ASSUMED 800mm COVER

EX STORM SEWER,
ASSUMED 900mm DIA,
ASSUMED 1500mm COVER

PR ELECTRICAL DUCT,
TO BE DETERMINED BY
ELECTRICAL CONSULTANT
FOR LIGHTING

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX GAS MAIN,
ASSUMED 1000mm DIA,
ASSUMED 600mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm x 400mm,
ASSUMED 600mm COVER

TYPICAL UTILITY CROSS-SECTION
THUNDERBIRD TO STADIUM

PR SOUTHBOUND LANES
5.7m

PR NORTHBOUND LANES
5.7m

EX SIDEWALK
1.8m

PR SIDEWALK
1.8m

PR BIKES LANES
4.6m

PR GREENSPACE
11.35m

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX GAS MAIN,
ASSUMED 1000mm DIA,
ASSUMED 600mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX WATER MAIN,
ASSUMED 250mm DIA,
ASSUMED 800mm COVER

EX STORM SEWER,
ASSUMED 900mm DIA,
ASSUMED 1500mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX GAS MAIN,
ASSUMED 1000mm DIA,
ASSUMED 600mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX WATER MAIN,
ASSUMED 250mm DIA,
ASSUMED 800mm COVER

EX STORM SEWER,
ASSUMED 900mm DIA,
ASSUMED 1500mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX WATER MAIN,
ASSUMED 250mm DIA,
ASSUMED 800mm COVER

EX STORM SEWER,
ASSUMED 900mm DIA,
ASSUMED 1500mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

PR SOUTHBOUND LANES
5.7m

PR NORTHBOUND LANES
5.7m

EX SIDEWALK
1.8m

PR SIDEWALK
1.8m

PR BIKES LANES
4.6m

PR GREENSPACE
11.35m

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX GAS MAIN,
ASSUMED 1000mm DIA,
ASSUMED 600mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX WATER MAIN,
ASSUMED 250mm DIA,
ASSUMED 800mm COVER

EX STORM SEWER,
ASSUMED 900mm DIA,
ASSUMED 1500mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX GAS MAIN,
ASSUMED 1000mm DIA,
ASSUMED 600mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX GAS MAIN,
ASSUMED 1000mm DIA,
ASSUMED 600mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX GAS MAIN,
ASSUMED 1000mm DIA,
ASSUMED 600mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX GAS MAIN,
ASSUMED 1000mm DIA,
ASSUMED 600mm COVER

EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
EX ELECTRICAL DUCT
ASSUMED 600mm X 400mm,
ASSUMED 600mm COVER

EX SANITARY SEWER,
ASSUMED 450mm,
ASSUMED 1500mm COVER

EX GAS MAIN,
ASSUMED 100mm DIA,
ASSUMED 600mm COVER

EX STORM SEWER,
ASSUMED 900mm DIA,
ASSUMED 1500mm COVER

EXISTING LANDSCAPE
7.87m (EST.)

EX SIDEWALK
1.8m (EST.)

Existing Landscape
7.87m (EST.)

Existing Landscape
4m (EST.)

PR SOUTHBOUND
LANE
3.3m

PR NORTHBOUND
LANE
3.3m

PR CYCLING LANES
3m

EXISTING LANDSCAPE
4m (EST.)

EX SIDEWALK
1.80m (EST.)

EX SIDEWALK
1.8m (EST.)

TYPICAL UTILITY CROSS-SECTION
AGRONOMY TO THUNERBIRD
APPENDIX B  – CONSTRUCTION SPECIFICATIONS
Part 1 General
1. Related Sections
   a. Roadway Drawings
   b. Detailed Design Report

2. References
   b. British Columbia Active Transportation Guide
   c. City of Vancouver Design Manual

3. Design Criteria
   a. **General.** Review and submit documents required to construct the work for accuracy, completeness, and compliance with the contract for approval by the Owner’s Representative (OR). Documents submitted without evidence of Contractor approval may be returned for resubmission. Time for approval starts over when documents are returned for revision or if additional information is requested by the OR. Do not perform work related to submitted documents or drawings before approval of the OR. Obtain written approval before changing or deviating from the approved drawings.
   b. Typical surfacing, as per City of Vancouver Design Guidelines, shall include the following:
      i. 50mm Superpave surface mix
      ii. 180mm Superpave base mix implemented in two lifts
      iii. 150mm minus crushed, 19mm granular base
   c. Typical surfacing for bike lane:
      i. 50mm porous concrete surface mix
      ii. 150mm crushed base implemented in two lifts
   d. Maximum grade of 2.5% in travel lanes

4. Execution
   a. Verify that rough-in utilities are in proper location.
   b. Verify that road surfaces are ready to receive work.

5. Materials
   a. **Material sources**
      i. Material source must be government-approved sources unless otherwise approved
   b. **Handling and Storing Material**
      i. Handle and store material to preserve its quality and fitness for the work
      ii. Use only approved portions of the right-of-way for storing material or equipment, do not use private property for storage without written permission
      iii. Provide security for stored material
   c. Aggregate Gradation shall be determined in accordance with ASTM C117 (Wash Test)
   d. Any Aggregate supplied must not rut when proof rolled with a truck having a 9 tonne single axle dual tire or 17 tonne tandem axle group with dual tires with a tire pressure of 600 kPa.
   e. Water for compaction or dust control shall be incidental to the bid price for the granular material.

6. Acceptance of Work
   a. Conformity with Contract Requirements
i. Perform work to the lines, grades, cross-sections, dimensions shown in the contract

ii. Unless specific contract tolerances are noted, established manufacturing tolerances will be accepted for standard manufactured items

iii. The owner may inspect, sample, or test work before final acceptance of the project.
Part 1 General

1. RELATED SECTIONS
   a. Structural Drawings
   b. Detailed Design Report

2. REFERENCES
   b. British Columbia Building Code 2018
   c. American Society for Testing and Materials International (ASTM)
   d. Canadian Standards Association (CSA International)

3. DESIGN CRITERIA
   a. Beam and column depths are shown on the drawings. Adjust beam and column material thicknesses and spacings, as required by the design criteria. Use greater or lesser beam and column depths only if approved by the Consultant.
   b. For beam and columns, conform to the minimum design thicknesses, 95% of the design thickness as limited by CSA-S136
   c. Maximum flexural deflections under specified live shall conform to the following:
      i. Beam and column, L/120.
   d. Wall Assembly:
      i. Refer to Structural Drawings for deflection requirements for, wind loads, tolerances, drift requirements and other design parameters.
      ii. Design to provide for movement of components without damage, failure of joint seals, undue stress on fasteners, or other detrimental effects when subject to seasonal or cyclic day/night temperature ranges.
      iii. Design to accommodate construction tolerances, deflection of building structural members, and clearances of intended openings.

4. QUALITY ASSURANCE
   a. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of kind indicated. Engineering services are defined as those performed for installations of sun controls that are similar to those indicated for this Project in material, design, and intent.
      i. Welding Standards: As follows:
         1. Structural Welding Code—Steel
      ii. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification. SMACNA Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" recommendations for fabrication, construction details, and installation procedures.

Part 2 Products

1. FRAMING MATERIALS
   a. Framing Materials: Cold-rolled steel, with metallic coating, minimum coating thickness Z180 (G60). Minimum 18 gauge.

2. ACCESSORIES
CANTILEVERED WALKWAY COVER

- **Stiffener Plates**: Formed sheet steel, thickness determined by performance requirements specified.

### 3. FASTENERS
- **Bolts, Nuts and Washers**: ASTM A307 or ASTM A325, hot dip galvanized to minimum requirements of CSSBI.
- **Anchorage Devices**: Drilled expansion bolts, screws with sleeves.

### 4. FABRICATION
- **Fabricate assemblies** of formed sections of sizes and profiles required.
- **Provide cut-outs** centered in webs of members to accommodate services and though-the-knockout style bridging.
- **Fit, reinforce, and brace framing members** to suit design requirements.
- **Fit and assemble** in largest practical sections for delivery to site, ready for installation.
- **Do welding** to CSA S136, as applicable.

### Part 3 Installation and Execution

#### 1. PREPARATION
- **Coordinate Installation Drawings**, diagrams, templates, instructions, and directions for anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

#### 2. ERECTION
- **Canopies** are to be installed according to approved shop drawings and plans.
- **The entire structure** shall be installed straight, true, and plumb according to standard construction procedures.
- **Canopies shall be installed** minimal slope to allow water flow from top of canopy to draining columns and eliminate ponding.
- **All joints, corners, and connections** shall be tight and clean.
- **All exposed fasteners** are to be painted to match the canopy color.
- **Decking is to be** aligned and secured to aluminum frame structure.

#### 3. COLUMN FOUNDATION
- **Styrofoam blockouts** shall be provided by the canopy manufacturer and installed by the General Contractor into the concrete foundation.
- **General Contractor shall pour** the required concrete foundation size around the Styrofoam blockouts provided by the manufacturer.
- **Canopy installer is to remove** the Styrofoam after the foundation has cured, set column in cavity, and fill with minimum 2000 psi grout to level of finished concrete slab.

#### 4. CLEANING
- **All canopy surfaces exposed** are to be cleaned after installation is complete.
- **Surplus materials and debris** shall be removed from the jobsite after installation is complete.

END OF SECTION
Part 1 General

1. RELATED SECTIONS
   a. Utilities Drawings
   b. Detailed Design Report

2. REFERENCES
   a. City of Vancouver Engineering Design Manual
   b. City of Surrey Design Criteria Manual
   c. UBC Integrated Stormwater Management Plan
   d. American Society for Testing and Materials International (ASTM)
   e. American Concrete Institute (ACI)
   f. American Water Works Associations (AWWA)
   g. Master Municipal Construction Documents (MMCD)

Part 2 Products

1. STORMWATER AND GRAVITY FED SANITARY MAINS AND CONNECTIONS
   a. PVC, class SDR for pipes under 150mm and SDR 35 for pipes in diameter up to 600mm
   b. Concrete (reinforced C76 required for all pipes 600mm in diameter and larger)
   c. Water

2. WATERMAINS AND CONNECTIONS
   a. Class 50 ductile iron pipe in accordance with AWWA, cement mortar lined to AWWA C104 and coated with 1mm thick asphalt coating or approved equivalent
   b. Type K copper pipes with brazed joints up to 75mm for connections up to 75mm
   c. Single rubber gasket Tyton joints in accordance with AWWA C111 for push-on bell and spigot type joints or approved equivalent
   d. Flat faced flanged joints in accordance with AWWA C110
   e. Fittings to be ductile iron in accordance with AWWA C110 along with pressure rating of 2415 kPa
   f. Minimum design pressure for piping is 1210 kPa

3. SANITARY FORCEMAINS
   a. PVC, Class C900 for mains under 300mm diameter and C905 for any larger mains

4. ACCESSORIES
   a. Ductile iron gate valves in accordance with AWWA C509 with flanged or hub ends
   b. Nelson-type circular valve boxes manufactured by Terminal City of Dobney foundry
   c. 150mm diameter Terminal City type C-71-P hydrants, tested to 2070 kPa hydrostatic pressure in accordance with AWWA C502
   d. Concrete catch basins to be purchased from City of Vancouver, including trapping hoods and typical sump

5. PIPE BEDDING AND SURROUND MATERIALS
   a. 19mm minus, MMS type 1, cleaned, granular pipe bedding with minimum bottom thickness of 100mm, 300mm top thickness, 225mm minimum side thickness
   b. Use native backfill wherever possible under paved areas
   c. Imported bedding must be approved by UBC Energy & Water Services prior to use
Part 3 Execution

1. GENERAL
   b. Existing utility mains should be left in place during construction unless explicit direction is provided by the Consultant or UBC Water & Energy Services
   c. Existing ground-level infrastructure including fire hydrants, manholes, cleanouts, and inspection chambers should be left in place during construction unless explicit direction is provided by the Consultant or UBC Water & Energy Services
   d. Relocated catch basins should be reused wherever possible as long as visual inspection suggests adequate quality. If any leakage is observed from catch basin, existing catch basin should be discarded, and new basin used as specified

2. PREPARATION AND TRENCHING
   a. Site preparation to follow details outlined in MMCD Section 02666
   b. Trenching to follow details outlined in City of Vancouver Construction Specifications Section 31 23 01

3. INSTALLATION
   a. Maintain 3m horizontal clearance between parallel sanitary sewer or storm sewer mains and water mains. If existing clearance is less, or if approved by UBC Water & Energy Services, installation should follow details in MMCD Design Guideline Manual Section 1.4 and Vancouver Coastal Health’s Water Supply System Construction Permit Guidelines and Application. Water main joints should be wrapped in shrink plastic or petroleum tape in accordance with AWWA C217, C214, and C209
   b. Maintain 750mm clearance between water mains and other utility services, and 3m clearance to building foundations
   c. Prior to covering, pipe and bedding should be inspected by UBC Energy & Water Services. Contractor shall provide written notification to both the Utilities Engineer and Head Plumber with a minimum of 24 hours’ notice
   d. Contractor shall be responsible for maintaining detailed records of pipe sizes and inverts to be provided to UBC’s Records Manager, Infrastructure Development, and Mechanical Utilities Engineer in accordance with Section 01 78 39 of UBC’s Project Record Documents Technical Guidelines
   e. Upon completion of pipe laying, pipes should be surrounded and covered with specified backfill. Joints and fittings should be exposed until field testing is complete
   f. Backfill and pipe surround should be compacted to at least 95% Modified Proctor Density

4. FLUSHING AND TESTING
   a. Cleaning, flushing, and pressure testing to be conducted by Contractor
   b. Engineer should be notified within 24 hours of and present for proposed test
   c. Contractor shall apply for UBC Hydrant Use Permit prior to using water supplied from UBC fire hydrants for cleaning and flushing
   d. Pressure and leakage testing for PVC piping to AWWA M23 standards, HDPE piping to AWWA M55 standards, with no leakage allowed and pressures not exceeding CSA B137.3

END OF SECTION
PERMEABLE CONCRETE

Part 1 General

1. RELATED SECTIONS
   a. Permeable Concrete Detail Drawing
   b. Detailed Design Report

2. REFERENCES
   a. City of Vancouver Engineering Design Manual
   b. UBC Integrated Stormwater Management Plan
   c. American Society for Testing and Materials International (ASTM)
   d. American Concrete Institute (ACI)
   e. American Association of State Highway and Transportation Officials
   f. National Ready Mixed Concrete Association
   g. UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds
   h. Flood Testing Labs

Part 2 Products

1. Specifications
   a. Final concrete mix must adhere to the following property requirements as determined through lab testing in accordance with ACI standards:

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>28-Day Compressive Strength</td>
<td>20 MPa</td>
</tr>
<tr>
<td>Infiltration Rate</td>
<td>8600 mm/hr</td>
</tr>
<tr>
<td>Void Space</td>
<td>15%</td>
</tr>
<tr>
<td>Unit Weight</td>
<td>1500 kg/m$^3$ to 2000 kg/m$^3$</td>
</tr>
<tr>
<td>Slump</td>
<td>15cm to 18cm</td>
</tr>
</tbody>
</table>

   b. Contractor to develop target void-density curve for final mix design for use during field testing

2. Materials
   a. Contractor to develop mix design meeting specifications outlined above and seek approval from Engineer prior to construction
   b. Calcium chloride is not permitted in any form in mix
   c. Material Source must be government-approved unless specified with grading and density following those outlined in Drawing D102
   d. Filter geotextiles shall meet requirements outlined in AASHTO M288 for Class 2

Part 3 Execution

5. PRE-INSTALLATION
   a. A minimum of two panel tests to be conducted on site on native material in accordance with ACI 522.1-13. Panels must have minimum area of 225 sq. ft, with width and thickness outlined in construction drawings.
   b. Dimensions and density of hardened cores must be recorded to establish acceptable reference points for quality assurance purposes
a. Do not compact subgrade beyond 90% of theoretical density to maintain void spaces
b. Subgrade should be cleaned prior to installation
c. Moisten subgrade and ensure no free-standing water is visible prior to placement

7. INSTALLATION
a. Mix must be completely discharged within one hour of initial mixing and visually inspected for consistency and even aggregate coating
b. Placement shall be done in a continuous pour into conventional formwork with mechanical screeds used and strike offs done 20 mm above formwork
c. Consolidate concrete using steel roller within 15 minutes of placement
d. Control joints shall be placed every 6m in with a depth of ¼ of the slab thickness
e. Moisten concrete surface with water then cover with plastic sheeting within 20 minutes of initial placement
f. Plastic cover should be held down and remain in place for a minimum of 7 days or until core tests are completed.
g. Formwork shall be left in place for a minimum of 28 days unless otherwise directed

8. INSPECTION AND TESTING
a. Three core samples will be tested for every 75 m³ poured on-site. The average density of these cores must be within 5% of the density determined from the test panel cores, thickness within 19mm, and average length within -10mm and 38mm of design values in accordance with ASTM C1754
b. Infiltration testing will be conducted in accordance with ASTM C1701

END OF SECTION
APPENDIX C – SAMPLE TRANSPORTATION CALCULATIONS

Road Crest Curve Calculations

Example curve: Crest curve at Station = 0 + 500

Elevation of highest point = ~91.75m

Length of crest curve = ~130m

Calculations shown below.

<table>
<thead>
<tr>
<th>CREST CURVE CALCULATION</th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>S (Sight Distance)</td>
<td>(50/3.6)^2.5 + (150/3.0)^2 / (2 * 0.3 * 9.81)</td>
<td>67.49511 m</td>
</tr>
<tr>
<td>Assume S &lt; L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L (Length of Vertical Curve)</td>
<td>(AS^2)/[100^2 * sqrt(2 * H1 + sqrt(2 * H2))^2]</td>
<td>33.80774 m</td>
</tr>
<tr>
<td>L (Length of Vertical Curve)</td>
<td>25 - [200^2 * sqrt(H1 + sqrt(H2))^2] / A</td>
<td>129.00009 m</td>
</tr>
<tr>
<td>Station VPC</td>
<td>Station VPL + L/2 = 0 + 500 - 65</td>
<td>0 + 435</td>
</tr>
<tr>
<td>Station VPT</td>
<td>Station VPL + L/2 = 0 + 500 - 65</td>
<td>0 + 565</td>
</tr>
<tr>
<td>Elevation VPC</td>
<td>Elevation VPL - G(L/2) = 91.75 - 0.0167 * 65</td>
<td>91.1845 m</td>
</tr>
<tr>
<td>Elevation VPC</td>
<td>Elevation VPL - G(L/2) = 91.75 - 0.0196 * 65</td>
<td>91.3665 m</td>
</tr>
<tr>
<td>Location of High Point</td>
<td>(g1^2 + g2^2) = (1.67^2 + 130^2) / (3)</td>
<td>72.36667 m</td>
</tr>
<tr>
<td>Elevation of High Point</td>
<td>90.66 + 0.0167 * 75 + (((-0.03 * 75 * 2) / (2 * 130)) + 91.76796 m</td>
<td></td>
</tr>
</tbody>
</table>
## APPENDIX D – STRUCTURAL CALCULATIONS

### A DIMENSIONS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Roof</td>
<td>3.6 m</td>
</tr>
<tr>
<td>Col to Col</td>
<td>1.8 m</td>
</tr>
<tr>
<td>Cover Length</td>
<td>3.16 m</td>
</tr>
<tr>
<td>Column Height</td>
<td>3.07 m</td>
</tr>
<tr>
<td>Length of Section</td>
<td>3.6 m</td>
</tr>
<tr>
<td>Reference height</td>
<td>3.5519 m</td>
</tr>
<tr>
<td>Maximum height</td>
<td>3.814 m</td>
</tr>
<tr>
<td>Cantilever Trib A</td>
<td>3.24 m²</td>
</tr>
</tbody>
</table>

### B SNOW

- **$I_s** = 1 Normal Importance
- **$S_s$** = 1.8 Vancouver City Hall
- **$C_b$** = 0.8
- **$w_v$** = 1.8
- **$w_l$** = 1.0
- **$C_s$** = 1
- **$C_a$** = 1
- **$S_r$** = 0.2

S = $I_s [S_s (C_b C_m C_a C_b) + S_r]$

### C WIND

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>$w_w$</td>
<td>0.45</td>
</tr>
<tr>
<td>$w_i$</td>
<td>0.7</td>
</tr>
<tr>
<td>$w_l$</td>
<td>0.7</td>
</tr>
<tr>
<td>$V_t$</td>
<td>1.999962111</td>
</tr>
<tr>
<td>$V_o$</td>
<td>19.6560216 m³</td>
</tr>
<tr>
<td>$C_p$</td>
<td>37.32156 m²</td>
</tr>
<tr>
<td>$C_t$</td>
<td>1</td>
</tr>
<tr>
<td>$C_g$</td>
<td>2</td>
</tr>
<tr>
<td>$c_i$</td>
<td>0.7</td>
</tr>
<tr>
<td>$c_l$</td>
<td>-0.5</td>
</tr>
<tr>
<td>$h/t$</td>
<td>1.067055556</td>
</tr>
<tr>
<td>$C_{pi}$</td>
<td>-0.7</td>
</tr>
</tbody>
</table>

Wind: -0.315 kPa  Wint: -0.88198329 kPa  | Wsum: -1.196983292 kPa

$P_i = I_w q C_{bi} C_t C_{gi} C_{pi}$

### D DEAD

<table>
<thead>
<tr>
<th>Section</th>
<th>W200x31</th>
<th>W200x31</th>
<th>W200x31</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4000 mm²</td>
<td>4000 mm²</td>
<td></td>
</tr>
<tr>
<td>rx</td>
<td>88.6 mm</td>
<td>88.6 mm</td>
<td></td>
</tr>
<tr>
<td>ry</td>
<td>92 mm</td>
<td>32 mm</td>
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<tr>
<td>Cross Section</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Steel Column</td>
<td>0.01228 m³</td>
<td>8050 kg/m³</td>
<td>0.969757 kN</td>
</tr>
<tr>
<td>Cantilever</td>
<td>0.004 m²</td>
<td>8050 kg/m³</td>
<td>0.315812 kN</td>
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<tr>
<td>Glass Panels</td>
<td>0.02 m</td>
<td>2500 kg/m³</td>
<td>0.4905 kN/m²</td>
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<tr>
<td>Glass Thickness</td>
<td>0.02 m</td>
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### E Load Combinations

<table>
<thead>
<tr>
<th>Load Combination</th>
<th>Cantilever</th>
<th>Column</th>
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<tbody>
<tr>
<td>Snow</td>
<td>1.48 kN/m</td>
<td>5.31 kN</td>
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<tr>
<td>Wind</td>
<td>1.08 kN/m</td>
<td>3.88 kN</td>
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<tr>
<td>Dead</td>
<td>0.76 kN/m</td>
<td>4.18 kN</td>
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<table>
<thead>
<tr>
<th>Load Combination</th>
<th>Cantilever</th>
<th>Column</th>
<th>Servicibility</th>
<th>Cantilever</th>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1.40</td>
<td>1.06 kN/m</td>
<td>5.85 kN</td>
<td>1.00°+1.05°+1.0°W</td>
<td>3.31</td>
<td>13.37</td>
</tr>
<tr>
<td>2:1.25+1.05 or 0.4W</td>
<td>2.42 kN</td>
<td>10.34 kN</td>
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<td></td>
<td></td>
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<tr>
<td>3:1.25+1.55 or 0.4W</td>
<td>3.59 kN</td>
<td>14.75 kN</td>
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<td></td>
<td></td>
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<tr>
<td>4:1.250+1.4W+0.55</td>
<td>3.19 kN</td>
<td>13.31 kN</td>
<td>1.250</td>
<td>0.94665</td>
<td></td>
</tr>
<tr>
<td>5:1.00</td>
<td>17.93 kN</td>
<td>11.64</td>
<td>0.4W</td>
<td>-0.430913985</td>
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Mf: 17.93 kN  VF: 11.35 kN  N/A
### FLEXURE

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<tr>
<th>CANTILEVER W200x31</th>
<th>COLUMN W200x31</th>
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<tr>
<td>E 200000 MPa</td>
<td>E 200000 MPa</td>
</tr>
<tr>
<td>G 78923.07692 MPa</td>
<td>G 78923.07692 MPa</td>
</tr>
<tr>
<td>J 119000 mm4</td>
<td>J 119000 mm4</td>
</tr>
<tr>
<td>Iy 4100000 mm4</td>
<td>Iy 4100000 mm4</td>
</tr>
<tr>
<td>bel 134 mm</td>
<td>bel 134 mm</td>
</tr>
<tr>
<td>t 10.2 mm</td>
<td>t 10.2 mm</td>
</tr>
<tr>
<td>Cw 4090000000 mm6</td>
<td>Cw 4090000000 mm6</td>
</tr>
<tr>
<td>zx 335000 mm3</td>
<td>zx 335000 mm3</td>
</tr>
<tr>
<td>sx 299000 mm3</td>
<td>sx 299000 mm3</td>
</tr>
<tr>
<td>Phi 0.9</td>
<td>Phi 0.9</td>
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</tbody>
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\[
b_{el}/t < 7.750576015 \text{ Class 1} \]
\[
< 9.086682225 \text{ Class 2} \]
\[
< 12.82853961 \text{ Class 3} \]

\[
\delta_{max} = 54.5921141 \text{ mm} \]

\[
\delta_{max} = 54.5921141 \text{ mm} \]

### MOMENT END PLATE CONNECTION DESIGN

#### PRYING ACTION

Equilibrium

\[
M_f = 17.93 \text{ kNm} \\
Lever Arm 1 = 0.2 \text{ m} \\
Lever Arm 2 = 0.1288 \text{ m} \\
F = 109.0756421 \text{ kN} \\
T_f1 = 70.89916735 \text{ kN} \text{ at 65\% of Load} \\
T_f2 = 38.17647472 \text{ kN} \text{ at 35\% of Load} \\
Nom. Area Bolt = 155 mm2 \\
Stress in Bolt 1 = 457.4139829 MPa < Fub = 825 \\
Stress in Bolt 2 = 246.2998369 MPa < Fub = 825 \\
14mm A325 Bolts \\
Fub = 825 MPa \\
Tr (Bolt) = 76.725 kN

#### END PLATE YIELDING

\[
M_f = 17.93 \text{ kNm} \\
End Plate Length = 0.5 \text{ mm} \\
Lever Arm = 0.125 \text{ mm} \\
\text{Equivalent Force} = 143.4562844 kN \\
End Plate Thickness = 10 mm \\
End Plate Width = 127 mm \\
End Plate Area = 1270 mm2 \\
F = 112.9577043 MPa < f_y = 400.05 \\
Tr (End Plate) = 400.05 MPa
\]
WELD STRENGTH

<table>
<thead>
<tr>
<th>Mf</th>
<th>17.63 kNm</th>
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<tr>
<td>Lever Arm</td>
<td>0.66 m</td>
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<tr>
<td>TF</td>
<td>298.16756658 kN</td>
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<tr>
<td>Vr</td>
<td>317.1677610 kN</td>
</tr>
<tr>
<td>&gt;Phi_v</td>
<td>0.67</td>
</tr>
<tr>
<td>&gt;Aw</td>
<td>1077.468 mm³</td>
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<tr>
<td>&gt;&gt;Weld leg</td>
<td>6 mm</td>
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<tr>
<td>&gt;=Weld Length</td>
<td>256 mm</td>
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<tr>
<td>&gt;X_u</td>
<td>460 MPa</td>
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<tr>
<td>&gt;Theta</td>
<td>90 deg</td>
</tr>
<tr>
<td>Mw</td>
<td>1</td>
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FOOTING DESIGN

OVERTURNING MOMENT DESIGN

|F_c | 25 MPa |
|q Allowable | 150 kPa |
|Total P | 14.14 kN |
|Areq | 0.222033333 m² |
|Breq | 0.478469763 m² |
|Use | A |
|Use e | 0.00600067 |
|Use b | 1.2 m |
|Pd | 11070 kN |
|A1 | 0.09 m² |
|A2 | 0.8 m² |
|VC | 1064.7 kN |

Depth of Footing | 1.3 |
Volume of Footing | 1.04 |
Weight of Footing | 6993913533 kN |

Overturning Mom. | 17.93 kNm |
Overturning Resis. | 18.84503811 kNm |

MOBILE BASEPLATE CONNECTION DESIGN

<table>
<thead>
<tr>
<th>Mf</th>
<th>17.63 kNm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lever Arm 1</td>
<td>0.2 m</td>
</tr>
<tr>
<td>Lever Arm 2</td>
<td>0.1288 m</td>
</tr>
<tr>
<td>F per bolt</td>
<td>109.0756421 kN</td>
</tr>
<tr>
<td>TF1</td>
<td>70.89918735 kN</td>
</tr>
<tr>
<td>TF2</td>
<td>31.17647472 kN</td>
</tr>
<tr>
<td>Nom. Area Bolt</td>
<td>315 mm²</td>
</tr>
<tr>
<td>Stress in Bolt 1</td>
<td>213.0767217 MPa</td>
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<tr>
<td>Stress in Bolt 2</td>
<td>111.1951579 MPa</td>
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<tr>
<td>Anchor Bolt Size</td>
<td>20 mm</td>
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<tr>
<td>Fub</td>
<td>825 MPa</td>
</tr>
<tr>
<td>Tr (Bolt)</td>
<td>151.925 kN</td>
</tr>
<tr>
<td>Development Ld</td>
<td>576 mm</td>
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</tbody>
</table>

>use 610mm (24") anchor bolts
**Load Case 1 (Bending + Compression)**

**Section classification** ($f_y = 350$ MPa):
- Section Class = 1

**Governing geometrical slenderness ratio**
- $k_a = 1.00$, $k_p = 1.00$, $k_L/L_a = 36.2$;
- $k_i = \frac{L_i}{L_a} = \frac{200}{200} = 1.00$

**Axial Load - (kN)**
- 0.00

**Factored Compressive Resistance Check**
- $n = 1.34$, $\alpha = 1.33$
- $C_t = \frac{C_t}{C_{ty}} = \frac{\phi AF_y}{(1+\alpha)^{0.5n}} = \frac{1}{334} = 0.003$

**Strong Axis Shear - (kN)**
- 0.00

**Strong axis shear strength check**
- $A_{st} = 1344$ mm$^2$
- $\frac{V_{st}}{\phi A_{st} F_y} = \frac{10}{0.65F_y} = 0.036$

**Strong Axis Moment - (kN-m)**
- 0.00

**Bending Stability Check**
- $L_s = 3.20$ m; $\alpha_s = 2.426$
- $\frac{M_{st}}{M_{st}} = 16 = 0.153$

**Axial Compression and Bending cross-sectional Strength Check**
- $C_t = \frac{C_t}{C_{ty}} = \frac{0.65 U_{st, M_{st}}}{\phi Z_{st} F_y} = 0.131$

**Axial Compression and Bending overall member Strength Check**
- $C_t = \frac{C_t}{C_{ty}} = \frac{0.65 U_{st, M_{st}}}{\phi Z_{st} F_y} = 0.132$

**Axial Compression and Bending lateral torsional buckling strength check**
- $C_t = \frac{C_t}{C_{ty}} = \frac{0.65 U_{st, M_{st}}}{M_{st}} = 0.133$
### Load Case 1 (Bending + Compression)

#### Section classification: \( f_s = 350 \text{ MPa} \)

**Section Class** = 1

**Governing geometrical slenderness ratio**
- \( k_1 = 1.00 \)
- \( k_2 = 1.00 \)
- \( k_L / r = 35.9 \)
- \( k_L / r = \frac{99}{200} = 0.497 \)

**Axial Load** - (kN)
- Axial Load: \( 10.2 \text{ (kN)} \)

**Factored Compressive Resistance Check**
- \( C_f = \frac{C_f}{\phi A F_y} \)
- \( C_f = 10 \)
- \( A = 150 \text{ MPa} \)
- \( 0.019 \)

**Strong Axis Moment** - (kN-m)
- Strong Axis Moment: \( 16.2 \text{ (kN-m)} \)

**Bending Stability Check**
- \( L = 3.18 \text{ m; } \alpha = 1.020 \)
- \( M_{Ed} = 17 \text{ kN-m} \)
- \( M_{Ed} = 85 \text{ kN-m} \)
- \( 0.192 \)

**Axial Compression and Bending cross-sectional Strength Check**
- \( \alpha_a = 0.98; \ U_a = 1.00 \)
- \( \frac{C_f}{\phi A F_y} = 0.85 U_a M_{Ed} \frac{1}{\phi_z F_y} \)
- \( 0.144 \)

**Axial Compression and Bending overall member Strength Check**
- \( \alpha_a = 0.98; \ U_a = 0.98 \)
- \( \frac{C_f}{C_{ax}} = 0.85 U_a M_{Ed} \frac{1}{\phi_z F_y} \)
- \( 0.143 \)

**Axial Compression and Bending lateral torsional buckling strength check**
- \( \alpha_a = 0.98; \ U_a = 1.00 \)
- \( \frac{C_f}{C_{ax}} = 0.85 U_a M_{Ed} \frac{1}{M_{Ed}} \)
- \( 0.182 \)
Permeable Concrete Storage Depth Calculations

10 – year, 24 – hour Storm Intensity = 2.8mm/hr

Total Precipitation = $i \times d = 2.8 \times 24 = 67.2$mm

Storage in Concrete Layer = Min. Depth $\times$ Void Space = 150mm $\times$ 15% = 22.5mm

Min. Depth of Reservoir Base $= \frac{\text{Total Precipitation} - \text{Storage in Concrete Layer}}{\text{Void Space}} = \frac{67.2\text{mm} - 22.5\text{mm}}{35\%}$

= 128mm, Round up to 200mm for contingency

50mm minimum depth for choker course, so 200mm $-$ 50mm = 150mm depth for reservoir course

<table>
<thead>
<tr>
<th>Layer</th>
<th>Void Space (%)</th>
<th>Depth (mm)</th>
<th>Storage (mm)</th>
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<tbody>
<tr>
<td>Permeable Concrete</td>
<td>15</td>
<td>150</td>
<td>22.5</td>
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<tr>
<td>Reservoir</td>
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<td>200</td>
<td>70</td>
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<tr>
<td>Total</td>
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<td>Unit</td>
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<tr>
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<td>32&quot; Flex Bollard - Emergency Access</td>
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<tr>
<td>Description</td>
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<td>Cost 1</td>
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<tr>
<td>Permanent Traffic Controls</td>
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<td>New Signage Implementation</td>
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**Phase 1 Construction**

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**Phase 2 Construction**

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**Phase 3 Construction**

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**Site Setup**

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## APPENDIX H – RISK REGISTER

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<th>Risk</th>
<th>Project Phase</th>
<th>Likelihood</th>
<th>Impact</th>
<th>Mitigation Strategy</th>
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<tr>
<td>Significant design changes</td>
<td>Design</td>
<td>Low</td>
<td>High</td>
<td>Ensure clarity when communicating with contractors and that all specifications and requirements are understood</td>
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<tr>
<td>Inaccurate cost estimate</td>
<td>Design</td>
<td>Low</td>
<td>High</td>
<td>Continually refine costs estimates and minimize major design changes throughout the project</td>
</tr>
<tr>
<td>Delays in obtaining permits</td>
<td>Design</td>
<td>Low</td>
<td>Moderate</td>
<td>Ensure all necessary documents and fees are included in application process</td>
</tr>
<tr>
<td>Schedule delays</td>
<td>Design</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Have clear schedule specifications and confirm design with contractors before the start of major work</td>
</tr>
<tr>
<td>On-site incidents</td>
<td>Construction</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Ensure equipment is only operated by qualified personnel. Implement adequate signage and minimize contact with pedestrians</td>
</tr>
<tr>
<td>Interrupting Buried Utilities</td>
<td>Construction</td>
<td>Low</td>
<td>High</td>
<td>Conduct One-Calls prior to digging and contractor to confirm utility depths. Hand-digging will be used when in proximity to utilities</td>
</tr>
<tr>
<td>Traffic Delays</td>
<td>Construction</td>
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<td>Moderate</td>
<td>Ensure Traffic Management Plan is understood and relayed to all contractors. Equipment transport will be done outside of peak hours</td>
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<tr>
<td>Damage during tree transplant</td>
<td>Construction</td>
<td>Moderate</td>
<td>Low</td>
<td>Ensure all tree work is done in accordance to UBC Tree Protection Guidelines</td>
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<tr>
<td>Contaminated or unsuitable soil</td>
<td>Construction</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Contractor to conduct adequate geotechnical studies. Contaminated soils will be removed and disposed of and replaced with new soil</td>
</tr>
<tr>
<td>Concrete Plastic Shrinkage</td>
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<td>Low</td>
<td>Ensure concrete curing specifications are conveyed to relevant contractors</td>
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<td>COVID 19 - Restrictions</td>
<td>Construction</td>
<td>Moderate</td>
<td>High</td>
<td>Contractors and on-site workers to follow all B.C. and WorkSafeBC COVID-19 protocols relevant to on-site work</td>
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<tr>
<td>Extreme weather</td>
<td>Construction</td>
<td>Low</td>
<td>High</td>
<td>Ensure on-site work and equipment are adequately stored when inclement weather is predicted</td>
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<td>Site Vandalism</td>
<td>Construction</td>
<td>Low</td>
<td>Moderate</td>
<td>Ensure all on-site work and equipment are adequately stored and protected after hours</td>
</tr>
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<td>Noise Complaints</td>
<td>Construction</td>
<td>Moderate</td>
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<td>Ensure noise sensitive work is done outside of the morning and evening periods</td>
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## APPENDIX I – SYNCHRO ANALYSIS

Thunderbird Boulevard at East Mall – 2020 AM

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<th>EST</th>
<th>EBR</th>
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<th>WBT</th>
<th>WBR</th>
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### Interaction Summary

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<td>Minimum Phc Ratio (550)</td>
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<td>Intersection Capacity Utilization (85%)</td>
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### Signal Phases

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### Baseline

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Synchro 6 Report

Page 1

### Synchro 6 Report

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