UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

# Chancellor Boulevard – East Mall Intersection Redesign

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## EXECUTIVE SUMMARY

TransitFlow prepared this construction design package for UBC's redesign of the Chancellor Boulevard – East Mall intersection at the Point Grey campus. Priorities include pedestrian and cyclist safety, traffic calming, rainwater capture, and creating a welcoming gateway presence. The design underwent an extensive iterative process to meet design requirements.

The intersection was redesigned as a roundabout using curvature to slow traffic, directly enhancing pedestrian and cyclist safety. To further the safety of pedestrians and cyclists, raised crosswalks with pedestrian crossing lights and bike lanes have been incorporated.

To prevent erosion of the Point Grey cliffs, the Chancellor Boulevard – East Mall intersection features a rain garden and drainage system leading to a storage tank. At the roundabout's center, a UBC Thunderbird-inspired gateway sign, reflecting Indigenous artistry, symbolizes the importance of UBC's connection with Indigenous culture.

The design adheres to the TAC, City of Vancouver, BC MoTI and Infrastructure guidelines. The construction will unfold in 3 phases starting on May 5th 2025, and completing on November 26th 2025. To allow the intersection to remain operational throughout construction a traffic management plan has been developed for each phase to minimize traffic flow interference. The Class A cost estimate projects the project to cost $5,645,000.

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# 1 INTRODUCTION

UBC has requested that TransitFlow redesign the Chancellor Boulevard – East Mall intersection located on the North end of the Point Grey campus. The University of British Columbia is located on the western edge of the West Point Grey with close to 75,000 student and faculty members. With the UBC Endowmnet Lands surrounding campus and an increasing student population the transportation infostructure in place is not able to meet the traffic flow demands. Originally the Chancellor Boulevard – East Mall intersection was designed to allow for high traveling speeds and thus has incorporated highway features. In anticipation of a continually growing population UBC is committed to encouraging active modes of transportation to meet their sustainability goals and manage traffic flow. The redesign of the Chancellor Boulevard – East Mall intersection to encourage active modes of transportation will help UBC meet their sustainability goals and benefit the surrounding community as the population grows.

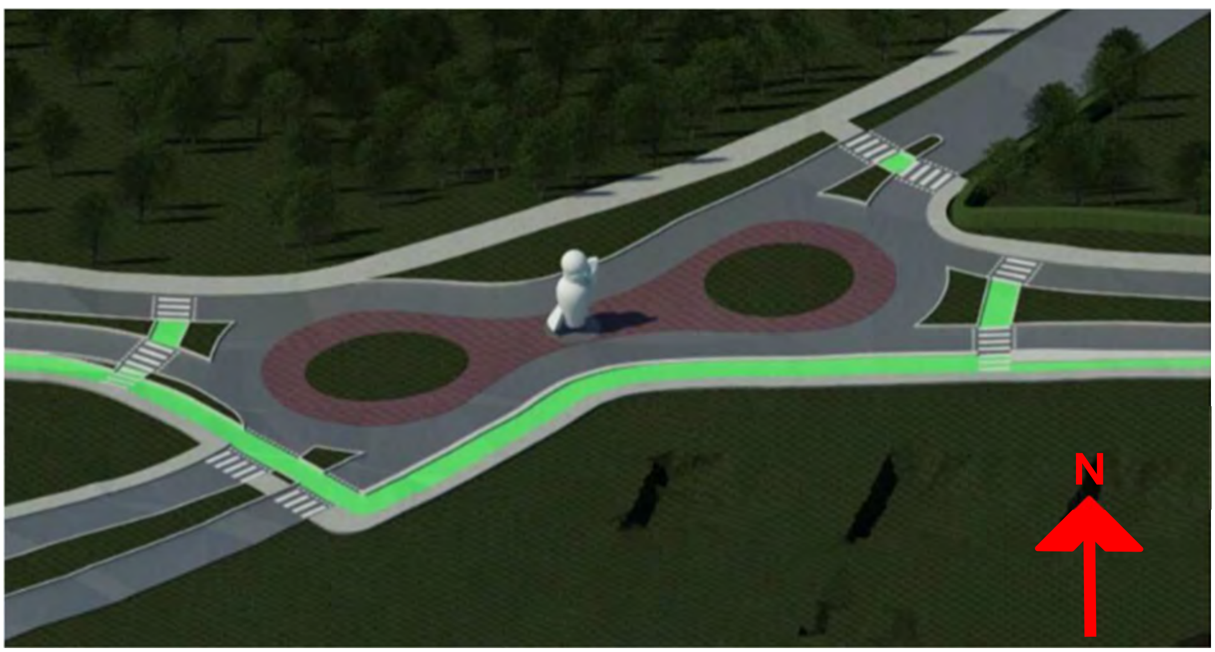



*Figure 1. 3D rendering of new Chancellor Boulevard – East Mall intersection*

# 2 SITE OVERVIEW AND DESIGN OBJECTIVES

The project site is located at the intersection of NW Marine Drive and East Mall within the University of British Columbia (UBC) campus in Vancouver, British Columbia. This location is a key entry point for vehicles, cyclists, and pedestrians approaching the campus from the northeast perimeter. Currently, the intersection runs as a T-junction with limited traffic control, resulting in operational inefficiencies and safety concerns for all modes of transportation.

*Figure 2. Google Earth indicating site location*

## 2.1 Project Objectives

The design of the Chancellor Boulevard – East Mall intersection will aim to prioritize active modes of transportation and improve the safety for all users. In addition to adhering to the TAC, City of Vancouver, BC MoTI and Infrastructure guidelines, the redevelopment of the intersection will incorporate the design requirements outlined below:

- Improve the safety of pedestrians and cyclists within the intersection

- Promote active modes of transportation
- Reduce the traveling speed of vehicles through the intersection
- Capture and repurpose all rainwater
- Establish an 8m tall welcome sign to create a sense of arrival

By fulfilling these parameters TransitFlow aims to design an intersection which will more effectively meet the needs of the surrounding community. These objectives have been addressed through an iterative design process to ensure a robust solution has been found. To ensure this design ties into UBC's larger development goals, SEEDS, UBC's sustainability program has been referenced.

## 2.2 Design Criteria and Adherence

*Table 1. Description of design criteria*

| Criteria | Description |
|---|---|
| **Mandatory Design Criteria** | |
| Emergency Response Accessibility | The design prioritizes an efficient and uninterrupted route for emergency vehicles. |
| Seamless Transition to UBC Campus | The design has been integrated into the existing roadway with clear signage and markings. |
| Adherence to Codes and Guidelines | The design has followed all legally binding and relevant codes to ensure safety and compliance with UBC development standards. |
| **Non-mandatory Design Criteria** | |
| Cost Considerations | Focusing on enhancing active modes of transportation and reducing environmental impacts, cost remains the top priority among the flexible evaluation criteria. |

| | |
|---|---|
| Resulting Level of Service (LOS) | To improve the functionality of the design for all users, the LOS has been improved and unified across the intersection. |
| Intersection Optimization | The design seeks to optimize the flow of traffic by incorporating features which are intuitive for users to navigate such as a roundabout. |

## 2.3 Community and Environmental Aspects

The design will prioritize minimal disruption to the surrounding ecosystem and community, particularly during construction and subsequent operation. The design for the UBC intersection seeks to harmonize human activity with the natural environment by minimizing disruption, reducing pollutant runoff, integrating biodiversity-enhancing features, and aligning with the university's established sustainability goals.

To mitigate the environmental impact of stormwater runoff, the rainwater management design will incorporate systems that filter and treat water before it is repurposed. Natural systems such as bioswales and rain gardens will be included to capture and slow runoff, promoting infiltration and reducing the transport of pollutants. These features will also enhance local biodiversity, supporting native plants and habitats while improving the aesthetic quality of the site.

Materials and systems will be selected to reduce the urban heat island effect and improve water quality. For example, the use of permeable pavements will allow water to seep through the surface, replenishing groundwater reserves and preventing erosion caused by concentrated surface flows (American Public Works Association (APWA), 2017).

# 3 FINAL DESIGN

The Chancellor Boulevard – East Mall intersection redesign represents a comprehensive effort to modernize the space while addressing critical safety, sustainability, and functionality challenges. The three key components of the intersection redesign are the welcome sign, the stormwater management system and the intersection itself. The welcome sign will aim to create a sense of arrival through incorporating artistic features which reflect the culture and community of UBC. To manage the stormwater a rain garden has been designed in addition to drainage infrastructure to capture rainwater for repurposing. The intersection will be redesigned in a dog-bone styled roundabout. This style was chosen due to the safety features introduced through design components such as curvature which calm traffic. To further improve visibility pedestrian crossing lights will be incorporated to improve safety for active mode transportation users.

The final design of the NW Marine Drive and East Mall intersection was developed through a rigorous evaluation of site conditions, project objectives, and stakeholder considerations. Several critical design issues were identified during the preliminary design phase, each requiring careful analysis to ensure safety, functionality, and long-term sustainability. This section outlines these key issues, and the design decisions made to address them.

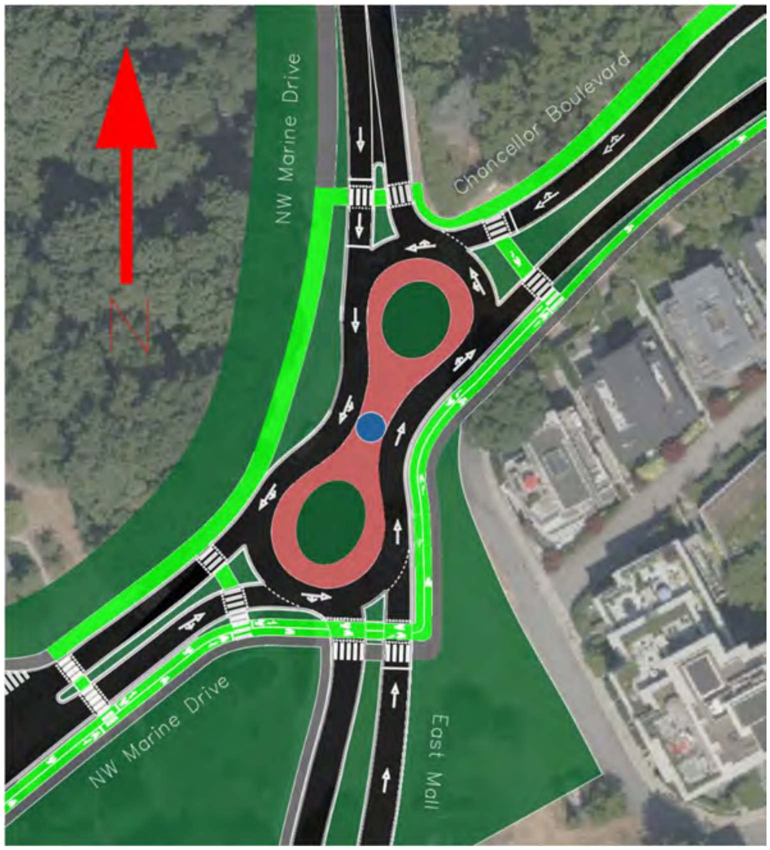



*Figure 3. Final dog-bone intersection design*

## 3.1 Intersection Design

One of the most pressing issues was the intersection's history of unsafe vehicle speeds and poor accommodations for active travel modes. The existing design functioned more like a highway than an urban gateway, leading to safety risks for pedestrians and cyclists. The chosen dog-bone-shaped double roundabout layout resolves these issues by naturally slowing vehicle speeds while maintaining continuous traffic flow. This configuration reduces conflict points and enhances safety, aligning with TAC geometric design guidelines and the project's objective of prioritizing active travel.

The lack of dedicated infrastructure for pedestrians and cyclists was a significant barrier to sustainable, multi-modal transportation. To address this, the design incorporates raised pedestrian crossings, protected bike lanes, and high-visibility markings. The crossings are strategically placed at key desired lines, while the bike lanes are physically separated from traffic, reducing collision risk. These elements ensure compliance with the Accessible Canada Act and promote a safer, more inclusive intersection for all users.

## 3.2 Stormwater Management

Capturing and repurposing stormwater on-site was a critical environmental consideration, especially given the proximity of the intersection to nearby cliffs. Uncontrolled runoff had contributed to cliff erosion, posing long-term stability risks. The final design includes a bioswale system, permeable pavements, and an underground detention tank capable of handling a 100-year storm event. These features not only prevent erosion but also support local biodiversity and align with Metro Vancouver's Stormwater Management Guidelines.

## 3.3 Gateway Design

Establishing a clear sense of arrival to UBC was another key objective, but balancing this with the natural beauty of the site was a challenge. After considering multiple options, the team selected a UBC-themed bird-statue sign as the preferred gateway feature. This design provides high visibility while symbolizing the transition into campus, and it is constructed with weather-resistant materials for longevity. The sign's form and materials were chosen to complement the surrounding landscape, contributing to UBC's broader aesthetic vision. See appendix B for foundation drawings and see appendix G for the cad drawings of the foundations for the gateway.

*Figure 4. Conceptual drawing of Thunderbird statue illustrated by Mason Nah*

## 3.4 Environmental Stewardship

The design prioritizes environmental stewardship by minimizing disruption to the surrounding ecosystem during construction and operation. It focuses on preserving natural features, protecting wildlife habitats, and maintaining the land's long-term sustainability through careful construction practices (United Nations Environment Program, 2021).

## 3.5 Aesthetics and Community Engagement

Engaging the community to design features which align with the aesthetics and culture of the community has become a cornerstone in the design for the intersection. Specifically, the UBC welcome sign design has been a point of collaboration with the community of local Indigenous artists. To create a sense of arrival and draw attention to this cultural collaboration the sign has been placed in the center of the roundabout.

## 3.6 Cost-Effectiveness

While the primary goal of this project has been to meet the requirements outlined, the cost-effectiveness of design decisions was carefully considered to ensure that an economical solution was found. With cost-effectiveness in mind, the final design not only meets the functional requirements but is economically justifiable without comprising on quality.

## 3.7 Layout Design Features

The new design of the Chancellor Boulevard – East Mall intersection introduces three primary features. These features include the dog-bone roundabout, the bioswale raingarden and the gateway sign. The roundabout spanning across the intersection in a northeast to southwest direction diverts all oncoming traffic in a counterclockwise direction. The center of the roundabout has been designed in a bog-bone shape and includes an over tracking area. This layout introduces curvature while also ensuring larger vehicles have room to safely maneuver through the intersection. Pedestrians and cyclists have a designated route in which to travel through the intersection and is a combination of shared and separated pathways, all of which are segregated from the motorists. To maximize the permeable area of the intersection the center of the roundabout has been designed as a bioswale raingarden. The welcoming gateway sign is located at the center of the raingarden to be in the line of sight of vehicles entering the UBC campus.

## 3.8 Dimensions

Below in Table 2 key dimensions of the intersection have been summarized.

*Table 2. Summary of intersection dimensions*

| Intersection Area | Component | Dimension (m) |
|---|---|---|
| Bike/Pedestrian Routes | Bike Lane | 1.5 |
| | Bike Lane Buffers | 0.6 |
| | Multi-Use Path Width | 3.5 |

| | | |
|---|---|---|
| | Crosswalk Width | 3.0 |
| Roundabout Dimensions | Rain Garden Diameter | 11 – 15 |
| | Over Tracking Diameter | 20 - 24 |
| Road Dimensions | Roundabout Traffic Lanes | 4.7 - 5.3 |
| | Traffic Lanes | 4.7 |

# 4 TRANSPORTATION DESIGN

## 4.1 Historic Analysis

Originally designed with features typically found along highways, the current intersection is allowing vehicles to travel in a manner which does not align with surrounding suburban communities. A historical analysis of the intersection revealed that vehicles travel through this intersection at an average speed of 45.6 km/hr and desire to travel at a speed of 60 km/hr. The table below summarizes the vehicle count for the current traffic flow at the intersection over a one-hour analysis period.

*Table 3. Current intersection vehicle count for one hour analysis period*

| | SW to NE | N to S | S left turn to SW | S right turn to NE | NE right turn to N | NE left turn to S | SW left turn to N | SW right turn to S | N right turn to SW | N left turn to NE |
|---|---|---|---|---|---|---|---|---|---|---|
| Car | 150 | 2 | 16 | 27 | 3 | 16 | 7 | 14 | 11 | 0 |
| Truck | 27 | 0 | 5 | 14 | 0 | 7 | 5 | 12 | 0 | 5 |
| Bus | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| bicycle | 14 | 4 | 0 | 3 | 0 | 1 | 2 | 0 | 5 | 0 |
| Total MV | 191 | 2 | 21 | 41 | 3 | 23 | 12 | 26 | 11 | 5 |

### 4.1.1 Growth Projections

The intersection has been designed to accommodate the increase in traffic flow associated with project population growth in 2050 and beyond. The population projections were extrapolated with information from (Greater Vancouver REALTORS®, 2024), (Chan, 2023), (CBC News, 2024). The figure below depicts the population growth predictions used for this project.

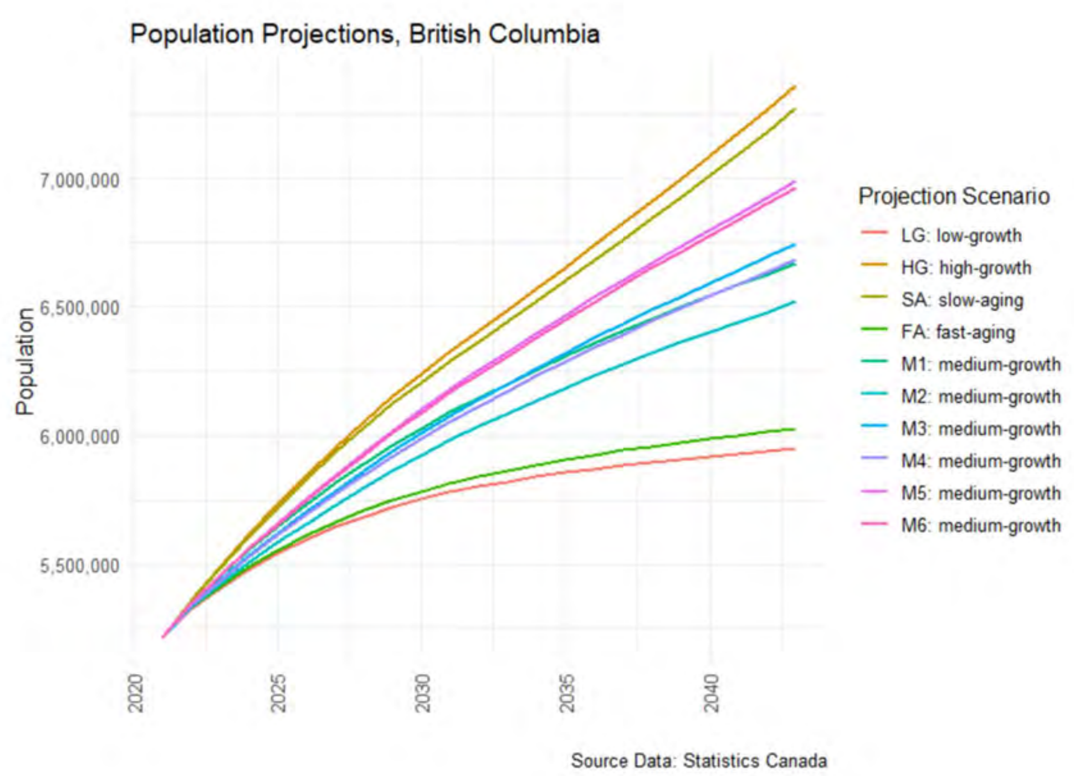



*Figure 5. BC Population Projections (Greater Vancouver REALTORS®, 2024)*

### 4.1.2 Design Implications

The chosen dog-bone-shaped double roundabout layout which naturally reduces vehicle speeds while maintaining continuous traffic flow and provides a more intuitive driving scheme in limiting driver to making right hand turns. This configuration reduces conflict points and enhances safety, aligning with TAC geometric design guidelines and the project's objective of prioritizing active travel.

## 4.2 Transportation Analysis

Following section outlines the details of the traffic flow analysis conducted for the chosen design shown in Figure 6 below.


*Figure 6. Final intersection design*

### 4.2.1 Design Layout Justification

The table below summarizes the key features of the transportation design for the intersection including the corresponding rationale.

*Table 4. Rationale for key design features*

| Key Design Feature | Rationale |
|---|---|
| Dog-bone Roundabout | Reduces vehicle speeds and likelihood of collisions by limiting driver speeds through turns and limiting driver's decision to only right hand turns which has higher visibility. |
| Over Tracking Area | A safety feature for when larger vehicles need to traverse the intersection |
| Separated Bike and Pedestrian Crossing | Where possible, promotes active transportation by providing an efficient and safe route through the intersection and separates the cyclists from slower pedestrians increasing safety and reducing frustration from both sides |
| Mixed pedestrian and bike crossing | Promotes active transportation by providing and safe route through the intersection |
| Double bike lane | Improves efficiency for cyclists in the intersection |
| Medians | Provides a sheltered space for slower pedestrians whilst crossing |

### 4.2.2 Traffic Model Parameters and Simulation

Traffic flow was modelled using Sidra, a tool that evaluates intersection performance under various configurations. Currently Sidra does not have a dog bone roundabout simulation model available. To approximate the dog bone roundabout configuration, two alternative designs were created. As shown in Figure 7 the first model referenced featured a traditional roundabout. The secondary model shown in Figure 8 was comprised of two connected roundabouts creating a double teardrop shape. The data from the Sidra analysis can be found in Appendix A.


*Figure 7. Synchro model for traditional roundabout*

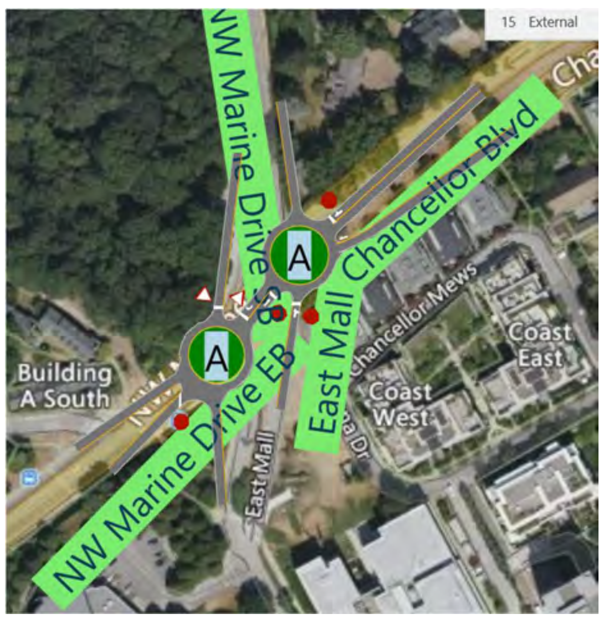



*Figure 8. Synchro model for teardrop roundabout*

This modeling approach allowed for the evaluation of key metrics such as Level of Service (LOS), speeds and delays under realistic traffic conditions. The vehicles considered for the modelling and simulation included city buses (TAC WB-15), trucks (heavy vehicles) and cars (light vehicles). The lane width for all vehicle movements was modelled as 3.7 meters (12 feet) to adhere to the TAC guidelines. Table ## below provides a summary of the traffic flow simulation findings over a one-hour analysis period.

*Table 5. Traffic flow analysis for new design over one hour analysis period*

| | SW to NE | N to S | S left turn to SW | S right turn to NE | NE right turn to N | NE left turn to S | SW left turn to N | SW right turn to S | N right turn to SW | N left turn to NE |
|---|---|---|---|---|---|---|---|---|---|---|
| Car (%) | 78.5 | 100 | 76.2 | 65.9 | 100 | 69.6 | 58.3 | 53.8 | 100 | - |
| Truck (%) | 14.1 | - | 23.8 | 34.1 | - | 30.4 | 41.7 | 46.2 | - | 100 |
| Bus (%) | 7.3 | - | - | - | - | - | - | - | - | - |
| Total number MV | 191 | 2 | 21 | 41 | 3 | 23 | 12 | 26 | 11 | 5 |

### 4.2.3 Pedestrian Crossings

Pedestrian crossings as shown in Figure 6 are located at each roundabout entry and exit point, ensuring direct and safe paths for crossing. To accommodate a variety of crosswalk users, including those with accessibility needs, the crosswalk has been designed with a width of three meters. Tactile paving has been placed at crosswalks to aid the visually impaired during crossing. High visibility of the crosswalks has been ensured with zebra marking, flashing pedestrian lights and evening lighting throughout the intersection.

The pedestrian crossing is unique along the east mall road where the pedestrian crosswalks have been separated from the bike crosswalks to increase safety between pedestrians and cyclists and reduce collisions between merging cyclists and pedestrians, as well as allowing cyclists to continue a relatively unimpeded path traversing the area.

### 4.2.4 Results Discussion

Initial results from the simulation model indicate that the proposed roundabout design reduces queue lengths and improves the wait times experienced at the current intersection. The new design shows an average wait time of 5 seconds compared to the current intersection which is now at 13 seconds of wait time. Introducing either of the designs modeled, the traditional roundabout or the teardrop roundabout, showed reduced delay times and improved the level of service (LOS) at the intersection. The selected design for new intersection was further justified by directly meeting the design requirement to reduce vehicle traveling speeds through the intersection as is shown in the summary of results shown in Table 6 below. See appendix A for the full SIDRA report.

*Table 6. Summary of key intersection analysis results*

| Shape | Population | Intersection LOS | Av. Travel Speed (km/h) | Desired Speed (km/h) |
|---|---|---|---|---|
| Current intersection | Current | A, B, C | 45.6 | 60 |
| Dog-bone | Current | A | 28 | 51.3 |
| | Future | A | 28 | 51.3 |

## 4.3 Active Transportation

To improve the safety of active transportation users the intersection has been designed with protected bike lanes, shown in green in Figure 6 along the perimeter of the intersection segregated from motorists by a curb. Along Northwest Marine Drive pedestrians utilize a designated sidewalk while cyclists maneuver through a separated bike lane protected from traffic as shown in Figure 9 below.

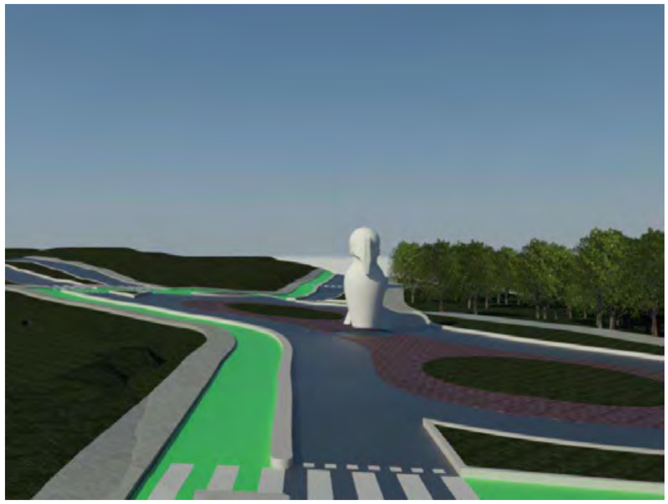


*Figure 9. 3D rendering of design looking West*

At the crossing on Chancellor Boulevard the westbound cyclists would be encouraged to use the crosswalk to join the double bike path. Eastbound cyclists would enter the double bike lane until they are routed off into the existing chancellor boulevard bike lane. See appendix G for cad drawings of the active transportation routes. See appendix H for more renders of the active transportation paths.

## 4.4 Traffic Control

Traffic control features have been incorporated in the design to ensure smooth traffic flow and adherence to roundabout regulations. To increase user awareness, advanced pavement markings and signage have been designed to designate pedestrian zones, exits, and lane usage. Yield signs have been incorporated which require drivers to yield to oncoming traffic, simplifying operations and lowering the possibility of collisions. Cars are encouraged to reduce their speed due to the integration of raised crosswalks and the narrowing of approach lanes entering the intersection and the curves from the dog-bone roundabout.

## 4.5 Traffic Calming

The design balances safety with vehicle speeds by incorporating a dog bone roundabout as the primary traffic calm element. The shape of the configuration, with the extended and narrow parts, will slow the vehicles down naturally without interrupting the flow. Raised pedestrian crossings and well-positioned multi-use pathways also improve pedestrian and cyclist safety. These factors fully engage together to provide a secure, more comfortable place for all users while adhering to the project target of focusing ahead and prioritizing active modes of transportation.

## 4.6 Intersection Tie-In

With minor modifications which include lane narrowing and repainting lane lines, the new intersection will seamlessly tie into the existing roadway. Depicted in Figure 10 and 11 below are the tie-ins to Northwest Marine Drive.

*Figure 10. West end of NW Marine Drive tie-ins*

*Figure 11. East end of NW Marine Drive tie-ins*

The minor modifications made to the Chancellor Boulevard and East Mall tie-in sections are shown in Figure 12 and 13 below.

*Figure 12. Chancellor Boulevard tie-ins*

*Figure 13. East Mall tie-ins*

# 5 STORMWATER MANAGEMENT DESIGN

The existing intersection is currently equipped with a rainwater management system that integrates curb and drop inlet drains. However, a site inspection revealed that this combination is only implemented along East Mall Road, whereas Chancellor Boulevard and other areas rely solely on drop inlets. This is concerning due to the high presence of green spaces, which increases the likelihood of clogging. Additionally, all observed drains exhibited significant corrosion. To address these deficiencies and enhance stormwater management efficiency, a new system has been designed outlined in depth in Appendix C.

To design the rain garden and stormwater system the 2012 Stormwater Source Control Design Guidelines (City of Vancouver, 2012) and the 2019 Engineering Design Manual (City of Vancouver, 2019) were referenced. The new system will incorporate bio-retention areas and a combination of curb and drop inlet drains. Bio-retention zones have been strategically placed throughout the green spaces surrounding the intersection to facilitate natural filtration and water infiltration. A summary of the increase in permeable area due to the bio-retention zones introduced in the new design is shown in Table 7 below.

*Table 7. Breakdown of intersection permeable areas*

| | **Impermeable Area ($m^2$)** | **Permeable Area ($m^2$)** | **Runoff Flow ($m^3/s$)** |
|---|---|---|---|
| Pre-development | 6,197 | 5,605 | 0.29 |
| Post-development | 5,707 | 6,093 | 0.25 |

Existing metal inlet drains will be replaced with Nyloplast alternatives, and curb-drop drains will be integrated to improve debris capture and filtration. Collected rainwater will be directed via PVC piping to a primary HDPE storage tank, situated beneath the roundabout. The positioning of new inlet drains will align with existing locations to utilize the natural slope for efficient water collection. Additionally, a 2% slope will be implemented on all curbside drains to optimize flow distribution. The bio-retention system will feature a partial infiltration rain garden, promoting soil filtration while incorporating a 2:1 slope ratio to prevent water spillage onto roadways.

For design considerations, the system is engineered to accommodate a 100-year storm event. Given a rain garden area and road runoff catchment area of approximately 300 m² and 11800m², respectively, a primary HDPE storage tank with a 1000 m³ capacity has been chosen. To handle flow distribution efficiently, a network of 6-inch pipes will connect to a 12-inch main pipe, directing water to the storage system.

## 5.1 Rain Garden

The rain garden, covering a total area of 300m$^2$ located at the center of the roundabout, has been designed to satisfy the full retention demand found from the stormwater analysis as is required for this design. With the addition of pervious pavement, this design exceeds the stormwater retention demand of the intersection. The rain garden has been designed with soil depth of 450mm and porous rock with a depth of 897mm.

## 5.2 Stormwater Analysis

Hydraulic modelling was conducted using Civil 3D to design the rainwater management system. The catchment area was divided into two distinct zones:

- Rain Garden: 300m²
- Roadway runoff catchment area: 11800m², accounting for impermeable surfaces.

The modelling assumed a rainfall intensity of 80 mm/hr over 2 hours, consistent with a 100-year return period. Runoff coefficients were set at 0.9 for roadway surfaces and 0.2 for bioretention areas to reflect their infiltration capacities. The system's retention tank and rain gardens are expected to reduce runoff and improve on-site water retention. To handle the flow of the system, 6-inch pipe network will be connected to a main 12-inch conduit which delivers all the collected rainwater to a 1000 m³ tank. Based on the hydraulic modelling the rainwater management system has been proven to reduce flood risks, retain stormwater on-site, and prevent runoff from impacting adjacent sensitive areas.

## 5.3 Sustainability and Material Selection

Sustainability is a key focus of this stormwater management strategy. The bio-retention areas will enhance soil quality and alleviate pressure on the existing drainage network by promoting natural water infiltration. Additionally, collected water will be repurposed for multiple uses, including irrigation during summer months, potential restroom/shower installations along beach trails, and the development of a water feature to support local wildlife during dry seasons.

The drainage system will primarily utilize polymer-based materials, including PVC, HDPE, and Nyloplast, selected for their durability, corrosion resistance, and cost-effectiveness. These materials offer significant advantages over traditional concrete and metal alternatives, reducing maintenance costs and minimizing greenhouse gas emissions associated with construction. By implementing these upgrades, the proposed system aims to enhance performance, extend longevity, and provide a more environmentally sustainable solution for stormwater management at the intersection.

# 6 GATEWAY DESIGN

The welcome sign will aim to create a sense of arrival through incorporating artistic features which reflect the culture and community of UBC. For the statue to best represent UBC, a bird statue inspired by the school mascot, the thunderbird, would be made. To represent the UBC's relationship with the indigenous community the bird will be depicted to reflect the local culture in collaboration with indigenous artists.

## 6.1 Footing Design

The statue is to be 8 meters tall with a reinforced concrete foundation of 6.4 x 6.4m and 1.5m thick. The foundation is a 35MPa concrete footing reinforced with 400 MPa steel dowels and cast in place anchor bolts. This design follows the CSA A23.3 code and is detailed in Appendix G.

*Table 8. Summary foundation resistance*

| Element | Component | Demand | Capacity | Demand/Capacity |
|---|---|---|---|---|
| Footing | Flexture Resistance (kNm) | 45 | 3885 | 0.012 |
| Footing | Bearing Resistance (kN) | 16044 | 16044 | 1 |
| Footing | Two-Way Shear Resistance (kN) | 1758 | 2422 | 0.73 |

# 7 ENVIRONMENTAL CONSIDERATIONS

Environmental stewardship is a cornerstone of the preliminary design, emphasizing sustainability and ecological sensitivity. The design for the UBC intersection seeks to harmonize human activity with the natural environment by minimizing disruption, reducing pollutant runoff, integrating biodiversity-enhancing features, and aligning with the university's established sustainability goals.

## 7.1 Minimizing Ecosystem Disruption

The design will prioritize minimal disruption to the surrounding ecosystem, particularly during construction and subsequent operation. Existing vegetation and natural features will be preserved wherever feasible to maintain ecological balance and provide continuity for local wildlife. Construction activities will be carefully managed to reduce noise, vibrations, and habitat destruction. Efforts will be made to avoid soil compaction and erosion, ensuring the site remains viable for replanting and sustainable land use after construction (United Nations Environment Program, 2021).

## 7.2 Reducing Pollutants in Runoff

Stormwater runoff often carries pollutants such as oil, sediment, and heavy metals, which can harm local waterways and ecosystems. The design will incorporate systems to filter and treat runoff before it enters nearby water bodies to address this. Bioswales, rain gardens, and vegetated filter strips will capture and treat stormwater, removing contaminants and improving water quality. These natural filtration systems will help ensure that runoff from the intersection does not degrade the ecological health of downstream environments.

## 7.3 Integrating Green Infrastructure for Biodiversity

Green infrastructure will play a pivotal role in enhancing biodiversity at the intersection. The design will incorporate native plants and landscaping features that provide habitat and food sources for local species. Trees and shrubs will be strategically placed to create microhabitats, promote connectivity for wildlife, and improve air quality. These features will support ecological strengthening and contribute to the aesthetic value of the intersection, making it a welcoming space for both people and wildlife (Landscape Architecture Foundation, 2022).

## 7.4 Aligning with UBC's Sustainability Goals

The university is committed to advancing sustainability through its operations, and the intersection redesign will align closely with these goals. The project will incorporate energy-efficient lighting, recycled or low-impact materials, and water-sensitive design principles. Green space enhancements will contribute to the university's efforts to further carbon sequestration, supporting its broader climate action commitments. Furthermore, the intersection's layout and functionality will prioritize active transportation, such as walking and cycling, promoting sustainable mobility and reducing reliance on carbon-intensive modes of transport (Greenroads Foundation, 2021).

## 7.5 Long-Term Environmental Benefits

Beyond immediate construction and functionality, the design aims to provide long-term environmental benefits. By integrating sustainable practices, the project will set a precedent for future regional infrastructure development. Regular monitoring and adaptive management strategies will ensure the ecological systems remain effective and responsive to changing conditions.

# 8 SCHEDULE

## 8.1 Construction Plan

To minimize disruption and maintain vehicular access to and from the UBC campus, the construction of the roundabout at Chancellor Boulevard and East Mall has been divided into three key phases, as illustrated in the phasing diagram. Each phase is designed to isolate specific legs of the intersection while allowing continuous traffic flow through the remaining legs. Construction activities will proceed in the following sequence:


*Figure 14. Construction phases for intersection implementation*

### 8.1.1 Phase 1 – North Leg Construction (Blue Zone)

Phase one focuses on the northbound approach and exit lanes of Chancellor Boulevard, including grading, utility relocation, and installation of stormwater infrastructure.

### 8.1.2 Phase 2 – South Leg Construction (Red Zone)

Upon completion of the northern segment, work will shift to the southbound lanes, targeting the connection between SW Marine Drive and Chancellor Boulevard. Activities in this phase include subgrade reconstruction, stormwater pipe tie-ins, and curb layout preparation.

### 8.1.3 Phase 3 – Central Roundabout Completion (Teal Zone)

The final phase addresses the core of the roundabout, integrating the previously constructed legs into a fully functioning traffic circle. This phase involves paving of the circulatory roadway, installation of the central island surface and statue foundation, line painting, signage, and finishing works.

## 8.2 Site Operations & Storage

A dedicated Site & Safety Office and Material Storage Zone are located on the east side of the intersection within the triangular green zone shown in the phasing map. These zones provide a secure location for construction equipment, traffic control supplies, and on-site meetings, without interfering with public circulation routes.

## 8.3 Schedule Overview

Maintaining a project start date of May 5, the anticipated final completion date is November 26$^{th}$, 2025. The below table provides an overview of the construction phasing schedule:

*Table 9. Summary of construction schedule*

| Construction Phases | Start Date | End Date |
| --- | --- | --- |
| **1** Pre-construction and surveying | April 24, 2025 | May 26, 2025 |
| **2** Site Prep, Stormwater System, and Road Construction, North Side | May 12, 2025 | July 29, 2025 |
| **3** Site Prep, Stormwater System, and Road Construction, South Side | July 29, 2025 | September 20, 2025 |
| **4** Roundabout Construction | September 23, 2025 | November 26, 2025 |

# 9 PROJECT MANAGEMENT DOCUMENTATION

## 9.1 Traffic Managment Plan

To ensure safe pedestrian and vehicular traffic during construction, a comprehensive Traffic Management Plan (TMP) has been developed for the roundabout installation at Chancellor Boulevard and East Mall. The TMP outlines the specific traffic control plan and summarizes the active transportation and vehicular rerouting plans through annotated drawings. All temporary traffic arrangements are designed in accordance with BC MoTI's Traffic Management Manual for Work on Roadways (2020) and UBC Campus Planning guidelines.

A complete version of the Traffic Management Plan, including control personnel, emergency planning and traffic control are provided in Appendix L.

### 9.1.1 Phase 1


*Figure 15. Phase 1 traffic management plan*

Phase will begin with the full closure of the north leg of the intersection, where Chancellor Boulevard connects to NW Marine Drive and adjacent residential areas. As shown in Figure X, the westbound traffic approaching from NW Marine Dr and Chancellor Blvd will be redirected south onto Iona Dr towards the left turn to Marine Dr. Pedestrian and cyclist access will be maintained via Memorial Road and surrounding open corridors, supported by temporary directional signage and barriers where needed.

### 9.1.2 Phase 2


*Figure 16. Phase 2 traffic management plan*

Similarly to phase one, phase two will require full closure of the leg of the intersection but this time at the south part where Chancellor Boulevard connects to East Mall. As shown in Figure X, Eastbound traffic heading toward campus via SW Marine Drive will be diverted via East Mall and Walter Gage Rd, bypassing the closed southern approach. Signage along all major approach points, including “Road Closed Ahead,” “Detour Ahead,” and 30 km/h speed limits, ensures advance warning and controlled traffic flow.

### 9.1.3 Phase 3

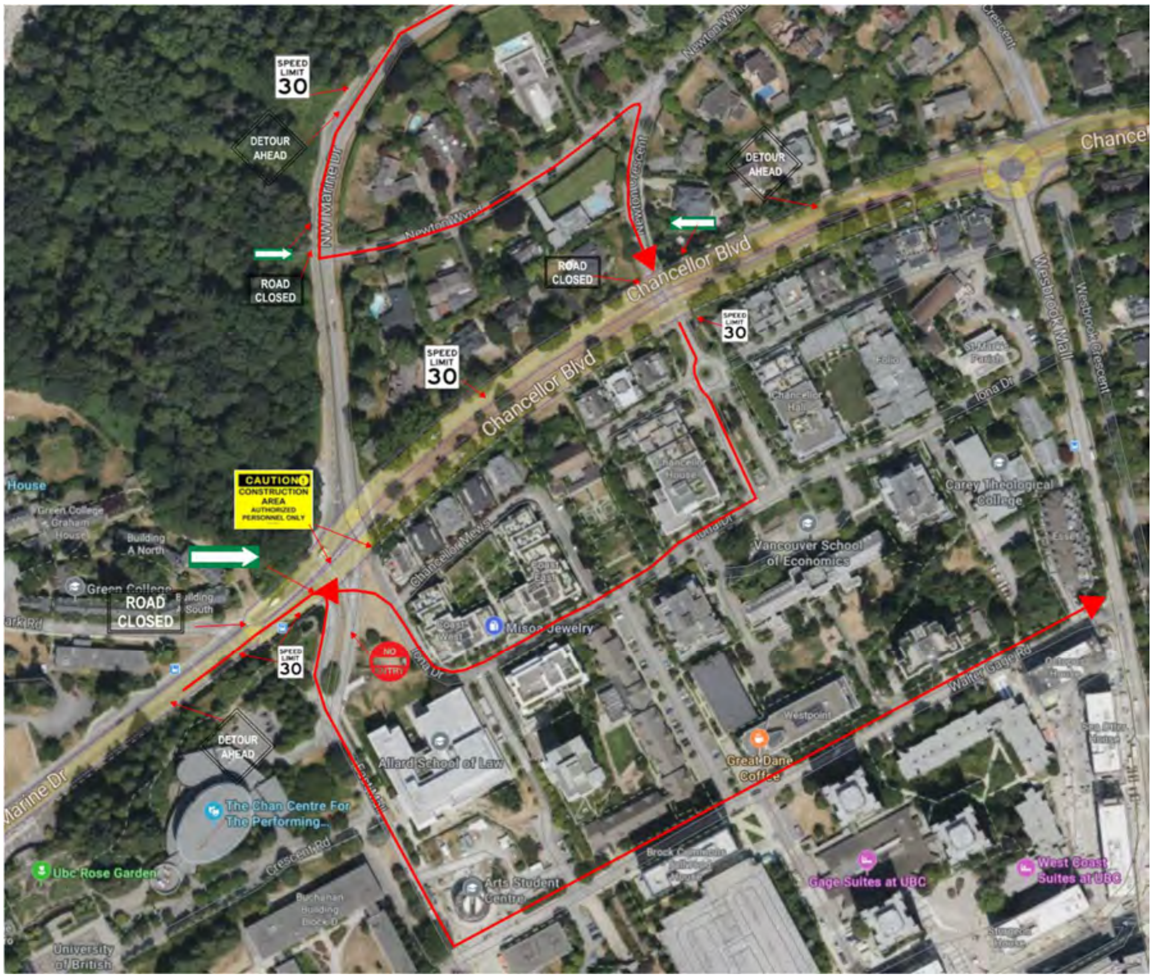



*Figure 17. Phase 3 traffic management plan*

In the final stage of the construction, a short-term full closure of all legs at the intersection will be required to complete the surface works and install the roundabout. During that time all the traffic will be temporarily rerouted though detour routes marked on Figure X with temporary signage. Once the roundabout is completed, full traffic operations will resume, and detours will be removed.

## 9.2 Maintenance Plan

The long-term performance, safety, and visual quality of the redesigned intersection depends on the implementation of a comprehensive maintenance strategy. This maintenance plan outlines key components of the site and their expected service lives, recommended inspection frequencies, and maintenance interventions to ensure continued functionality and minimize lifecycle costs. The plan emphasizes durable materials, sustainable systems, and proactive inspections to support UBC’s long-term infrastructure and environmental objectives.

### 9.2.1 Pavement and Road Surface

The intersection’s asphalt surfaces are designed for a service life of approximately 20-25 years. Regular maintenance will include crack sealing every 3 – 5 years and resurfacing every 10 – 15 years to maintain surface integrity and safety. Thermoplastic pavement markings will require reapplication every 2 – 3 years to ensure visibility and compliance with road standards.

### 9.2.2 Stormwater Management Infrastructure

Stormwater systems, including bioswales, permeable pavements, precast pipes, and an underground retention tank, are designed to manage a 100-year storm event. These components require semi-annual inspections to check for sediment buildup, clogs, or damage. Vegetation in bioswales should be trimmed biannually, and permeable surfaces should be cleaned every 6 – 12 months to maintain permeability. The system as a whole should be flushed and tested every five years to ensure peak performance.

### 9.2.3 Pedestrian and Cycling Infrastructure

Concrete sidewalks and protected bike lanes are expected to have a 30 – 40 year lifespan. Maintenance includes annual inspections for surface degradation, with spot repairs as needed every 5 – 7 years. Lane markings and signage should be reviewed and updated on a 2 – 3 year cycle to preserve user safety and accessibility.

### 9.2.4 Lighting and Electrical Systems

LED lighting installed along pedestrian pathways and within the roundabout is expected to last 10 – 15 years, with minor servicing such as bulb replacement and connection testing every 3 – 5 years. Electrical components should be inspected annually as part of broader safety audits.

### 9.2.5 Landscaping and Green Infrastructure

All landscaped areas feature drought-tolerant, native species to reduce irrigation needs. Tree health assessments should be conducted annually, with pruning every 3 – 5 years. Irrigation systems, where installed, should be checked each season for leaks, clogs, or controller malfunctions. Groundcover and shrugs should be replenished as necessary to retain visual quality and ecological function.

### 9.2.6 Gateway Feature – Thunderbird Statue

The 8-meter-tall thunderbird-inspired gateway statue is constructed from weather-resistant materials and anchored to a reinforced concrete foundation. It is designed for a service life of over 50 years with minimal intervention. Surface inspections should occur every 5 years, while electrical lighting (if integrated) should be serviced in alignment with the broader lighting plan. Graffiti and vandalism risk is mitigated with anti-graffiti coating, and cleaning is recommended twice annually.

### 9.2.7 Estimated Annual Maintenance Cost

Based on the detailed Class A cost estimate, the projected annual maintenance cost ranges from $123,000 to $210,000, depending on service intervals, surface wear, and weather-related degradation. This estimate includes routine inspections, pavement marking renewal, bioswale cleaning, lighting servicing, and upkeep of the gateway feature. See Appendix K for a breakdown of the total estimated annual maintenance budget.

## 9.3 High-Level Risks

A proactive approach to risk management is essential for ensuring the successful implementation of the intersection redesign. The following section summarizes the high-level risks identified during the planning and design phases, along with their associated likelihoods, potential impacts, and recommended mitigation strategies. These risks were categorized using a 5x5 risk matrix and ranked according to their calculated risk score (likelihood x impact).

The matrix was developed in accordance with industry-standard construction risk assessment practices and considers technical, environmental, construction, financial, and stakeholder-related factors.

### 9.3.1 Key High-Level Risks Identified

The most significant risks to project delivery and performance include the following six risks:

1. **Traffic Congestion During Construction (Risk Score: 15 – High)**

   Due to the intersection's role as a campus gateway, traffic delays and confusion are highly likely during construction. This could impact campus operations, particularly during peak academic periods.

   **Mitigation**: A phased construction plan and detailed traffic management strategy were developed to maintain continuous vehicle, cyclist, and pedestrian access.

2. **Construction Delays Due to Weather (Risk Score: 12 – High)**

   Weather disruptions, particularly heavy rainfall, may impact grading, paving, and bioswale installation.

   **Mitigation**: A contingency schedule and flexible sequencing have been incorporated, along with the use of weather-resilient construction materials where possible.

3. **Pedestrian and Cyclist Safety Post-Construction (Risk Score: 12 – High)**

   While safety improvements are a key design goal, unforeseen design execution issues or user behavior could compromise active transportation safety.

**Mitigation**: Raised crosswalks, protected bike lanes, high-visibility markings, and signage have been integrated to enhance safety. Post-construction audits are also recommended.

4. **Unforeseen Utility Conflicts (Risk Score: 12 – High)**

   The lack of complete as-built drawings and underground utility records could result in conflicts during excavation.

   **Mitigation**: Conservative assumptions have been made in the design, and coordination with utility providers will occur prior to construction. Ground-penetrating radar surveys are recommended.

5. **Failure to Obtain Timely Permits (Risk Score: 12 – High)**

   Delays in regulatory approvals could affect the construction timeline.

   **Mitigation**: Permit requirements were identified early, and coordination with Campus + Community Planning and other agencies will begin during the preliminary phase.

6. **Long-Term Maintenance Challenges (Risk Score: 12 – High)**

   Insufficient maintenance planning could lead to early infrastructure degradation and safety concerns.

   **Mitigation**: A detailed service-life maintenance plan has been developed, with estimated annual costs and intervention frequencies for all major components.

### 9.3.2 Risk Mitigation Summary and Monitoring

All high-risk items will be monitored continuously throughout the project lifecycle. The project team recommends assigning a risk owner for each high-level category to ensure accountability and timely intervention. Risks will be reassessed at key project milestones, including:

- Completion of detailed design and permitting
- Pre-construction mobilization
- Post-construction commissioning and review

A visual heat map illustrating the full risk profile can be seen below in Figure 18. The complete risk description and scoring table is included in Appendix J.

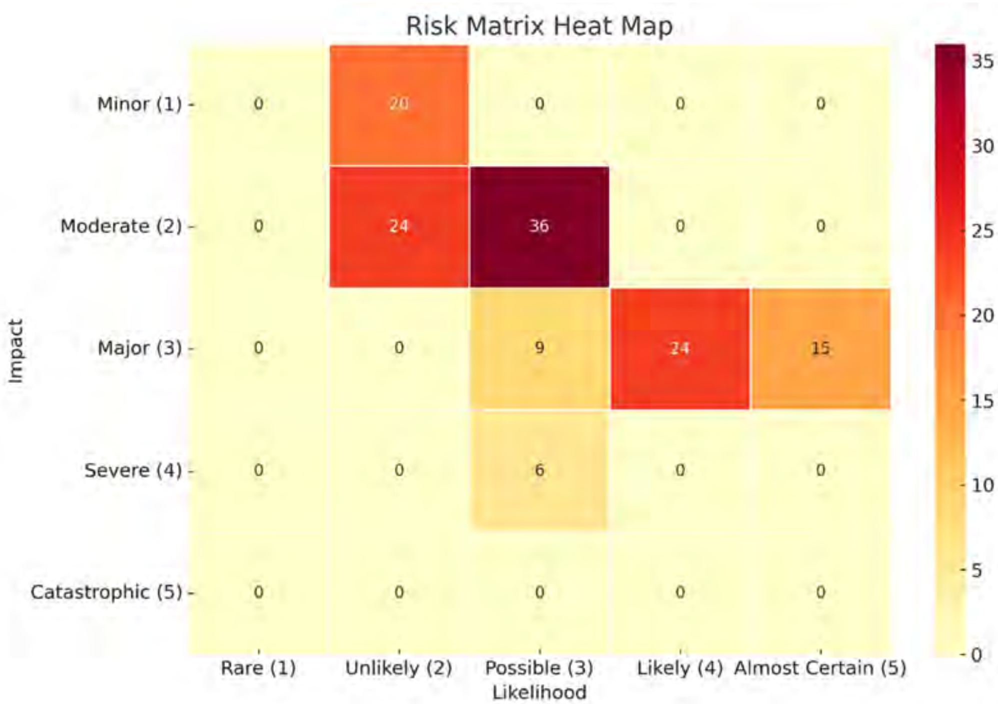



*Figure 18. Risk matrix heat map*

## 10 COST ESTIMATE

This Class A cost estimate reflects the current design scope, construction methods, and regional pricing assumptions. It serves as the financial foundation for project execution, permitting processes, and contractor bidding. The detailed breakdown is provided as a cost table in Appendix E.

## 10.1 Cost Distribution Overview

To better visualize the distribution of construction costs across the project's major components, a pie chart was developed, shown in Figure 19 below.

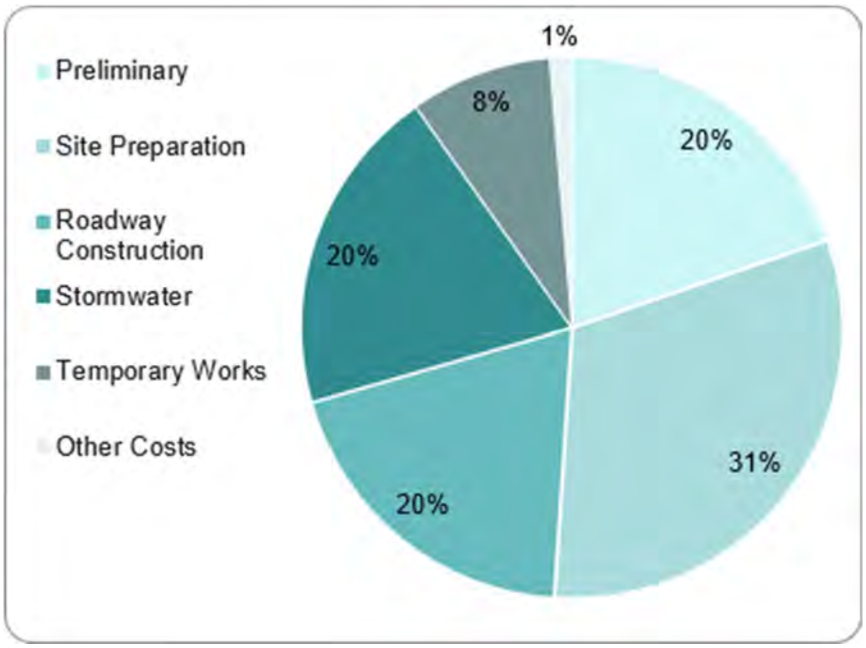



*Figure 19. Distribution of costs*

As shown, site preparation constitutes the largest share of the budget at 31%, primarily due to the extensive earthworks, asphalt/concrete removal, and grading required to reconfigure the intersection. Preliminary costs, roadway construction, and stormwater infrastructure each account for roughly 20%, reflecting the project's emphasis on safe design execution, long-term surface durability, and environmental compliance. Temporary works, including traffic control and detour infrastructure, make up 8%, while aesthetic and environmental features contribute only 1%, indicating cost efficiency in delivering high-impact visual and cultural enhancements. This distribution supports a balanced approach between structural integrity, safety, and campus character. See Appendix E for the full breakdown of the cost estimates.

## 10.2 Construction Costs

The construction cost estimate for the UBC intersection redesign was developed at a Class A level of accuracy, reflecting detailed quantity takeoffs, current unit rates, and allowances for construction complexity and contingencies. The estimate accounts for all direct construction activities, preliminary works, infrastructure improvements. And environmental and aesthetic components, with a 10% contingency applied across the board.

The total estimated construction cost is $5,645,000, broken down into the following major categories:

### 10.2.1 Preliminary Costs

This category includes project management and coordination, permitting and regulatory approvals, surveying, and site mobilization. These essential activities ensure the project starts smoothly and complies with relevant standards. The total for this category is approximately $1,112,000.

### 10.2.2 Site Preparation

Site preparation covers clearing, grubbing, demolition of existing surfaces, and earthworks. This phase ensures the area is properly graded and prepped for infrastructure installation. The estimated cost for site preparation is roughly $1,766,000, largely driven by excavation and compaction activities.

### 10.2.3 Roadway Construction

This category includes granular base preparation, asphalt paving, concrete curbing, street lighting, and roundabout construction. Special attention is given to constructing the central islands of the dog-bone-shaped roundabout and integrating pedestrian and cycling improvements. The total estimated cost for roadway works is $1,100,000.

### 10.2.4 Stormwater Infrastructure

To meet UBC’s requirements for on-site rainwater retention and prevent erosion near the adjacent cliffs, the stormwater system includes bioswales, a retention tank, culverts, and manholes. This robust system is estimated at $1,109,000.

### 10.2.5 Temporary Works

Temporary traffic control, detour paving, safety barriers, and signage are included to ensure construction does not severely disrupt campus activity. The cost for temporary works totals approximately $476,000, reflecting both safety needs and the scale of detour infrastructure required.

### 10.2.6 Aesthetic and Environmental Features

This includes the construction of the 8-meter-tall Thunderbird-inspired bird statue at the center of the roundabout, landscaping restoration, and post-construction inspections. These features are essential to establishing a welcoming campus gateway. The estimated cost for this category is $75,000.

### 10.2.7 Contingency

A 10% contingency has been applied to all cost items to account for uncertainties such as minor design adjustments, unforeseen site conditions, and market variability in materials or labor.

# 11 CONSULTATION PLAN

Prior to construction, a multifaceted approach will be taken to provide information and collaborate with the involved stakeholders and public.

*Table 10. Stakeholder consultation plan*

| Stakeholder | Engagement/Contact Method |
|---|---|
| Green College Residents | Physical mail will be sent outlining construction impacts and pre-construction meeting details, where attendees can ask questions about the plan and schedule. |
| Residents along Chancellor Blvd. between NW Marine Dr and Wesbrook Mall | |
| Leadership of St. Mark's Church, The Chapel of Epiphany, Allard School of Law, and the Depts of Anthropology and Sociology | A meeting will be arranged to discuss the potential impacts of the construction signage, as well as the details of the pre-construction meetings, where attendees are welcome to ask questions about the construction schedule and plans. |
| UBC students | Emails will be sent outlining construction impacts and pre-construction meeting details, including opportunities to ask questions about the schedule and plans. |
| Public Information Session | These meetings aim to clearly explain the project's purpose, process, and timeline, fostering public understanding and support. Attendees can also sign up for email updates. |

Once construction begins, monthly update meetings will be held to share progress and answer questions, with details communicated to stakeholders using the same methods as before. After project completion, a final meeting will be held, along with a feedback form for stakeholders to share their thoughts on the project's outcomes and suggest areas for improvement.

## REFERENCES


ADS Pipe. (2024, December 4). *Nyloplast*. https://www.adspipe.com/nyloplast

Advanced Drainage Systems. (n.d.). *Nyloplast*. https://www.ads-pipe.com/nyloplast

American Public Works Association. (2017). *Stormwater management manual*. APWA.

American Society of Civil Engineers. (2019). *Sustainable design and construction practices*. ASCE.

Bank of Canada. (2024, December 1). *Inflation calculator*. https://www.bankofcanada.ca/rates/related/inflation-calculator/

BC Ministry of Transportation and Infrastructure. (2023). *Supplement to TAC geometric design guide for British Columbia*. Government of British Columbia. https://www2.gov.bc.ca

British Columbia Building Code. (2022). *Building code compliance guidelines*. Government of British Columbia.

Canada Mortgage and Housing Corporation. (2019). *Maintaining stormwater management systems*. https://www.cmhc-schl.gc.ca

Canada, N. S. (2019). *Sustainability practices for urban development*. Natural Step Canada.

Canadian Construction Association. (2018). *Construction risk assessment and management best practices*. https://www.cca-acc.com

Canadian Society of Civil Engineering. (2020). *Infrastructure resilience professional (IRP) guidelines*. CSCE.

Canadian Standards Association. (2020). *Guideline on the development of sustainable and resilient infrastructure*. CSA Group.

Canadian Urban Institute. (2020). *Complete streets: Designing for all users*. CanUrb.

CBC News. (2024, March 27). Metro Vancouver's population expected to surpass 4 million by 2050. https://www.cbc.ca/news/canada/british-columbia/metro-vancouver-population-surpass-4-million-2050-1.7255765

Chan, K. (2023, August 10). Metro Vancouver's population forecast for 2050 broken down by subregions. *Daily Hive*. https://dailyhive.com/vancouver/metro-vancouver-population-forecast-2050-subregions

City of Vancouver. (2012). *Stormwater source control design guidelines*. https://vancouver.ca

City of Vancouver. (2018). *Rainwater management bulletin*. City of Vancouver.

City of Vancouver. (2019). *Engineering design manual*. https://vancouver.ca

City of Vancouver. (2020). *Greenest City Action Plan 2020–2050*. City of Vancouver.

City of Vancouver. (2021). *Design manual for streets and infrastructure projects*. Engineering Services, City of Vancouver.

City of Vancouver. (2021). *Zoning and development by-law*. City of Vancouver.

Engineers and Geoscientists British Columbia. (2022). *Budget guidelines for consulting engineering services*. EGBC.

Engineers Canada. (2020). *Risk management guidelines for design professionals*. https://engineerscanada.ca

Engineers Canada. (2021). *National guidelines on sustainable development and environmental stewardship for engineers*. https://engineerscanada.ca

Environment and Climate Change Canada. (2019). *Green infrastructure guide for stormwater management*. Government of Canada.

Federal Highway Administration. (2018). *Pedestrian safety guide and countermeasure selection system*. U.S. Department of Transportation.

Global Infrastructure Basel Foundation. (2021). *SuRe®: The standard for sustainable and resilient infrastructure*. https://www.gib-foundation.org

Greater Vancouver REALTORS®. (2024, February 8). *Population growth projections: Canada & BC – What it means for housing*. https://www.gvrealtors.ca/news-archive/the-lede-blog--statscan-population-growth-projections.html

Greenroads Foundation. (2021). *Sustainable transportation certification manual*. Greenroads Foundation.

Infrastructure Canada. (2020). *Smart cities challenge finalists*. Infrastructure Canada.

International Erosion Control Association. (2018). *Best practices for erosion and sediment control*. IECA.

International Organization for Standardization. (2018). *ISO 31000:2018 - Risk management — Guidelines*.

International Organization for Standardization. (2020). *ISO 37120: Sustainable cities and communities – Indicators for city services and quality of life*. ISO.

KWL. (2012). *Stormwater source control design guidelines*. KWL.

Landscape Architecture Foundation. (2022). *Benefits of green infrastructure in urban spaces*. https://www.lafoundation.org

Methvin. (n.d.). *The art of construction estimating*. https://buildrates.methvin.org/estimating-production-rates

Metro Vancouver. (2012). *Stormwater source control design guidelines*. Metro Vancouver.

Metro Vancouver. (2018). *Engineering design manual*. Metro Vancouver.

Metro Vancouver. (2018). *Rainwater management bulletin*. Metro Vancouver.

Metro Vancouver. (2019, November 5). *A Rain City Strategy: A green infrastructure and rainwater management initiative*. https://vancouver.ca

Metro Vancouver. (2022). *Best management practices for stormwater management*. Metro Vancouver.

Ministry of Transportation and Infrastructure. (2016). *BC supplement to TAC*. MoTI BC.

NACTO. (2020). *Designing streets for all*. National Association of City Transportation Officials.

National Association of City Transportation Officials. (2020). *Urban street stormwater guide*. https://nacto.org

Natural Resources Canada. (2021). *Planning for climate resilient infrastructure*. Natural Resources Canada.

Smart Growth Network. (2020). *Principles of smart growth for urban development*. https://smartgrowth.org

Transportation Association of Canada. (2017). *Geometric design guide for Canadian roads* (6th ed.). Transportation Association of Canada.

Tugce Conger, A. C. (2019). *Rain City Strategy*. City of Vancouver.

UBC Campus and Community Planning. (2022). *Design guidelines and construction standards*. The University of British Columbia.

UBC Planning. (n.d.). *UBC Vancouver campus plan*. UBC Planning.

UBC Sustainability. (2023). *UBC climate action plan 2030*. UBC.

United Nations Environment Program. (2021). *Integrated rainwater management for urban resilience*. UNEP.

University of British Columbia. (2023). *Campus design guidelines*. https://planning.ubc.ca

Urban Land Institute. (2019). *Sustainable design in urban environments*. Urban Land Institute.

Washington State Department of Transportation. (2023, May). *SR 9/Bickford Ave. intersection improvements*. https://wsdot.wa.gov/construction-planning/search-projects/sr-9-bickford-ave-intersection-improvements-complete-may-2023

World Bank. (2019). *Guidelines for urban infrastructure projects in developing areas*. World Bank.

# APPENDIX A – SIDRA SOFTWARE REPORT

## INTERSECTION SUMMARY

**: S2 [S2 R (Site Folder: Double Teardrop Roundabout)]**

**Output produced by SIDRA INTERSECTION Version: 9.1.6.228**

Double Teardrop Roundabout

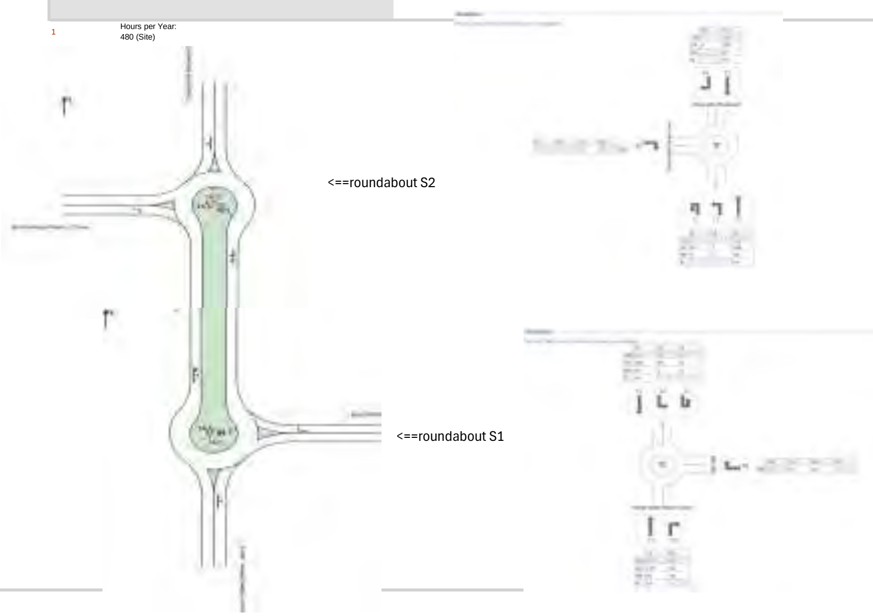
Site Category: (None)

Roundabout

| Intersection Performance - Hourly Values | | | |
|---|---|---|---|
| Performance Measure | Vehicles: | All MCs | Persons |
| Travel Speed (Average) | km/h | 38.1 | 34.8 km/h |
| Travel Distance (Total) | veh-km/h | 48.3 | 107.9 pers-km/h |
| Travel Time (Total) | veh-h/h | 1.3 | 3.1 pers-h/h |
| Desired Speed | km/h | 51.3 | |
| Speed Efficiency | | 0.74 | |
| Travel Time Index | | 7.15 | |
| Congestion Coefficient | | 1.35 | |
| | | | |
| Demand Flows (Total) | veh/h | 472 | 1415 pers/h |
| Arrival Flows (Total) | veh/h | 472 | |
| Percent Heavy Vehicles (Demand) | % | 21.7 | |
| Percent Heavy Vehicles (Arrivals) | % | 21.7 | |
| Degree of Saturation | | 0.156 | |
| Practical Spare Capacity | % | 445.4 | |
| Effective Intersection Capacity | veh/h | 3026 | |
| | | | |
| Control Delay (Total) | veh-h/h | 0.25 | 0.67 pers-h/h |
| Control Delay (Average) | sec | 1.9 | 1.7 sec |
| Control Delay (Worst Lane by MC) | sec | 4.8 | |
| Control Delay (Worst Movement by MC) | sec | 5.9 | 5.9 sec |
| Geometric Delay (Average) | sec | 1.8 | |
| Stop-Line Delay (Average) | sec | 0.1 | |
| Idling Time (Average) | sec | 0 | |
| Intersection Level of Service (LOS) | | LOS A | |
| | | | |
| 95% Back of Queue - Veh (Worst Lane) | veh | 0.7 | |
| 95% Back of Queue - Dist (Worst Lane) | m | 5.5 | |
| Ave. Que Storage Ratio (Worst Lane) | | 0.34 | |
| Effective Stops (Total) | veh/h | 154 | 456 pers/h |
| Effective Stop Rate | | 0.33 | 0.32 |
| Proportion Queued | | 0.07 | 0.07 |
| Performance Index | | 3.2 | 3.2 |
| | | | |
| Cost (Total) | $/h | 118.53 | 118.53 $/h |
| Fuel Consumption (Total) | L/h | 10.9 | |
| Carbon Dioxide (Total) | kg/h | 26.3 | |
| Hydrocarbons (Total) | kg/h | 0.003 | |
| Carbon Monoxide (Total) | kg/h | 0.03 | |
| NOx (Total) | kg/h | 0.108 | |

| Intersection Performance - | | | |
|---|---|---|---|
| Performance Measure | Vehicles: | All MCs | Persons |
| Demand Flows (Total) | veh/y | 226,358 | 679,074 pers/y |
| Delay (Total) | veh-h/y | 122 | 321 pers-h/y |
| Effective Stops (Total) | veh/y | 74,121 | 218,898 pers/y |
| Travel Distance (Total) | veh-km/y | 23,198 | 51,799 pers-km/y |
| Travel Time (Total) | veh-h/y | 608 | 1,487 pers-h/y |
| | | | |
| Cost (Total) | $/y | 56,893 | 56,893 $/y |
| Fuel Consumption (Total) | L/y | 5,209 | |
| Carbon Dioxide (Total) | kg/y | 12,643 | |
| Hydrocarbons (Total) | kg/y | 1 | |
| Carbon Monoxide (Total) | kg/y | 13 | |
| NOx (Total) | kg/y | 52 | |

1 Hours per Year: 480 (Site)




## INTERSECTION SUMMARY

**Site: S1 [wS1 R (Site Folder: Double Teardrop Roundabout)]**

**Output produced by SIDRA INTERSECTION Version: 9.1.6.228**

Double Teardrop Roundabout

Site Category: (None)

Roundabout

**Intersection Performance - Hourly Values**

| Performance Measure | Vehicles: | All MCs | Persons | |
|---|---|---|---|---|
| Travel Speed (Average) | km/h | 27.2 | 20.5 | km/h |
| Travel Distance (Total) | veh-km/h | 77.5 | 142.6 | pers-km/h |
| Travel Time (Total) | veh-h/h | 2.9 | 7 | pers-h/h |
| Desired Speed | km/h | 54.1 | | |
| Speed Efficiency | | 0.5 | | |
| Travel Time Index | | 4.47 | | |
| Congestion Coefficient | | 1.99 | | |
| | | | | |
| Demand Flows (Total) | veh/h | 528 | 1483 | pers/h |
| Arrival Flows (Total) | veh/h | 528 | | |
| Percent Heavy Vehicles (Demand) | % | 24.9 | | |
| Percent Heavy Vehicles (Arrivals) | % | 24.9 | | |
| Degree of Saturation | | 0.184 | | |
| Practical Spare Capacity | % | 362 | | |
| Effective Intersection Capacity | veh/h | 2872 | | |
| | | | | |
| Control Delay (Total) | veh-h/h | 0.3 | 0.72 | pers-h/h |
| Control Delay (Average) | sec | 2 | 1.8 | sec |
| Control Delay (Worst Lane by MC) | sec | 6 | | |
| Control Delay (Worst Movement by MC) | sec | 6.9 | 6.9 | sec |
| Geometric Delay (Average) | sec | 1.8 | | |
| Stop-Line Delay (Average) | sec | 0.2 | | |
| Idling Time (Average) | sec | 0 | | |
| Intersection Level of Service (LOS) | | LOS A | | |
| | | | | |
| 95% Back of Queue - Veh (Worst Lane) | veh | 0.8 | | |
| 95% Back of Queue - Dist (Worst Lane) | m | 6.9 | | |
| Ave. Que Storage Ratio (Worst Lane) | | 0.42 | | |
| Effective Stops (Total) | veh/h | 173 | 470 | pers/h |
| Effective Stop Rate | | 0.33 | 0.32 | |
| Proportion Queued | | 0.09 | 0.08 | |
| Performance Index | | 4.6 | 4.6 | |
| | | | | |
| Cost (Total) | $/h | 253.92 | 253.92 | $/h |
| Fuel Consumption (Total) | L/h | 19.8 | | |
| Carbon Dioxide (Total) | kg/h | 48.6 | | |
| Hydrocarbons (Total) | kg/h | 0.005 | | |
| Carbon Monoxide (Total) | kg/h | 0.05 | | |
| NOx (Total) | kg/h | 0.247 | | |

**Intersection Performance -**

| Performance Measure | Vehicles: | All MCs | Persons | |
|---|---|---|---|---|
| Demand Flows (Total) | veh/y | 253,642 | 711,815 | pers/y |
| Delay (Total) | veh-h/y | 144 | 348 | pers-h/y |
| Effective Stops (Total) | veh/y | 83,115 | 225,561 | pers/y |
| Travel Distance (Total) | veh-km/y | 37,220 | 68,458 | pers-km/y |
| Travel Time (Total) | veh-h/y | 1,370 | 3,341 | pers-h/y |
| | | | | |
| Cost (Total) | $/y | 121,882 | 121,882 | $/y |
| Fuel Consumption (Total) | L/y | 9,505 | | |
| Carbon Dioxide (Total) | kg/y | 23,318 | | |
| Hydrocarbons (Total) | kg/y | 2 | | |
| Carbon Monoxide (Total) | kg/y | 24 | | |
| NOx (Total) | kg/y | 118 | | |

1 Hours per Year: 480 (Site)

## INTERSECTION SUMMARY

**Site: S2 [S2 R (Site Folder: Double Teardrop Roundabout)]**

**Output produced by SIDRA INTERSECTION Version: 9.1.6.228**

Double Teardrop Roundabout

Site Category: (None)

Roundabout

**Intersection Performance - Hourly Values**

| Performance Measure | Vehicles: | All MCs | Persons |
|---|---|---|---|
| Travel Speed (Average) | km/h | 37.9 | 34.5 km/h |
| Travel Distance (Total) | veh-km/h | 73.4 | 163 pers-km/h |
| Travel Time (Total) | veh-h/h | 1.9 | 4.7 pers-h/h |
| Desired Speed | km/h | 51.4 | |
| Speed Efficiency | | 0.74 | |
| Travel Time Index | | 7.08 | |
| Congestion Coefficient | | 1.36 | |
| | | | |
| Demand Flows (Total) | veh/h | 710 | 2125 pers/h |
| Arrival Flows (Total) | veh/h | 710 | |
| Percent Heavy Vehicles (Demand) | % | 21.8 | |
| Percent Heavy Vehicles (Arrivals) | % | 21.8 | |
| Degree of Saturation | | 0.239 | |
| Practical Spare Capacity | % | 255.2 | |
| Effective Intersection Capacity | veh/h | 2967 | |
| | | | |
| Control Delay (Total) | veh-h/h | 0.4 | 1.06 pers-h/h |
| Control Delay (Average) | sec | 2 | 1.8 sec |
| Control Delay (Worst Lane by MC) | sec | 5.4 | |
| Control Delay (Worst Movement by MC) | sec | 5.9 | 5.9 sec |
| Geometric Delay (Average) | sec | 1.8 | |
| Stop-Line Delay (Average) | sec | 0.2 | |
| Idling Time (Average) | sec | 0 | |
| Intersection Level of Service (LOS) | | LOS A | |
| | | | |
| 95% Back of Queue - Veh (Worst Lane) | veh | 1.1 | |
| 95% Back of Queue - Dist (Worst Lane) | m | 9.2 | |
| Ave. Que Storage Ratio (Worst Lane) | | 0.57 | |
| Effective Stops (Total) | veh/h | 238 | 698 pers/h |
| Effective Stop Rate | | 0.33 | 0.33 |
| Proportion Queued | | 0.1 | 0.1 |
| Performance Index | | 5.1 | 5.1 |
| | | | |
| Cost (Total) | $/h | 181.27 | 181.27 $/h |
| Fuel Consumption (Total) | L/h | 16.8 | |
| Carbon Dioxide (Total) | kg/h | 40.7 | |
| Hydrocarbons (Total) | kg/h | 0.005 | |
| Carbon Monoxide (Total) | kg/h | 0.04 | |
| NOx (Total) | kg/h | 0.169 | |

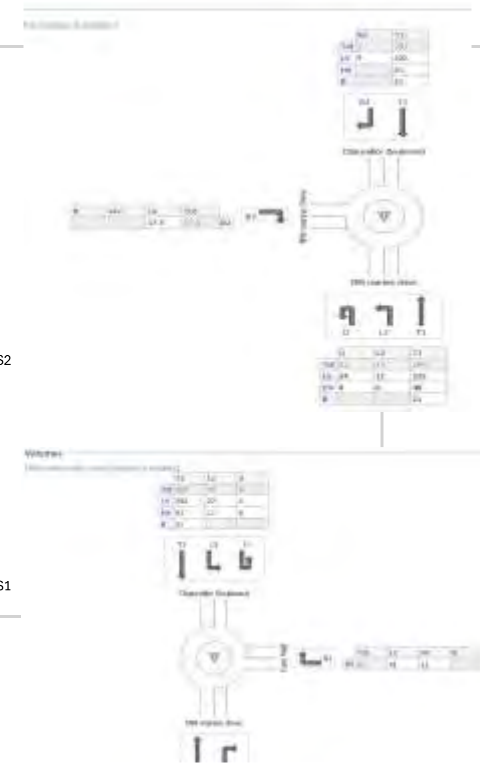
**Intersection Performance -**

| Performance Measure | Vehicles: | All MCs | Persons |
|---|---|---|---|
| Demand Flows (Total) | veh/y | 340,800 | 1,020,126 pers/y |
| Delay (Total) | veh-h/y | 192 | 511 pers-h/y |
| Effective Stops (Total) | veh/y | 114,087 | 335,219 pers/y |
| Travel Distance (Total) | veh-km/y | 35,245 | 78,231 pers-km/y |
| Travel Time (Total) | veh-h/y | 930 | 2,267 pers-h/y |
| | | | |
| Cost (Total) | $/y | 87,011 | 87,011 $/y |
| Fuel Consumption (Total) | L/y | 8,050 | |
| Carbon Dioxide (Total) | kg/y | 19,542 | |
| Hydrocarbons (Total) | kg/y | 2 | |
| Carbon Monoxide (Total) | kg/y | 21 | |
| NOx (Total) | kg/y | 81 | |

1 Hours per Year: 480 (Site)

<==roundabout S2

<==roundabout S1



## INTERSECTION SUMMARY

**Site: S1 [wS1 R (Site Folder: Double Teardrop Roundabout)]**

Output produced by SIDRA INTERSECTION Version: 9.1.6.228

Double Teardrop Roundabout

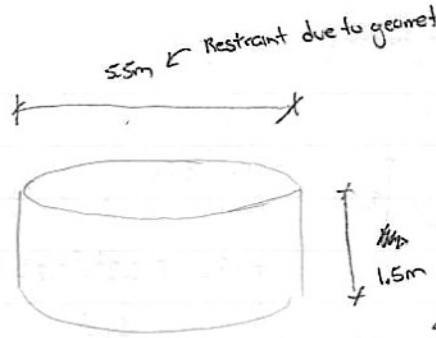
Site Category: (None)

Roundabout

| Intersection Performance - Hourly Values | | | | |
|---|---|---|---|---|
| Performance Measure | Vehicles: | All MCs | Persons | |
| Travel Speed (Average) | km/h | 27 | 20.4 | km/h |
| Travel Distance (Total) | veh-km/h | 117 | 214.8 | pers-km/h |
| Travel Time (Total) | veh-h/h | 4.3 | 10.5 | pers-h/h |
| Desired Speed | km/h | 54.1 | | |
| Speed Efficiency | | 0.5 | | |
| Travel Time Index | | 4.43 | | |
| Congestion Coefficient | | 2.01 | | |
| | | | | |
| Demand Flows (Total) | veh/h | 796 | 2228 | pers/h |
| Arrival Flows (Total) | veh/h | 796 | | |
| Percent Heavy Vehicles (Demand) | % | 25 | | |
| Percent Heavy Vehicles (Arrivals) | % | 25 | | |
| Degree of Saturation | | 0.281 | | |
| Practical Spare Capacity | % | 202.1 | | |
| Effective Intersection Capacity | veh/h | 2828 | | |
| | | | | |
| Control Delay (Total) | veh-h/h | 0.48 | 1.17 | pers-h/h |
| Control Delay (Average) | sec | 2.2 | 1.9 | sec |
| Control Delay (Worst Lane by MC) | sec | 7 | | |
| Control Delay (Worst Movement by MC) | sec | 8.4 | 8.4 | sec |
| Geometric Delay (Average) | sec | 1.8 | | |
| Stop-Line Delay (Average) | sec | 0.4 | | |
| Idling Time (Average) | sec | 0 | | |
| Intersection Level of Service (LOS) | | LOS A | | |
| | | | | |
| 95% Back of Queue - Veh (Worst Lane) | veh | 1.4 | | |
| 95% Back of Queue - Dist (Worst Lane) | m | 11.7 | | |
| Ave. Que Storage Ratio (Worst Lane) | | 0.72 | | |
| Effective Stops (Total) | veh/h | 268 | 721 | pers/h |
| Effective Stop Rate | | 0.34 | 0.32 | |
| Proportion Queued | | 0.13 | 0.11 | |
| Performance Index | | 7.4 | 7.4 | |
| | | | | |
| Cost (Total) | $/h | 385.41 | 385.41 | $/h |
| Fuel Consumption (Total) | L/h | 30.3 | | |
| Carbon Dioxide (Total) | kg/h | 74.4 | | |
| Hydrocarbons (Total) | kg/h | 0.007 | | |
| Carbon Monoxide (Total) | kg/h | 0.08 | | |
| NOx (Total) | kg/h | 0.38 | | |

| Intersection Performance - | | | | |
|---|---|---|---|---|
| Performance Measure | Vehicles: | All MCs | Persons | |
| Demand Flows (Total) | veh/y | 381,979 | 1,069,541 | pers/y |
| Delay (Total) | veh-h/y | 232 | 560 | pers-h/y |
| Effective Stops (Total) | veh/y | 128,657 | 346,085 | pers/y |
| Travel Distance (Total) | veh-km/y | 56,179 | 103,124 | pers-km/y |
| Travel Time (Total) | veh-h/y | 2,083 | 5,059 | pers-h/y |
| | | | | |
| Cost (Total) | $/y | 184,996 | 184,996 | $/y |
| Fuel Consumption (Total) | L/y | 14,549 | | |
| Carbon Dioxide (Total) | kg/y | 35,694 | | |
| Hydrocarbons (Total) | kg/y | 4 | | |
| Carbon Monoxide (Total) | kg/y | 36 | | |
| NOx (Total) | kg/y | 183 | | |
| | | | | |
| 1 | Hours per Year: 480 (Site) | | | |

# APPENDIX B – FOUNDATION CALCULATION




5×8

check for a theoretical $P_f$ =

$f'_c = 35\,MPa$

$f_y = 400\,MPa$

$A = \pi \cdot \frac{5.5^2}{4} = 23.8\,m^2$

Soil Bearing pressure => Bridge standards & procedures manual (2016) for Concrete Structures
=100 KPa

UBC26 prelim Geotech Report

SLS = 500 KPa

* dimension of Statue $\boxed{5\times5\times8m}$ = $200\,m^3$

* Weight $7930\,Kg/m^3 \cdot 200\,m^3 = 1586\,000\,kg$

$1586000 \cdot 0.5 = 317\,200\,Kg$

* assume 50% mass hollow *

Weigh = 7779.33 KN

* $SL = 3\,KPa \cdot \left(\frac{\pi}{4} \cdot 5.5^2\right) = 71.4\,KN$

Service Load = 7779.33 + 71.4 = 7850.73 KN

Bearing Cap = 500 KPa

$\frac{7850.73}{A} + 23.5 \cdot 1.5\,KN/m^2 = 500\,KPa$ ← If soil Con'd are 500 KPa

$A = \frac{7850.73}{464.75} = 16.892\,m^2$

Use $A = 23.8\,m^2$

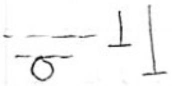
footing depth = 1.5m

factored load

$1.25 \cdot 7779.33 + 71.4 = 9795.56\,kN$

30M bars foundation

75mm concrete cover



$d_1 = 1500 - 75 - 30 \cdot 1.5 = 1380\,mm$

$d_2 = 1500 - 75 - 30/2 = 1410\,mm$

$d_{avg} = 1500 - 75 - 30 = 1395\,mm$

$0.5$

$1m$

4x4x8

3.85

*Stepped footing

2-way shear check

*assum 5m metal Column plate

$f'_c = 35$

5

3.2

5.75 2705

$d_{avg} = 1000-75-30 = 895$

$d_{min} = 880$

$d_2 = 910$

$d_v = 0.9 \cdot 880 = 792$

$5000 + 895 = 5895$

$V_f = P_f \cdot \frac{32.2 - 27.3}{27.3} = 1758.2 \text{ kN}$

$\pi R^2 = \pi \cdot 3.2^2 = 32.2 \text{ m}^2$

$f_L =$

$P_f = 9795.56$

*No size effect

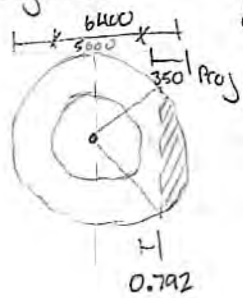
$V_r = 0.38 \cdot 0.65 \sqrt{35} \cdot (\pi \cdot 5.895) \cdot 0.895 / 1000$
$= 2422 \text{ kN} \geq V_f$ ✓

$6.4 - 5 = \frac{1.4/2}{1} = 1.4 < 2 \Rightarrow$ No size eff

$b_o = 895 +$

1-way check

$d_v = 0.792m$



$a = \left(\frac{c^2+4h^2}{8h}\right)^2 \arccos\left(\frac{c^2-4h^2}{c^2+4h^2}\right) - \frac{c}{16h}(c^2-4h^2)$

~1-way shear does not apply with $d_v$

Flexure

$\min A_s = 0.002 \cdot 1000 \cdot 6400 = 12800 / 500$   25M ~ 500mm² ← go with 25M

$= 26$ bars   25M ~ 300

44 bars

1000

1455

19.6

499.8 kPa

$M_f = 499.8 \cdot 1.455 \cdot 0.350 \cdot \frac{0.350}{2} = 44.54 \text{ kN}\cdot\text{m}$

$M_r = \phi_s f_y A_s (d_{min} - \beta_1 c/2) = 340 \cdot 13000 \left(880 - \frac{1.95}{2}\right) = 3885 \text{ kN m} \geq M_f$ ✓

$\alpha_1 = 0.8$

$\beta_1 = 0.88$

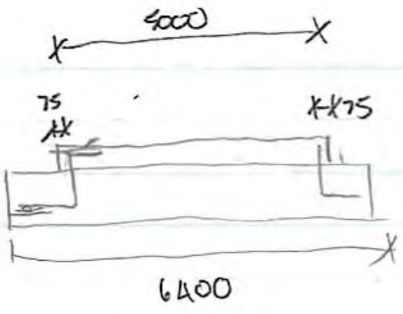
$\beta_1 c = \frac{340 \cdot 13000}{0.8 \cdot 0.65 \cdot 30 \cdot 1455} = 1.95 \leq 0.5 \cdot d$ ✓

Bearing

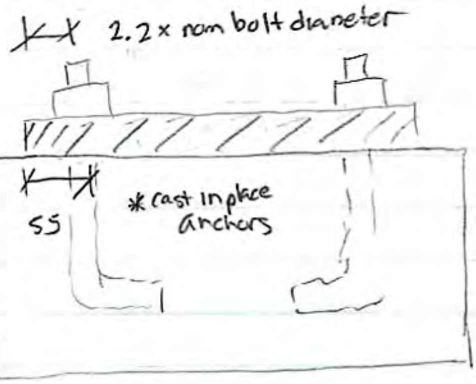
$F_b = 0.85 \cdot 0.65 \cdot 19.6 \sqrt{\frac{32.1}{19.6}} = 19.8 \cdot 35 = 693 \text{ kN} > 16043.58$

45 148 mm²

45-35M dowel Req'd




44 bars each way




ASTM F1554, Grade 36

$F_y$ = 248 ~~MPa~~ kN/m$^2$

$F_u$ = 400 kN/m$^2$

$F_y = 380$

$\phi V_n = \phi F_{nv} \cdot A_b$

$\phi V_n = (0.450 \cdot F_u) \cdot 0.75 \cdot A_b$

Weight static site class C

$\frac{V}{W} = 0.303 = 0.303 \cdot 9795.56 = 2968.96 \approx 3000$ kN

$\frac{0.75 \cdot 3000 \text{ kN} \cdot 10^3}{0.45 \cdot 650 \cdot 0.75} = 8200$

1" ≈ .25M → 500 ⇒ 16.4 bolts

grade 55 bolts $F_u = 650$ $F_y = 380$ 17 bolts

17 bolts

# APPENDIX C – STORMWATER DESIGN OUTPUTS

# SUMMARY SHEET - PRE-DEVELOPMENT

| | |
|---|---|
| Project Name: | Rainwater Management Plan for a Site Development in the City of Vancouver BC |
| Designed by: | Amanda Markman |
| Calculation Date: | 26-Mar-25 |
| Checked by: | Mason Nah |

| | |
|---|---|
| IDF Used: | 2014 |
| Return Period | 10 |
| n | 0.013 |
| Inlet Time (min): | 5 |

| | Catchment Properties | | | | Flows | | | Design Summary | |
|---|---|---|---|---|---|---|---|---|---|
| Catchment Area | Tipe of Surface | Area, A Size | C | Time of Concentration | Intensity | C*A | $Q_{peak}$ | Base Area | Volume Capture |
| | | | | | From IDF Curve, I = A*T^B | | Rational Method | | |
| | | $m^2$ | | min | mm/hr | ha | $m^3/s$ | $m^2$ | $m^3$ |
| | Permeable | 3,082.89 | 0.18 | | | | | | |
| A1 | Impervious | 989.50 | 0.88 | | | | | | |
| | **Total** | **4,072.39** | **0.43** | **15** | **139.1** | **0.17** | **0.07** | **51.8** | **23.75** |
| | Permeable | 2,293.16 | 0.3 | | | | | | |
| A2 | Impervious | 846.41 | 0.83 | | | | | | |
| | **Total** | **3,139.57** | **0.44** | **15** | **139.1** | **0.14** | **0.05** | **44.3** | **20.31** |
| | Permeable | 424.14 | 0.3 | | | | | | |
| A3 | Impervious | 588.81 | 0.83 | | | | | | |
| | **Total** | **1,012.94** | **0.61** | **15** | **139.1** | **0.06** | **0.02** | **1,571.4** | **-** |
| | Permeable | 278.88 | 0.13 | | | | | | |
| A4 | Impervious | 1,523.92 | 0.88 | | | | | | |
| | **Total** | **1,802.80** | **0.76** | **15** | **139.1** | **0.14** | **0.05** | **79.8** | **36.57** |
| | Permeable | - | 0.18 | | | | | | |
| A5 | Impervious | 1,759.14 | 0.88 | | | | | | |
| | **Total** | **1,759.14** | **0.88** | **15** | **139.1** | **0.15** | **0.06** | **95.6** | **42.22** |
| **TOTAL SUM** | | 1.18 | ha | | | | 0.26 | | |

| | | % |
|---|---|---|
| Permeable | 6,079.08 | 52% |
| Impervious | 5,707.77 | 48% |
| **Total** | 11,786.84 | |

# SUMMARY SHEET - POST-DEVELOPMENT WITHOUT G.I.

| | |
|---|---|
| Project Name: | Rainwater Management Plan for a Site Development in the City of Vancouver BC |
| Designed by: | Amanda Markman |
| Calculation Date: | 26-Mar-25 |
| Checked by: | Rohit Sharma |

| | |
|---|---|
| IDF Used: | 2050 |
| Return Period | 10 |
| n | 0.013 |
| Inlet Time (min): | 5 |

| | Catchment Properties | | | | Flows | | |
|---|---|---|---|---|---|---|---|
| Catchment Area | Tipe of Surface | Area, A Size | C | Time of Concentration | Intensity | C*A | $Q_{peak}$ |
| | | | | | From IDF Curve, I = A*T^B | | Rational Method |
| | | $m^2$ | | min | mm/hr | ha | $m^3/s$ |
| | Permeable | 3,082.89 | 0.18 | | | | |
| A1 | Impervious | 989.50 | 0.88 | | | | |
| | **Total** | **4,072.39** | **0.43** | **5** | **139.1** | **0.17** | **0.07** |
| | Permeable | 2,293.16 | 0.3 | | | | |
| A2 | Impervious | 846.41 | 0.83 | | | | |
| | **Total** | **3,139.57** | **0.44** | **5** | **139.1** | **0.14** | **0.05** |
| | Permeable | 424.14 | 0.3 | | | | |
| A3 | Impervious | 588.81 | 0.83 | | | | |
| | **Total** | **1,012.94** | **0.61** | **5** | **139.1** | **0.06** | **0.02** |
| | Permeable | 278.88 | 0.13 | | | | |
| A4 | Impervious | 1,523.92 | 0.88 | | | | |
| | **Total** | **1,802.80** | **0.76** | **5** | **139.1** | **0.14** | **0.05** |
| | Permeable | - | 0.18 | | | | |
| A5 | Impervious | 1,759.14 | 0.88 | | | | |
| | **Total** | **1,759.14** | **0.88** | **5** | **139.1** | **0.15** | **0.06** |
| **TOTAL SUM** | | 1.18 | ha | | | | 0.26 |

# SUMMARY SHEET - POST-DEVELOPMENT WITH G.I.

| | |
|---|---|
| Project Name: | Rainwater Management Plan for a Site Development in the City of Vancouver BC |
| Designed by: | Amanda Markman |
| Calculation Date: | 26-Mar-25 |
| Checked by: | Rohit Sharma |

| | |
|---|---|
| IDF Used: | 2050 |
| Return Period | 10 |
| n | 0.013 |
| Inlet Time (min): | 5 |

| | Catchment Properties | | | | Flows | | | Design Summary | | | Flow with Volume Control |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Catchment Area | Tipe of Surface | Area, A Size | C | Time of Concentration | Intensity | C*A | $Q_{peak}$ | Base Area | Volume Capture | Volume from Storm | |
| | | | | | From IDF Curve, I = A*T^B | | Rational Method | | | | |
| | | $m^2$ | | min | mm/hr | ha | $m^3/s$ | $m^2$ | $m^3$ | $m^3$ | $m^3$ |
| A1 | Permeable | 3,082.89 | 0.3 | | | | | | | | |
| | Impervious | 989.50 | 0.83 | | | | | | | | |
| | **Total** | **4,072.39** | **0.43** | **5** | **139.1** | **0.17** | **0.07** | **51.8** | **23.75** | **20.24** | **0.05** |
| A2 | Permeable | 2,293.16 | 0.3 | | | | | | | | |
| | Impervious | 846.41 | 0.83 | | | | | | | | |
| | **Total** | **3,139.57** | **0.44** | **5** | **139.1** | **0.14** | **0.05** | **44.3** | **20.31** | **36.40** | **0.04** |
| A3 | Permeable | 424.14 | 0.3 | | | | | | | | |
| | Impervious | 588.81 | 0.83 | | | | | | | | |
| | **Total** | **1,012.94** | **0.61** | **5** | **139.1** | **0.06** | **0.02** | **490.7** | **14.13** | | **0.02** |
| A4 | Permeable | 278.88 | 0.13 | | | | | | | | |
| | Impervious | 1,523.92 | 0.88 | | | | | | | | |
| | **Total** | **1,802.80** | **0.76** | **5** | **139.1** | **0.14** | **0.05** | **79.8** | **36.57** | **20.90** | **0.04** |
| A5 | Permeable | - | 0.18 | | | | | | | | |
| | Impervious | 1,759.14 | 0.88 | | | | | | | | |
| | **Total** | **1,759.14** | **0.88** | **5** | **139.1** | **0.15** | **0.06** | **95.6** | **42.22** | **20.39** | **0.05** |
| **TOTAL SUM** | | 1.18 | ha | | | | 0.26 | | | | **0.20** |

| | | |
|---|---|---|
| Permeable | 6,079.08 | 52% |
| Impervious | 5,707.77 | 48% |
| **Total** | 11,786.84 | |

# Stormwater Analysis

## Rational Method Pre-Development

*Use the Rational Method to find the runoff preak flow of the PRE-Development site.*

$$Q = \frac{C \times I \times A}{360}$$

Where:

| | |
|---|---|
| Q | Peak Flow [$m^3/s$] |
| C | Runoff Coefficient |
| A | Drainage Area [ha] |
| I | Rainfall Intensity [mm/hr] |

*Will have to do weighted average for the Runoff Coefficient because there is two different types of surface*

Q = 0.26 $m^3/s$

If

C = 0.56

A = 1.18 ha

I = 139.1 mm/hr

| | | | | |
|---|---|---|---|---|
| $C_{permeable}$ | 0.3 | $A_{permeable}$ | 5,589.75 | $m^2$ |
| $C_{Impermeable}$ | 0.8 | $A_{Impermeable}$ | 6,197.09 | $m^2$ |
| | | Total = | 11,786.84 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 5 | min |

*To find Intensity of the pre-development, we are using 100-year Return Period and the Time of Concentration (no pipes) is 5 min for the IDF 2014*

## Rational Method Post-Development

Q = 0.25 $m^3/s$

If

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C = | 0.54 | | $C_{permeable}$ | 0.3 | $A_{permeable}$ | 6,079.08 | $m^2$ |
| A = | 1.18 | ha | $C_{Impermeable}$ | 0.8 | $A_{Impermeable}$ | 5,707.77 | $m^2$ |
| I = | 139.1 | mm/hr | | | Total = | 11,786.84 | $m^2$ |

$I = A \times T^B$

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

## Peak Flow S.C. 1

Q = 0.07 $m^3/s$

If

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C = | 0.43 | | $C_{permeable}$ | 0.3 | $A_{permeable}$ | 3,082.89 | $m^2$ |
| A = | 0.41 | ha | $C_{Impermeable}$ | 0.83 | $A_{Impermeable}$ | 989.50 | $m^2$ |
| I = | 139.1 | mm/hr | | | Total = | 4,072.39 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

## Peak Flow S.C. 2

Q = 0.05 $m^3/s$

If

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C = | 0.44 | | $C_{permeable}$ | 0.3 | $A_{permeable}$ | 2,293.16 | $m^2$ |
| A = | 0.31 | ha | $C_{Impermeable}$ | 0.83 | $A_{Impermeable}$ | 846.41 | $m^2$ |
| I = | 139.1 | mm/hr | | | Total = | 3,139.57 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

## Peak Flow S.C. 3

Q = 0.02 $m^3/s$

If

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C = | 0.61 | | $R_{permeable}$ | 0.3 | $A_{permeable}$ | 424.14 | $m^2$ |
| A = | 0.10 | ha | $R_{Impermeable}$ | 0.83 | $A_{Impermeable}$ | 588.81 | $m^2$ |
| I = | 139.1 | mm/hr | | | Total = | 1,012.94 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

## Peak Flow S.C. 4

Q = 0.05 $m^3/s$

If

C = 0.76

A = 0.18 ha

I = 139.1 mm/hr

| | | | | |
|---|---|---|---|---|
| $R_{permeable}$ | 0.13 | $A_{permeable}$ | 278.88 | $m^2$ |
| $R_{Impermeable}$ | 0.88 | $A_{Impermeable}$ | 1,523.92 | $m^2$ |
| | | Total = | 1,802.80 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

## Peak Flow S.C. 5

Q = 0.06 $m^3/s$

If

C = 0.88

A = 0.18 ha

I = 139.1 mm/hr

| | | | | |
|---|---|---|---|---|
| $R_{permeable}$ | 0.18 | $A_{permeable}$ | | $m^2$ |
| $R_{Impermeable}$ | 0.88 | $A_{Impermeable}$ | 1,759.14 | $m^2$ |
| | | Total = | 1,759.14 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

## Sub Catchment Area = Total Area

| | Area | |
|---|---|---|
| SC 1 | 4,072.39 | $m^2$ |
| SC 2 | 3,139.57 | $m^2$ |
| SC 3 | 1,012.94 | $m^2$ |
| SC 4 | 1,802.80 | $m^2$ |
| SC 5 | 1,759.14 | $m^2$ |
| | **11,786.84** | **$m^2$** |
| in ha | **1.18** | **ha** |

# Amanda Markman - Infiltration Rain Garden Design

## Rain Garden 1 Sizing

The size is based on the upstream impervious area that it serves. This relationship can be defined by the ratio of impervious area to pervious area (I/P ratio). The ratio of upstream impervious area (catchment area) to Base Area of Rain Garden.

### Sizing for Depth Capture Area: X mm in 24hrs

### Maximum Rock Depth According to Drain Time

*Determine the maximum rock depth according to drain time (4 days max.) - Allowable range: 300 to 2000 mm*

$$D_R = \frac{K_S \times T \times 24}{n}$$

Where:

| | |
|---|---|
| Dr | Depth of rock reservoir [mm] |
| Ks | Saturated hydraulic conductivity of Subsurface Soil [mm/hr] |
| T | Allowable drain time [days] |
| n | Porosity of drain rock reservoir [unitless] |

If

| | | |
|---|---|---|
| $D_R$ = | 411.43 | mm |
| $K_S$ = | 1.5 | mm/hr |
| T = | 4 | days |
| n = | 0.35 | --- |

Round down to nearest 50mm increment: 450 mm

### Determine the Base Area of Rain Garden and Rock Reservoir

$$I/P = \frac{24 \times K_S + D_P + D_R \times n + 0.2 \times D_S}{R} - 1$$

Where:

| | |
|---|---|
| I/P | Ratio of impervious tributary area to rain garden base area [unitless] |
| R | Rainfall Capture depth [mm] |
| $K_S$ | Saturated hydraulic conductivity of Subsurface Soil [mm/hr] |
| $D_P$ | Depth ponding [mm] - 200mm standard |
| $D_S$ | Soil layer depth [mm] -Standard Value: 450 mm |
| n | Porosity of drain rock reservoir [unitless] |
| $D_R$ | Depth (thickness) of Rock Reservoir |

I/P = 19.1

If

| | | | |
|---|---|---|---|
| $K_S$ = | 1.5 | mm//hr | Page 27, try Silty Clay Loam |
| $D_P$ = | 200 | mm | |
| n = | 0.35 | | All examples were 0.35 |
| $D_S$ = | 450 | mm | |
| R = | 24 | mm | |
| $D_R$ = | 450 | mm | |

## Find the Rain Garden Base Area

$$BaseArea = \frac{ImperviousTributaryArea}{{}^{I}/_{P}}$$

| | | |
|---|---|---|
| BaseArea = | 149.06 | $m^2$ |

If

| | | |
|---|---|---|
| Impervious = | 2,853.9 | $m^2$ |
| I/P = | 19.1 | unitless |

*Calculate the FOOTPRINT of the facility based on the Base Area and Side slopes*

$$Footprint\ of\ Rain\ Garden = Base\ Area + Side\ Slope\ Area$$

## Calculate Allowance Discharge Through the Orifice

$$Q = \frac{0.25 \times A_{Site}}{1000}$$

Where:

| | |
|---|---|
| Q | Allowable discharge through orifice [$m^3/s$] |
| 0.25 | Recommended unit discharge |
| $A_{site}$ | Total site area draining to swale, including the swale area [ha] |

If

| | | |
|---|---|---|
| Q = | 0.00 | $m^3/s$ |
| $A_{site}$ = | 0.6 | ha |

Q = 0.589342 L/s

## Solving the Orifice Equation for Area of the Orifice

$$A_O = \frac{Q_{Site}}{K \times \sqrt{2g\Delta h}}$$

Where:

| | |
|---|---|
| $A_O$ | Area of the orifice opening [$m^2$] |
| $Q_{site}$ | Theoretical discharge through infiltration from impervious area [$m^3/s$] |
| K | Orifice coefficient - Typical value: 0.6 |
| g | Gravitational constant [$m/s^2$] |
| h | Differential head equivalent to depth of the perforated drain pipe in the rock trench [Typical value: 0.3m] |

Diameter 0.28057284 m

| | | |
|---|---|---|
| $A_O$ | 0.06182742 | $m^2$ |

If

| | | |
|---|---|---|
| $Q_{site}$ | 0.09 | $m^3/s$ |
| K | 0.6 | |
| g | 9.81 | $m/s^2$ |
| h | 0.3 | m |

## Depth of the Rock Reservoir Above the orifice

$$D_R = \frac{R \times \left(\frac{I}{P} + 1\right) - \frac{0.09mm}{hr} \times 24hrs \times \left(\frac{I}{P} + 1\right) - 24 \times K_S - 0.2 \times D_S}{n}$$

Where:

| | |
|---|---|
| $D_R$ | Depth (thickness) of rock reservoir [mm] |
| R | Rainfall Capture depth |
| I/P | ratio of impervious tributary area to rain garden |
| $K_S$ | Saturated hydraulic conductivity of substance soil |
| $D_S$ | Soil layer depth; standard value = 300 [mm] |
| n | porosity of drain rock in reservoir |

| | | |
|---|---|---|
| $D_R$ | 897 | mm |

if

| | | |
|---|---|---|
| R | 24 | mm |
| I/P | 19.1 | |
| $K_S$ | 1.5 | |
| $D_S$ | 450 | |
| n | 0.35 | |

## Rational Method Post-Development

*Use the Rational Method to find the runoff preak flow of the Post-Development site.*

$$Q = \frac{R \times A \times I}{360}$$

Where:

| | |
|---|---|
| Q | Peak Flow [$m^3/s$] |
| R | Runoff Coefficient |
| A | Drainage Area [ha] |
| I | Rainfall Intensity [mm/hr] |

*Will have to do weighted average for the Runoff Coefficient because there is two different types of*

Q = 0.12 $m^3/s$

If

R = 0.54

A = 0.59 ha

I = 139.1 mm/hr

| | | | | |
|---|---|---|---|---|
| $R_{permeable}$ | 0.3 | $A_{permeable}$ | 3,039.54 | $m^2$ |
| $R_{Impermeable}$ | 0.8 | $A_{Impermeable}$ | 2,853.88 | $m^2$ |
| | | Total = | 5,893.42 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

*To find Intensity of the pre-development, we are using 10-year Return Period and the Time of Concentration (no pipes) is 5 min for the IDF 2100*

## Infiltration Rain Garden

$$Required\ Rainfall\ Capture\ Volume = Area\ \times 24mm$$

Capture Volume = 68.5 $m^3$

otal Impervious Area : 2,853.88 $m^2$

## Rational Method Post-Development with GI

*Use the Rational Method to find the runoff preak flow of the Post-Development site.*

$$Q = \frac{R \times A \times I}{360}$$

Where:

| | |
|---|---|
| Q | Peak Flow [$m^3/s$] |
| R | Runoff Coefficient |
| A | Drainage Area [ha] |
| I | Rainfall Intensity [mm/hr] |

*Will have to do weighted average for the Runoff Coefficient because there is two different types of*

Q = 0.14 $m^3/s$

If

| | | |
|---|---|---|
| R = | 0.77 | |
| A = | 0.46 | ha |
| I = | 139.1 | mm/hr |

| | | | | |
|---|---|---|---|---|
| $R_{permeable}$ | 0.3 | $A_{permeable}$ | 250.00 | $m^2$ |
| $R_{Impermeable}$ | 0.8 | $A_{Impermeable}$ | 4,382.00 | $m^2$ |
| | | Total = | 4,632.00 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

# Amanda Markman - Infiltration Rain Garden Design

## Rain Garden 1 Sizing

The size is based on the upstream impervious area that it serves. This relationship can be defined by the ratio of impervious area to pervious area (I/P ratio). The ratio of upstream impervious area (catchment area) to Base Area of Rain Garden.

### Sizing for Depth Capture Area: X mm in 24hrs

### Maximum Rock Depth According to Drain Time

*Determine the maximum rock depth according to drain time (4 days max.) - Allowable range: 300 to 2000 mm*

$$D_R = \frac{K_S \times T \times 24}{n}$$

Where:

| | |
|---|---|
| Dr | Depth of rock reservoir [mm] |
| Ks | Saturated hydraulic conductivity of Subsurface Soil [mm/hr] |
| T | Allowable drain time [days] |
| n | Porosity of drain rock reservoir [unitless] |

| | | | |
|---|---|---|---|
| | $D_R$ = | 411.43 | mm |
| If | $K_S$ = | 1.5 | mm/hr |
| | T = | 4 | days |
| | n = | 0.35 | --- |

Round down to nearest 50mm increment: 450 mm

### Determine the Base Area of Rain Garden and Rock Reservoir

$$I/_P = \frac{24 \times K_S + D_P + D_R \times n + 0.2 \times D_S}{R} -$$

Where:

| | |
|---|---|
| I/P | Ratio of impervious tributary area to rain garden base area [unitless] |
| R | Rainfall Capture depth [mm] |
| $K_S$ | Saturated hydraulic conductivity of Subsurface Soil [mm/hr] |
| $D_P$ | Depth ponding [mm] - 200mm standard |
| $D_S$ | Soil layer depth [mm] -Standard Value: 450 mm |
| n | Porosity of drain rock reservoir [unitless] |
| $D_R$ | Depth (thickness) of Rock Reservoir |

I/P = 19.1

If

| | | | |
|---|---|---|---|
| $K_S$ = | 1.5 | mm//hr | Page 27, try Silty Clay Loam |
| $D_P$ = | 200 | mm | |
| n = | 0.35 | | All examples were 0.35 |
| $D_S$ = | 450 | mm | |
| R = | 24 | mm | |
| $D_R$ = | 450 | mm | |

## Find the Rain Garden Base Area

$$BaseArea = \frac{ImperviousTributaryArea}{I/P}$$

BaseArea = 149.06 $m^2$

If

| | | |
|---|---|---|
| Impervious = | 2,853.9 | $m^2$ |
| I/P = | 19.1 | unitless |

*Calculate the FOOTPRINT of the facility based on the Base Area and Side slopes*

$$Footprint\ of\ Rain\ Garden = Base\ Area + Side\ Slope\ Area$$

## Calculate Allowance Discharge Through the Orifice

$$Q = \frac{0.25 \times A_{Site}}{1000}$$

Where:

| | |
|---|---|
| Q | Allowable discharge through orifice [$m^3/s$] |
| 0.25 | Recommended unit discharge |
| $A_{site}$ | Total site area draining to swale, including the swale area [ha] |

If

| | | |
|---|---|---|
| Q = | 0.00014734 | $m^3/s$ |
| $A_{site}$ = | 0.6 | ha |

| | | |
|---|---|---|
| Q = | 0.147336 | L/s |

## Solving the Orifice Equation for Area of the Orifice

$$A_O = \frac{Q_{Site}}{K \times \sqrt{2g\Delta h}}$$

Where:

| | |
|---|---|
| $A_O$ | Area of the orifice opening [$m^2$] |
| $Q_{site}$ | Theoretical discharge through infiltration from impervious area [$m^3/s$] |
| K | Orifice coefficient - Typical value: 0.6 |
| g | Gravitational constant [$m/s^2$] |
| h | Differential head equivalent to depth of the perforated drain pipe in the rock trench [Typical value: 0.3m] |

If

| | | |
|---|---|---|
| $A_O$ | 0.00010122 | $m^2$ |

| | | |
|---|---|---|
| $Q_{site}$ | 0.00014734 | $m^3/s$ |
| K | 0.6 | |
| g | 9.81 | $m/s^2$ |
| h | 0.3 | m |

## Depth of the Rock Reservoir Above the orifice

$$D_R = \frac{R \times \left(\frac{I}{P} + 1\right) - \frac{0.09mm}{hr} \times 24hrs \times \left(\frac{I}{P} + 1\right) - 24 \times K_S - 0.2 \times D_S}{n}$$

Where:

| | |
|---|---|
| $D_R$ | Depth (thickness) of rock reservoir [mm] |
| R | Rainfall Capture depth |
| I/P | ratio of impervious tributary area to rain garden |
| $K_S$ | Saturated hydraulic conductivity of substance soil |
| $D_S$ | Soil layer depth; standard value = 300 [mm] |
| n | porosity of drain rock in reservoir |

| | | |
|---|---|---|
| $D_R$ | 897 | mm |

if

| | | |
|---|---|---|
| R | 24 | mm |
| I/P | 19.1 | |
| $K_S$ | 1.5 | |
| $D_S$ | 450 | |
| n | 0.35 | |

## Rational Method Post-Development

*Use the Rational Method to find the runoff preak flow of the Post-Development site.*

$$Q = \frac{R \times A \times I}{360}$$

Where:

| | |
|---|---|
| Q | Peak Flow [$m^3/s$] |
| R | Runoff Coefficient |
| A | Drainage Area [ha] |
| I | Rainfall Intensity [mm/hr] |

*Will have to do weighted average for the Runoff Coefficient because there is two different types of*

Q = 0.12 $m^3/s$

If

R = 0.54

A = 0.59 ha

I = 139.1 mm/hr

| | | | | |
|---|---|---|---|---|
| $R_{permeable}$ | 0.3 | $A_{permeable}$ | 3,039.54 | $m^2$ |
| $R_{Impermeable}$ | 0.8 | $A_{Impermeable}$ | 2,853.88 | $m^2$ |
| | | Total = | 5,893.42 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

*To find Intensity of the pre-development, we are using 10-year Return Period and the Time of Concentration (no pipes) is 5 min for the IDF 2100*

## Infiltration Rain Garden

$$Required\ Rainfall\ Capture\ Volume = Area\ \times 24mm$$

Capture Volume = 68.5 $m^3$

Total Impervious Area = 2,853.88 $m^2$

## Rational Method Post-Development with GI

*Use the Rational Method to find the runoff preak flow of the Post-Development site.*

$$Q = \frac{R \times A \times I}{360}$$

Where:

| | |
|---|---|
| Q | Peak Flow [$m^3$/s] |
| R | Runoff Coefficient |
| A | Drainage Area [ha] |
| I | Rainfall Intensity [mm/hr] |

*Will have to do weighted average for the Runoff Coefficient because there is two different types of*

Q = 0.06 $m^3$/s

If

| | | |
|---|---|---|
| R = | 0.47 | |
| A = | 0.34 | ha |
| I = | 139.1 | mm/hr |

| | | | | |
|---|---|---|---|---|
| $R_{permeable}$ | 0.3 | $A_{permeable}$ | 2,293.16 | $m^2$ |
| $R_{Impermeable}$ | 0.8 | $A_{Impermeable}$ | 1,148.74 | $m^2$ |
| | | Total = | 3,441.90 | $m^2$ |

$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

# Amanda Markman - Pervious Pavement Design

## Pervious Pavement Sizing

### Maximum Rock Depth According to Drain Time

*Determine the maximum rock depth according to drain time (4 days max.) - Allowable range: 300 to 2000 mm*

$$D_R = \frac{K_S \times T \times 24}{n}$$

Where:

| | |
|---|---|
| Dr | Depth of rock reservoir [mm] |
| Ks | Saturated hydraulic conductivity of Subsurface Soil [mm/hr] |
| T | Allowable drain time [days] |
| n | Porosity of drain rock reservoir [unitless] |

| | | |
|---|---|---|
| $D_R$ = | 411.43 | mm |

If

| | | |
|---|---|---|
| $K_S$ = | 1.5 | mm/hr |
| T = | 4 | days |
| n = | 0.35 | --- |

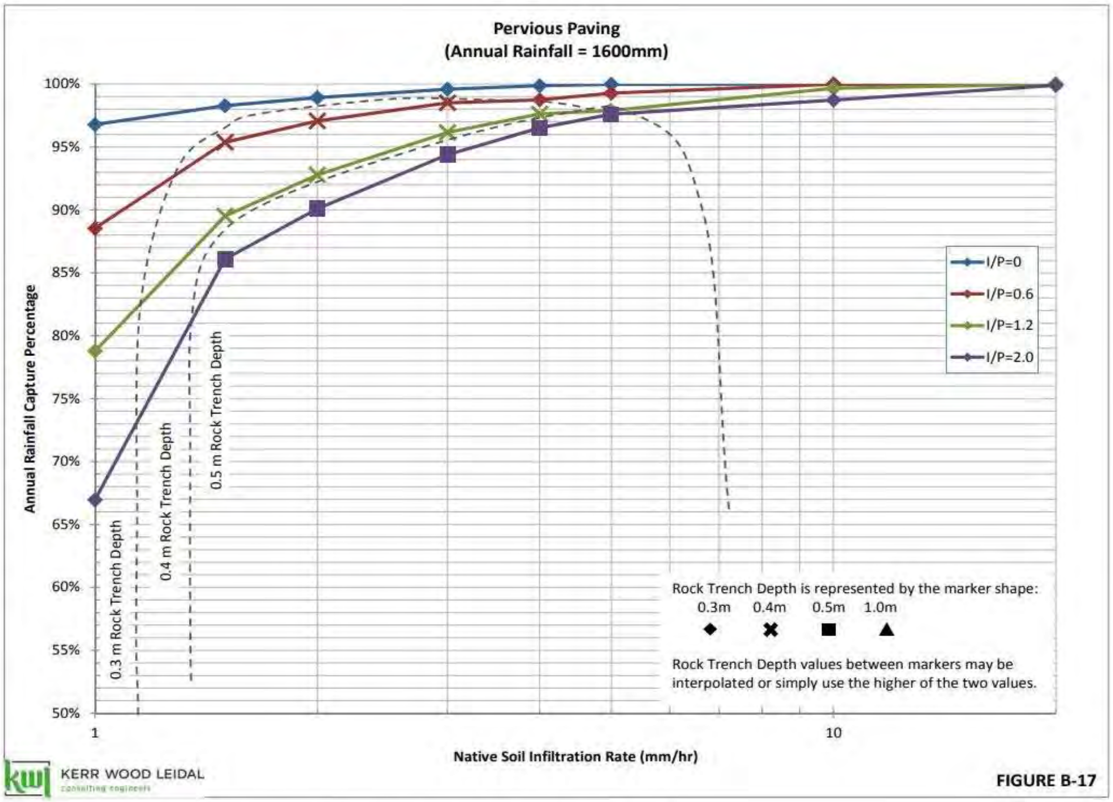
### Determine the I/P Ratio

*Determine I/P ratio using Figure B-17 Graph of Stormwater Sounce Control Design Guide 2012*

Since $D_R$ = 411mm > 400mm

I will use a target capture percentage of 85% so a I/P ratio of 1.2

I/P = 1.2




C:\Users\LMorgan\Desktop\BCWWA2012\252-261_copies\400-Work\Results\PPSummaryGraphs-Kwantlen.xlsx1600-proposed

## Find the Pervious Area

*After isolating for Pervious Area we get:*

$$PerviousArea = \frac{ImperviousTributaryArea}{{}^{I}/_{P} + 1}$$

| | | |
|---|---|---|
| PerviousArea = | 2,594.44 | $m^2$ |

If

| | | |
|---|---|---|
| Impervious = | 5,707.8 | $m^2$ |
| I/P = | 1.2 | unitless |

# Peak Flow S.C. 4

*Use the Rational Method to find the runoff preak flow of the Post-Development site.*

$$Q = \frac{R \times A \times I}{360}$$

Where:

| | |
|---|---|
| Q | Peak Flow [$m^3/s$] |
| R | Runoff Coefficient |
| A | Drainage Area [ha] |
| I | Rainfall Intensity [mm/hr] |

*surface*

Q = 0.10 $m^3/s$

If

| | | |
|---|---|---|
| R = | 0.77 | |
| A = | 0.34 | ha |
| I = | 139.1 | mm/hr |

| | | | | |
|---|---|---|---|---|
| $R_{permeable}$ | 0.3 | $A_{permeable}$ | 178.30 | $m^2$ |
| $R_{Impermeable}$ | 0.8 | $A_{Impermeable}$ | 3,192.60 | $m^2$ |
| | | Total = | 3,370.90 | $m^2$ |

$I = A \times T^{b}$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

## Rational Method Post-Development

*Use the Rational Method to find the runoff preak flow of the Post-Development site.*

$$Q = \frac{R \times A \times I}{360}$$

Where:

| | |
|---|---|
| Q | Peak Flow [$m^3/s$] |
| R | Runoff Coefficient |
| A | Drainage Area [ha] |
| I | Rainfall Intensity [mm/hr] |

*Will have to do weighted average for the Runoff Coefficient because there is two different types of*

Q = 0.07 $m^3/s$

If

R = 0.80

A = 0.22 ha

I = 139.1 mm/hr

| | | | | |
|---|---|---|---|---|
| $R_{permeable}$ | 0.3 | $A_{permeable}$ | - | $m^2$ |
| $R_{Impermeable}$ | 0.8 | $A_{Impermeable}$ | 2,248.60 | $m^2$ |
| | | Total = | 2,248.60 | $m^2$ |

I = A x $T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

*To find Intensity of the pre-development, we are using 10-year Return Period and the Time of Concentration (no pipes) is 5 min for the IDF 2100*

## Infiltration Rain Garden

$$Required\ Rainfall\ Capture\ Volume = Area \times 24mm$$

Capture Volume = 54.0 $m^3$

Total Impervious Area = 2,248.60 $m^2$

## Rational Method Post-Development with GI

*Use the Rational Method to find the runoff preak flow of the Post-Development site.*

$$Q = \frac{R \times A \times I}{360}$$

Where:

| | |
|---|---|
| Q | Peak Flow [$m^3/s$] |
| R | Runoff Coefficient |
| A | Drainage Area [ha] |
| I | Rainfall Intensity [mm/hr] |

*Will have to do weighted average for the Runoff Coefficient because there is two different types of*

Q = 0.03 $m^3/s$

If

| | | |
|---|---|---|
| R = | 0.30 | |
| A = | 0.22 | ha |
| I = | 139.1 | mm/hr |

| | | | | |
|---|---|---|---|---|
| $R_{permeable}$ | 0.3 | $A_{permeable}$ | 2,248.60 | $m^2$ |
| $R_{Impermeable}$ | 0.8 | $A_{Impermeable}$ | - | $m^2$ |
| | | Total = | 2,248.60 | $m^2$ |

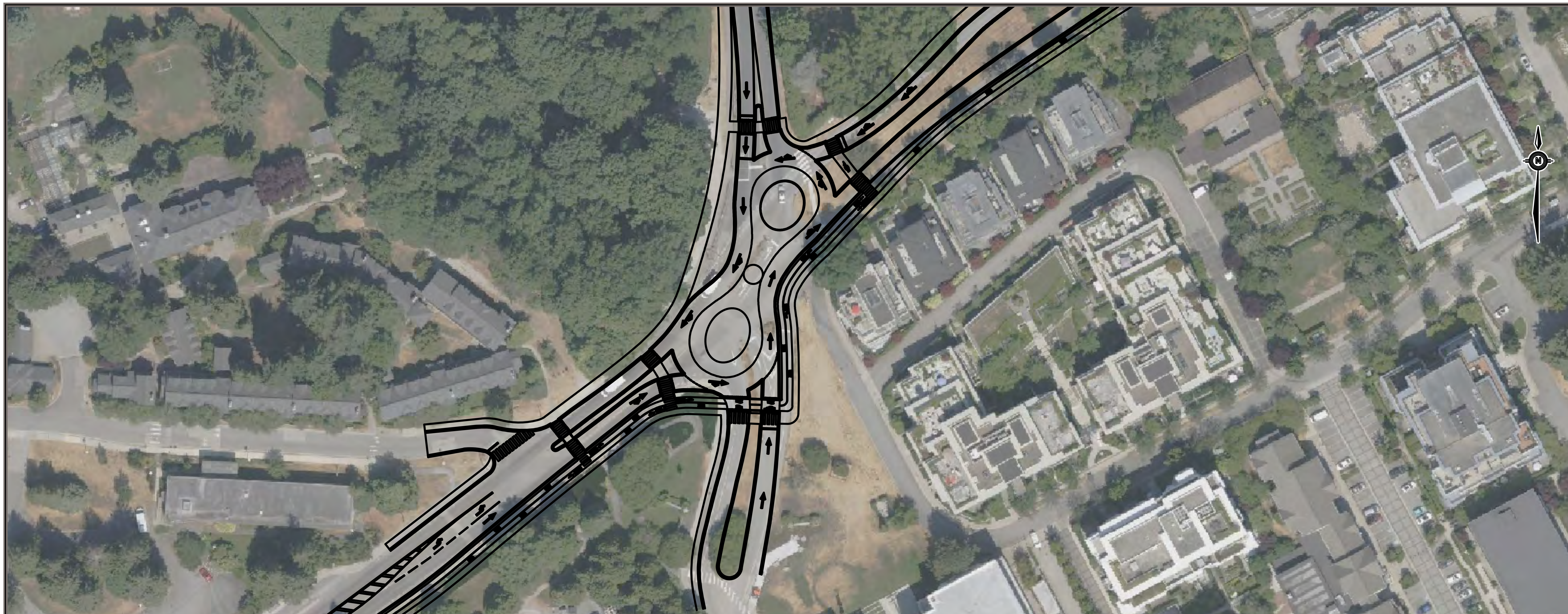
$I = A \times T^B$

A, B IDF Equation Coefficient

| | | | | | | |
|---|---|---|---|---|---|---|
| A = | 34 | B= | -0.567 | T = | 0.083 | hr |

# APPENDIX D – CONSTRUCTION PLAN AND PHASING

# CHANCELLOR BOULEVARD & EAST MALL INTERSECTION REDESIGN - PROPOSED CONSTRUCTION PHASES



**SITE LOCATION**
SCALE: 1:3000

| CLIENT | | PROJECT NO. | OFFICE | DES | CKD | REV | DRAWING |
|---|---|---|---|---|---|---|---|
| | | | VANC | AM | AM | A | |
| | | DATE | SHEET No. | DWN | APP | STATUS | |
| | | APRIL 2, 2025 | of | AM | | DRAFT | |

Google Maps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Google Maps


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Google Maps


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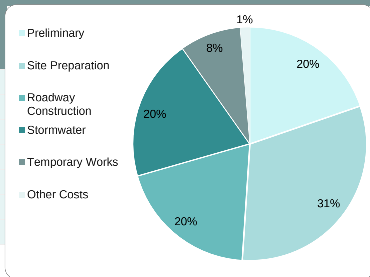
# APPENDIX E – CLASS A COST ESTIMATE

# COST ESTIMATE

| COST CATEGORY | | TOTAL COST |
|---|---|---|
| Preliminary | $ | 1,112,000 |
| Site Preparation | $ | 1,766,000 |
| Roadway Construction | $ | 1,100,000 |
| Stormwater | $ | 1,109,000 |
| Temporary Works | $ | 476,000 |
| Other Costs | $ | 75,000 |
| **Overall Cost:** | $ | 5,645,000 |




**Project Name:**
Chancellor Boulevard - East Mall Intersection Redesign

**Project Manager:**
UBC

**Start Date:**
May 1, 2025

**End Date:**
August 31, 2025

| Cost Category | Description | Quantity | Units | Rate/Unit Cost $ | Contingency (10%) | Cost ($) |
|---|---|---|---|---|---|---|
| **Preliminary** | Project Management & Coordination | 1 | LS | 750750 | 75075 | 750750 |
| | Permitting & Regulatory Approvals | 1 | LS | 21450 | 2145 | 21450 |
| | Surveying & Engineering Studies | 1 | LS | 64350 | 6435 | 64350 |
| | Construction Safety & WorkSafeBC Compliance | 1 | LS | 17160 | 1716 | 17160 |
| | Public Consultation & Notifications | 1 | LS | 14300 | 1430 | 14300 |
| | Mobilization & Site Establishment | 1 | LS | 71500 | 7150 | 71500 |
| | Quality & Environmental Management | 1 | LS | 28600 | 2860 | 28600 |
| | Traffic Management Plan Implementation | 1 | LS | 42900 | 4290 | 42900 |
| **Site Preparation** | Clearing & Grubbing | 1 | LS | 71500 | 7150 | 71500 |
| | Asphalt/Concrete Removal | 8000 | m² | 30 | 24000 | 240000 |
| | Curb & Sidewalk Removal | 800 | m | 50 | 4000 | 40000 |
| | Earthworks & Excavation | 3000 | m³ | 187 | 56111 | 561111 |
| | Temporary Access | 1000 | m² | 21 | 2052 | 20523 |
| | Compaction & Grading | 3000 | m³ | 178 | 53306 | 533055 |
| | Utility Relocation & Coordination | 500 | m | 197 | 9852 | 98524 |
| | Temporary Drainage Solutions | 1 | LS | 35750 | 3575 | 35750 |
| | Erosion Control Measures | 200 | m² | 26 | 513 | 5131 |
| **Roadway Construction** | Granular Base Preparation | 600 | Ton | 222 | 13299 | 132990 |
| | Asphalt Pavement Installation | 350 | Ton | 222 | 7758 | 77578 |
| | Concrete Work (Curbs, Gutters, Sidewalks) | 200 | m | 197 | 3941 | 39409 |
| | Pavement Markings & Signage | 100 | m | 141 | 1407 | 14075 |
| | Street Lighting & Electrical Works | 7 | Each | 21450 | 15015 | 150150 |
| | Roundabout Central Island (form + fill + surfacing) | 4000 | m² | 116 | 46240 | 462400 |
| | Central Island Reinforced Base | 48 | m³ | 325 | 1570 | 15696 |
| | Intersection Realignment | 1 | LS | 57200 | 5720 | 57200 |
| | Bicycle & Pedestrian Infrastructure Improvements | 1 | LS | 50050 | 5005 | 50050 |
| **Stormwater** | Soil Excavation for Drainage | 2000 | m³ | 178 | 35537 | 355370 |
| | Precast Concrete Pipes & Culverts | 200 | m | 540 | 10791 | 107907 |
| | Stormwater Retention Tank Installation | 1 | Each | 85800 | 8580 | 85800 |
| | Bioswales & Green Infrastructure | 6 | Each | 50050 | 30030 | 300300 |
| | Manhole & Catch Basin Installations | 6 | Each | 21450 | 12870 | 128700 |
| | Riprap & Erosion Control Measures | 100 | Ton | 122 | 1216 | 12155 |
| | Final Stormwater Testing & Certification | 1 | Each | 10725 | 1073 | 10725 |
| | Stormwater Discharge Connection | 1 | Each | 7150 | 715 | 7150 |
| **Temporary Works** | Traffic Control Measures | 1 | LS | 17160 | 1716 | 17160 |
| | Detour Routes & Temporary Pavement | 5000 | m² | 34 | 17103 | 171027 |
| | Work Zone Safety Barriers & Lighting | 200 | m | 141 | 2815 | 28150 |
| | Temporary Signage & Wayfinding | 30 | Each | 7150 | 21450 | 214500 |
| | Emergency Vehicle Access Plans | 1 | Each | 2145 | 215 | 2145 |
| **Other Costs** | Landscaping & Restoration | 200 | m² | 3 | 60 | 601 |
| | Statue Construction | 80 | m³ | 340 | 2720 | 27200 |
| | Gateway & Aesthetic Features | 1 | LS | 35750 | 3575 | 35750 |
| | Environmental Impact Mitigation | 1 | LS | 4290 | 429 | 4290 |
| | Post-Construction Inspections & Approvals | 1 | Each | 7150 | 715 | 7150 |

# APPENDIX F – PROJECT SCHEDULE

# Marine & Chancellor Redesign

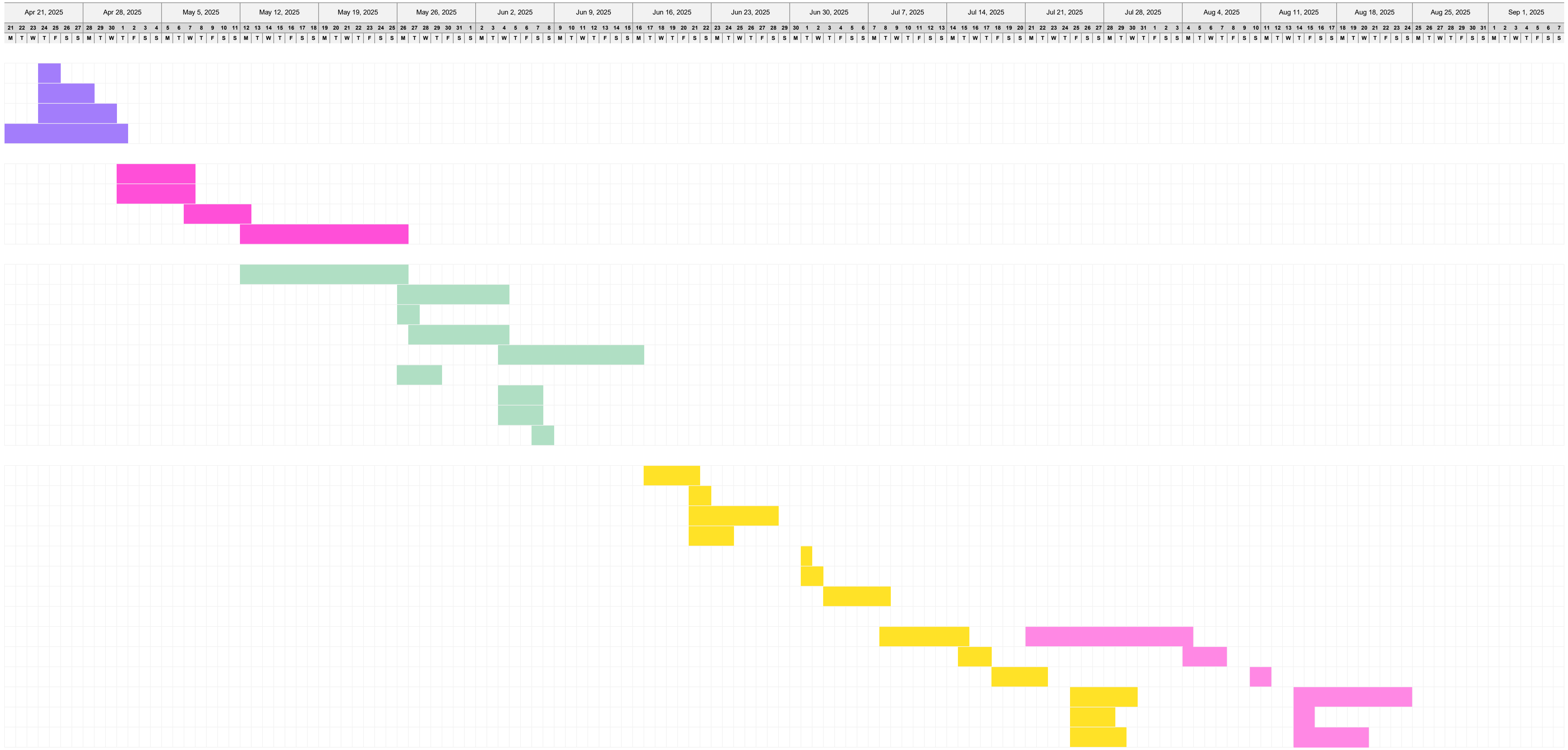
Transit Flow Consulting

**Project start:** Thu, 4-24-2025

**Display week:** 1

| TASK | ASSIGNED TO | PROGRESS | START | END |
|---|---|---|---|---|
| **Pre-Construction** | Phase 1 | | | |
| Final Contract Signec | Client | 0% | 4-24-25 | 4-25-25 |
| Safety Documents | TFC | 0% | 4-24-25 | 4-28-25 |
| Mobilize on site | TFC | 0% | 4-24-25 | 4-30-25 |
| Inform Residents & Place Signage | TFC | 0% | 4-10-25 | 5-1-25 |
| **Surveying** | | | | |
| Control Survey | Sureyor | 0% | 5-1-25 | 5-7-25 |
| General Layout Mark | Sureyor | 0% | 5-1-25 | 5-7-25 |
| Traffic Control Zone | TFC | 0% | 5-7-25 | 5-12-25 |
| Median Removals | TFC | 0% | 5-12-25 | 5-26-25 |
| **Site Prep** | Phase 2 | | | |
| Clearing & Grubbing | GC | 0% | 5-12-25 | 5-26-25 |
| Existing Infrastructure Removal | GC | 0% | 5-26-25 | 6-4-25 |
| 1. Pavement Remo | GC | 0% | 5-26-25 | 5-27-25 |
| 2. Pipe removal | GC | 0% | 5-27-25 | 6-4-25 |
| Earthworks & Excavation | GC | 0% | 6-4-25 | 6-16-25 |
| Temporary Sidewalk Installation | GC | 0% | 5-26-25 | 5-29-25 |
| Utility Relocation & Coordination | GC | 0% | 6-4-25 | 6-7-25 |
| Temporary Drainage Solutions | GC | 0% | 6-4-25 | 6-7-25 |
| Erosion Control Measures | GC | 0% | 6-7-25 | 6-8-25 |
| **Stormwater** | | | | |
| Precast Concrete Pipes & Culverts Installation | GC | 0% | 6-17-25 | 6-21-25 |
| Stormwater Retention Tank Installation | GC | 0% | 6-21-25 | 6-22-25 |
| Bioswales & Green Infrastructure | GC | 0% | 6-21-25 | 6-28-25 |
| Manhole & Catch Basin Installations | GC | 0% | 6-21-25 | 6-24-25 |
| Riprap & Erosion Control Measures | GC | 0% | 7-1-25 | 7-1-25 |
| Stormwater Discharge Connection | GC | 0% | 7-1-25 | 7-2-25 |
| Final Stormwater Testing & Certification | GC | 0% | 7-3-25 | 7-8-25 |
| **Roadway Construction** | | | | |
| Compaction & Gradir | GC | 0% | 7-8-25 | 7-15-25 |
| Granular Base Preparation | GC | 0% | 7-15-25 | 7-17-25 |
| Asphalt Pavement Installation | GC | 0% | 7-18-25 | 7-22-25 |
| Concrete Work (Curbs, Gutters, Sidewalks) | GC | 0% | 7-25-25 | 7-30-25 |
| Pavement Markings & Signage | GC | 0% | 7-25-25 | 7-28-25 |
| Street Lighting & Electrical Works | GC | 0% | 7-25-25 | 7-29-25 |

*Insert new rows ABOVE this one*



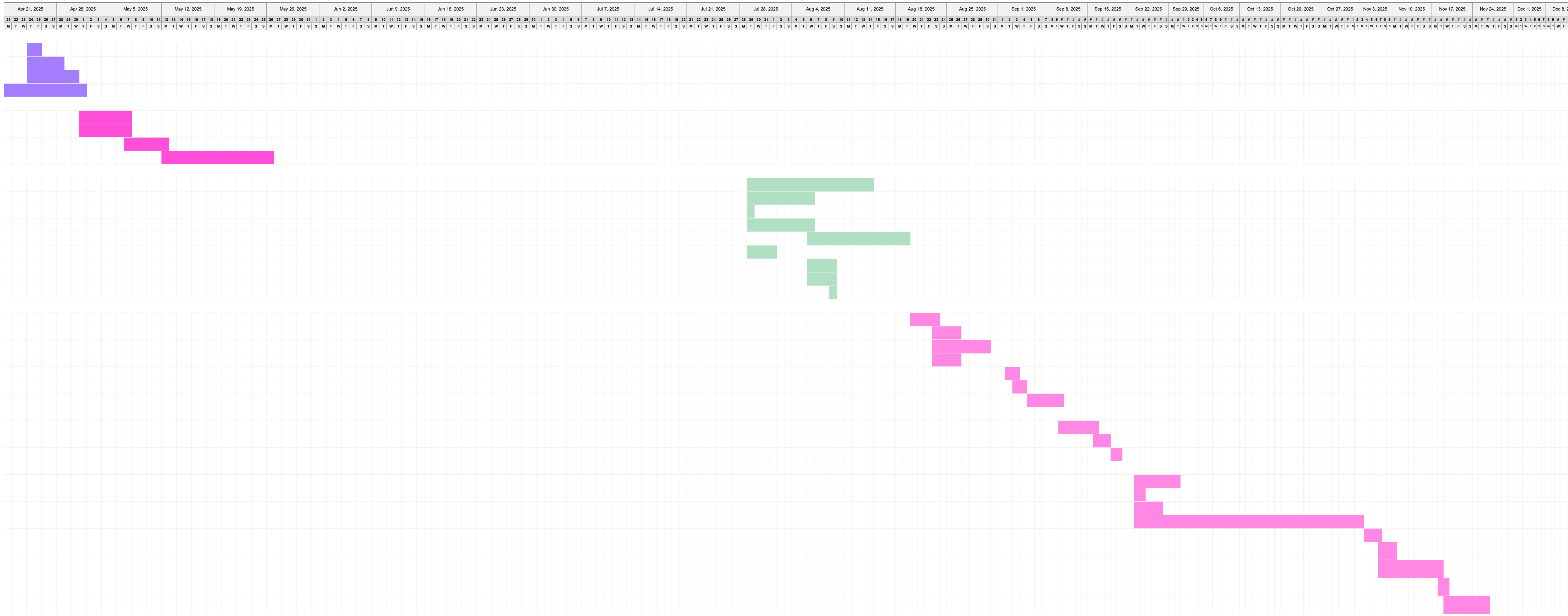
# Marine & Chancellor Redesign

**Transit Flow Consulting**

**Project start:** Thu, 4-24-2025

**Display week:** 1

| TASK | ASSIGNED TO | PROGRESS | START | END |
|---|---|---|---|---|
| **Pre-Construction** | **IGNORE THIS SECTION** | | | |
| Final Contract S | Client | 0% | 4-24-25 | 4-25-25 |
| Safety Documer | TFC | 0% | 4-24-25 | 4-28-25 |
| Mobilize on site | TFC | 0% | 4-24-25 | 4-30-25 |
| Inform Residents & Place Signage | TFC | 0% | 4-10-25 | 5-1-25 |
| **Surveying** | **IGNORE THIS SECTION** | | | |
| Control Survey | Sureyor | 0% | 5-1-25 | 5-7-25 |
| General Layout | Sureyor | 0% | 5-1-25 | 5-7-25 |
| Traffic Control Z | TFC | 0% | 5-7-25 | 5-12-25 |
| Median Remova | TFC | 0% | 5-12-25 | 5-26-25 |
| **Site Prep** | **Phase 3 Start** | | | |
| Clearing & Grub | GC | 0% | 7-29-25 | 8-14-25 |
| Existing Infrastructure Removal | GC | 0% | 7-29-25 | 8-6-25 |
| 1. Pavement F | GC | 0% | 7-29-25 | 7-29-25 |
| 2. Pipe remov | GC | 0% | 7-29-25 | 8-6-25 |
| Earthworks & Excavation | GC | 0% | 8-6-25 | 8-19-25 |
| Temporary Sidewalk Installation | GC | 0% | 7-29-25 | 8-1-25 |
| Utility Relocation & Coordination | GC | 0% | 8-6-25 | 8-9-25 |
| Temporary Drainage Solutions | GC | 0% | 8-6-25 | 8-9-25 |
| Erosion Control Measures | GC | 0% | 8-9-25 | 8-9-25 |
| **Stormwater** | | | | |
| Precast Concrete Pipes & Culverts | GC | 0% | 8-20-25 | 8-23-25 |
| Stormwater Retention Tank Installation | GC | 0% | 8-23-25 | 8-26-25 |
| Bioswales & Green Infrastructure | GC | 0% | 8-23-25 | 8-30-25 |
| Manhole & Catch Basin Installations | GC | 0% | 8-23-25 | 8-26-25 |
| Riprap & Erosion Control Measures | GC | 0% | 9-2-25 | 9-3-25 |
| Stormwater Discharge Connection | GC | 0% | 9-3-25 | 9-4-25 |
| Final Stormwater Testing & | GC | 0% | 9-5-25 | 9-10-25 |
| **Roadway Construction** | | | | |
| Compaction & G | GC | 0% | 9-10-25 | 9-16-25 |
| Granular Base Preparation | GC | 0% | 9-16-25 | 9-18-25 |
| Asphalt Pavement Installation | GC | 0% | 9-19-25 | 9-20-25 |
| **Phase 4 Start** | | | | |
| Concrete Work (Curbs, Gutters | GC | 0% | 9-23-25 | 9-30-25 |
| Pavement Markings & Signage | GC | 0% | 9-23-25 | 9-24-25 |
| Street Lighting & Electrical Works | GC | 0% | 9-23-25 | 9-27-25 |
| Roundabout Construction | GC | 0% | 9-23-25 | 11-3-25 |
| Intersection Realignment | GC | 0% | 11-4-25 | 11-7-25 |
| Bicycle & Pedestrian Infrastructure Improvements | GC | 0% | 11-7-25 | 11-10-25 |
| Landscape Restoration | Landscape | 0% | 11-7-25 | 11-18-25 |
| Statue Construction | GC | 0% | 11-18-25 | 11-19-25 |
| Finishing (Inspections, cleaning, approvals) | GC | 0% | 11-19-25 | 11-26-25 |



# APPENDIX G – CAD DRAWINGS

## GENERAL NOTES:

1. All construction and materials shall be in accordance with:
   - The Master Municipal Construction Document and Standard Detail Drawings (MMCD - Platinum Edition)
   - BC MOTI 2020 Standard Specifications for Highway Construction
   - BC MOTI Electrical and Traffic Control Manual
   - For construction contract drawings and all specifications
   - Applicable contract documents and all specifications
   - Ministry of Transportation "B.C. Traffic Control Manual for Work on Roadways", latest edition;
   - WorkSafeBC, latest edition

The Contractor shall maintain on site copies of the above documents and shall ensure that all trades are thoroughly familiar with the applicable section of the documents.

2. Before commencing construction, the Ministry will schedule a pre-construction meeting.
3. The Contractor shall expose and verify the location and elevation of all existing services in the field prior to construction and notify the contract administrator of any discrepancies, conflicts or omissions prior to construction.
4. Figured dimension shall govern scaled dimensions.
5. The Contractor shall ensure that all approvals required for the proposed works have obtained from all authorities and agencies prior to commencing the work.
6. The Contractor shall contact the appropriate personnel at least 72 hours prior to the work. Scheduling and other construction constraints imposed by these works shall be taken into account.
7. Residents directly affected by construction of these works and services shall be given 48 hours written notice of the proposed start of construction.
8. The Contractor shall repair or replace any existing streets, services, landscaping, private landscaping or private improvements that may be damaged as a result of construction. Repairs to existing Ministry services such as water, sanitary sewer, storm sewer or traffic lighting shall be made by the Ministry at cost to the contractor.
9. As part of the project, the Contractor is responsible for conducting all necessary tests, inspections, and approvals outlined in the contract documents. Before issuing the Substantial Completion Certificate, the Contractor must provide the contract administrator with copies of all test results. Additionally, reports and test results must be submitted to the Ministry's site inspector as the work progresses or upon request. The cost of all testing is included in the contract.
10. The Contractor will submit a traffic and pedestrian safety control plan prior to the pre-construction meeting.
11. The Contractor bears sole responsibility for ensuring construction safety at the work site, complying with relevant construction safety legislation, regulations, and codes, including but not limited to the Workers Compensation Act and associated regulations, as well as adhering to good construction practices.

### DRAWING NOTES - ENVIRONMENTAL

1. Tree protection barriers shall be installed around the drip line of each tree to be retained, before any site activities, in such a manner that its branches, root systems and trunk will not be damaged by any site activity.
2. The contractor shall comply with previsions of any provincial or local government enactments that may apply to the impacts on nesting birds of removing trees.
3. Construction and operational activities on the site (including management of rain water) should respect aquifer water quantity and quality (e.g. no leaking machinery, appropriate machinery refueling practices, prompt, spill clean-up, proper waste management during construction, preparation of operational spill response plans, etc.).

### DRAWING NOTES - EARTHWORKS & GRADING

1. In areas with setbacks and discharges to creeks, streams, and watercourses, approval from federal and provincial authorities may be necessary. The Contractor is responsible for engaging a certified environmental professional conduct essential studies and secure any required permits and approvals before commencing construction.
2. Geotechnical consultant to assess and authorize the natural subgrade before initiating the placement of fill.
3. Geotechnical consultant to review and approve fill material before initiating the material use.
4. Before introducing structural fill, clear vegetation, remove organic material, and eliminate any unsuitable substances as needed.
5. Conform to MMCD specifications by compacting all earth fills and granular material layers.
6. Ensure that all proposed grading aligns with the existing ground elevations, unless specified otherwise.
7. Proof rolling should involve at least four passes of a vibratory smooth drum roller (eg. minimum 8 tonne deadweight) for the detection of unstable of "soft" areas.

## DRAWINGS NOTES - ROADWORKS

GEOMETRICS

1. Implement smooth vertical and horizontal curves to shape changes in grade and direction.
2. Execute earthworks according to the contract documents, which involve tasks such as removing loose or detrimental materials, addressing soft spots, compacting, and grading slopes.
3. Construct embankments in accordance with the standards and specifications outlines in the contract documents, ensuring proper placement, shaping, compaction, and protection.
4. In instances where existing ditches need infilling or services are establishes in fill sections, utilize granular material for filling, ensuring it is supplied, placed, and compacted in accordance with MMCD specifications.
5. Adhere to MMCD specifications for all sub-base road and granular base materials.
6. Extend the road sub-base and base a minimum of 0.3 meters beyond the road edge or curb and gutter.
7. Ensure compliance with the specifications outlined in the MMCD specifications and detail drawings when placing asphalt pavement and concrete.
8. Unless approved otherwise, asphaltic concrete for roadwork must be applied by two lifts.
9. Connect to existing pavement by cutting back to sound material as required to create a tidy vertical face.
10. Ensure that all new pavement is graded to prevent ponding, with a minimum cross slope of 2% on any new overlain road surface.
11. Adjust all valve boxes, manholes, etc., within the paved surface of the roadway to the finished course elevation before applying the finish course paving.
12. Concrete barrier curbs must adhere to the MOTI standard drawing SP582-01.04 and combined curb and gutters must adhere to the MOTI standard drawing SP582-01.01. Mountable concrete curb and gutter must adhere to the MOTI standard drawing SP582-01.02.

ASPHALT

1. Ensure compliance with the specifications outlines in the MMCD specifications and detail drawings when placing asphalt pavement and concrete.
2. Unless approved otherwise, asphaltic concrete for road work must be applied in two lifts.
3. Asphalt mix must be in compliance with Section 952 of the 2020 Standard Specification for Highway Construction Volume 1.
4. Quality control, inspection, and testing of asphalt pavement must be conducted and recorded according to Section 952.02 of the 2020 Standard Specification of Highway Construction Volume 1.
5. Sourced aggregates for paving must be compliant with Section 502.06.05 of the 2020 Standard Specification of Highway Construction Volume 1.

## DRAWING NOTES - STORMWATER

PVC PLASTIC DRAINAGE PIPE

1. All storm sewer main and catchbasin lead material to be PVC.
2. The pipe shall be homogeneous throughout and free from visible cracks, flaws, foreign inclusion, or other jurious defects. The pipe shall be uniform in color, opacity and other physical properties.
3. The minimum pipe stiffness when tested in accordance with SS 318.10.02 and ASTM D2412 shall be 320 kPa.
4. There shall be no evidence of spitting, cracking or breaking when the pipe is tested in accordance with ASTM D2412. Three specimens, each with a length equal to one pipe diameter shall be tested; all shall meet the required stiffness

STORM DRAINAGE

1. The Contractor is responsible for performing tie-ins and connections to existing storm sewers under the supervision and direction of the Ministry. Costs associated with this task are incidental to the relevant item in the schedule of quantities and prices. A minimum of 72 hours' notice must be provided for any tie-in activities.
2. New sewer lines connecting to existing lines must be plugged until undergo testing and flushing.
3. All drain pipe shall be of first quality, sound, true in form and free form defects of all kinds.
4. Ensure a minimum slope of 0.5% on catch basin leads.
5. Prevent the entry of deleterious materials into the Ministry's sewer system.
6. Include inspection chambers for completeness in storm service connections.

## DRAWING NOTES - CONCRETE REINFORCEMENT

1. Compliance to the following sections in the BC MOTI 2020 Standard Specifications for Highway Construction shall apply for Concrete Reinforcement Specifications. Refer to Section 412 - Concrete Reinforcement for detailed construction specifications.
2. Galvanized reinforcement steel shall conform to the requirements of ASTM A767M - Class II Coating, as per Section 412.11.03.
3. Reinforcement bars shall be cut and bent to the shapes shown on the drawings, and shall be bent cold unless otherwise permitted, as per Section 412.31
4. Unless otherwise shown on the drawings, hooks and bend dimensions shall conform the requirements of Section 412.31.01
5. Reinforcing bars shall be stored on platforms, skids or other suitable supports clear of the ground, as per Section 412.32
6. Placing and fastening of reinforcement shall conform to the requirements of Section 412.33
7. Tolerances for placing reinforcement shall, unless otherwise specified, be as shown in Table 412-D of Section 412.33.01
8. Concrete cover for reinforcing steel shall be in accordance with Section 412.33.03 and the Ministry "Bridge Standards and Procedure Manual - Supplement to CHBDC S6"
9. Special Requirements for splicing, such as particular locations for splices, use of overlength bars or special lap length, shall be as shown on the Drawings, as per Section 412.34

## DRAWING NOTES - PAVEMENT MARKINGS & SIGNAGE PLAN

1. All signage recommendations should be complemented by Reference to Specifications for Standard Highway Sign Materials, Fabrication and Supply by the Ministry of Transportation and Infrastructure
2. All pavement marking recommendations should be complemented by reference to Pavement Marking Service Agreement 2008 by the Ministry of Transportation and Infrastructure
3. Preserve all currently installed signs, remove any surplus signs upon completion of the work, and return them to the Ministry
4. The Ministry is responsible for installing temporary and permanent street, traffic, and advisory sings, as well as pavement markings not explicitly depicted on the drawings.
5. The Ministry is responsible for removing existing conflicting pavement markings
6. All signage must be retro-reflective to show the same color, shape and message at night as they appear in daytime
7. Signs shall be clearly and permanently labeled (using durable, weather resistant material) or engraved with an identification coding.
8. Edges of all substrate material shall be deburred to provide a smooth finished edge.
9. The Ministry is responsible for removing all existing conflicting pavement markings.

LEGEND

NOTES

REVISIONS

| NUM | DATE | DWN | CKD | APR | DESCRIPTION |
|---|---|---|---|---|---|
| A | 11/01/23 | JDM | JW | DNM | ISSUED FOR RECORD |

PROFESSIONAL SEAL

CLIENT

**CHANCELLOR BOULEVARD AND EAST MALL INTERSECTION REDESIGN**

**DRAWING INDEX, GENERAL NOTES & LEGEND**

| PROJECT NO. | OFFICE | DES | CKD | REV | DRAWING |
|---|---|---|---|---|---|
| | VANC | AM | JW | A | G-100 |
| DATE | SHEET No. | DWN | APP | STATUS | |
| April 4th, 2025 | of | AM | AM | RECORD | |

# CHANCELLOR BOULEVARD & EAST MALL INTERSECTION REDESIGN - PROJECT LOCATION


**SITE LOCATION**
SCALE: 1:3000

| CLIENT | | PROJECT NO. | OFFICE | DES | CKD | REV | DRAWING |
|---|---|---|---|---|---|---|---|
| | | | VANC | AM | AM | A | G-101 |
| | | DATE | SHEET No. | DWN | APP | STATUS | |
| | | MARCH 7, 2025 | of | AM | | DRAFT | |


NOTE: WHEN CONVERTING METRIC TO IMPERIAL ELEVATIONS INCLUDE 91.62 FEET TO THE IMPERIAL GEODETIC BASE.
FOR DETAILS REFER TO UBC MONUMENT – PLAN STANDARD NO.01–01

THE UNIVERSITY OF BRITISH COLUMBIA ASSUMES NO RESPONSIBILITY FOR CORRECTNESS OF INFORMATION SHOWN.
Acad 24.1s (LMS Tech) C:\Users\Rohit\Downloads\site-base\site-base.dwg {03}, Mar 05, 2025 – 11:25pm

THE UNIVERSITY OF BRITISH COLUMBIA
INFRASTRUCTURE DEVELOPMENT

| NO | DESCRIPTION | DATE | BY |
|---|---|---|---|
| 36 | SUB RESIDENCES | 15 OCT 19 | EL |
| 37 | GAGE APPT. NEW ELEVATOR FOOTPRINT | 14 APR 22 | PL |
| 33 | TALLWOOD HOUSE NAME UPDATE | 06 SEP 16 | EL |
| 34 | TALLWOOD SITE UPDATES AS PER D. BENSON | 06 DEC 17 | EL |
| 35 | BROCK LANE REF. 1210–1178 CAD FILE | 22 MAY 19 | PL |

SECTOR INDEX

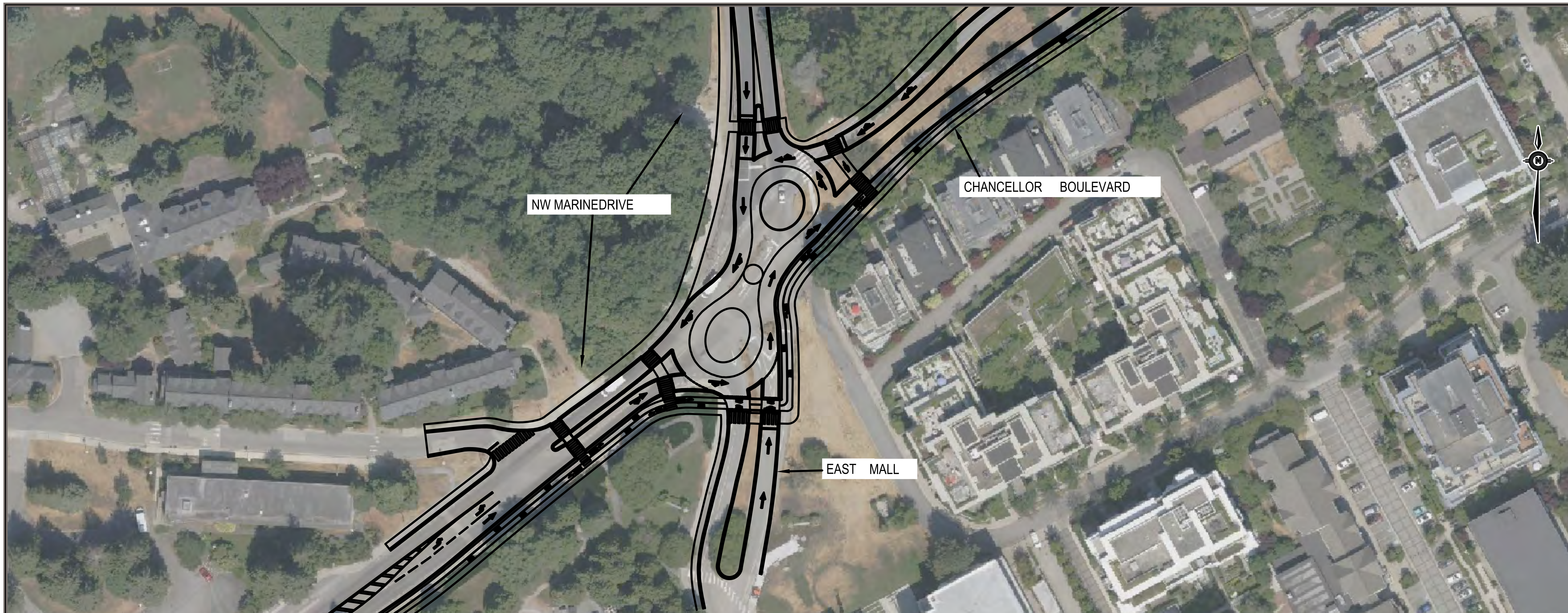
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 13 | 14 | 23 | | | |
| 4NORTH | 4 | 5 | 12 | 15 | 22 | 24 | 30 | |
| 3NORTH | 3 | 6 | 11 | 16 | 21 | 25 | 29 | 31 |
| 2NORTH | 2 | 7 | 10 | 17 | 20 | 26 | 28 | |
| | 1 | 8 | 9 | 18 | 19 | 27 | | |
| | 1WEST | 8WEST | | | | | | |

SCALE: 1:600 1"= 50'

SITE

SECTOR 03

# CHANCELLOR BOULEVARD & EAST MALL INTERSECTION REDESIGN - PROPOSED DESIGN

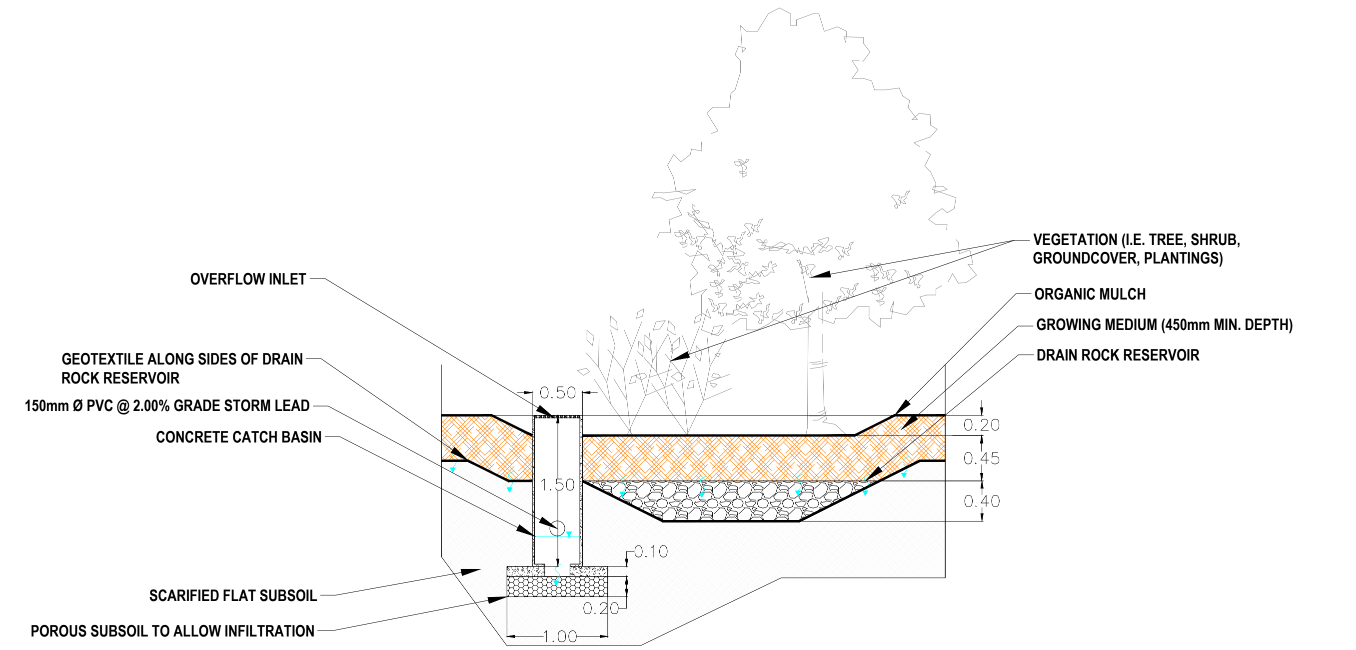



**SITE LOCATION**
SCALE: 1:3000

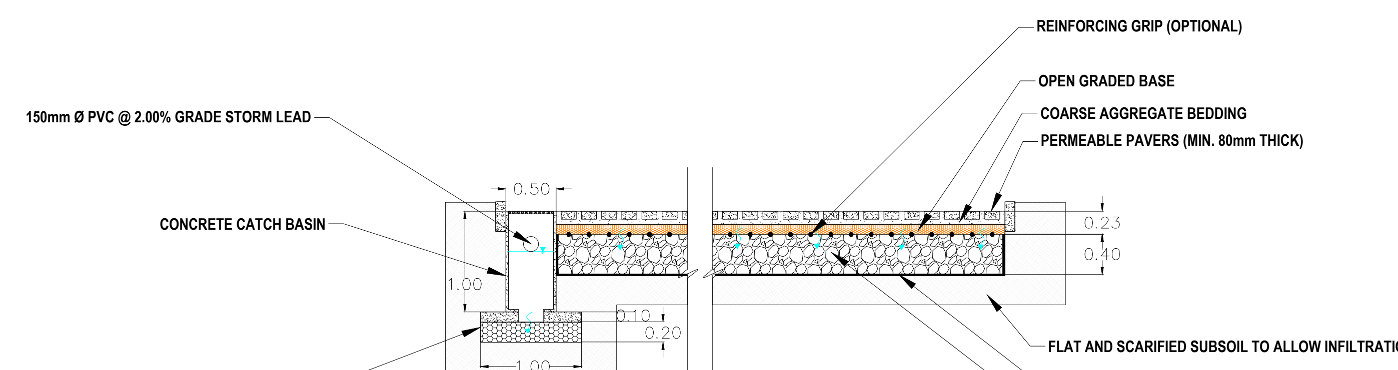
| CLIENT | | PROJECT NO. | OFFICE | DES | CKD | REV | DRAWING |
|---|---|---|---|---|---|---|---|
| | | | VANC | AM | AM | A | G-101 |
| | | DATE | SHEET No. | DWN | APP | STATUS | |
| | | MARCH 7, 2025 | of | AM | | DRAFT | |

# GREEN INFRASTRUCTURE DESIGN OF CHANCELLOR BLVD & EAST MALL INTERSECTION


**INTERSECTION MAP**
SCALE: 1:1,000




**RAIN GARDEN PROFILE VIEW**
SCALE: 1:75



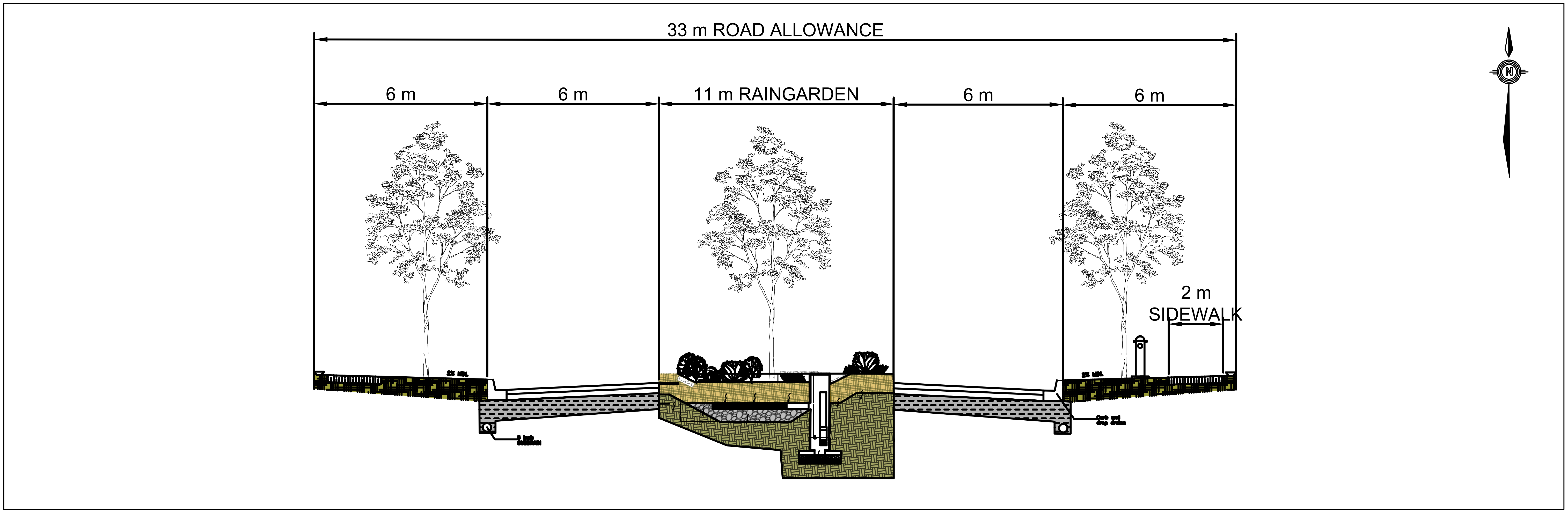

**PERMEABLE PAVEMENT PROFILE VIEW**
SCALE: 1:75

**MAINTENANCE NOTES:**

- VACCUM SWEET THE PREVIOUS PAVING ANNUALLY TO REMOVE BUILT UP FINES ON THE SURFACE
- UNDERLAIN SUMP SHOULD BE INSPECTED ANNUALLY AND CLEANED AS REQUIRED
- SEDIMENT SHOULD BE REMOVED FROM THE SUMP BOTTOM

| CLIENT | | PROJECT NO. | OFFICE | DES | CKD | REV | DRAWING |
|---|---|---|---|---|---|---|---|
| | | | VANC | AM | MN | A | W-101 |
| | | DATE | SHEET No. | DWN | APP | STATUS | |
| | | MARCH 18, 2025 | of | AM | | DRAFT | |

# RAIN GARDEN DESIGN FOR DOGBONE ROUNDABOUT AT CHANCELLOR BLVD - EAST MALL INTERSECTION




**PLAN**
SCALE: 1:180

LEGEND

NOTES

| NUM | DATE | DWN | CKD | APR | DESCRIPTION |
|---|---|---|---|---|---|
| A | 06-DEC-2024 | AM | AM | AM | ISSUED FOR REVIEW |

REVISIONS

PROFESSIONAL SEAL

CLIENT

TransitFlow.

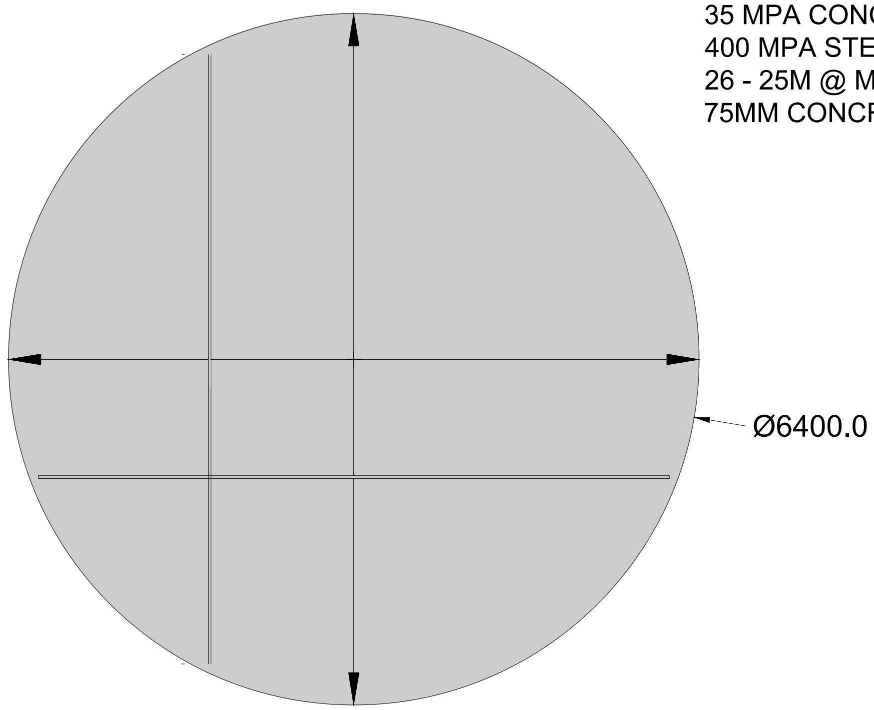
**CHANCELLOR BLVD - EAST MALL INTERSECTION REDESIGN**

**DETAILED DESIGN OF RAIN GARDEN AT DOGBONE ROUNDABOUT**

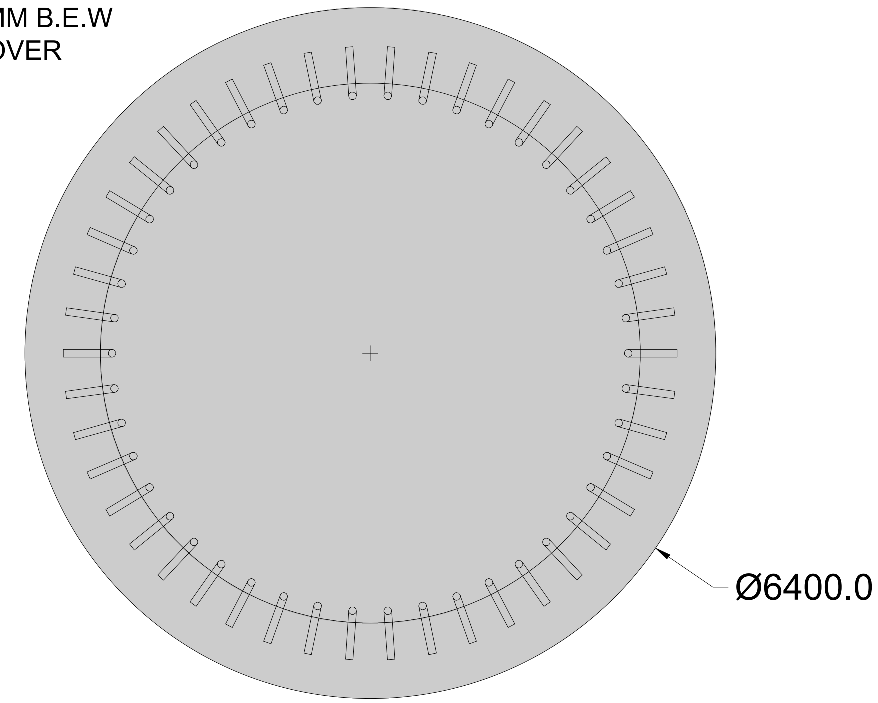
| PROJECT NO. | OFFICE | DES | CKD | REV | DRAWING |
|---|---|---|---|---|---|
| | VANC | AM | JW | A | D-01 |
| DATE | SHEET No. | DWN | APP | STATUS | |
| DEC 06, 2024 | of | AM | M | DRAFT | |

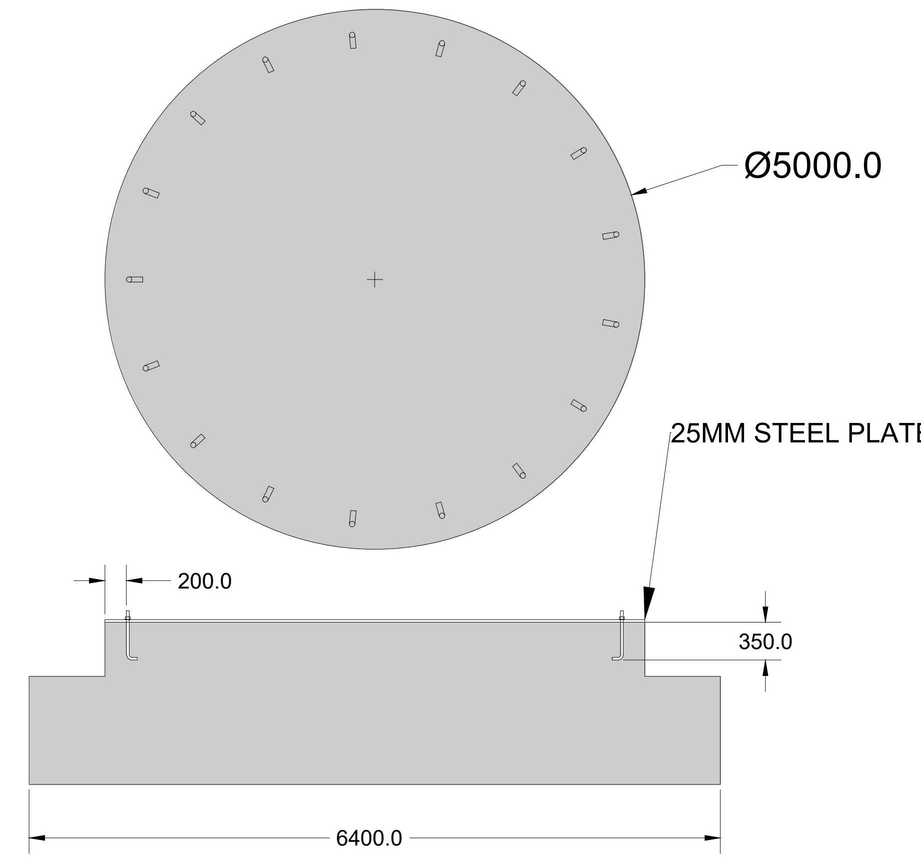
35 MPA CONCRETE STRENGTH
400 MPA STEEL
26 - 25M @ MIN 245 MM B.E.W
75MM CONCRETE COVER

17 - 1" CAST-IN-PLACE ANCHOR BOLT
ASTM F1554 GRADE 55
1" DIA, 30" BODY L, 1"-8 THREAD, 4" HOOK L

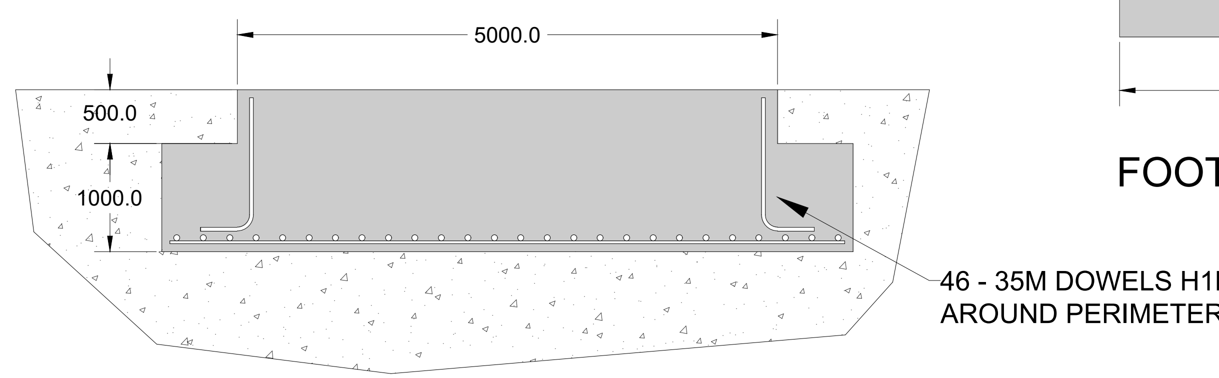



TYPICAL FOOTING BAR LAYOUT




FOOTING CAST IN ANCHOR BOLTS




FOOTING BEARING REINFORCEMENT

ALL UNITS IN MM UNLESS OTHERWISE MENTIONED
A. FOR CONSTRUCTION
B. NO NOT MEASURE FROM THIS DRAWING

STATUE FOOTING CROSS-SECTION

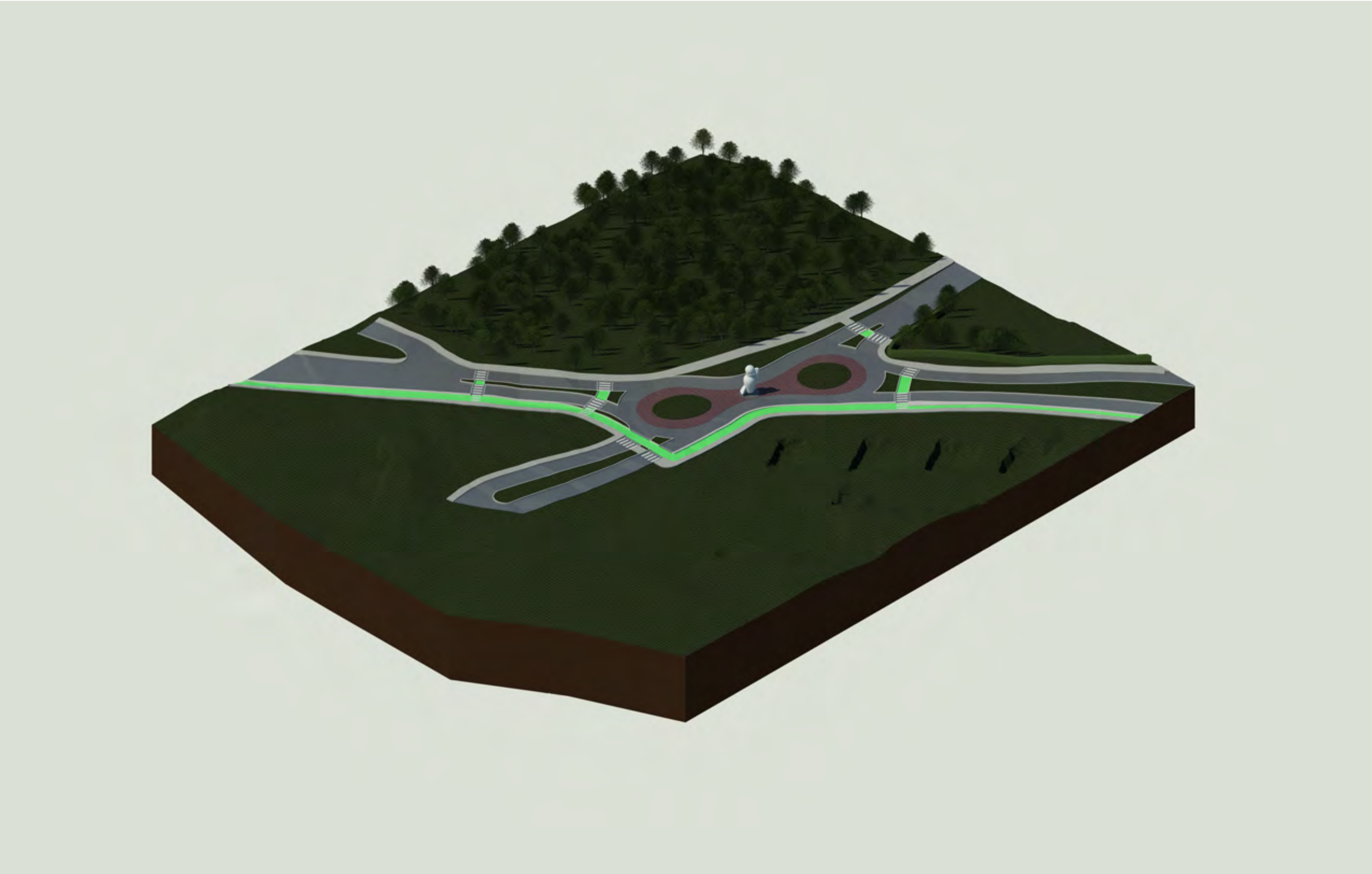
| | |
|---|---|
| DRAWN BY: MASON NAH | PLOT DATE: 2025.2.14 |
| CH. BY: | SCALE: 1:70 |
| DESIGNED BY: MASON NAH | APPR. BY: |

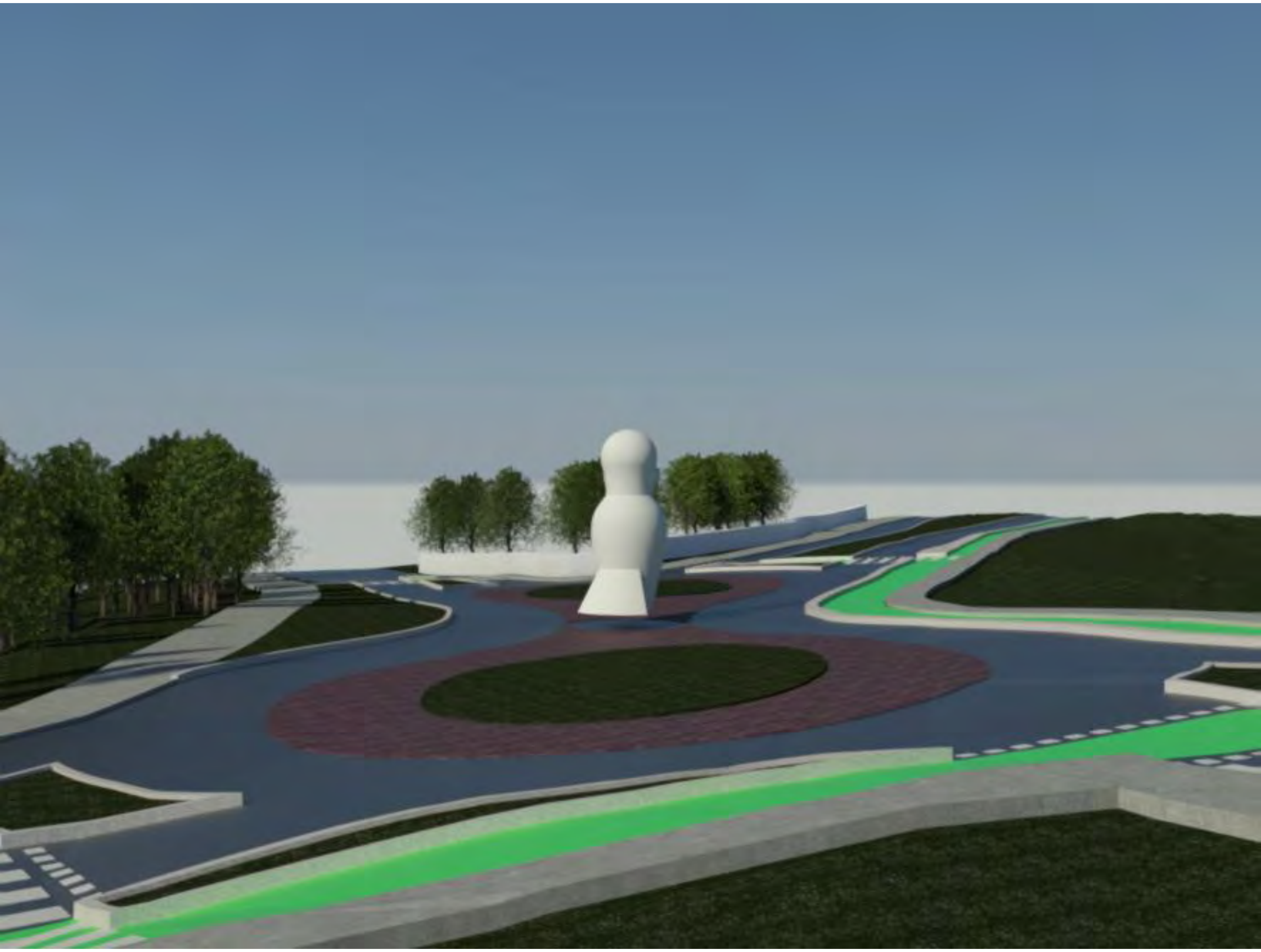
ISSUES:

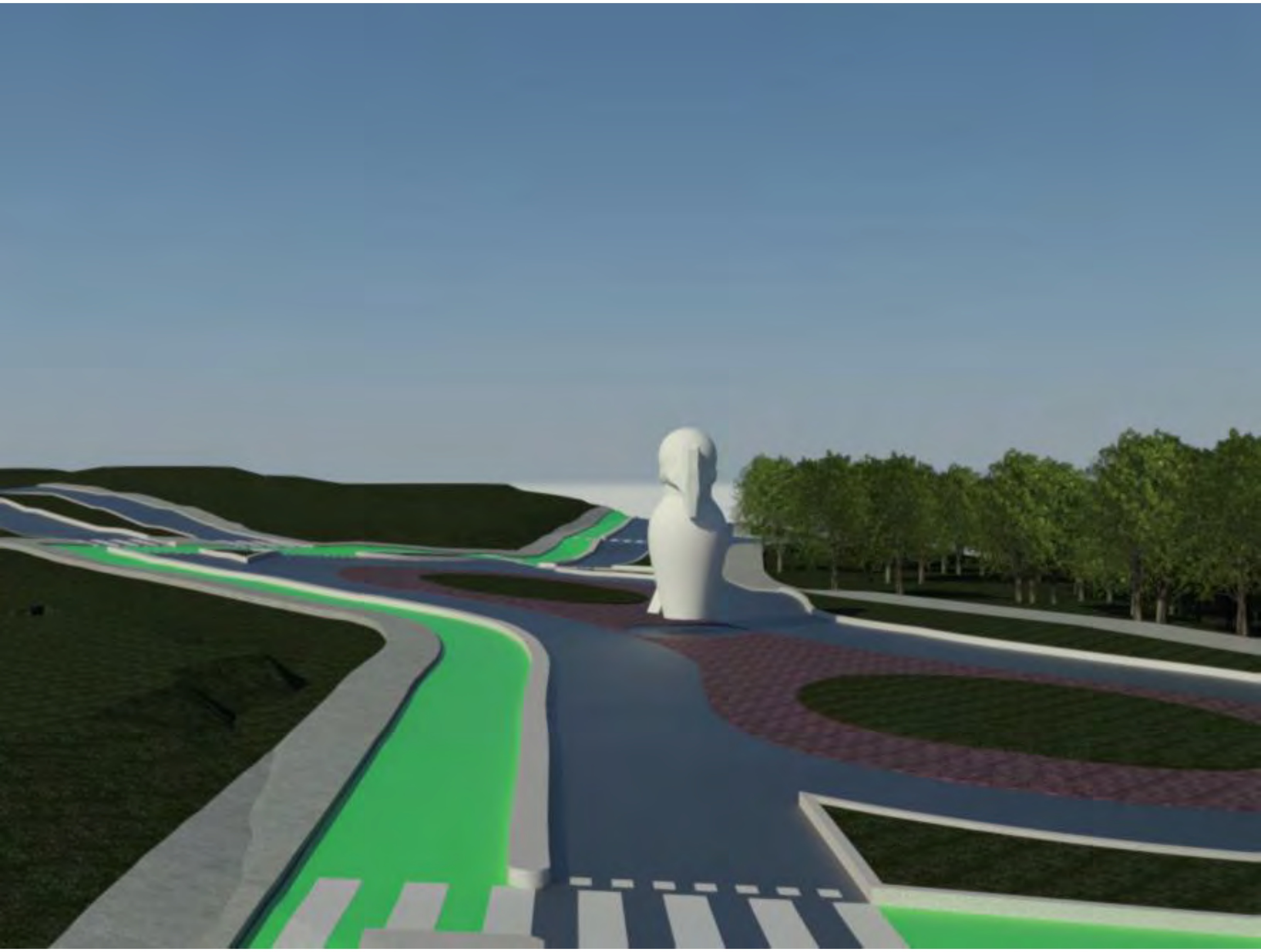
| DATE: | NOTES: |
|---|---|
| 2025.1.16 | Missing anchor detailing and dimensions |
| | |

DRAWING NO. 2
Rev. B

# APPENDIX H – REVIT 3D MODELS







# APPENDIX I – GATEWAY SIGN IMAGE

# APPENDIX J – RISK MATRIX TABLE

Risk Matrix Table

| ID | Description | Likelihood | Impact | Score | Level |
|---|---|---|---|---|---|
| R1 | Construction delays due to weather | 4 | 3 | 12 | High |
| R2 | Unforeseen underground utility conflicts | 3 | 4 | 12 | High |
| R3 | Traffic congestion during construction | 5 | 3 | 15 | High |
| R4 | Stormwater drainage system failure | 2 | 5 | 10 | Medium |
| R5 | Pedestrian/cyclist safety concerns post-construction | 3 | 4 | 12 | High |
| R6 | Cost overruns due to material shortages | 3 | 3 | 9 | Medium |
| R7 | Erosion of adjacent cliffs from poor stormwater retention | 2 | 5 | 10 | Medium |
| R8 | Public opposition to gateway sign or other design elements | 3 | 2 | 6 | Low |
| R9 | Failure to meet accessibility requirements | 2 | 4 | 8 | Medium |
| R10 | Long-term maintenance challenges | 4 | 3 | 12 | High |
| R11 | Failure to obtain necessary permits on time | 3 | 4 | 12 | High |
| R12 | Environmental impact on local wildlife or ecosystems | 2 | 4 | 8 | Medium |
| R13 | Modeling errors leading to unexpected traffic issues | 2 | 4 | 8 | Medium |

# APPENDIX K – ANNUAL MAINTENANCE BUDGET

## Total Estimated Annual Maintenance Budget

| Category | Estimated Annual Cost ($) |
| --- | --- |
| Roadway & Pavement | $65,000 - $100,000 |
| Stormwater System | $20,000 - $40,000 |
| Pedestrian & Bike Infrastructure | $18,000 - $32,000 |
| Landscaping & Green Infrastructure | $10,000 - $17,000 |
| Gateway Sign | $10,000 - $21,000 |
| **Total Estimated Cost** | **$123,000 - $210,000 per year** |

# APPENDIX L – TRAFFIC MANAGEMENT PLAN

# Traffic Management Plan

**Project Title: UBC Chancellor Blvd & East Mall Roundabout Construction**

**Date: April 2025**

## 1.0 Introduction

This Traffic Management Plan (TMP) outlines the infrastructure upgrades and consecutive control measures for the construction of a roundabout at Chancellor Boulevard and East Mall. The redesigned intersection includes a doughnut-shaped single-lane roundabout, a rain garden and a welcoming UBC statue.

Construction activity will significantly impact traffic circulation in the area, necessitating carefully phased lane closures, detours as well as Traffic control and on-site adjustments will be executed by a qualified traffic control company and supervised by certified Traffic Control Supervisors (TCS), in compliance with the:

BC Ministry of Transportation and Infrastructure (MoTI) 2020 Traffic Management Manual for Work on Roadways (2020 TMM)
MoTI Manual of Standard Traffic Signs and Pavement Markings
MoTI Standard Specifications – Section 194

## 2.0 Project Overview

This section provides a description of the planned work, geographical description of the project location and pre-construction traffic operations (traffic volume, speed limits, etc.).

### 2.1 Project Description

The scope of work includes full intersection reconfiguration, rain garden installation, new pavement and curbs, subgrade and utility work, and installation of landscaping and public statue.

The project is expected to occur over a 5-month period from April to September 2025, divided into three construction phases.

### 2.2 Project Area

The project is situated at a minor gateway to UBC's Point Grey campus. Chancellor Boulevard connects westbound traffic from the city to the university, while East Mall is a campus collector road. The area sees substantial vehicles, cyclist, and pedestrian traffic due to its proximity to UBC residences, parking lots, and trail access. The site lies on the traditional, ancestral, and unceded territory of the Musqueam people, and the design includes Indigenous public realm elements that acknowledge the cultural significance of this location.

### 2.3 Anticipated Traffic Disruptions

- Partial lane closures on Chancellor Blvd and East Mall during each construction phase
- Short-term full closure of internal intersection area during excavation and paving activities

## 3.0 Implementation Plan

This Implementation Plan outlines the role of individuals involved in the implementation of this Traffic Management Plan.

Traffic control people (TCPs) will be on-site to set up and take down the lane closure and associated devices, assist with any incidents that may occur, and assist with access and egress into the work area as needed.

### 3.1 Site Supervisor

The Site Supervisor for this project will be responsible for conducting daily toolbox meetings, addressing issues as they occur, leading the crew, and being the point of contact with the Ministry Representative.

As part of the role, the site supervisor will ensure that:

- Each crew member is familiar with the Traffic Control Plan
- Each crew member wears the required safety apparel
- Each crew member has adequate training on the equipment they will be using
- The work area is protected by implementing this TMP

Site supervisor will also be responsible for liaising with the Traffic Control Manager and Traffic Control Supervisor to inform them of the work schedule, day's activities, and to address any incidents, improvements or changes which need to be made.

### 3.2 Control Manager

The Traffic Control Manager for this project will be responsible for preparing, implementing and managing this Traffic Management Plan. She will be responsible for, but not limited to, the following tasks:

- Monitoring traffic operations to determine effectiveness and possible improvements to the TMP
- Overseeing modifications to the TMP as required
- Ensuring daily traffic control logs are maintained
- Sets up and implements a monitoring schedule for both active and inactive work periods throughout the course of the project
- Notifying the MoTI and emergency personnel of any major incidents within or near the project location
- Liaising with the Site Supervisor as needed

### 3.3 Traffic Control Supervisor (TCS)

Typically, there will only be 1 TCP on site as the work area is not on the travelled roadway. In these cases, the TCP will assume the role of, and be considered, the Traffic Control Supervisor.

However, if more than 1 TCP is on site, such as during busy periods or if an incident occurs, a Traffic Control Supervisor will be named on the day of. Their name will be recorded on the Daily Traffic Control Log.

The Traffic Control Supervisor (TCS) will be responsible for, but not limited to, the following tasks:

- Overseeing traffic control operations, ensuring traffic control is executed according to the Traffic Control Plan, and taking note of any improvements or changes that should be made
- Ensuring compliance with the requirements outlined in Part 18 of WorkSafe BC's Occupational Health and Safety Regulations regarding supervision of TCPs
- Supervision and authority over all the TCPs on site
- Providing directions to TCPs
- Ensuring traffic control devices are in place, checked, maintained, and moved as required
- Ensuring daily traffic control setups are documented and changes are identified in the daily traffic control log
- Ensuring traffic concerns are reported to the Traffic Control Manager and/or Site Supervisor, as required

On site, the TCS will also be responsible for ensuring all TCPs are:

- Carrying evidence of their current TCP certification
- Wearing the required safety apparel and have the appropriate equipment
- Performing traffic control duties competently and safely
- Positioned in safe locations
- Provided with rest breaks

### 3.3.1 Before Work Begins

- Confirm the TMP for the day's activities and document traffic management strategies to be implemented
- Conduct safety meeting with TCPs and coordinate with the Prime Contractor's staff on the traffic management requirements of the day
- Place signs and traffic control devices according to the drawings found in this TMP and the 2020 TMM. Note any adjustments which may need to be made based on local site conditions.
- Cover conflicting signs
- Inspect and check for the effectiveness of signing and traffic control devices.

### 3.3.2 During Active Work

- Periodically inspect and check all signs and devices
- Adjust signs as required
- Monitor traffic delays to ensure they do not exceed 20 minutes. Re-open the lane if necessary.

### 3.3.3 At the End of Shift

- Conduct a pre-close inspection
- Remove unnecessary signage
- Reinstate all vehicle traffic lanes
- Liaise with the Prime Contractor's staff to see if there are any considerations or concerns regarding the TMP and associated strategies
- Complete Daily Traffic Control Log
- Complete Incident Management Report – as required

### 3.4 Traffic Control Person (TCP)

The Traffic Control People (TCPs) used on this project will:

- Be adequately trained in a manner acceptable to WorkSafeBC
- Carry evidence of their current TCP certification
- Ensure compliance with the requirements outlined in Part 18 – Traffic Control of WorkSafeBC's Occupational Health and Safety Regulations
- Perform their work effectively in accordance with the traffic control arrangements and procedures for the work
- Try to assess the layout through the eyes of a road user to help anticipate traffic control issues
- Communicate instructions and directions to drivers effectively by using traffic control motions and signals that are precise and deliberate to be clearly understood by road users
- Identify required changes to the Traffic Control Plan and bring them forward to the TCS

## 4.0 Traffic Control Plan

This Traffic Control Plan documents how traffic control will be achieved during the construction period. Typical traffic control layouts will be implemented as mentioned in the sections below. The TCS will implement the traffic control layouts outlined in this TMP. Minor adjustments made to the typical traffic control layouts (such as adjusting signs for local site conditions) will follow guidelines outlined in the 2020 TMM and will be documented in the Daily Traffic Control Log. Major adjustments which have the potential to impact traffic operations will be noted and a revised TMP will be submitted to the Ministry for approval before implementation.

### 4.1 Traffic Control Devices and Signage

All signs, cones, barricades, and delineators will comply with MoTI Standard Drawings. Key sign types include:

- “Construction Ahead,” “Lane Closed,” “Detour,” and “Road Closed” signs at approach roads
- Reduced speed signage (30 km/h) near active work zones
- Pedestrian detour signage and ADA-compliant temporary ramps
- Temporary traffic signals or flaggers as required

### 4.2 Detour and Lane Closure Plan

Phase 1: The north leg of Chancellor Boulevard will be closed for reconstruction and tie-ins. East Mall and the south leg will remain open, with a temporary two-way slip road in place to maintain north–south traffic movement. Detours and signage will be installed to redirect vehicles and active transportation users around the closure.

Phase 2: The south leg of Chancellor Boulevard, connecting to SW Marine Drive, will be closed for reconstruction and tie-ins. Access to East Mall and Chancellor Blvd will be maintained via the newly constructed north leg. Detours will be adjusted accordingly, and pedestrian routes will continue to be rerouted.

Phase 3: The central roundabout area will be closed for final construction activities, including paving, line painting, landscaping, and installation of the Indigenous public statue. A short-term full closure of all legs will be required to safely complete surface work and install the central island with rain garden. During this period, detours will be in effect and clearly marked. Once surface work is complete, the roundabout will be reopened to full traffic access, with all detours and temporary controls removed.

### 4.3 Pedestrian Accommodation

Temporary pedestrian detours will be signed and routed through parallel sidewalks and paved shoulders. All crosswalks within the work zone will be closed and replaced with clearly marked safe paths. ADA-compliant ramps and detectable warning strips will be installed where needed.

### 4.4 Cyclist Routing

Cyclists will be rerouted through Memorial Road and Lower Mall, with advance signage provided 100 m before each detour point. Bike lane closures will be clearly marked and physically blocked with barriers.

### 4.5 Transit Coordination

UBC Campus Planning and TransLink will coordinate the temporary relocation of bus stops affected by sidewalk and curb work. Notices will be posted one week in advance.

## 5.0 Working Hours and Scheduling

Construction will take place between 7:00 AM and 5:00 PM, Monday through Saturday. No work is expected on Sundays or statutory holidays. Night work is not anticipated, though contingency approvals have been sought for urgent tasks such as watermain tie-ins.

During inactive hours, the site will be secured, and normal traffic flow restored where feasible, with advance signage indicating “Work Zone Ahead – Reduced Speed Applies.”

## 6.0 Incident and Emergency Response Plan

The Incident Management Plan included in this TMP establishes general protocols for the TCS to follow in the event of an incident. It aims to maintain efficient emergency services, enable safe traffic movements, and reduce the time required to restore traffic flow, should an incident occur.

All crew members will be familiar with the incident management procedures outlined in this TMP. The Prime Contractor will ensure that resources are available to respond to emergencies as needed. The TCS, Traffic Control Manager and Site Supervisor will work together to provide efficient response and coordination, including any changes that may need to be made to the traffic control layout.

Incidents covered in this Incident Management Plan include unforeseen events which affect traffic operations. Examples include vehicle collisions, breakdowns, stalls, objects falling from vehicles, or any other event which causes disruptions to traffic flow. It also includes situations where emergency vehicles require access to and/or through the construction zone.

If the incident occurs within the construction zone, the Prime Contractor will be responsible for providing, or obtaining, towing services. Should the incident occur outside the construction zone but have the potential to impact traffic operations within the construction zone, the Prime Contractor will coordinate with the Ministry's Maintenance Contractor (MC).

Note: Procedures for tracking and responding to incidents such as worker injuries on the work site would be covered in the Occupational Health and Safety (OHS) Plan.

### 6.1 Detection of an Incident

The TCS will monitor the areas within, and in the vicinity of, the work zone. If an incident is detected, the TCS will immediately respond.

If any of the crew members or TCPs detect an incident, they will relay all relevant information to the TCS. Relevant information includes the following:

- Location of the incident
- Number of people involved and their current condition
- Whether or not emergency services may need to be called
- Any other relevant information such as accessibility issues, fire, or hazards

### 6.2 Incident Management Procedures

The TCS will then verify the incident, assess the severity of the incident, call emergency services if required, and inform the Traffic Control Manager who will work with the TCS, Site Supervisor, and relevant field staff to respond to the incident appropriately.

The TCS will follow the procedure below, coordinating with the Traffic Control Manager and Site Supervisor as necessary:

1) Based on the severity of the incident, monitor and secure the area as necessary
2) Adjust the traffic control layout as required to allow emergency services access to the incident as quickly as possible
3) Direct emergency responders to the incident and assist as necessary
4) Modify the traffic control layout as necessary if possible. This includes removing any field equipment or materials which may interfere with incident management operations.

The Site Supervisor will be responsible for the following:

1) Informing all crew members (by radio or directly talking to them) of the incident and the possibility of emergency crews entering the work zone
2) Notifying the Ministry Representative and the MC as soon as practical – including the following information, as available:
    a) That an incident has occurred
    b) Planned clearance time of the incident
    c) Clearance measures required
    d) Response measures taken
    e) Planned measures, including modified traffic control layout, to restore traffic flow
3) Providing regular updates to the Ministry Representative and MC – typically every 30 mins.

### 6.3 Information

Upon notification of the incident, the Ministry Representative will immediately contact the Transportation Management Centre BC (TMCBC) to notify them of the incident, changes to traffic patterns, and estimated clearance time. The Ministry Representative will update TMCBC with information as made available from the Site Supervisor.

Depending on the severity of the incident, if there are significant delays (longer than 30 mins), TCPs and other crew members may be used to walk the queue and inform drivers of the following information:

- That an incident has occurred
- Estimated delay and clearance time
- Alternate routes (if available)

### 6.4 Resumption of Traffic Flow

At the conclusion of the incident, crew members will work with the TCS and Site Supervisor to clear the incident area of equipment and debris before restoring traffic flow to the layouts in this TMP. The Site Supervisor will notify the Ministry Representative once the incident is cleared, and normal traffic flow is restored.

In addition, the TCS will work with the Traffic Control Manager and Site Supervisor for the following:

1) Survey the incident area for any damage to infrastructure, equipment and materials. If significant damage is observed, the affected area should be protected from general traffic and the public. The Site Supervisor will notify the Ministry Representative of any repairs which may need to be made.
2) Complete the Incident Management Report – which will then be sent to the Ministry Representative
3) Relevant parties will meet to discuss the incident including:
    - What happened?
    - Why did it happen?
    - What could have prevented it from happening?
    - What improvements can be made to the traffic control layouts or the TMP to prevent this, or similar incidents, from happening again in the future?

## 7.0 Public Notification Plan

This Public Information Plan details methods for communicating to the travelling public the impacts of the project, especially any delays in travel. It also outlines methods for providing work updates to the Road Authority.

Two weeks prior to the beginning of the work, the Site Supervisor will notify the Ministry Representative of the proposed schedule and anticipated traffic impacts. The Ministry Representative will then notify TMCBC who will post the notification onto DriveBC. Any changes to the proposed schedule will require in advance notice of at least 24 hours. On top of that, UBC Communications will distribute advance notice via:

- Campus-wide emails and facility bulletin boards
- Temporary digital signage near the project site
- Updates to UBC social media and website

Notice of traffic changes will be posted two weeks prior to Phase 1 and updated three days before each new phase. Due to the minimal impacts expected, dynamic message signs will not be used for this project. Instead, static advance warning signs will be used and indicated in the traffic control drawings.

## 8.0 Emergency Contact List

| | |
|---|---|
| Emergency – Police, Fire, Ambulance | 911 |
| UBC Hospital Emergency Department | 604-822-7662 |
| Campus Security | 604-822-2222 |
| Local RCMP (non-emergency) | XXX-XXX-XXXX |
| Local Fire Department (non-emergency) | XXX-XXX-XXXX |
| BC Ambulance (non-emergency) | XXX-XXX-XXXX |
| Local Hospital (non-emergency) | XXX-XXX-XXXX |
| BC Hydro | XXX-XXX-XXXX |
| FortisBC Gas | XXX-XXX-XXXX |
| Telus | XXX-XXX-XXXX |
| Shaw | XXX-XXX-XXXX |
| WorkSafeBC | XXX-XXX-XXXX |
| Provincial Emergency Program | XXX-XXX-XXXX |
| Ministry of Transportation | XXX-XXX-XXXX |
| Ministry Representative | XXX-XXX-XXXX |
| Road Area Manager | XXX-XXX-XXXX |
| Operations Manager | XXX-XXX-XXXX |
| District Manager | XXX-XXX-XXXX |
| Maintenance Contractor | XXX-XXX-XXXX |
| Local Road Maintenance Contractor | XXX-XXX-XXXX |
| Contractor | XXX-XXX-XXXX |
| Site Supervisor | XXX-XXX-XXXX |
| Traffic Control Manager | XXX-XXX-XXXX |
| Traffic Control Supervisor | XXX-XXX-XXXX |