University of British Columbia

Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

# Wesbrook Mall Phase 4 Redesign

Prepared by: Josh Bian, Joshua Chong, George Gu, Alvin Lok, Simar Sidhu, Jason Wongso

Prepared for:

Course Code: CIVL 446

University of British Columbia

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**Acknowledgments**

This project would not have been possible without the help of UBC staff, SEEDS members, design instructors, and student designers involved with the Wesbrook Mall Redesign initiative. We would like to extend our gratitude to Dr. Yahya Nazhat for leading the project and coordinating plenaries. We are thankful to Dr. Clark Lim, Krista Falkner for guiding our team as design instructors. Continued guidance, mentorship, and support from UBC staff and SEEDS team helped immensely with the success of the preliminary design deliverables.

**SEEDS Sustainability Program**

Krista Falkner, P.Eng, Manager, Campus + Community Planning

David Gill, Program and Policy Planner

**UBC Staff**

Dr. Yahya Nazhat, Course Coordinator and Project Leader

Dr. Clark Lim, P.Eng, Design Instructor

# Executive Summary


The final design of the Phase 4 Wesbrook Mall Redesign will maximize safety for all transportation users, while minimizing costs and tree removals across the corridor. Active transportation modes and transit reliability was deemed as the main priority in the final design. This includes a 3.0m travel lane, 3.4m bus lane, and a 2.0m bike lane on the northbound (NB) side in place of the existing parking lane. Similar dimensions are used on the southbound (SB) side, with parts of the median removed to create space for a protected bike lane and on-street parking.

A 35m long underpass with dimensions of 3.3 x 3.1m (HxW) provides a safe and efficient pedestrian crossing path across Wesbrook Mall. Blue Light Emergency Phones, fire suppression systems, and lighting enhances user safety. Impeller pumps with jellyfish filters are used to remove water from the underpass during heavy precipitation events.

Green Infrastructure in the form of permeable pavements and rain gardens are utilized to reduce polluted runoff and retain stormwater on-site.

Construction is scheduled to begin in June 2022, with the expected completion date of March 2023.

The final class A cost estimate for the project is $4.5 million.

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# 1.0 Introduction

Team 11 Consultants completed the Wesbrook Mall Phase 4 redesign between Thunderbird Blvd. and 16th Ave as requested by UBC SEEDS in December 2021. Major components in the design include reallocation of surface auto, transit, biking, and pedestrian facilities along with construction of a pedestrian underpass south of the Thunderbird Arena.

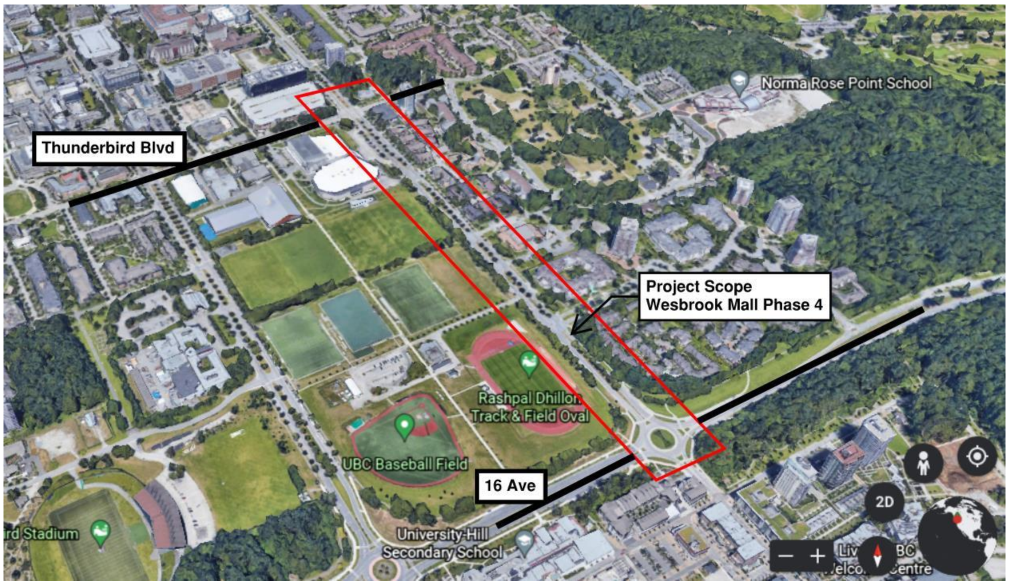


*Figure 1. Map of Project Scope*

Team contributions are listed below:

*Table 1. Team Contributions & Review*

| Team Member | Contributions | Review |
|---|---|---|
| Simar Sidhu | Drainage/Utility Drawings , X-sections, Key Design Components Write Up | Josh Bian, Alvin Lok |
| George Gu | Introduction, Initial design, Underpass Pump Design, Underpass Accessories, Technical Considerations | Simar Sidhu, Jason Wongso |
| Joshua Chong | Traffic Modeling & Forecasting, Planview Drawing, Standard Detail Drawings, Signage Plans | Josh Bian, Alvin Lok |
| Jason Wongso | Executive Summary, Green Infrastructure, Life-cycle Assessment | Joshua Chong, Simar Sidhu |
| Josh Bian | Underpass Design and Detailed Drawings | George Gu, Jason Wongso |
| Alvin Lok | Construction Management, Cost Estimate, Scheduling, Risk Analysis | Joshua Chong, George Gu |

The scope of the project involves 5 main goals. This includes:

1. Encourage, prioritize, and maximize the safety of all active transportation modes including transit, cycling, and walking.
2. Design a pedestrian grade separated crossing to allow for safe and efficient pedestrian travel at Wesbrook Mall.
3. Incorporate GI infrastructure to retain stormwater on site.
4. Create a curbside management strategy working in conjunction with a separated bike facility to maintain safety and efficiency for users.
5. Reduce costs where possible.

The following sections describes the team's process and methodology used to develop a final design.

# 2.0 Design Criteria

To meet the goals mentioned above, the team applied best practice standards along with various requests made by the client. The final design followed the same criteria mentioned by the preliminary design; minimizing cost, tree removal, parking removal, utilities relocation as well as improving sustainability with Green Infrastructure, and prioritizing transit and active transportation. The recommended design widths are provided and listed below in Table 2.

*Table 2. Transportation Facility - Minimum vs Design Widths*

| Facility Type | Design Constrained Widths (m) | Design Recommendation Widths (m) |
|---|---|---|
| Sidewalks | 2.0 | 2.2 |
| Bike Lane | 1.8 | 2.0 |
| Bus Lane | 3.4 | minimum |
| Travel Lane | 3.0 | 3.2 - 4.0 |
| Parking | 2.2 | 2.5 |

## 2.1 Standards and Software

The team utilized various engineering standards, specifications, and software packages throughout the design phase of the project. The following table below outlines them:

*Table 3. Standards, Codes & Software Packages*

| Standards / Codes | Software Packages |
|---|---|
| BC Active Transportation Design Guide (BCATDG) | Synchro 6 |
| TAC (TAC) Geometric Design Guide for Canadian Roads | Sidra Intersection 9 |
| City of Vancouver Engineering Design Manual | AutoCAD |
| Geometric Design of Highway and Streets AASHTO | CIVIL 3D |
| UBC Transportation Plan / City of Vancouver Transportation 2040 | - |
| Manual on Uniform Traffic Control Devices (MUTCD) | - |

# 3.0 Key Roadway Design Components

The key roadway design components are showcased in the detailed design drawings package prepared according to City of Vancouver Geometric Design guidelines with additional technical guidance from BCATDG and TAC. The drawing package includes five planview drawings of the project scope with detailed proposed design for the corridor. Proposed signage plans are included aligning with MUTCD standards to identify existing, relocated and new signage for implementation. Standard geometric details are also developed to help facilitate the design of detailed specifications. The planview drawings are supplemented with cross-section drawings detailing key locations and segments. The utility drawings highlight the existing drainage, relocation of catch basins, and other utilities in conflict with the proposed design. This section discusses in detail key components that guided the design for the Wesbrook Mall corridor. Drawing packages are attached before the Appendix.

The Phase 4 redesign of Wesbrook Mall prioritizes active transportation with focus on dedicated transit and bike lanes along the corridor. The proposed design includes raised bike lanes and bus lanes with reductions in travel lane width and removal of parking lanes. Additionally, changes are proposed for the existing sidewalks, bus stop locations, and utilities. The pedestrian crossing at Thunderbird Arena will see a significant improvement with a dedicated pedestrian underpass. Adhering to UBC's stormwater retention goals, GI infrastructure in the form of rain gardens, permeable pavement and concrete is incorporated at feasible locations. The proposed cross-section is within the existing right of way avoiding potential property conflicts. This section explains the components of each feature of the design in detail. Figure 2 below lists the dominant features of the design:

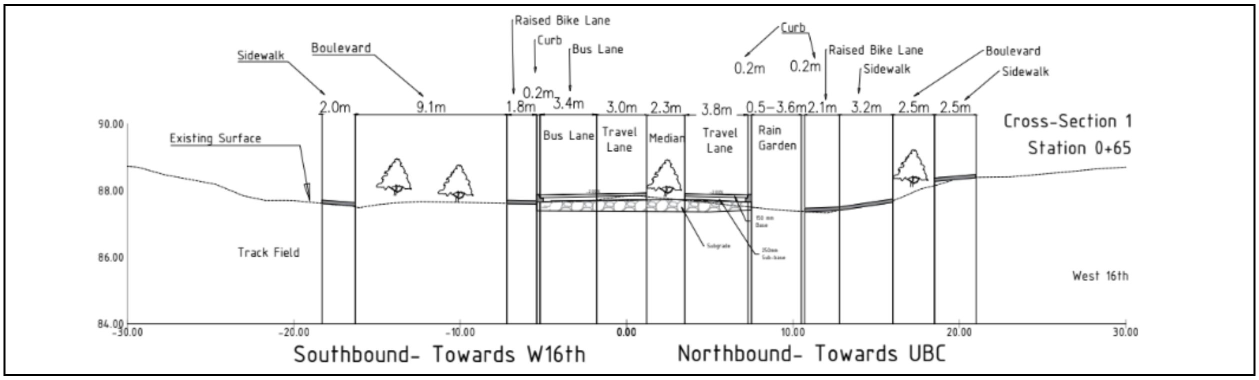


*Figure 2. Typical Cross Section*

## 3.1 Travel Lanes

The proposed design features one travel lane heading in the NB and SB directions separated by a median along the span of the corridor. Travel lanes are adjacent to the median with a width of 3.0-3.5m, accompanied by turn lanes at Thunderbird Blvd, and Thunderbird Arena. The turn lanes have an average width of 3.2m. The travel lanes and turning lane widths are minimized throughout the design to discourage single occupancy vehicles and provide additional right of way width for transit, sidewalks and bike lanes.

## 3.2 Bus Lanes

A key feature of the redesign are dedicated bus lanes to assist with projected volume of transit at peak hours. The SB direction has a 3.4m wide bus lane for the length of the corridor. In the NB direction, the 3.4m bus lane starts at Thunderbird Arena near the proposed underpass and ties into the Phase 2 bus lane at Thunderbird Blvd. The bus lanes are adjacent to the 0.9m proposed buffer, where feasible, to provide physical separation for vulnerable road users such as cyclists and pedestrians from motor vehicle traffic.

## 3.3 Bus Stops

Two bus stops are incorporated in the SB direction and a 3.0m bus bay in NB direction. The bus stop near Thunderbird Blvd requires relocation of the bus bulge to aid the required minimum widths for the SB cross-section of roadway. The second SB bus stop at Hampton Place is an in-lane stop to provide comfortable pedestrian street space for boarding and alight and avoid potential utility conflicts at the location. Figure 3 and figure 4 show images of the bus stops in the SB direction.

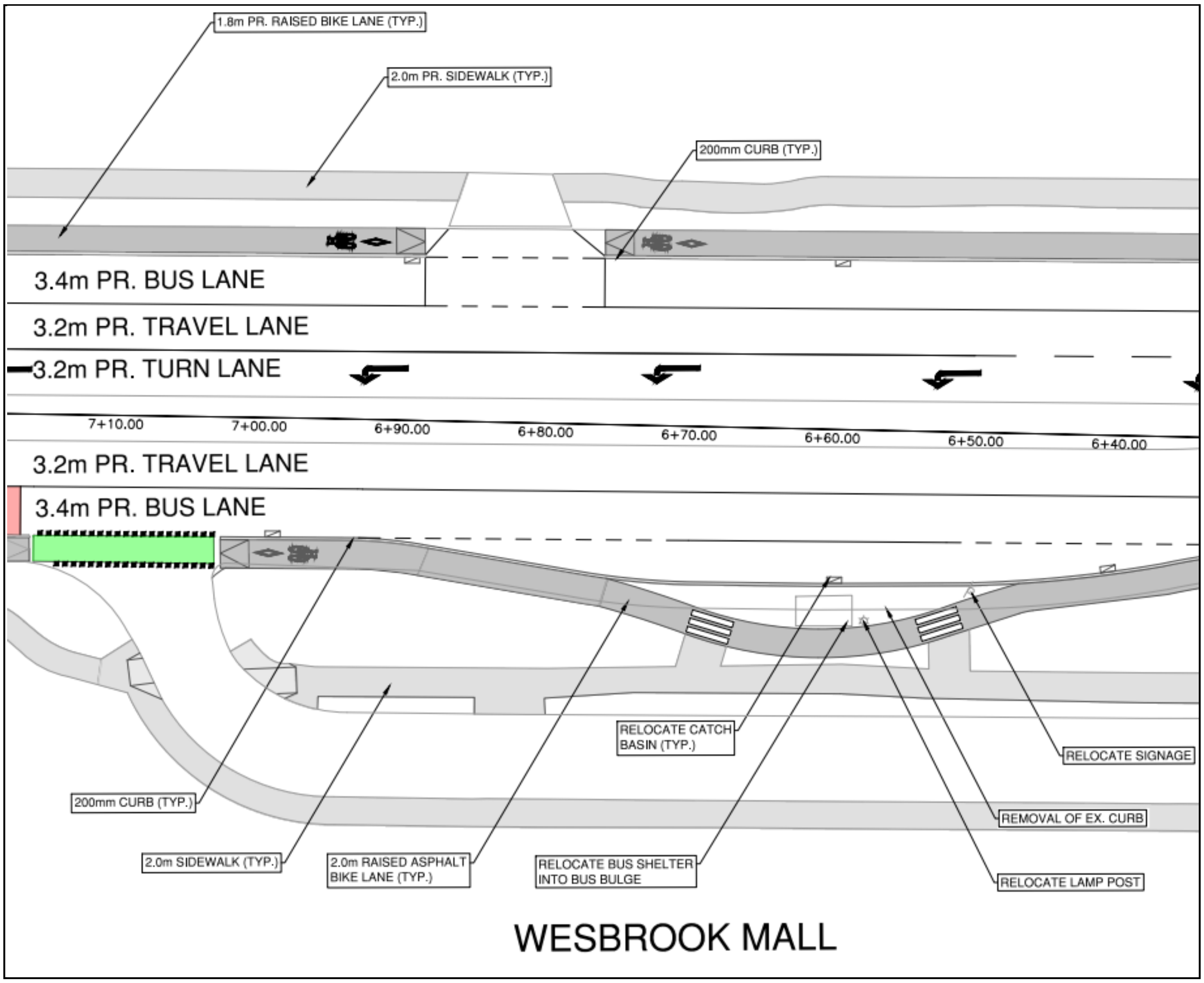


*Figure 3. Southbound Thunderbird Boulevard Bus Stop - Planview*

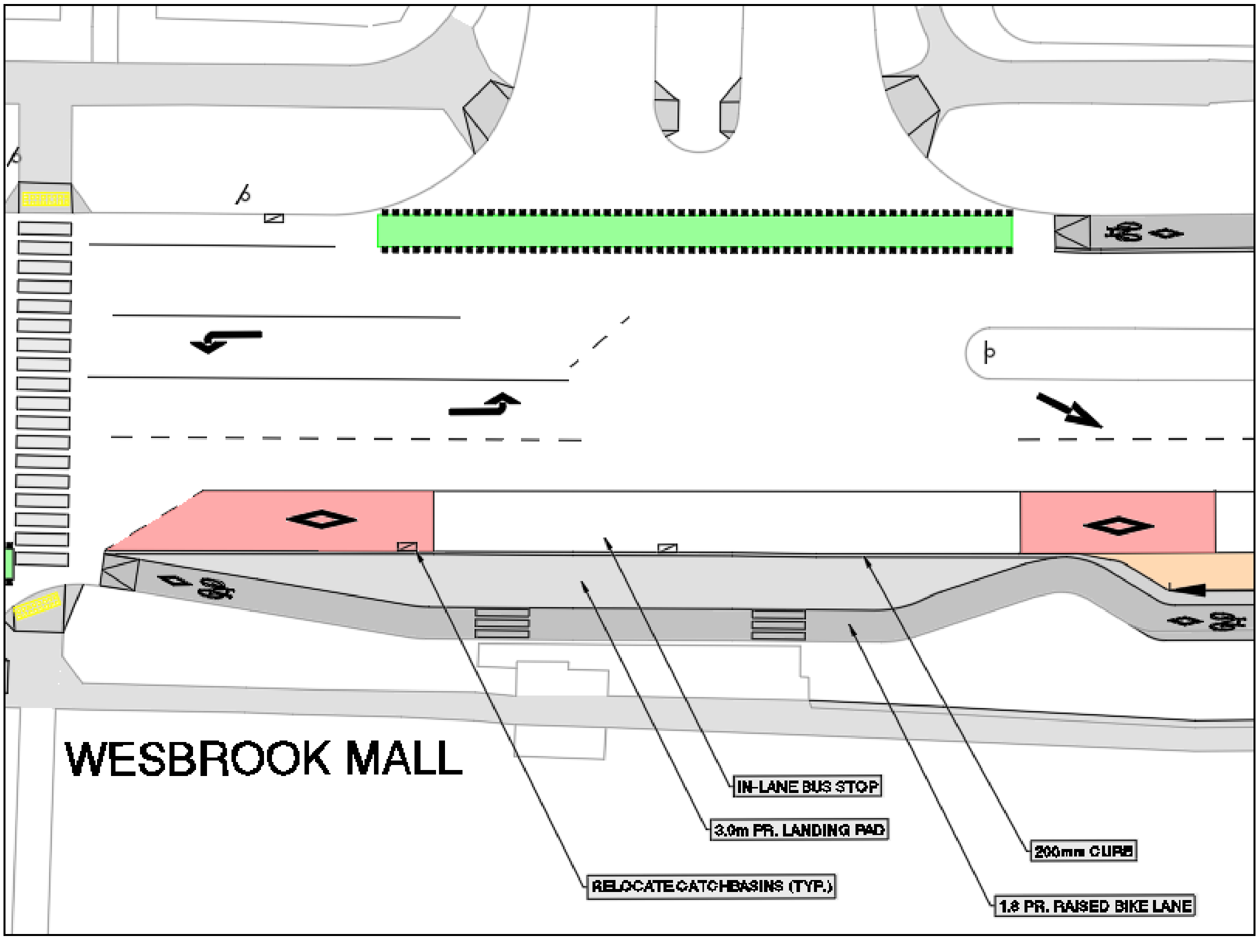


*Figure 4. Southbound Hampton Place In-Lane Bus Stop - Planview*

## 3.4 Parking Lanes

Another key feature of the redesign is the reduction of the parking lanes. A parking inventory assessment during the morning and afternoon peak periods, determined the feasibility in removing the segment from Thunderbird Blvd to the underpass to provide right of way space for the exclusive bus lane and raised bike lane. Parking remains in the SB direction with a width of 2.4m from the underpass until Hampton Place. Parking also remains shortly after the SB Hampton in-lane bus to provide easy accessibility for field users. The 2.5m wide NB parking lane from the underpass to Hampton Place also serves as the loading zone at Hampton Place. Figure 5 represents the typical parking remaining just south of the underpass.

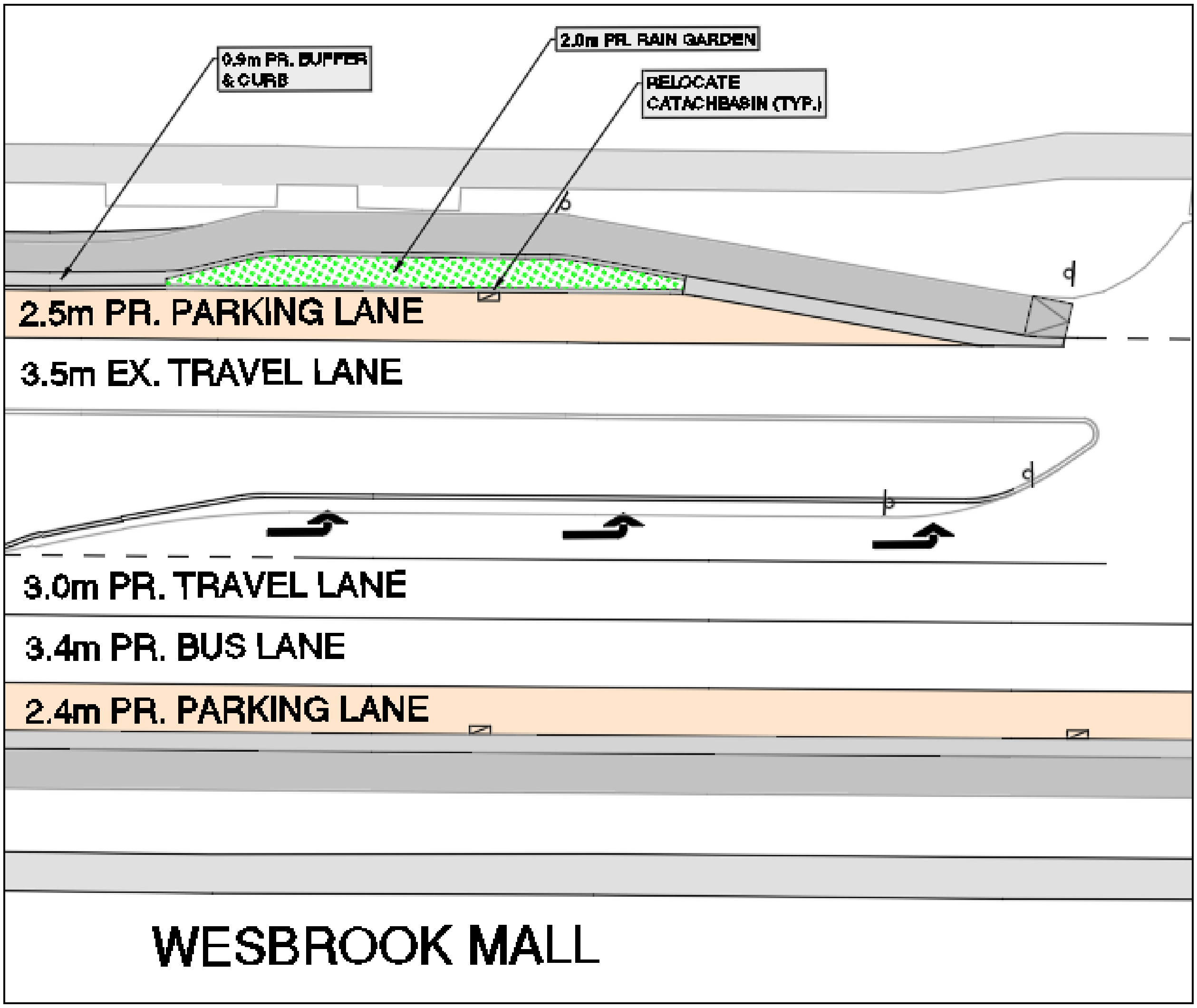


*Figure 5. Typical Parking South of the Underpass - Planview*

## 3.5 Bike Lanes

Raised bike lanes are designed unidirectionally with a minimum width of 1.8m in both directions along the corridor. To provide safety, comfort, and additional space for a door zone for parked cars, a 0.6m to 0.9m buffer separation is implemented where feasible along Wesbrook Mall. The bike lanes are dedicated for other active transportation modes such as e-scooters and future micro mobility as well.

## 3.6 Pedestrians

Sidewalks are redeveloped to be 2.0m wide in both NB and SB directions. No significant modifications are proposed for the existing 2.0m sidewalks. The existing green boulevard separates pedestrians from bikes. Repavement is also required to install permeable material.

## 3.7 GI Infrastructure

Rain gardens are proposed at 3 locations to reduce water run-off and to enhance roadway aesthetics. Permeable pavement for the pedestrian sidewalk and parking pockets are designed to increase the infiltration and stormwater retention goal set by UBC. GI infrastructure is an important criteria for this project hence emphasis is placed to incorporate them as much as possible.

## 3.8 Utilities

Due to imprecise knowledge of underground utilities at project site, the team is required to exercise extreme caution during excavation. Because no new right of way was added, the majority of existing utilities such as the hydrants, telecom manholes, power manholes, existing gas valves, etc. are unaffected. The largest impact is on the 37 catch basins which require relocation. The underpass area has significant utility conflicts with several storm and sewer manholes requiring relocation. Gas lines, power lines, waterlines and sanitary lines will be redirected. The existing and abandoned utility pipes also require removal in the underpass construction area.

# 4.0 Technical Design Considerations

## 4.1 Roadworks

Technical design considerations for roadworks include:

1. Allocating space to optimize facilities for automobiles, transit, cyclists, and pedestrians.
    a. Providing enough space to include dedicated transit lanes in areas assessed to develop a queue during busy times.
    b. Establish continuous, raised bike lanes throughout the length of the road to provide cyclists with separation from motor vehicle traffic.
    c. Weave cycling lanes behind bus stop landing pads to minimize conflicts between transit users and cyclists.
    d. Retain parking spaces as much as possible to provide space for varsity field users and visitors to residences.
2. Minimizing tree removals

    Tree removals were minimized by strategically placing new and realigned automobile, transit, and cycling lanes in avoidance of trees. Curb cuts on the center median are implemented on the SB side instead of the NB side to avoid tree removals: cycling lanes were weaved around bus stops to avoid existing trees.
3. Applying Green Infrastructure

    Rain gardens and permeable pavements were efficiently designed at new catch basins and curb parking pockets to minimize changes to existing infrastructure while establishing more sustainable solutions for new GI infrastructure.
4. Establishing an aesthetical and spacious design for the pedestrian underpass

To ensure the pedestrian underpass fits the aesthetics of the local environment, the team designed the underpass with modest sized entrances while providing adequate of lighting and headspace underground to improve the user experience

## 4.2 Underpass

The main technical challenges for the underpass included facility design, tunneling, dewatering, and minimizing impacts on existing infrastructure.

1. Facility design

   To ensure the underpass meets existing municipal design standards and guidelines, the dimensions, ramp grade, and stair height are carefully considered and incorporated into the final design.

2. Tunneling

   The underpass tunnel will be prefabricated and placed using a cut and cover method. Because of factors relating to low excavation depth, soil conditions/type, and overall tunnel length, cut and cover was chosen as the preferred excavation mode compared to other methods such as blasting or boring. Soil conditions beneath and beside the proposed location have been assessed and geotechnical reports were analyzed to ensure feasibility of tunnel design.

3. Dewatering

   A pump installed in a vault below the tunnel will remove excess water accumulated during storms. The pump was selected to meet the head and flow criteria while also considering maintenance and power consumption. Technical considerations also include additional pipes and electrical connections for the operation of the pump. Jellyfish filters from Langley Concrete reduce the impact of clogging of the pump due to debris. The pump includes water pressure sensors to only operate during precipitation events, and requires regular maintenance and inspection. The considerations are captured in the final design and can be found in Appendix F

4. Minimizing impacts on existing infrastructure and traffic

   The depth, pathing, and grade of the underpass were designed to minimize utility relocations. Traffic disruptions will be reduced by closing only half of the road, keeping a minimum number of lanes open during construction Detailed Design

# 5.0 Underpass

The pedestrian underpass dimensions were retained from the preliminary design phase and underwent further analysis and detailing to ensure adequate serviceability, aesthetics, and compatibility with the new roadway. The final detailed design has an overall span of 35m across with 1.75m wide entrances. The overall tunnel dimension is 3.3x3.1m (H x W) with 300mm walls. Details can be found in Drawing Number 24-30 of the drawing package.

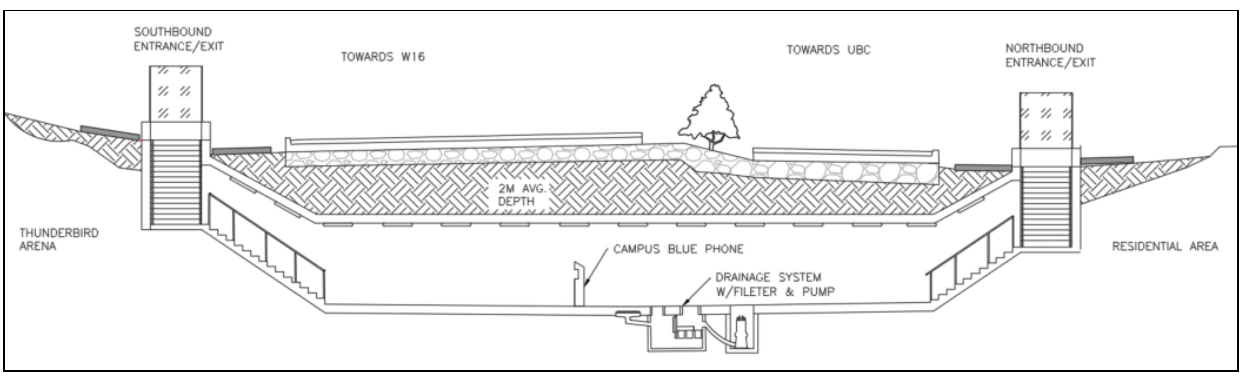


*Figure 6. Underpass - Plan View*

## 5.1 Demands

Structural analysis was conducted to determine the critical demands on the structure. To ensure proper steps were followed, Team 11 used the following guidelines and manuals:

- CSA A-23.3 (2014) Design of Reinforced Concrete Structures

- CSA S-16 (2019) Design of Steel Structures
- CSA S-6 (2019) Canadian Highway Bridge Design Code
- BC Building Code (2018) Section 4.1: Structural Loads and Procedures
- BC Bridge Standards and Procedures Manual (2016)

Demands were computed based on vehicle/pedestrian live loads and soil/concrete dead loads. Lateral loads induced from soil pressure were also determined using soil mechanics principles. The tunnel was simplified into a box structure with fixed connections at each corner; the loads were then imputed into RISA to determine the critical moment and shear forces at their respective locations on the structure. he critical shear force and moment at the corners of the bottom slab are 138.6kN and 69.3kNm as shown on Figure 7 below. Additionally, a bearing demand of 92.4kPa was also computed based on the identified soil classification.

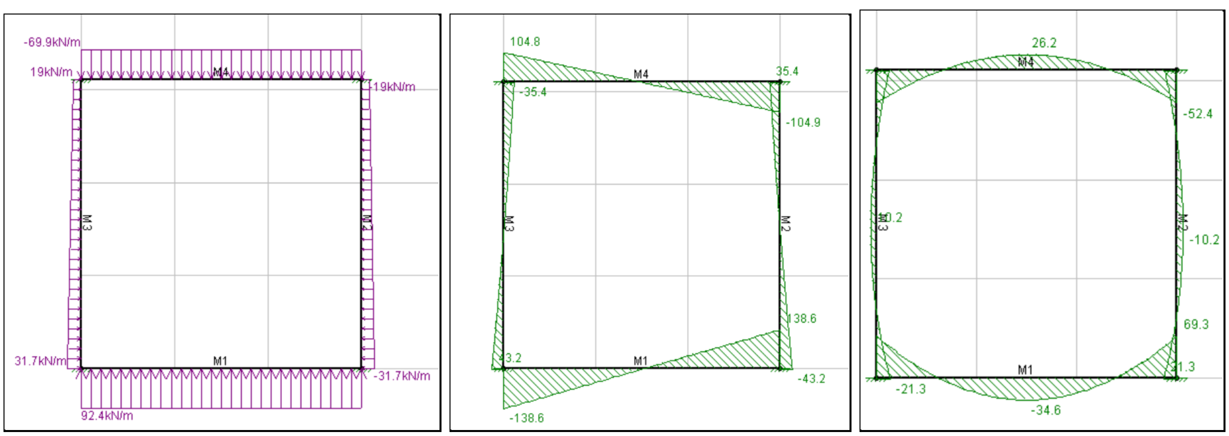


*Figure 7. RISA Inputs and Results Design*

Reinforcement selection and placement  was the primary focus during the detailed design phase. It was determined that a 75mm clear cover was required where the concrete is in contact with the soil while a 40mm cover was required to protect the interior face from freeze thaw cycles. In each wall, 20M longitudinal bars spaced at approximately 500mm were selected to resist the flexural demands. 20M transverse reinforcement was also used for adequate crack control. The resisting moment and shear capacities were 74.9kNm and 167.1kN while the bearing capacity was 150 kPa. The design thus passed all required demand checks.

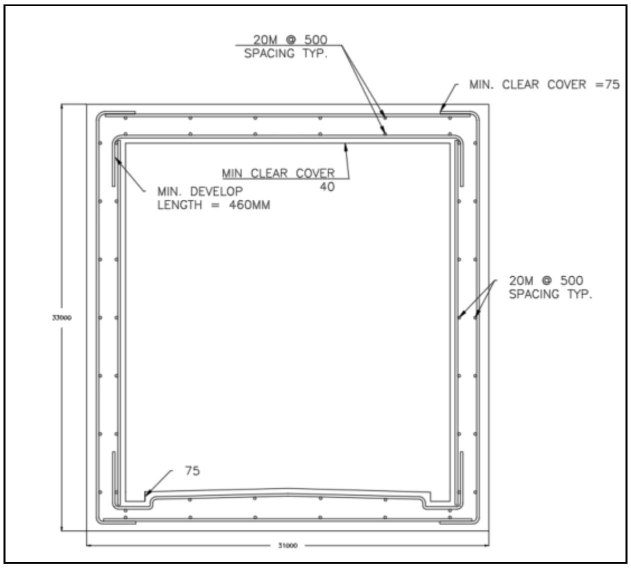


*Figure 8. Reinforcement Details*

Additionally, 10M transverse and longitudinal stair reinforcements at various spacings were used to minimize cracks and deflections. The load demands at the stairs were deemed not critical due to lower soil loads; hence, the stair walls and roof used the same 20M reinforcement design as described above.

## 5.2 Additional Features

To complete the design, 9 lights were selected to span across the ceiling with sprinklers placed in 2.3m intervals throughout. A UBC Campus Blue Phone will be used in the middle of the underpass. Handrails will be located along the stairs in compliance with BC Building Code Standards.

To ensure the underpass does not fail due to settlement, a check concluded acceptable final settlement of 3cm based on soil conditions provided by the UBC groundwater and geotechnical investigation. Detailed calculations can be found in Appendix G.

The head requirement for the pump is 7m from the elevation of the pump vault to the catch basin at ground level. A design flow demand of 25GPM was determined based on a 1 in 100 year hourly precipitation estimate of 10mm/hr. The design precipitation was assumed in reference to the historical rain event that occurred in November 2021. The underpass is situated on the highly permeable upper quadra sand layer (Piteau and Associate) while the groundwater is 45m below the surface. Therefore, infiltration into the tunnel will only occur through soil above the underpass.

Upon considering operational efficiency under varying flow conditions. The pump selected is a NS 4-23 CVBP end suction close coupled single stage pump that will operate when the pressure sensor is triggered when the pump is submerged. The pump will be connected to the existing AC main and powered on by a capacitor when an inflow is detected. The pump system and demand curve can be found in Appendix F.

# 6.0 Green Infrastructure

Green Infrastructure in the form of permeable pavements and rain gardens is used across the corridor to retain stormwater on-site. The following section highlights the details of the GI Infrastructure implemented in the redesign.

## 6.1 Pervious Concrete

Pervious concrete will be used for the pedestrian sidewalk. It uses less sand and fine aggregates in the mix design, creating more voids in the material, which allows stormwater to seep through the surface, preventing standing water from forming in freezing temperatures. The absence of standing water and the increased roughness of the surface improve traction for pedestrians, improving safety and comfort.This also eliminates the need for de-icing salt reducing the long-term accumulation of chloride in the soil, which can negatively impact the environment.

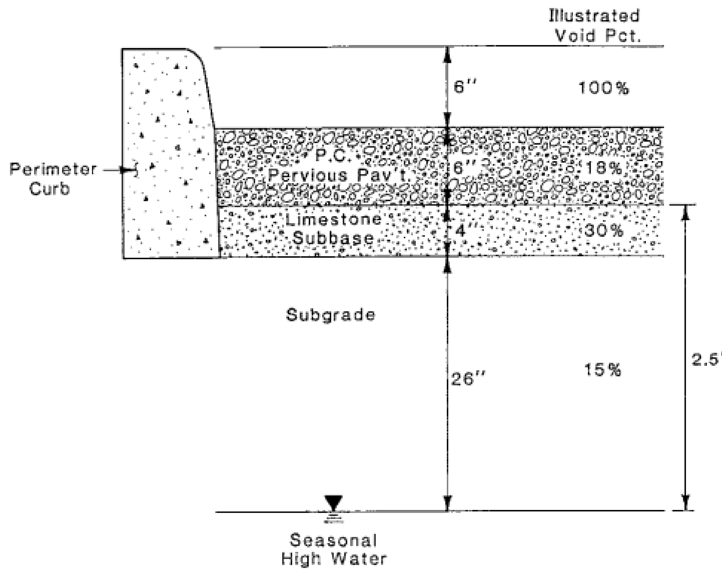


*Figure 9. Standard Detailed Drawing of Pervious Concrete Sidewalk (ACI, 2011)*

## 6.2 Permeable Interlocking Concrete Pavement

Permeable Interlocking Concrete Pavement (PICP) is used in the parking pockets along Wesbrook Mall. This form of permeable pavement promotes stormwater infiltration and groundwater recharge. The concrete pavers also form an interlocking pattern which improves aesthetics. The joints between the bricks are filled with permeable aggregates that filter stormwater before it reaches the soil subgrade. While this comes at a higher cost compared to regular asphalt pavement, PICP has a longer expected service life, minimizing future maintenance costs and environmental impact. The surface of the PICP will need to be regularly cleaned using high pressure water to optimize the stormwater infiltration rate throughout its lifespan.

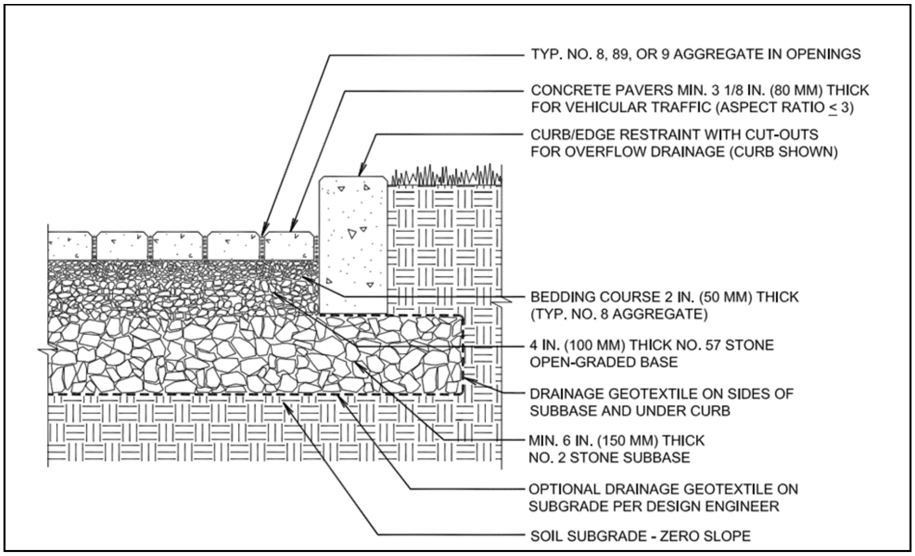


*Figure 10. Standard Detailed Drawing of Permeable Interlocking Concrete Pavement (ICPI, 2022)*

## 6.3 Rain Garden

Rain gardens will be installed along the curb extensions on both sides of the corridor (see Drawing Number 1-5 in Drawing Packages). These create more pervious area along the corridor, promoting stormwater infiltration and groundwater recharge. The soil filters out runoff pollutants before reaching the soil subgrade. Rain gardens also provide additional aesthetic value, although regular maintenance such as trash removal, weeding, and dead vegetation removal are required to keep the space clean.

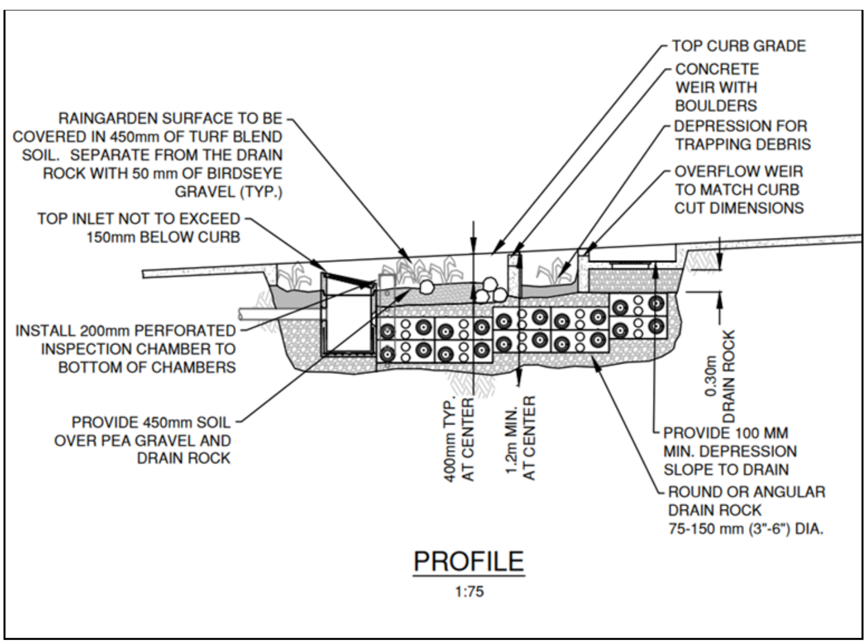


*Figure 11. Standard Detailed Drawing of Rain Garden (City of North Vancouver, 2020)*

# 7.0 Modeling

Modeling was conducted to determine the extent of the NB bus lane redesign along the entire Wesbrook Mall corridor. The analysis of the 2021 Base Synchro Models and 2050 Design Models determined that the existing 95th percentile queue length is satisfactory for the bus lane to begin just north of the underpass.

## 7.1 Modeling Methodology

This section describes the process of developing Synchro models for the Thunderbird Blvd intersection accounting for the key considerations such as traffic volumes, signal timings, and Synchro model parameters.

## 7.2 Compilation of Available Data

The historical turning movement counts (TMC) provided by SEEDs were reviewed and compiled. The historical TMCs consisted of 2018 and 2019 counts. Signal timing reports were also provided for the Thunderbird Blvd and Wesbrook Mall intersection.

## 7.3 Balancing & Developing 2021/2050 volumes

Intersection volumes at Thunderbird Blvd and 16th Ave along Wesbrook mall were reviewed and adjustments were made for volume balancing based on reasonable estimates for changes such as land development. To account for recent population growth at UBC, a 1% compound annual growth rate was applied to both intersections. This growth rate was established based on a review of the historical traffic data from UBC's Annual Fall Transportation Plan and UBC statistics on students, staff, and faculty from UBC Data & Analytics. Figures 12 and 13 below illustrate the 2021 and 2050 volumes developed in Synchro 6 models.

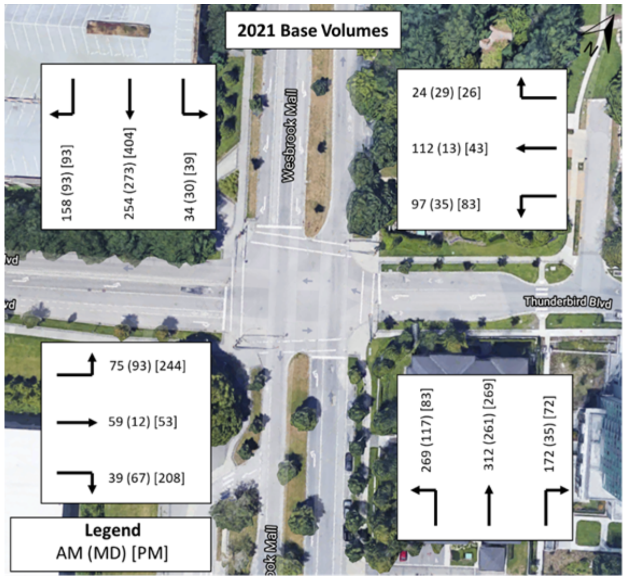


*Figure 12. Thunderbird Blvd 2021 Volumes*

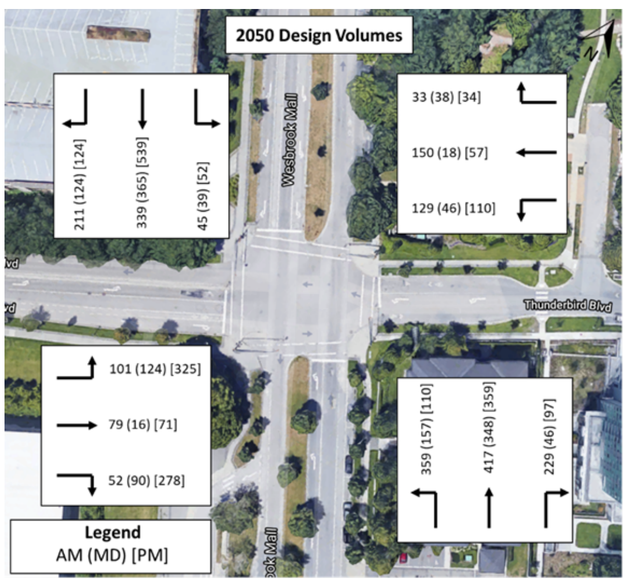


*Figure 13. Thunderbird Blvd 2050 Volumes*

To determine the length of the NB bus lane leading into the Thunderbird Blvd intersection, analyses were conducted for the Synchro models to determine parameters including total delay, volume to capacity ratio (v/c), LOS, and the 95th percentile queue length. Tables 4 and 5 outline the Synchro 6 model outputs for the above elements. The model outputs are separated into AM Peak Period, (MD Peak Period) and [PM Peak Period].

*Table 4. Thunderbird Blvd 2021 Synchro Model Output Results*

| Approach | V/C Ratio | Total Delay (s) | LOS | 95% Queue Length (m) |
|---|---|---|---|---|
| EBLT | 0.60 (0.53) [0.76] | 39.8 (37.8) [35.3] | D (D) [D] | 20.4 (27.3) [48.2] |
| EBTH | 0.22 (0.07) [0.17] | 24.3 (25.3) [17.8] | C (C) [B] | 14.5 (4.8) [10.8] |
| EBRT | 0.20 (0.30) [0.54] | 7.4 (8.1) [22.4] | A (A) [C] | 2.8 (4.8) [39.1] |
| WBLT | 0.62 (0.19) [0.53] | 38.1 (27.8) [37.8] | D (C) [D] | 23.6 (11.8) [23.7] |
| WBLT, WBTH | 0.54 (0.16) [0.32] | 29.7 (13.3) [22.3] | C (B) [C] | 25.2 (8.9) [12.0] |
| NBLT | 0.52 (0.23) [0.55] | 9.7 (5.1) [29.3] | A (A) [C] | 36.5 (12.8) [#32.3] |
| NBTH, NBRT | 0.62 (0.28) [0.39] | 10.9 (4.9) [11.7] | B (A) [B] | 92.8 (29.6) [59.7] |
| SBLT | 0.17 (0.10) [0.16] | 18.9 (11.7) [12.3] | B (B) [B] | 11.2 (7.5) [9.8] |
| SBTH | 0.36 (0.30) [0.49] | 17.9 (11.8) [13.7] | B (B) [B] | 57.0 (49.3) [70.0] |
| SBRT | 0.31 (0.15) [0.21] | 9.9 (6.4) [8.3] | A (A) [A] | 22.6 (12.3) [13.4] |
| Intersection | - | 17.6 (11.3) [19.8] | B (B) [B] | - |

*Table 5. Thunderbird Blvd 2050 Synchro Model Output Results*

| Approach | V/C Ratio | Total Delay (s) | LOS | 95% Queue Length (m) |
|---|---|---|---|---|
| EBLT | 0.75 (0.61) [0.95] | 47.9 (38.2) [55.7] | D (D) [E] | 26.3 (33.2) [#64.6] |
| EBTH | 0.23 (0.08) [0.19] | 21.0 (23.1) [16.2] | C (C) [B] | 17.1 (5.4) [12.3] |
| EBRT | 0.22 (0.33) [0.64] | 5.6 (6.7) [24.8] | A (A) [C] | 2.5 (4.5) [52.8] |
| WBLT | 0.67 (0.22) [0.61] | 35.4 (25.8) [38.3] | D (C) [D] | 28.8 (13.6) [28.7] |
| WBLT, WBTH | 0.58 (0.18) [0.37] | 27.1 (11.5) [22.5] | C (B) [C] | 30.7 (9.8) [14.9] |
| NBLT | 0.78 (0.39) [1.02] | 24.5 (7.8) [112.3] | C (A) **[F]** | #87.7 (19.5) [#54.1] |
| NBTH, NBRT | 0.91 (0.41) [0.58] | 29.9 (7.4) [17.1] | C (A) [B] | #200.2 (48.9) [97.6] |
| SBLT | 0.62 (0.16) [0.36] | 55.6 (15.6) [21.5] | E (B) [C] | #22.0 (10.8) [16.7] |
| SBTH | 0.62 (0.46) [0.73] | 27.2 (17.0) [22.3] | C (B) [C] | 78.1 (79.5) [114.2] |
| SBRT | 0.50 (0.23) [0.31] | 16.6 (9.8) [11.5] | B (A) [B] | 35.1 (20.5) [21.2] |
| Intersection | - | 28.0 (13.7) [30.7] | C (B) [C] | - |

Notation: AM (MD) [PM]

#: actual queue length may be longer. The values are still valid for design purposes.

m: queue lengths are metered out.

The HCM grades the LOS of a facility on a scale from A to F. All intersections with a LOS F have been bolded and highlighted in red. A review of the Synchro model results indicated that while most of the v/c ratios are below 1.0, a few movements, especially turning movements, do have a v/c ratio near or greater than 1.0.

## 7.4 Results

Table 5 above indicates the NB left hand turning movement having an LOS F in the 2050 model. This LOS is reasonable because of the competing green time between the eastbound (EB) movement and students departing from campus via Thunderbird Parkade in the evening. This can be adjusted by retiming the signal for the intersection to optimize the phases within this rush hour period.

The maximum queue length for the morning peak NB through movements are 92.8m and 200.2m for 2021 and 2050 respectively, given that the exclusive bus lane within the design will occur approximately 140m away from the Thunderbird Blvd intersection. Sample 2050 synchro model reports are provided for the AM and PM peak periods in Appendix D.

## 7.5 Limitations

The existing 2021 and 2050 design year models were coded in Synchro 6 without the exclusive bus lanes heading NB and SB. Operationally, the Synchro model results for through movements heading both NB & SB are expected to perform even better than the results provided in Tables 4 and 5. Other alternative options were considered such as transit signal preemption for transition, but it was determined that the current operations would be adequate for this design.

## 7.6 Sidra Modeling - 16th Ave

A sample Sidra model was developed for the 16th Ave and Wesbrook Mall intersection to determine existing queue lengths headed SB, but it was concluded that no geometric changes or lane changes would occur at the roundabout. A sample report for Sidra lane movements and results are provided in Appendix D.

# 8.0 Construction Works

## 8.1 Schedule

The construction schedule has been developed to minimize delays and reduce negative effects on traffic on Wesbrook Mall. Construction will begin with mobilization in June 2022, and continue on until March 2023. Mobilization for roadworks and the underpass will begin simultaneously, but excavation of the underpass will start only once the preceding road section is finished repaving. This reduces the time that Wesbrook Mall is closed, and allows for the simultaneous construction of both the roadworks and the underpass. The area's key dates for the completion of each stage are listed below in Table 6.:

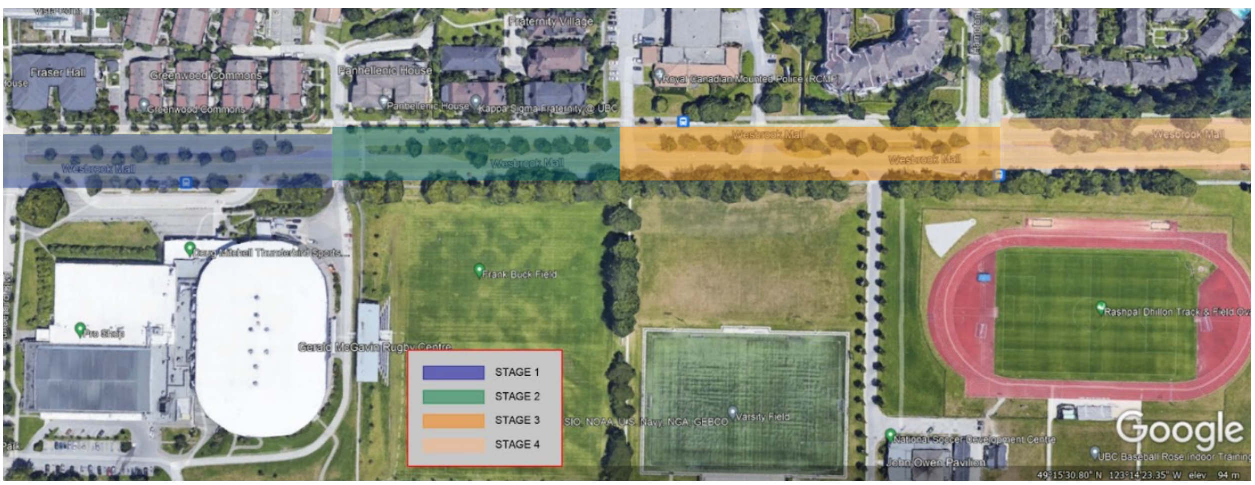


*Figure 14. Construction Phasing*

*Table 6. Construction Phasing Key Dates*

| Stage | Start | End |
|---|---|---|
| 1 | June 1, 2022 | July 1, 2022 |
| 2 | July 1, 2022 | October 1, 2022 |
| 3 | October 1, 2022 | December 1, 2022 |
| 4 | December 1, 2022 | February 2, 2023 |
| Cleanup and Demobilization | Feb 2, 2023 | March 15, 2023 |

See a full breakdown of the schedule in Appendix B.

## 8.2 Risks

Since Team 11 Consultants released the preliminary design report, changes in macroeconomic trends have caused significant changes to a few key risks. While factors such as safety, execution, and adverse weather are still just as harmful as they were previously, hazards relating to commodities prices, interest rates, or other macroeconomic factors have increased in both probability and impact.

## 8.3 Inflation

Russia's invasion of Ukraine, and subsequent sanctions imposed on them by western nations, has increased commodities prices drastically. The restrictions on Russian financial institutions makes it impossible to trade certain Russian exports, including items which are crucial to the construction industry such as crude oil, nickel, steel, iron, and other precious metals.

The current geopolitical crisis represents high volatility in global markets, and Team 11 Consultants is not confident in predictions of the prices of these goods in the short term. To mitigate the effects of uncertainty, we recommend the purchasing of futures contracts to secure prices of commodities. Due to the severe and current impacts of this volatility, we have assigned maximum probability and impact scores for this hazard.

## 8.4 Interest Rates

The United States Federal Reserve has announced its intention to aggressively raise interest rates to reduce spending and control inflation. The Bank of Canada has also signaled similar intentions. When interest rates increase, this will increase the cost of borrowing for all parties, thereby increasing cost of capital. The level of impact is dependent on the change in interest rates imposed, and as this rate is unpredictable. We have assigned a maximum probability and impact score to this hazard.

## 8.5 Risk Register and Matrix

Below is a risk register detailing the various risks discussed above, as well as a risk matrix showing the relative risk of each item.

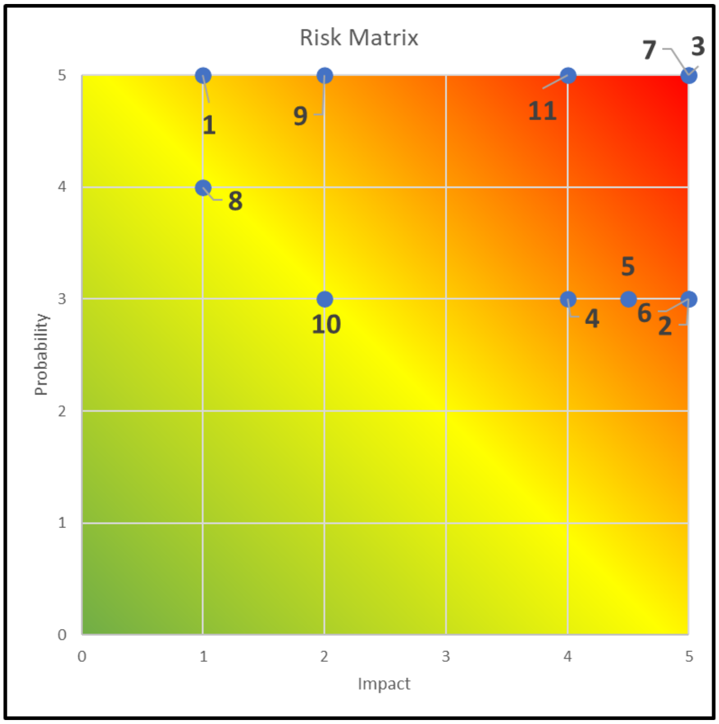


*Figure 15. Risk Matrix*

*Table 7. Risk Register*

| Item | Hazard | Impact | Probability Score | Impact Score | Risk Score |
|---|---|---|---|---|---|
| **1** | Project defaults on loans due to low cash flows | Project lockout and/or cancellation | 1 | 5 | 5 |
| **2** | Unexpected adverse weather conditions due to climate change | Delays levy heavy monetary costs and social costs due to increased public disruption | 5 | 3 | 15 |
| **3** | Increase in consumer price index during project | Cost of project increases | 5 | 5 | 25 |
| **4** | Increase in labor costs during project | Cost of project increases | 4 | 3 | 12 |
| **5** | Labor shortage during construction or operation | Halting or slowdown of activities, incurring high costs for owner | 4.5 | 3 | 13.5 |
| **6** | Bank of Canada increases interest rates | Increasing debt service raises project costs for owner | 5 | 3 | 15 |
| **7** | Unstable supply chain causes shortages to material or equipment | Halting or slowdown of activities, incurring high costs for owner | 5 | 5 | 25 |

| | | | | | |
|---|---|---|---|---|---|
| **8** | Public opposition to additional traffic | Delays or cancellation of project, leading to reputational and monetary losses | 1 | 4 | 4 |
| **9** | Poor implementation during EPC phase leading to unsafe designs or work conditions | Injury or death of project personnel or users | 2 | 5 | 10 |
| **10** | Shortage or mismanagement of project funds leads to bloated budget | Heavy costs for client and possible cancellation of project | 2 | 3 | 6 |
| **11** | Operational hazards due to construction flaws or user error | User safety threatened following project completion | 4 | 5 | 20 |

## 8.6 Class A Cost Estimate

The cost estimate was developed with consideration of the risks in Section 8.2. RSMeans Estimating Software containing standard costs of construction items was used to model cost. Revisions to the roadworks scope of work and green infrastructure yield a final construction cost of $4.5 million CAD, with an additional $130,000 in consulting fees, bringing the total to $4.7 million. This figure accounts for inflation, currency exchange rates, contractor markup, and bonds and insurance. Due to the factors mentioned above in Section 8.5, the contingency has been increased to 20%, up from 10%. A cost summary is shown below, and a full breakdown of project cost can be found in Appendix C.

*Table 8. Class A Cost Estimate Summary*

| Cost Summary | |
|---|---|
| Roadworks Cost | $1,271,235 |
| Underpass Cost | $297,970 |
| **Adjustments** | |
| Inflation | 1.376 |
| Currency | 1.28 |
| Contingency | 1.2 |
| Contractor Markup | 1.2 |
| Bonds and Insurance | 1.05 |
| Management and Permitting | 1.085 |
| Project Construction Cost | **$4,534,000** |
| Consulting Fees | **$130,000** |
| Final Project Cost | **$4,664,000** |

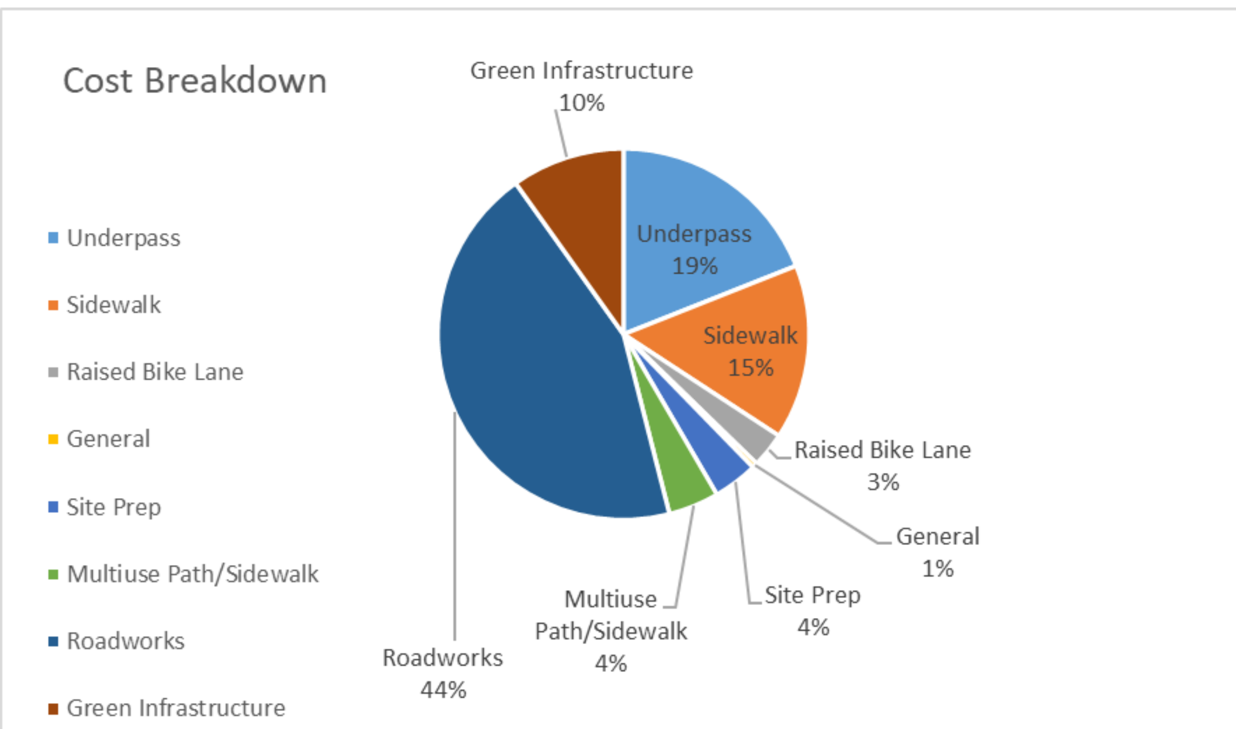


*Figure 16. Class A Cost Estimate Chart Breakdown.*

# 9.0 Life Cycle Analysis

Every engineering project has a wide range of environmental impacts, making it essential to understand the sources of those impacts to adopt proper mitigation policies. The Life Cycle Analysis (LCA) is a method used to assess the environmental impacts of the project throughout its life cycle. The life cycle stages included in this assessment are shown in the figure 17 below.

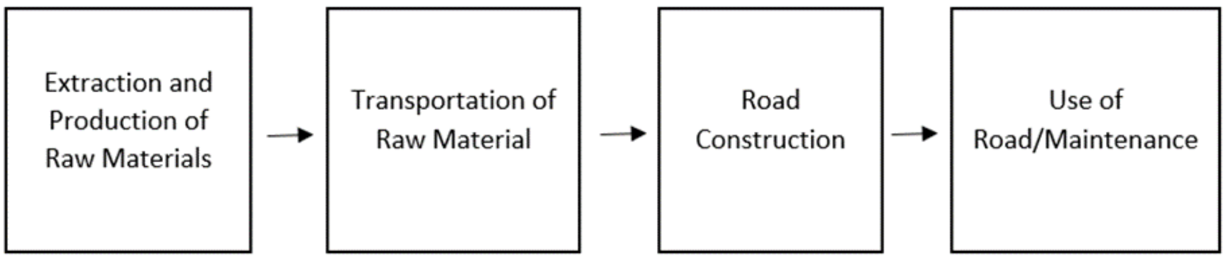


*Figure 17. Life Cycle Analysis Process*

*Table 9. Life Cycle Analysis Stages*

| LCA Stage | Description |
|---|---|
| Extraction and Production of Raw Materials | Impacts from extraction and production of construction materials |
| Transportation of Raw Material | Transportation of material and machines to construction Site |
| Road Construction | Impacts from on-site construction activities |
| Use of Road/Maintenance | Environmental impacts due to operations and maintenance |

In this LCA, the environmental impacts of each life-cycle stage are quantified based on the following categories:

*Table 10. LCA Impact Categories*

| Impact Category | Abbreviation | Unit of Measure |
|---|---|---|
| Global Warming Potential | GWP | kg $CO_2$ eq. |
| Acidification Potential of Soil and Water | AP | kg $SO_2$ eq. |
| Eutrophication Potential | EP | kg N eq. |
| Abiotic Depletion Potential (Fossil Fuel) | ADP | MJ |

The table below shows the life cycle components and the resulting impact categories.

*Table 11: LCA Results*

| Life Cycle Stage and Components | | | Impact Categories | | | |
|---|---|---|---|---|---|---|
| **Material Production** | | | **GWP** | **AP** | **EP** | **ADP** |
| **Roadworks** | **Input** | **Unit** | **Total kg $CO_2$ eq** | **Total kg $SO_2$ eq** | **Total kg N eq** | **Total MJ eq** |
| Asphalt | 2842 | m3 | 1.15E+06 | 1.03E+04 | 1.63E+02 | 4.81E+05 |
| Permeable Pavements (Sidewalk, Parking Pockets) | 230.2 | m3 | 5.15E+04 | 1.66E+02 | 6.16E+01 | 3.90E+04 |
| **Underpass** | **Input** | **Unit** | **Total kg $CO_2$ eq** | **Total kg $SO_2$ eq** | **Total kg N eq** | **Total MJ eq** |
| Steel | 22080 | kg | 4.03E+04 | 1.63E+02 | 1.38E+02 | 1.65E+04 |
| Concrete | 76.44 | m3 | 1.71E+04 | 5.52E+01 | 2.05E+01 | 1.29E+04 |
| **Material Transportation** | | | | | | |
| **Transportation of Materials** | **Input** | **Unit** | **Total kg $CO_2$ eq** | **Total kg $SO_2$ eq** | **Total kg N eq** | **Total MJ eq** |
| Transportation of concrete | 4500 | tkm | 4.11E+02 | 1.54E+00 | 4.38E-01 | 9.20E+02 |
| Transportation of steel | 7000 | tkm | 6.39E+02 | 2.40E+00 | 6.82E-01 | 1.43E+03 |
| Transportation of construction equipment | 2000 | tkm | 1.83E+02 | 6.86E-01 | 1.95E-01 | 4.09E+02 |
| **Construction** | | | | | | |
| **Road and Underpass Construction** | **Input** | **Unit** | **Total kg $CO_2$ eq** | **Total kg $SO_2$ eq** | **Total kg N eq** | **Total MJ eq** |
| Earthworks | 704 | hrs | 1.41E+00 | 6.68E-03 | 3.80E-04 | 2.83E+00 |
| Fill | 1408 | hrs | 6.15E+03 | 3.61E+01 | 5.81E+00 | 1.32E+04 |
| Underpass | 704 | hrs | 1.48E+06 | 8.67E+03 | 1.39E+03 | 3.16E+06 |
| **Use of Road/Maintenance** | | | | | | |
| **Operation and Maintenance** | **Input** | **Unit** | **Total kg $CO_2$ eq** | **Total kg $SO_2$ eq** | **Total kg N eq** | **Total MJ eq** |

| **Life Cycle Stage and Components** | | | **Impact Categories** | | | |
|---|---|---|---|---|---|---|
| Electricity for Annual Road Operation | 876 | kWh | 5.46E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Road Resurfacing | 240 | hrs | 1.05E+03 | 6.16E+00 | 9.91E-01 | 2.24E+03 |
| Waste | 2000 | kg | 9.62E+00 | 5.07E-02 | 1.48E-03 | 1.60E+01 |
| Transportation of waste | 1000 | tkm | 5.22E+02 | 3.01E+00 | 7.20E-01 | 1.08E+03 |

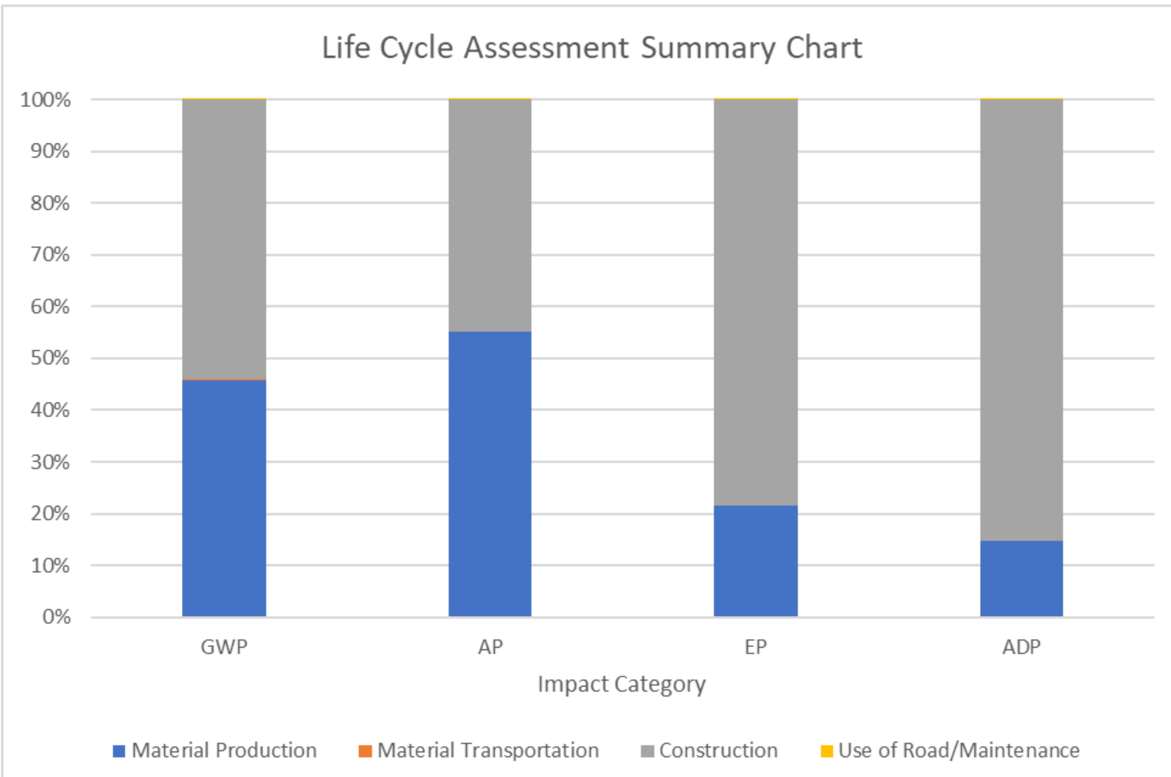


*Figure 18. LCA Summary Chart*

The results of the life cycle analysis shows that most of the environmental impacts originate from the construction process. This means that further measures need to be taken to minimize the environmental risks during construction. As such, contractors are expected to prepare an environmental assessment plan as part of the tendering process.

Furthermore, a maintenance plan was developed to extend the service life of the main components of the project. The operations and maintenance costs can be found in Appendix C. The table below provides a summary of the maintenance plan for the main components of the corridor such as the main road, green infrastructure, and the pedestrian underpass.

*Table 12. Maintenance Plan*

| Structure | Type of Work | Frequency |
|---|---|---|
| Road | Normal wear and tear (Potholes, minor cracks, paint damages on lane markings) | Annual or as needed |
| Road | De-icing, cleaning, tree trimming, road signage maintenance | Annual or as needed |
| Road | Road resurfacing | Every 20 years |
| Rain Garden | Trash and weed removal | Weekly |
| Rain Garden | Bioretention soil replacement | Every 2 years |
| Permeable Pavements (sidewalk and parking pockets) | Surface cleaning (high pressure water spraying and vacuum cleaning) | Weekly |
| Permeable Pavements (sidewalk and parking pockets) | Pavement Resurfacing | Every 20 years |
| Underpass | Structural Inspection | Annual |
| Underpass | Structural Maintenance | Every 5 years or as needed |
| Underpass | Cleaning and Graffiti Removal | Monthly or as needed |
| Underpass | Lighting Replacement and Maintenance | Every 6 months |
| Underpass | Pump maintenance | Monthly |

# 10.0 Additional Considerations

This report concludes Team 11's scope of work as requested by UBC SEEDS, which covers all the technical steps and considerations leading up to construction. Permits were not considered in this report due to the project's scale and its location on University Endowment Lands. However, it is recommended for the contractor to check with UBC SEEDS and applicable regulatory bodies prior to commencing construction to minimize lead times and prevent delays. Furthermore, Team 11 is willing to continue working alongside the selected contractor to overcome any unforeseen challenges. Additionally, Team 11 recommends UBC Seeds to continue conducting stakeholder consultation throughout the construction process to ensure that all stakeholder opinions and concerns are properly addressed.

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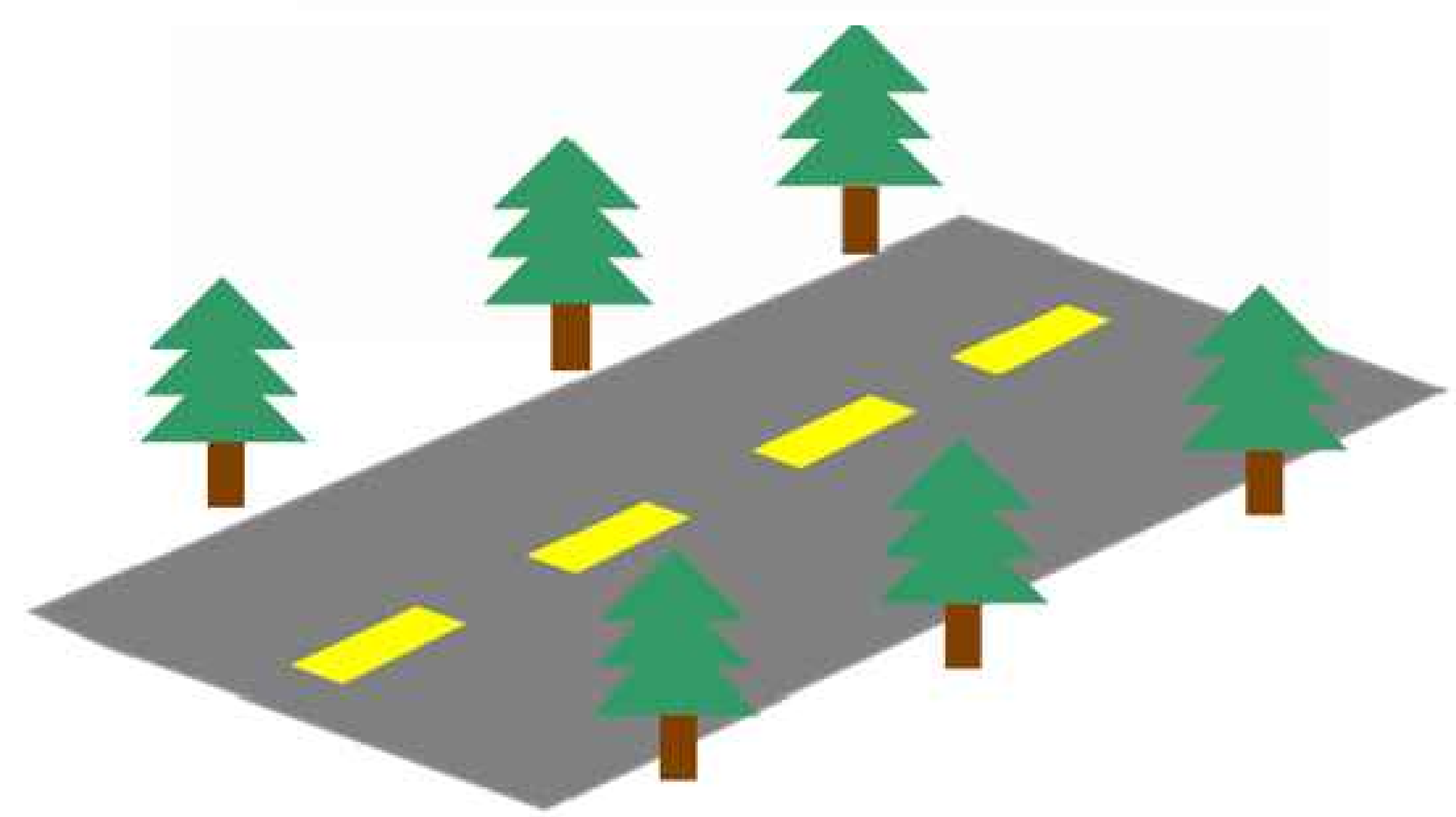
# WESBROOK MALL REDESIGN PHASE 4
# DETAIL DESIGN DRAWINGS

PREPARED BY: JOSHUA CHONG, SIMAR SIDHU, JOSH BIAN, GEORGE GU

**TEAM 11 CONSULTANTS**



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## 1. GENERAL NOTES

1. ALL CONSTRUCTION AND MATERIALS SHALL BE IN ACCORDANCE WITH THE CURRENT UNIVERSITY OF BRITISH COLUMBIA AND CONSTRUCTION DOCUMENTS, SPECIFICATIONS AND STANDARD DRAWINGS; CONSTRUCTION PLANS AND DRAWINGS; WORKSAFEBC REQUIREMENTS AND APPLICABLE CONTRACT DOCUMENTS AND ALL SPECIFICATIONS REFERENCED THERIN.
2. ALL APPLICABLE ON-SITE WORKS SHALL MEET THE REQUIREMENTS OF THE UNIVERSITY OF BRITISH COLUMBIA AND THE RELEVANT SECTIONS OF THE BC PLUMBING CODE.
3. THE CONTRACTOR SHALL MAINTAIN COPIES OF THE ABOVE DOCUMENTS ON SITE AND SHALL ENSURE THAT ALL TRADES ARE THOROUGHLY FAMILIAR WITH THE APPLICABLE SECTIONS OF THESE DOCUMENTS.
4. THE CONTRACTOR SHALL ENSURE THAT ALL APPROVALS REQUIRED FOR THE PROPOSED WORKS HAVE BEEN OBTAINED FROM ALL AUTHORITIES AND AGENCIES PRIOR TO COMMENCEMENT OF ANY CONSTRUCTION.
5. THE LOCATIONS OF EXISTING UNDERGROUND SERVICES HAVE BEEN DETERMINED FROM RECORD INFORMATION OBTAINED FROM UNIVERSITY OF BRITISH COLUMBIA AND OTHERS. THE CONTRACTOR SHALL VERIFY THE LOCATION AND ELEVATION OF ALL THE EXISTING SERVICES PRIOR DISCREPANCIES, CONFLICTS OR OMISSIONS.
6. THE CONTRACTOR SHALL USE EXTREME CARE WHEN WORKING NEAR EXISTING SERVICES. ANY SERVICES DISTRUSTED SHALL BE REPLACED TO THE SATISFACTION OF UNIVERSITY OF BRITISH COLUMBIA AND OTHER AGENCIES AT THE EXPENSE OF THE CONTRACTOR.
7. THE CONTRACTOR IS RESPONSIBLE FOR ALL MATERIALS TESTING. ALL TESTING SHALL BE CONDUCTED BY SUITABLY QUALIFIED FIRMS.
8. THE CONTRACTOR IS RESPONSIBLE FOR SAFETY IN AND ABOUT EH JOB SITE DURING CONSTRUCTION. THE CONTRACTOR SHALL MAINTAIN ADEQUATE BARRIERS AND CONSTRUCTION SIGNS TO PREVENT INJURY TO THE PUBLIC AND ALL PERSONNEL ON SITE.
9. THE CONTRACTOR SHALL CONDUCT A BC ONE CALL AND NOTIFY ALL APPROPRIATE PARTIES UNIVERSITY OF BRITISH COLUMBIA, BC HYDRO, AND AFFECTED UTILITY OWNERS, 48 HOURS PRIOR TO COMMENCING CONSTRUCTION. THE CONTRACTOR SHALL NOTIFY UNIVERSITY OF BRITISH COLUMBIA AND THE ENGINEER AT LEAST 48 HOURS IN ADVANCE OF COMMENCING CONSTRUCTION.
10. THE CONTRACTOR SHALL MAKE ALL NECESSARY ARRANGEMENTS, IF REQUIRED, FOR THE INSPECTION OF ALL REQUIRED UTILITY CONNECTIONS.
11. THE CONTRACTOR SHALL PROVIDE WRITTEN NATIVE TO ALL RESIDENTS AFFECTED BY CONSTRUCTION AT LEAST 48 HOURS PRIOR TO CONSTRUCTION. COPIES OF THE NOTICE SHALL BE PROVIDED TO UNIVERSITY OF BRITISH COLUMBIA AND THE ENGINEER.
12. CONTRACTOR SHALL PROVIDE UNIVERSITY OF BRITISH COLUMBIA WITH ALL "AS CONSTRUCTED" INFORMATION AND SUPPLY UNIVERSITY OF BRITISH COLUMBIA WITH AN INDEPENDENT TOPOGRAPHIC SURVEY OF "AS-BUILT" LOCATIONS OF THE SURFACE FEATURES INCLUDING BUT NOT LIMITED TO ELEVATIONS FOR MANHOLE RIMS AND INVERTS, WATER VALVE BOXES, HYDRANTS AND SERVICE LOCATIONS. THE DATA SHALL BE PROVIDED IN ELECTRONIC FORMAT ACCEPTABLE TO UNIVERSITY OF BRITISH COLUMBIA AND SHALL INCLUDE THE DATE OF SURVEY, SURVEYORS NAMES AND CONTACT INFORMATION.
13. TEMPORARY EXCAVATION FOR THE CONSTRUCTION OF UNDERGROUND SERVICES SHALL CONFORM TO WORKERS COMPENSATION BOARD INDUSTRIAL HEALTH AND SAFETY REGULATIONS. IF STEEPER SLOPES ARE REQUIRED, THEY SHALL BE REVIEWED BY A GEOTECHNICAL ENGINEER PRIOR TO WORKERS ENTERING THE EXCAVATION.
14. THE CONTRACTORS SHALL ENSURE THAT STREETS ARE KEPT CLEAN AND FREE OF EQUIPMENT AND MATERIAL AT ALL TIMES WHEN CONSTRUCTION ACTIVITY IS NOT UNDERWAY.

## 2. SURVEY

1. LEGAL AND TOPOGRAPHIC INFORMATION PROVIDED BY LIGMA SURVEYS.
2. GROUND ELEVATIONS WERE OBTAINED BY FIELD SURVEYS CONDUCTED ON JAN. 01, 2022 AND WERE DERIVED FROM UNIVERSITY OF BRITISH COLUMBIA CONTROL MONUMENT 69S4200 ELEVATION 81.231 NAD 24.
3. HORIZONTAL DISTANCES ARE GROUND-LEVEL DISTANCES UNLESS SPECIFIED OTHERWISE.
4. THE ACCURACY AND COMPLETENESS OF THE TOPOGRAPHIC DATA IS CONSIDERED SUFFICIENT FOR ENGINEERING DESIGN PURPOSES AND HAS NOT BEEN VERIFIED.
5. THE CONTRACTOR IS RESPONSIBLE FOR CONFIRMING THE ACCURACY AND COMPLETELY OF THE DATA PRIOR TO RELYING ON THE DATA FOR CONSTRUCTION PURPOSES.

## 3. EARTHWORKS AND GRADING

1. OBTAIN THE GEOTECHNICAL ENGINEER'S ACCEPTANCE OF THE MATERIAL PROPOSED FOR USE AS STRUCTURAL FILL MATERIAL PRIOR TO THE MATERIAL BEING DELIVERED TO THE SITE.
2. REMOVE VEGETATION AND ORGANIC MATERIAL AND ALL OTHER MATERIAL DEEMED UNSUITABLE BY THE GEOTECHNICAL ENGINEER, INCLUDING BUT NOT LIMITED TO BOULDERS AND WOOD WASTE, PRIOR TO PLACING STRUCTURAL FILL MATERIAL AND DISPOSE OFF-STIE AND AN APPROVED LOCATION THAT IS ACCEPTABLE TO UNIVERSITY OF BRITISH COLUMBIA.
3. OBTAIN THE GEOTECHNICAL ENGINEER'S ACCEPTANCE OF EXCAVATED SUBGRADES PRIOR TO PLACING STRUCTURAL FILL MATERIAL.
4. TRENCH BACKFILL IN AREAS THAT WILL BE PAVED OR OTHER SETTLEMENT-SENSITIVE AREAS SHALL CONSIST OF GRANULAR MATERIAL PLACED AND COMPACTED IN DISCRETE LIFTS OF MAXIMUM 300MM IN THICKNESS OR IN ACCORDANCE WITH THE GEOTECHNICAL ENGINEER'S REQUIREMENTS.
5. BACKFILL WITHIN PACED AREAS SHALL BE COMPACTED TO 95% MODIFIED PROCTOR DENSITY, OR IN ACCORDANCE WITH THE GEOTECHNICAL ENGINEER'S REQUIREMENTS. LANDSCAPE AREAS SHALL BE COMPACTED TO 90% MODIFIED PROCTOR DENSITY OR IN ACCORDANCE WITH THE GEOTECHNICAL ENGINEER'S REQUIREMENTS.
6. THE CONTRACTOR IS RESPONSIBLE FOR COMPACTION TESTING AND SHALL PROVIDE UNIVERSITY OF BRITISH COLUMBIA AND THE ENGINEER WITH EVIDENCE THAT COMPACTION OF SUBGRADE FILL MATERIAL AND GRANULAR MATERIALS MEETS PROJECT SPECIFICATIONS.

## 4. WATERWORKS

1. ALL WATERWORKS TO BE IN ACCORDANCE WITH MASTER MUNICIPAL SPECIFICATIONS SECTION 33 11 01 WATERWORKS AND THE RELEVANT SECTIONS OF THE BC PLUMBING CODE AND SHALL PASS THE INSPECTION OF THE UNIVERSITY OF BRITISH COLUMBIA PLUMBING INSPECTOR.
2. CONFIRM WATERMAIN WORKING PRESSURE WITH ENGINEER PRIOR TO CONSTRUCTION.
3. MINIMUM COVER ON MAINS SHALL BE 1.0M.
4. PIPE SHALL BE CEMENT MORTAR LINED DUCTILE IRON PIPE CONFORMING TO AWWA 151 PRESSURES CLASS 350. PUSH-ON JOINT HUBS SHALL BE PROVIDED WITH TIE-ROD LUGS. 300MM PIPE SHALL BE PROVIDED WITH A MINIMUM OF FOUR LUGS.
5. FITTINGS SHALL BE DUCTILE IRON CONFORMING TO AWWA C110 OR COMPACT DUCTILE IRON CONFORMING TO C153 AND CEMENT MORTAR LINED TO AWWA C104, SUITABLE FOR PRESSURE RATING OF 2415 KPA.
6. FATE VALVES SHALL BE CAST DUCTILE IRON BODY CONFORMING TO AWWA C500 OR DUCTILE IRON BODY CONFORMING TO AWWA C509 TO WORKING PRESSURE 1380 KPA, SOLID WEDGE RESILIENT-SEATED NON-RISING STEM.
7. JOINT RESTRAINTS SHALL BE UNI-FLANGE OR APPROVED EQUIVALENT SUITABLE FOR DUCTILE IRON PUSH-ON PIPE JOINTS.
8. A MINIMUM 3M HORIZONTAL DISTANCE SHALL BE MAINTAINED BETWEEN A WATERMAIN AND A SANITARY OR STORM SEWER. MAINTAIN A MINIMUM OF 0.5M VERTICAL CLEARANCE WHERE SEWERS CROSS WATERMAINS.
9. WATERMAIN PIPE JOINTS SHALL BE WRAPPED WHERE THE SEPARATION BETWEEN A WATERMAIN AND SANITARY OR STORM SEWER IS LESS THAN 3M. THE JOINTS SHALL BE WRAPPED WITH PETROLATUM TAPE, SUCH AS DENSO TAPE, OR APPROVED EQUIVALENT. MASTIC OR COMPOUND SHALL BE APPLIED TO EACH JOIN PRIOR TO WRAPPING. THE MASTIC SHALL BE DENSO PASTE OR APPROVED EQUIVALENT.
10. THE PIPE SURFACE SHALL BE CLEANED PRIOR TO APPLICATION OF THE MASTIC. THE MASTIC SHALL BE APPLIED TO ALL IRREGULAR SURFACES TO ENSURE THE SMOOTH APPLICATION OF TAPE.
11. TAPE SHALL BE WRAPPED OVER THE PREPARED SURFACE IN SMOOTH EVEN SPIRALS WITH AN OVERLAP OF 50,, FOR EACH SPIRAL. TENSION APPLIED DURING THE WRAPPING MUST NOT CAUSE STRETCHING OF THE TAPE. FOLDS AND AIR POCKETS SHALL BE PRESSED OUT BY HAND.
12. MATERIALS AND APPLICATION SHALL CONFORM TO AWWA C217, CURRENT VERSION.
13. DEFLECTION OF PIPE JOINTS SHALL NOT EXCEED ON-HALF MAXIMUM DEFLECTION SPECIFIED IN AWWA C600 OR ONE-HALF MAXIMUM DEFLECTION RECOMMENDED BY PIPE MANUFACTURER.
14. TESTING, FLUSHING AND CHLORINATION OF WATERMAINS SHALL BE IN ACCORDANCE WITH MASTER MUNICIPAL SPECIFICATIONS SECTION 33 11 01 WATERWORKS. THE CONTRACTOR IS RESPONSIBLE FOR ARRANGING FOR THE COLLECTION AND TESTING OF BACTERIOLOGICAL SAMPLES. UNIVERSITY OF BRITISH COLUMBIA OR THE CITY'S REPRESENTATIVE SHALL WITNESS THE TESTING AND COLLECTION OF THE SAMPLES. NOTIFY UNIVERSITY OF BRITISH COLUMBIA AND THE ENGINEER 48 HOURS IN ADVANCE OF TESTING. BACTERIOLOGICAL TESTING SHALL BE CONDUCTED BY A SUITABLY QUALIFIED TESTING LABORATORY. PROVIDE TEST RESULTS TO UNIVERSITY OF BRITISH COLUMBIA AND THE ENGINEER.
15. THE EXISTING WATER SUPPLY SYSTEM SHALL REMAIN IN OPERATION AND MAINTAINED AT ALL TIMES DURING THE PROJECT. THE CONTRACTOR SHALL PROVIDE ANY AND ALL BYPASS PIPING AND VALVES THAT MAY BE REQUIRED DURING TIE-IN TO AND COMMISSIONING OF THE NEW PUMP STATION.
16. THE NEW WATERMAINS, PUMP STATION, AND CHAMBERS MUST BE CONSTRUCTED, TESTED, COMMISSIONED AND ACCEPTED BY UNIVERSITY OF BRITISH COLUMBIA PRIOR TO CONNECTING THE EXISTING DISTRIBUTION SYSTEM TO THE NEW WORKS.
17. ON BEHALF OF THE CONTRACTOR UNIVERSITY OF BRITISH COLUMBIA AND THE ENGINEER WILL PROVIDE A MINIMUM OF 48 HOURS IN ADVANCE OF CLOSING ANY VALVES, DISCONNECTING ANY PIPE OR MAKING NEW CONNECTIONS.
18. THE CONTRACTOR SHALL PROVIDE UNIVERSITY OF BRITISH COLUMBIA AND THE ENGINEER WITH A WORK PLAN FOR TESTING AND COMMISSIONING OF THE NEW WATERMAINS AND PUMP STATION. THE PLAN SHALL DEMONSTRATE HOW THE WATER SUPPLY TO RESIDENTS WILL BE MAINTAINED AT ALL TIMES DURING THE PROJECT, INCLUDING DURING TESTING AND COMMISSIONING.

## 5. STORM SEWER

1. ALL STORM SEWER WORKS TO BE IN ACCORDANCE WITH MASTER MUNICIPAL SPECIFICATIONS SECTION 33 40 01 STORM SEWERS AND THE RELEVANT SECTIONS OF THE BC PLUMBING CODE AND SHALL PASS THE INSPECTION OF UNIVERSITY OF BRITISH COLUMBIA PLUMBING INSPECTOR.
2. UNLESS OTHERWISE NOTED MAINS SHALL BE PVC DR35 PIPE CONFORMING TO ASTM D2412 AND ASTM D3034 AND CERTIFIED TO CSA 182.2. MAINS 250MM OR GREATER MAY BE NON-REINFORCED CONCRETE CLASS 3 PIPE CONFORMING TO ASTM C14 WITH THE PIPE DESIGN FOR RUBBER GASKET JOINTS.
3. MANHOLES SHALL BE IN ACCORDANCE WITH MASTER MUNICIPAL SPECIFICATIONS SECTION 33 44 01 MANHOLES AND CATCHBASINS. UNLESS OTHERWISE NOTED MANHOLES SHALL BE 1050MM DIAMETER CONFORMING TO ASTM C478 WITH FRAME AND COVER TO ASTM A48 AND SUITABLE FOR H20 LOADING.
4. CATCHBASINS SHALL BE 600MM DIAMETER WITH FRAME AND GRATE SUITABLE FOR H20 LOADING AND SHALL BE IN ACCORDANCE WITH MASTER MUNICIPAL SPECIFICATIONS SECTION 33 44 01 MANHOLES AND CATCHBASINS.
5. CATCH BASIN LEADS SHALL BE 150MM PVC DR28 CONFORMING TO ASTM D3034 AND CERTIFIED TO CSA 182.2.

## 6. ROADWORKS

1. ALL ROADWORKS SHALL BE IN ACCORDANCE WITH MASTER MUNICIPAL SPECIFICATIONS SECTIONS: 31 22 16 RESHAPING GRANULAR ROADBED, 32 11 23 GRANULAR BASE, 32 11 16.1 GRANULAR SUBBASE, AND 31 22 16.1 RESHAPING EXISTING SUBGRADE.
2. OBTAIN THE GEOTECHNICAL ENGINEER'S ACCEPTANCE OF EXCAVATED AND CONSTRUCTED SUBGRADES PRIOR TO PLACING ANY GRANULAR MATERIALS.
3. ALL AGGREGATE MATERIALS SHALL BE IN ACCORDANCE WITH MASTER MUNICIPAL SPECIFICATIONS SECTION 31 05 17 AGGREGATES AND GRANULAR MATERIALS.
4. SUBGRADE AND GRANULAR BASE MATERIALS SHALL BE COMPACTED TO 95% MODIFIED PROCTOR DENSITY OR IN ACCORDANCE WITH THE GEOTECHNICAL ENGINEER'S REQUIREMENTS.
5. THE CONTRACTOR IS RESPONSIBLE FOR COMPACTION TESTING AND SHALL PROVIDE EVIDENCE THAT COMPACTION OF GRANULAR MATERIALS MEETS PROJECT SPECIFICATIONS. ALL TESTING SHALL BE CONDUCTED BY A SUITABLY QUALIFIED FIRM.
6. ASPHALT PACING SHALL BE IN ACCORDANCE WITH MASTER MUNICIPAL SPECIFICATIONS SECTION 21 12 16 HOT-MIX ASPHALT CONCRETE PAVING. IF THE ASPHALT PAVING IS PLACED IN TWO LAYERS, THE MIX TYPE SHALL BE MASTER MUNICIPAL SPECIFICATIONS LOWER COURSE #2 FOR BASE COURSE AND UPPER COURSE #2 FOR SURFACE COURSE. IF THE ASPHALT PAVEMENT WILL BE PLACED IN A SINGLE LAYER THE MIX TYPE SHALL BE MASTER MUNICIPAL SPECIFICATIONS UPPER COURSE #2.
7. THE CONTRACTOR SHALL PROVIDE UNIVERSITY OF BRITISH COLUMBIA AND THE ENGINEER WITH A MIX DESIGN AND TRIAL MIX TEST RESULTS FOR THE ASPHALTIC CONCRETE THE CONTRACTOR INTENDS TO PLACE A MINIMUM OF 14 DAYS PRIOR TO PAVING.
8. THE CONTRACTOR IS RESPONSIBLE FOR ASPHALT TESTING AND SHALL PROVIDE UNIVERSITY OF BRITISH COLUMBIA AND THE ENGINEER WITH EVIDENCE THAT THE THICKNESS AND PROPERTIES OF THE FINISHED PAVING MEETS PROJECT SPECIFICATIONS AND MIX DESIGN VALUES.
9. THE CONTRACTOR SHALL CONFIRM THE ADEQUACY OF THE PAVEMENT STRUCTURE INDICATED FOR PAVED AREAS AND ROADWAYS WITH THE GEOTECHNICAL ENGINEER PRIOR TO PLACING SUBBASE GRAVELS.
10. ALL VALVE BOXES, MANHOLES ETC. LOCATED IN PAVED AREAS SHALL BE ADJUSTED TO FINISHED GRADE PRIOR TO PAVING.

## 7. EROSION AND SEDIMENT CONTROL

1. THE CONTRACTOR SHALL IMPLEMENT EROSION AND SEDIMENT CONTROL MEASURES DURING CONSTRUCTION OF THE WORKS. EROSION AND SEDIMENT CONTROL SHALL BE IN ACCORDANCE WITH UNIVERSITY OF BRITISH COLUMBIA REQUIREMENTS
2. THE CONTRACTOR SHALL PROVIDE UNIVERSITY OF BRITISH COLUMBIA 24 HOUR EMERGENCY CONTACT NAMES AND TELEPHONE NUMBERS PRIOR TO COMMENCING CONSTRUCTION ACTIVITIES.
3. ALL WORK SHALL BE UNDERTAKEN AND COMPLETED IN SUCH A MANNER AS TO PREVENT THE RELEASE OF SEDIMENT LADEN WATER INTO ANY WATER COURSE, STORM SEWER OR DRAINAGE SYSTEM. NO SEDIMENT LADEN WATER SHALL BE PUMPED OR OTHERWISE DISCHARGED DIRECTLY TO A WATER COURSE, STORM SEWER OR DRAINAGE SYSTEM IN A MANNER THAT BYPASSES SEDIMENTATION CONTROL FACILITIES.
4. THE CONTRACTOR IS RESPONSIBLE FOR INSTALLING EROSION AND SEDIMENT CONTROL PRIOR TO COMMENCING CONSTRUCTION ACTIVITIES.
5. THE CONTRACTOR IS RESPONSIBLE FOR MONITORING AND MAINTAIN ALL EROSION AND SEDIMENT CONTROL WORKS IN PROPER OPERATING CONDITION.
6. THE EROSION AND SEDIMENT CONTROL WORKS SHALL BE INSPECTED ON A WEEKLY BASIS. THE INSPECTIONS SHALL BE RECORDED IN A LOG BOOK. THE LOG BOOK SHALL BE MADE AVAILABLE TO UNIVERSITY OF BRITISH COLUMBIA UPON REQUEST. DURING PERIODS OF SIGNIFICANT RAINFALL, ADDITIONAL INSPECTIONS, INCLUDING ON WEEKENDS, SHALL BE PERFORMED TO ENSURE SEDIMENT CONTROL WORKS ARE FUNCTIONING PROPERLY.
7. SEDIMENT REMOVED FROM THE EROSION AND SEDIMENT CONTROL WORKS SHALL BE DISPOSED OF IN A MANNER THAT PREVENTS ITS RE-ENTRY INTO THE SITE DRAINAGE SYSTEM AND/OR ANY STORM SEWER SYSTEM OF WATER COURSE.
8. INSTALL SEDIMENT BARRIERS AT CATCH BASINS OR OTHER DRAINAGE FACILITIES LOCATED WITHIN THE PROJECT SITE AND OUTSIDE OF THE PROJECT SITE THAT ARE NEAR THE WORK AREA PRIOR TO COMMENCING CONSTRUCTION ACTIVITIES.
9. A STABILIZED CONSTRUCTION ENTRANCE CONSISTING OF 75MM CLEAR CRUSH ROCK UNDERLAIN BY ARMTEX 250 FILTER CLOTH, OR APPROVED EQUIVALENT, SHALL BE INSTALLED AT ALL CONSTRUCTION ENTRANCES TO PREVENT VEHICLES FROM TRACKING MATERIAL OFF THE SITE. IF MATERIAL CONNECT BE REMOVED FROM VEHICLES LEAVING THE SITE, THE CONTRACTOR SHALL INSTALL A WHEEL WASH.
10. ROADWAYS, WHETHER PUBLIC OR PRIVATE, USED BY CONSTRUCTION-RELATED VEHICLES AND EQUIPMENT TO ACCESS THE SITE SHALL BE SWEPT DAILY. MECHANICALLY SWEEP CLEAN ROADWAYS FOR DURATION OF THE CONSTRUCTION PROGRAM. DO NOT SWEEP OR WASH SEDIMENT INTO CATCH BASINS, MANHOLES, DITCHES OR SWALES.
11. STOCKPILED MATERIAL SHALL BE COVERED WITH 6MIL POLYETHYLENE SHEETING. THE SHEETING SHALL BE SECURED IN A PLACE IN MANNER THAT PREVENTS THE STOCKPILED MATERIAL FROM BEING EXPOSED TO THE ELEMENTS.
12. USE DUST CONTROL MEASURES TO REDUCE DUST GENERATED BY CONSTRUCTION ACTIVITIES, EXCAVATED AREAS SHALL BE SPRINKLED UNTIL DAMP OR AT THE DISCRETION OF THE ENGINEER. DO NOT OVER WATER AS TO CREATE RUNOFF.
13. THE CONTRACTOR SHALL ENSURE THAT THE TOTAL SUSPENDED SOLIDS OF THE WATER DISCHARGING FROM THE PROJECT SITE ARE AT ALL TIMES THAN 75MG/L WITH PH BETWEEN 6 AND 9
14. FAILURE TO IMPLEMENT EROSION AND SEDIMENT CONTROL OR COMPLY WITH EROSION AND SEDIMENT CONTROL REQUIREMENTS MAY RESULT IN A STOP WORK ORDER.

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QUALITY ASSURANCE Josh Bian DATE 2022-03-26
DRAWN Joshua Chong DATE 2022-03-26

WESBROOK MALL REDESIGN
PHASE 4
GENERAL NOTES - CONSTRUCTION SPECIFICATIONS

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| 01 | 1228 | R | - | B |


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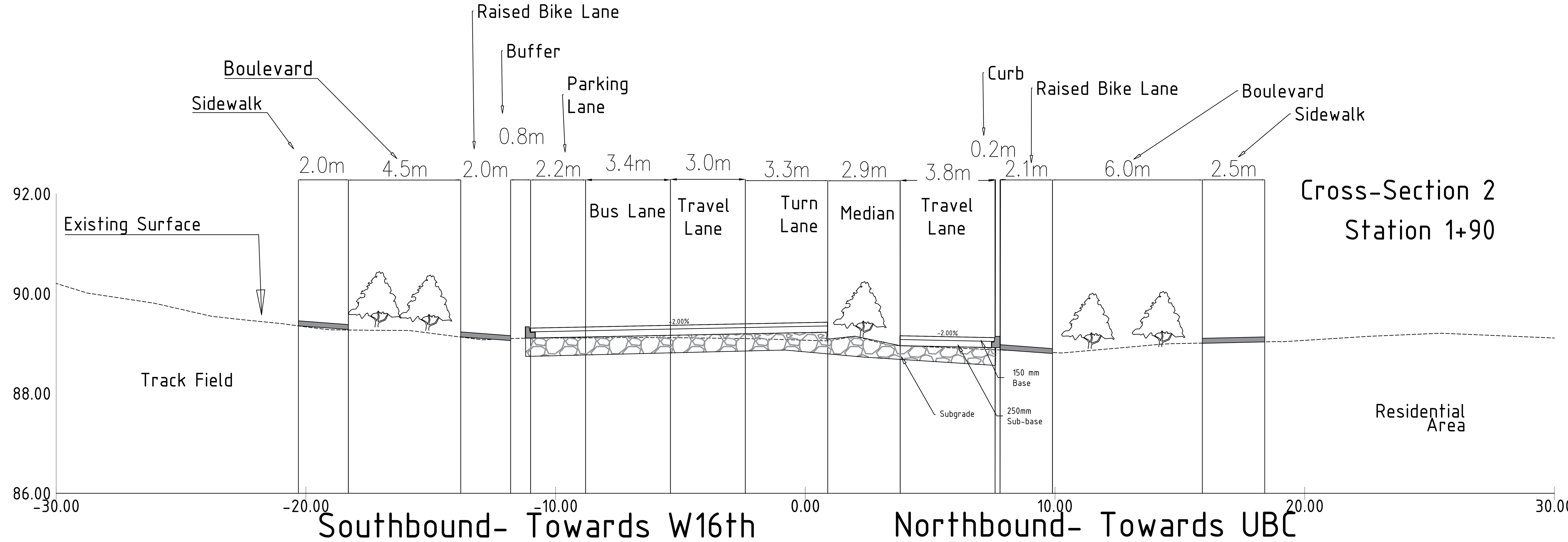
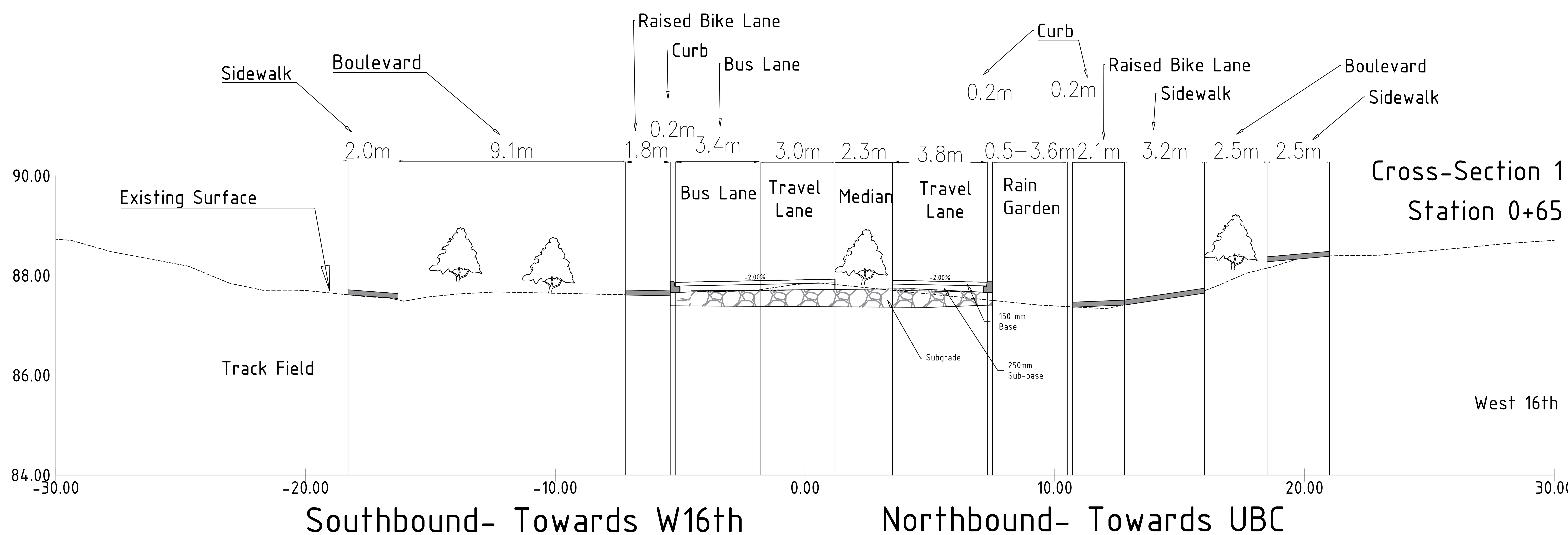



Cross-Section 2
Station 1+90




Cross-Section 1
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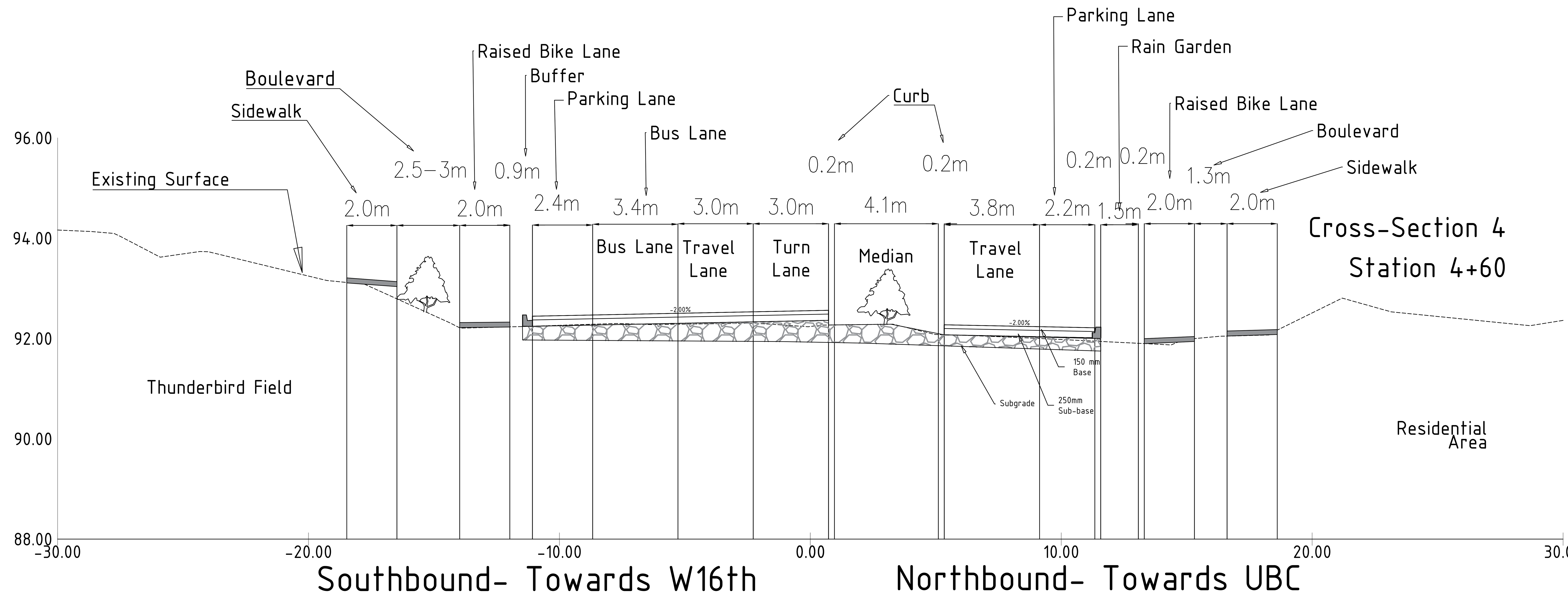


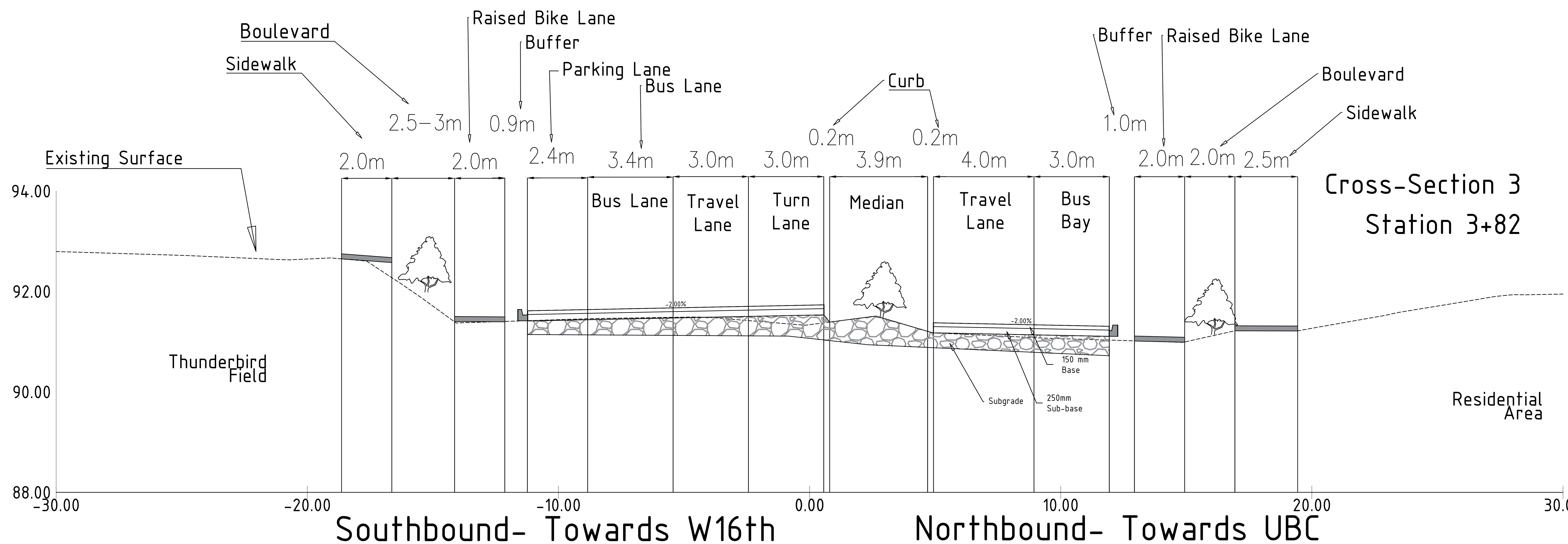


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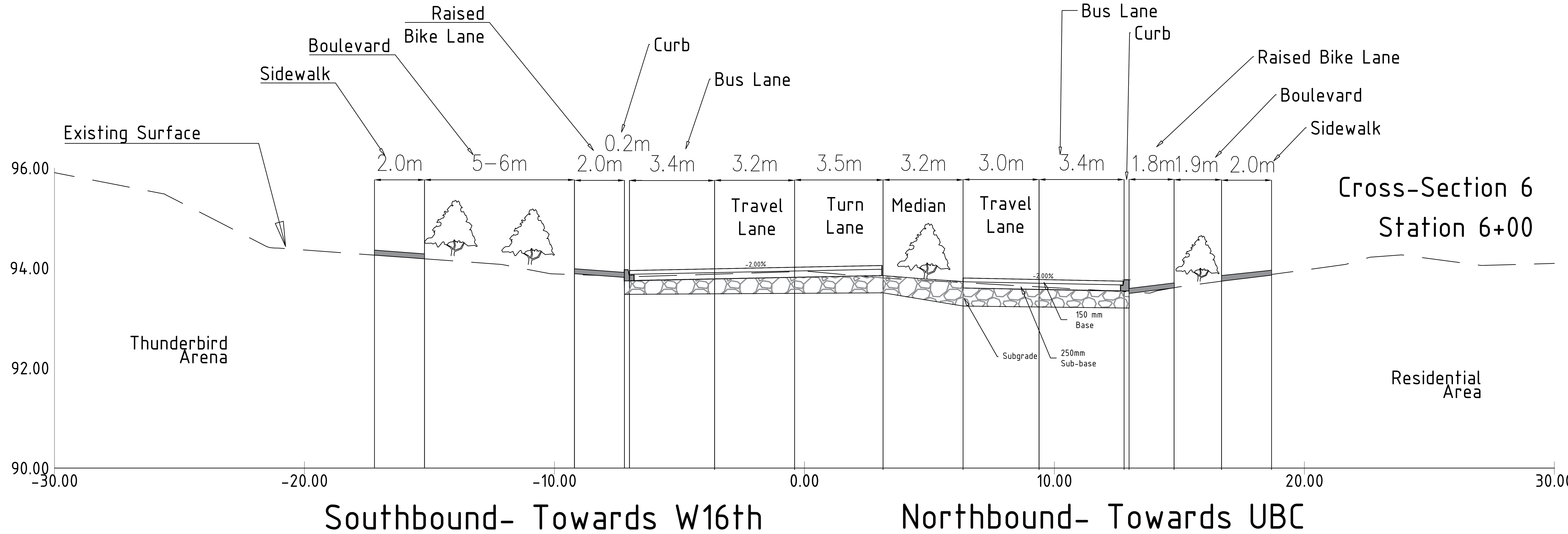


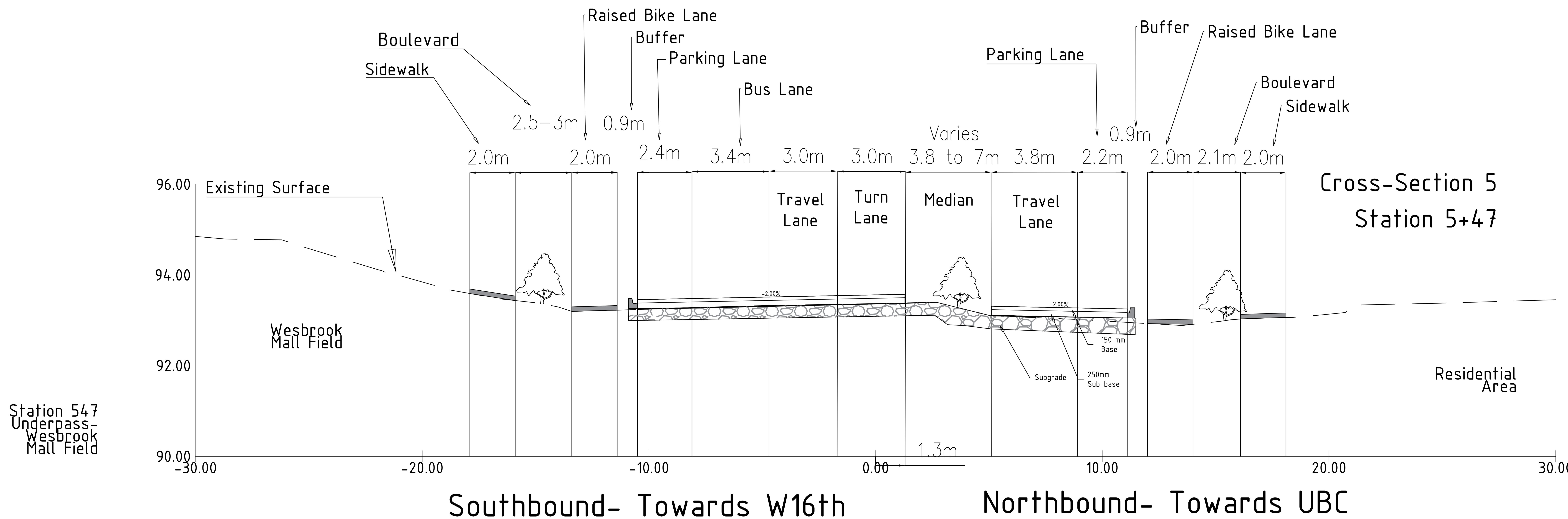


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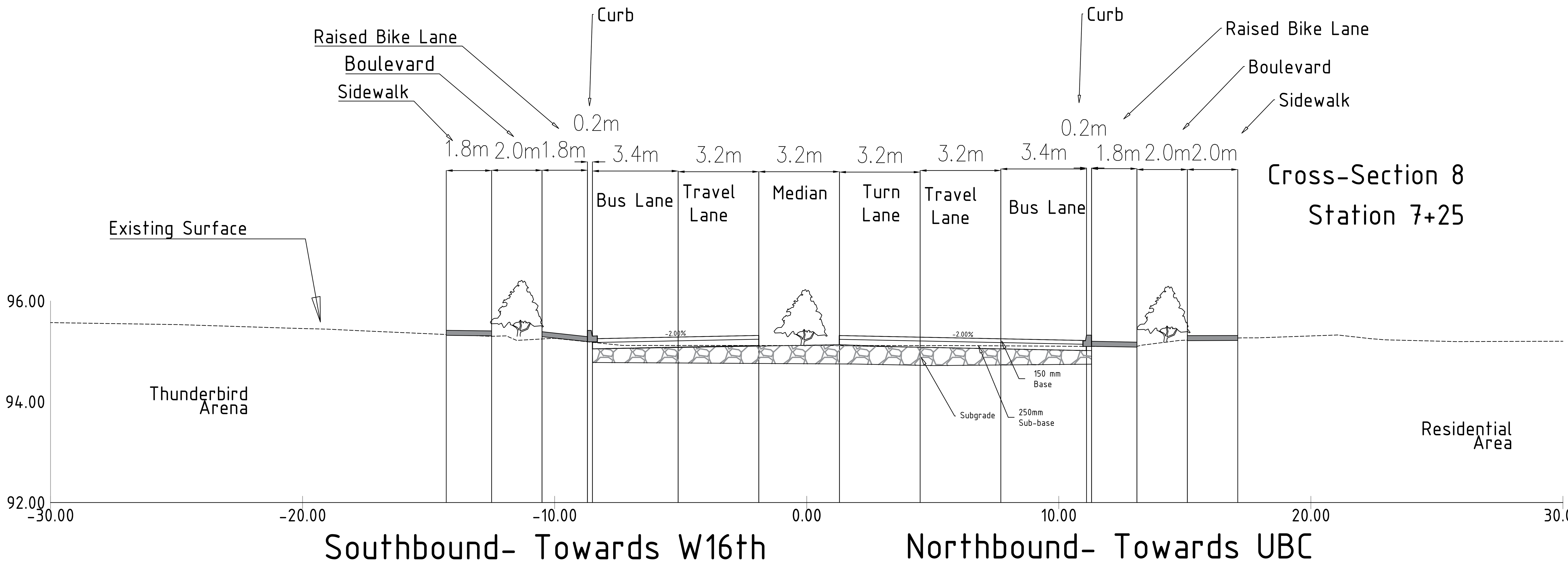


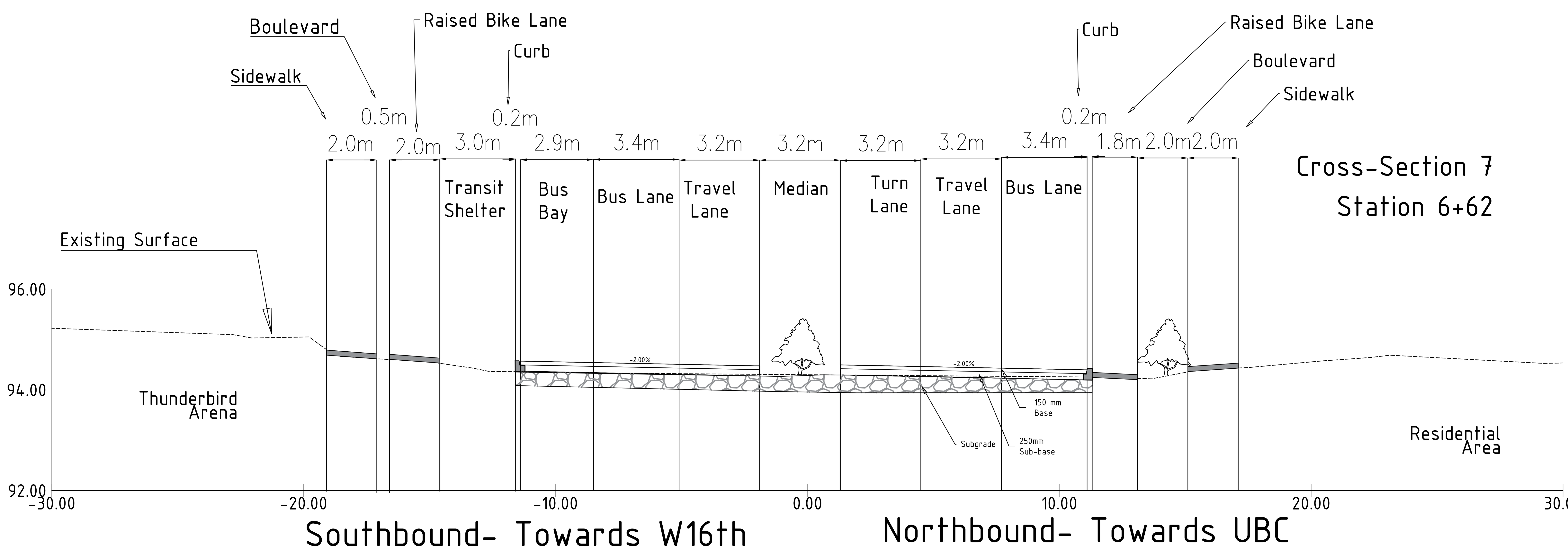


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WESBROOK MALL REDESIGN
PHASE 4
Wesbrook Mall Plan

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 9 | B |


"BY SEALING AND SIGNING THIS DRAWING, I CERTIFY THAT THE INFORMATION CONTAINED IN THESE ACCURATELY REFLECTS THE ORIGINAL DESIGN, ADDENDA, CHANGE ORDERS AND MATERIAL DESIGN CHANGES MADE DURING CONSTRUCTION AND FIELD REVIEWED BY ME, OR MY REPRESENTATIVE, AND THAT THE AS-CONSTRUCTED WORKS SUBSTANTIALLY COMPLY WITH THE ORIGINAL DESIGN INTENT. HOWEVER, I DO NOT ACCEPT RESPONSIBILITY OF THE ACCURACY OR COMPLETENESS OF THE AS-CONSTRUCTED INFORMATION SUPPLIED BY OTHERS CONTAINED IN THESE DRAWINGS."

ISSUED FOR CONSTRUCTION
2022-03-26

UBC sustainability

SCALE 0 2 1:200 10m

CAD FILENAME Wesbrook Mall Phase 4
DATE 2022-03-26

| REV | DATE | REVISIONS | SIGNATURE |
|---|---|---|---|
| 1 | 2021-11-23 | ISSUED FOR PRELIMINARY DESIGN | |
| 2 | 2022-03-26 | ISSUED FOR CONSTRUCTION | |
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TEAM 11 CONSULTANTS

SENIOR DESIGNER
DATE 2022-03-26

DESIGNED Simar Sidhu DATE 2022-03-26
QUALITY CONTROL Alivn Lok DATE 2022-03-26
QUALITY ASSURANCE Josh Bian DATE 2022-03-26
DRAWN Simar Sidhu DATE 2022-03-26

WESBROOK MALL REDESIGN
PHASE 4
Wesbrook Mall Plan

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
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| 01 | 1228 | R | 10 | B |


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WESBROOK MALL REDESIGN
PHASE 4
Wesbrook Mall Plan

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WESBROOK MALL REDESIGN
PHASE 4
Wesbrook Mall Plan

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 12 | B |


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PHASE 4
Wesbrook Mall Plan

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WESBROOK MALL REDESIGN
PHASE 4
Wesbrook Mall Plan

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| 01 | 1228 | R | 14 | B |


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WESBROOK MALL REDESIGN
PHASE 4
Wesbrook Mall Signage Plan

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 15 | B |


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WESBROOK MALL REDESIGN
PHASE 4
Wesbrook Mall Signage Plan

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| 01 | 1228 | R | 16 | B |


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WESBROOK MALL REDESIGN
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WESBROOK MALL REDESIGN
PHASE 4
Wesbrook Mall Signage Plan

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
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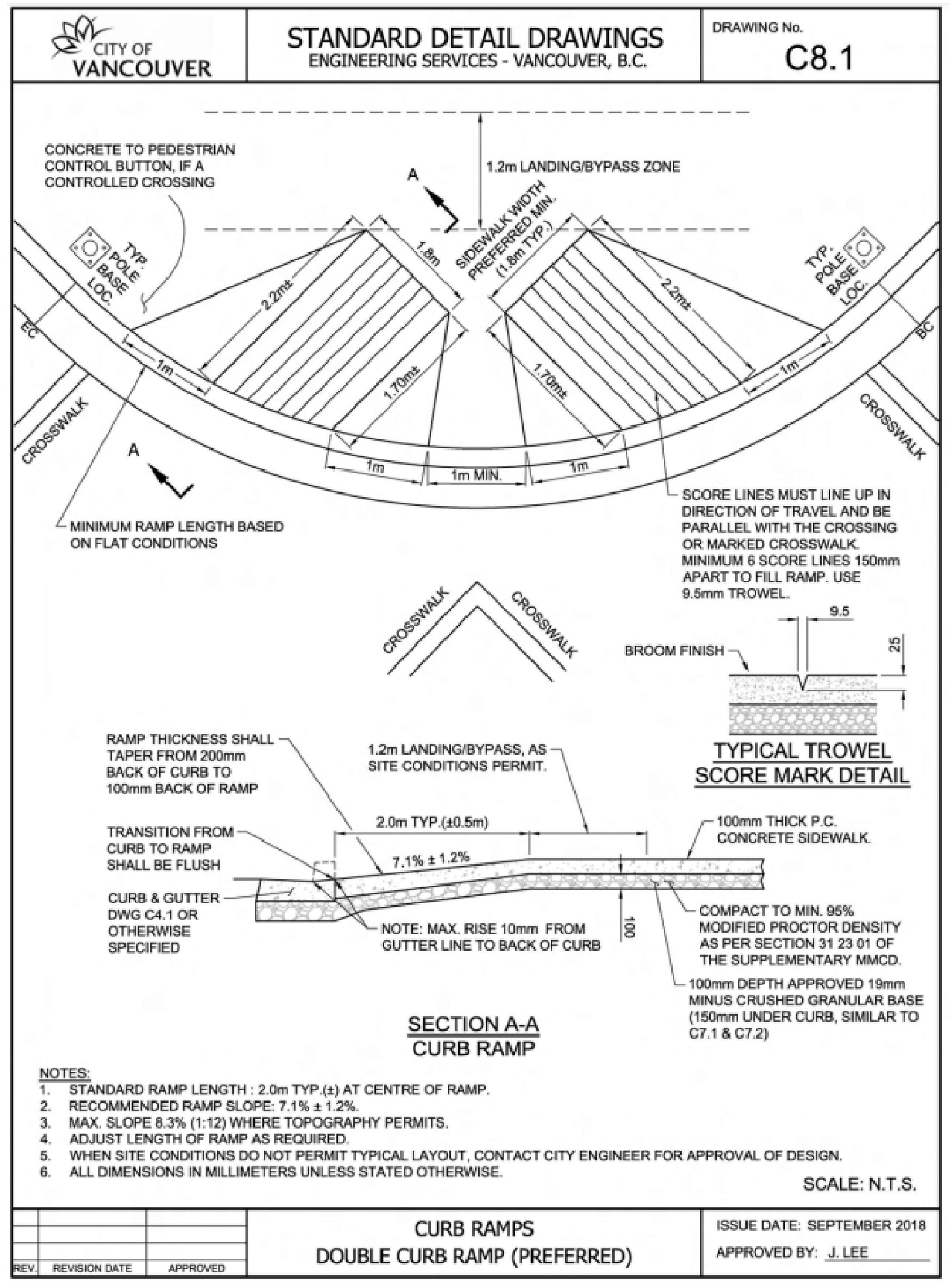
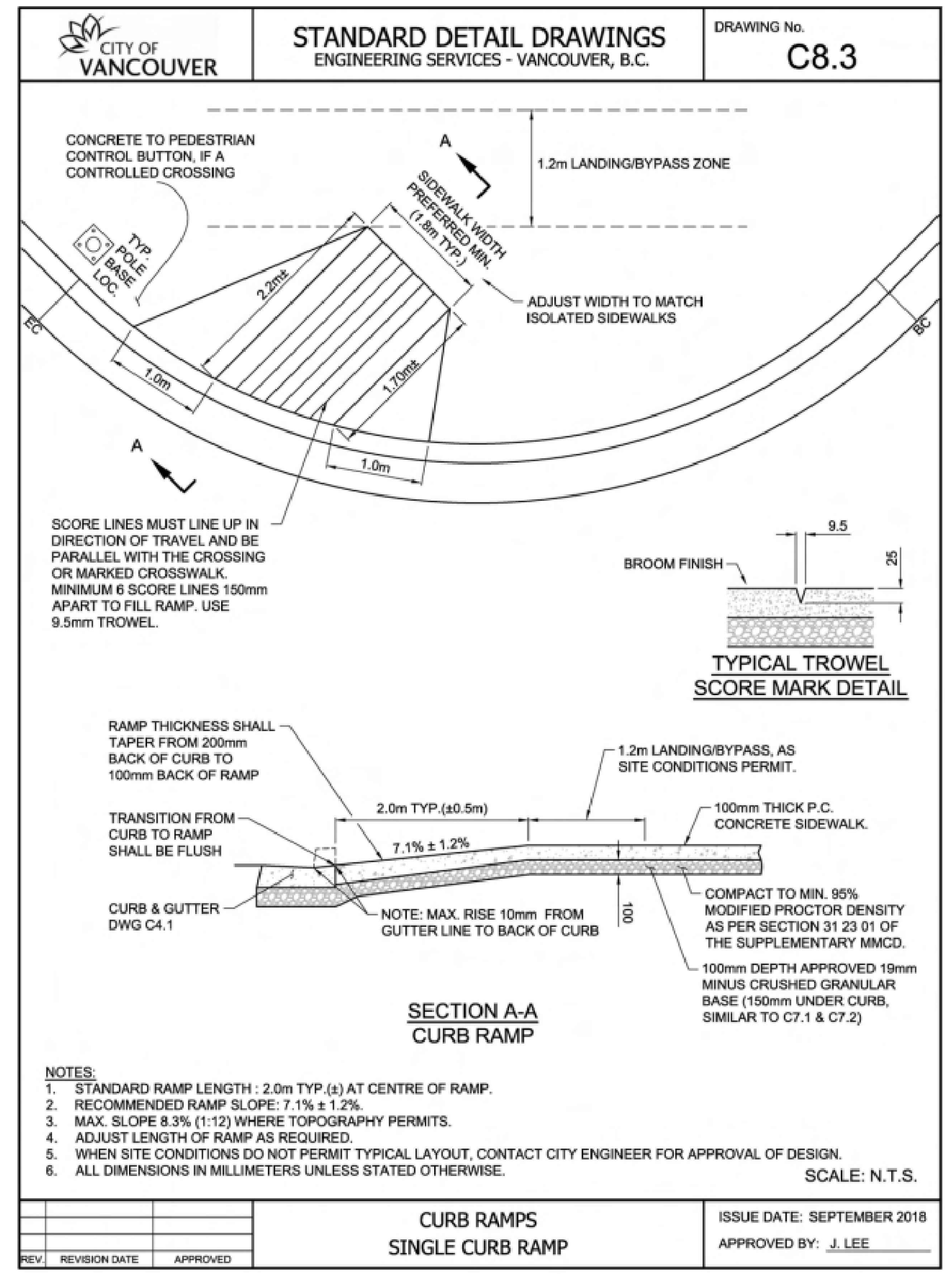
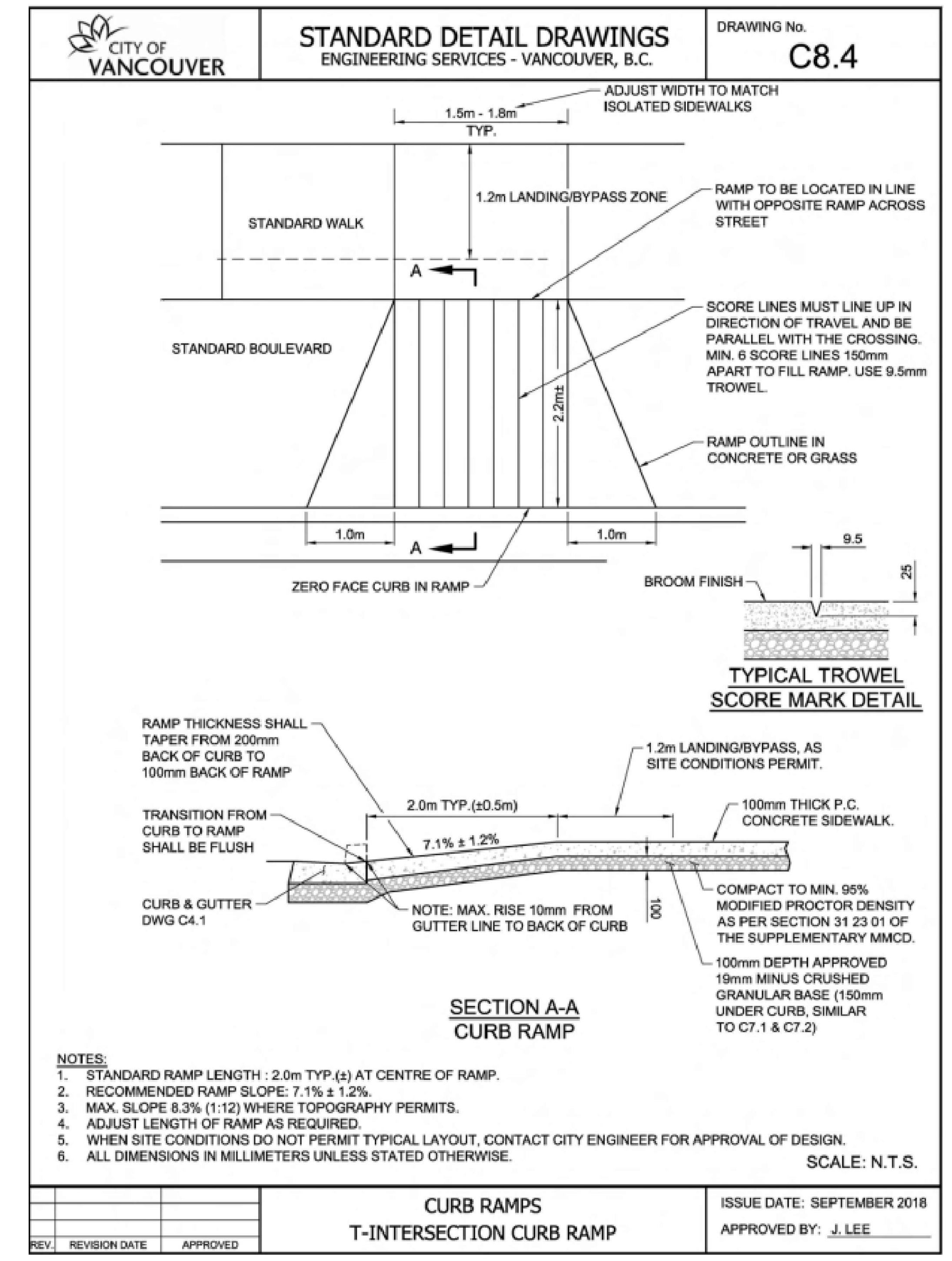
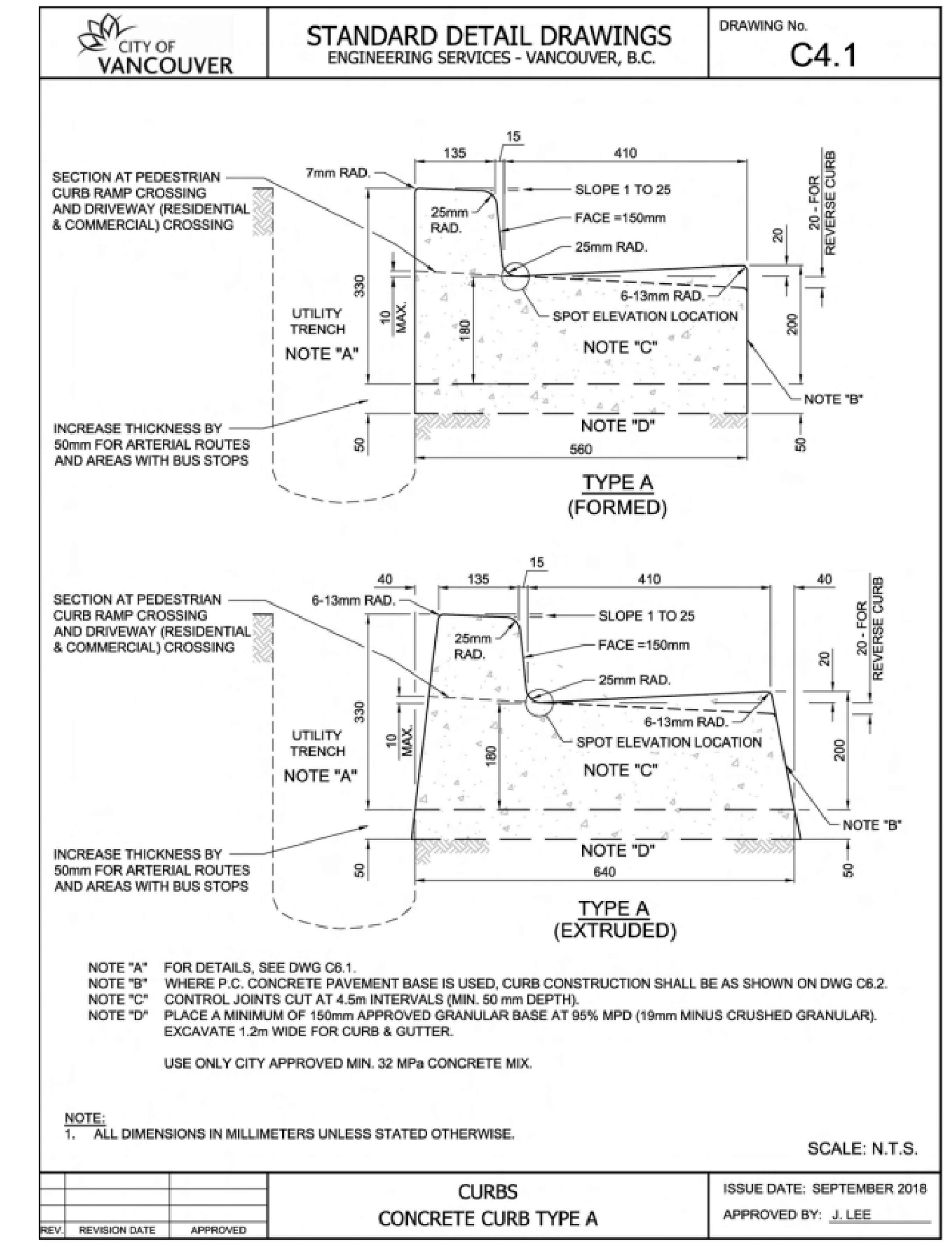
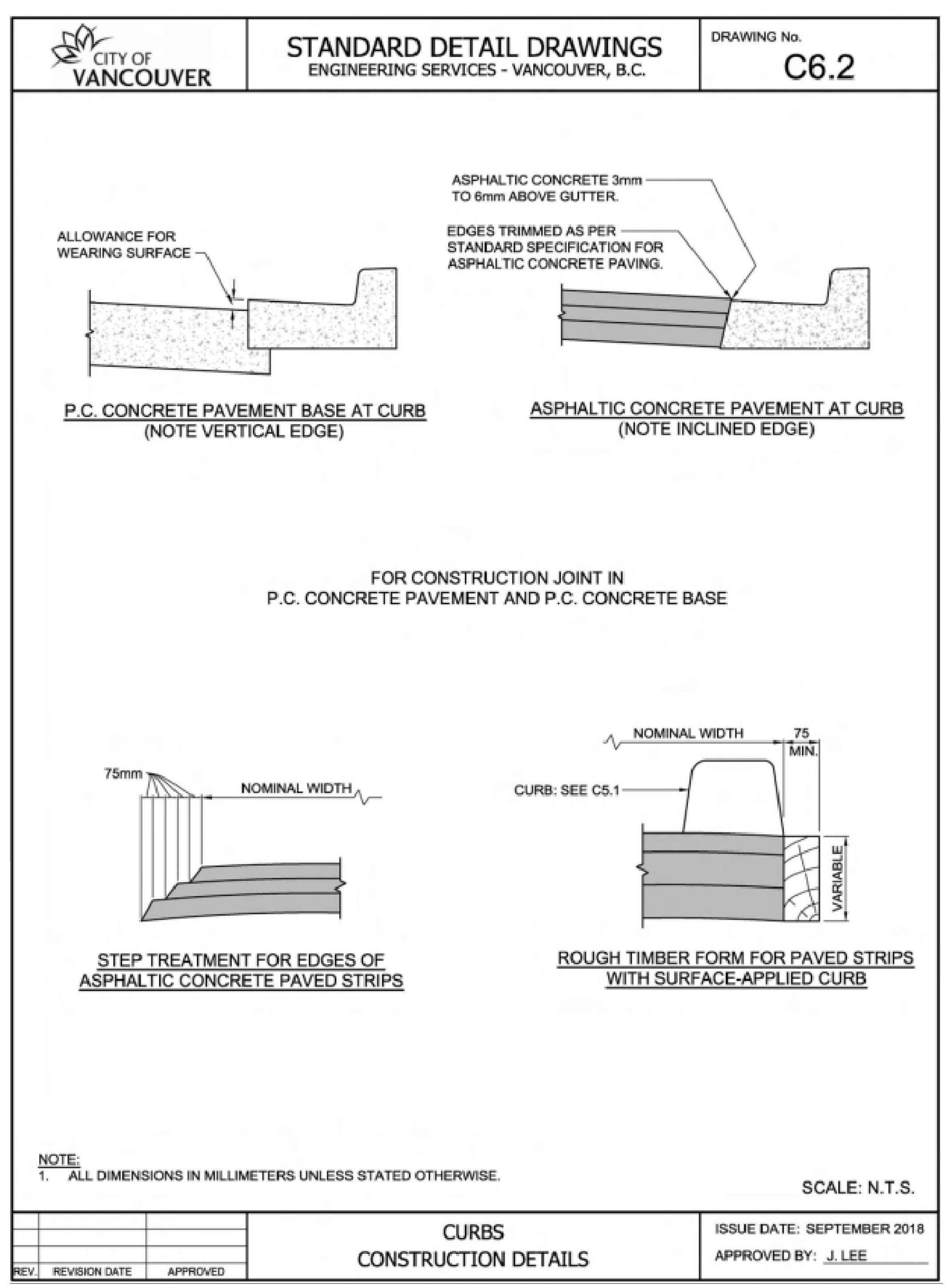
| 01 | 1228 | R | 19 | B |

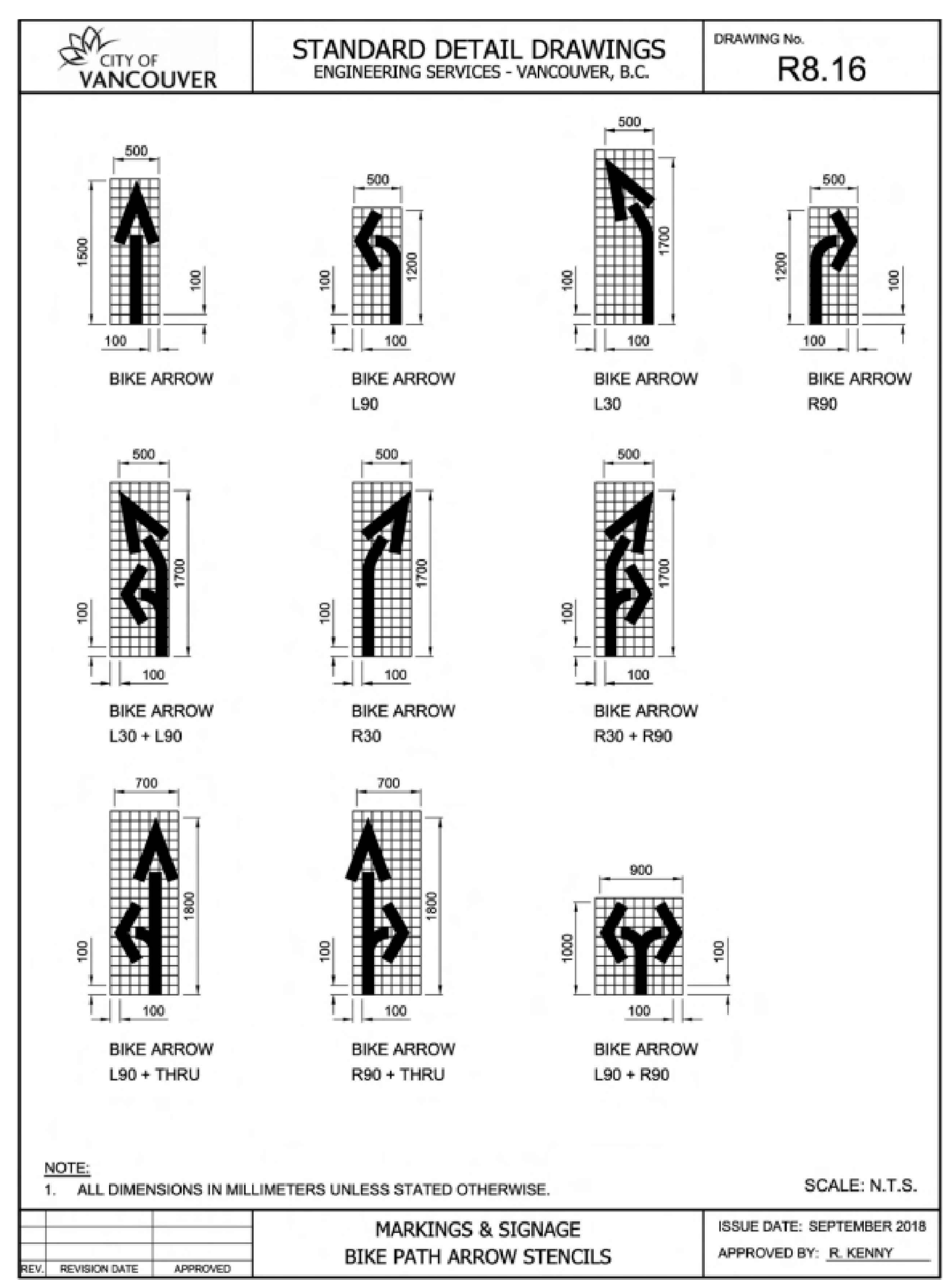


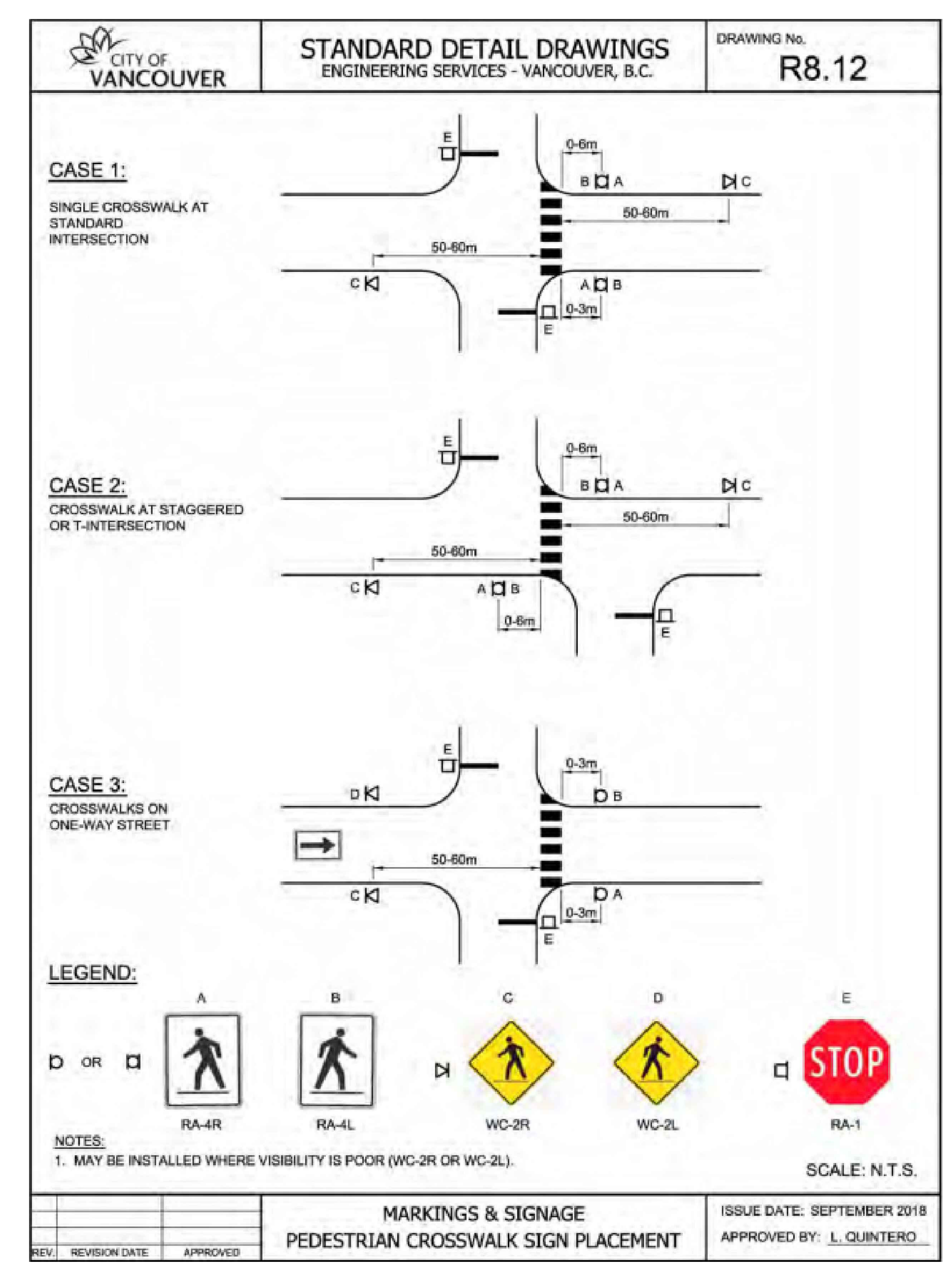



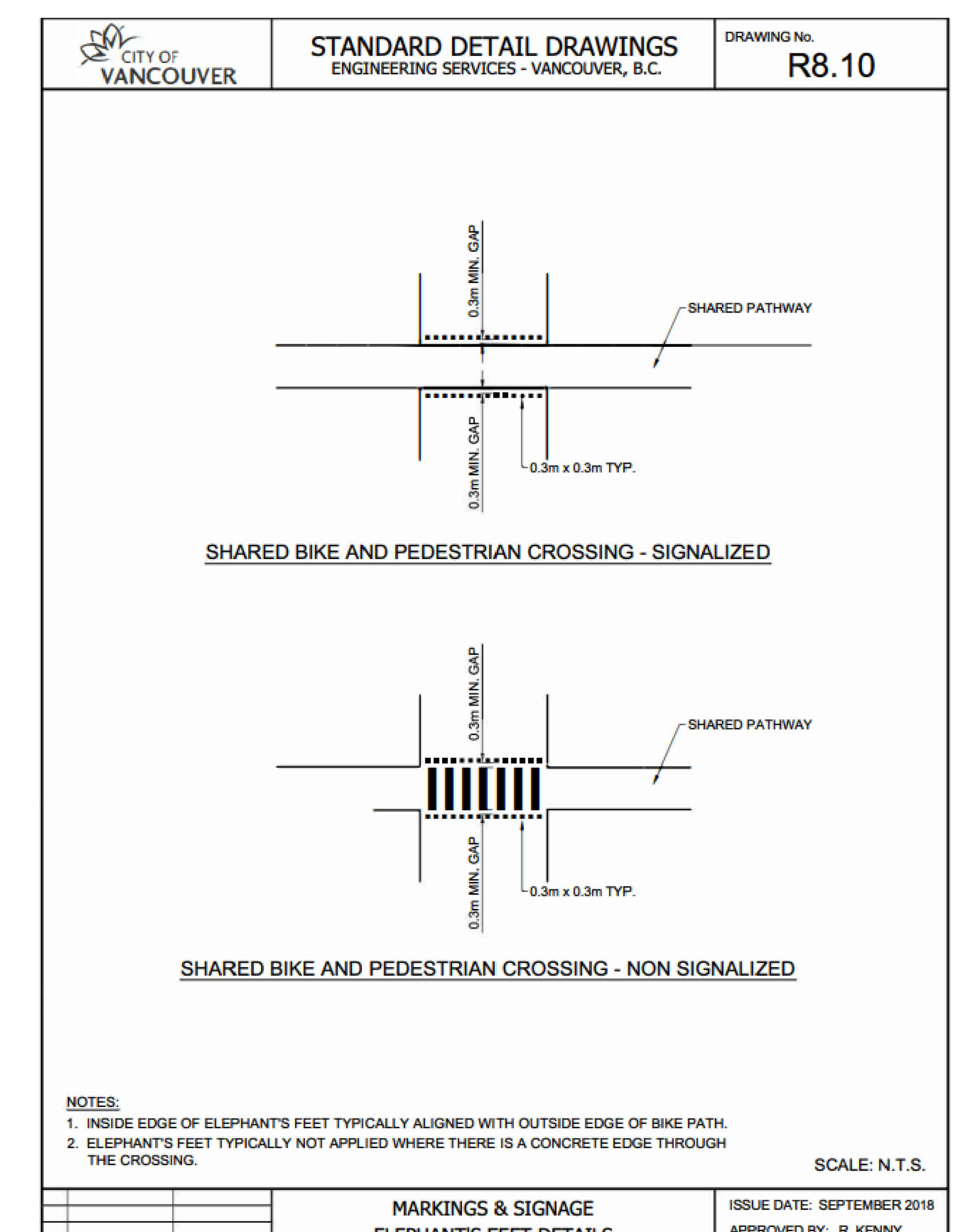

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CAD FILENAME Wesbrook Mall Phase 4
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**TEAM 11 CONSULTANTS**

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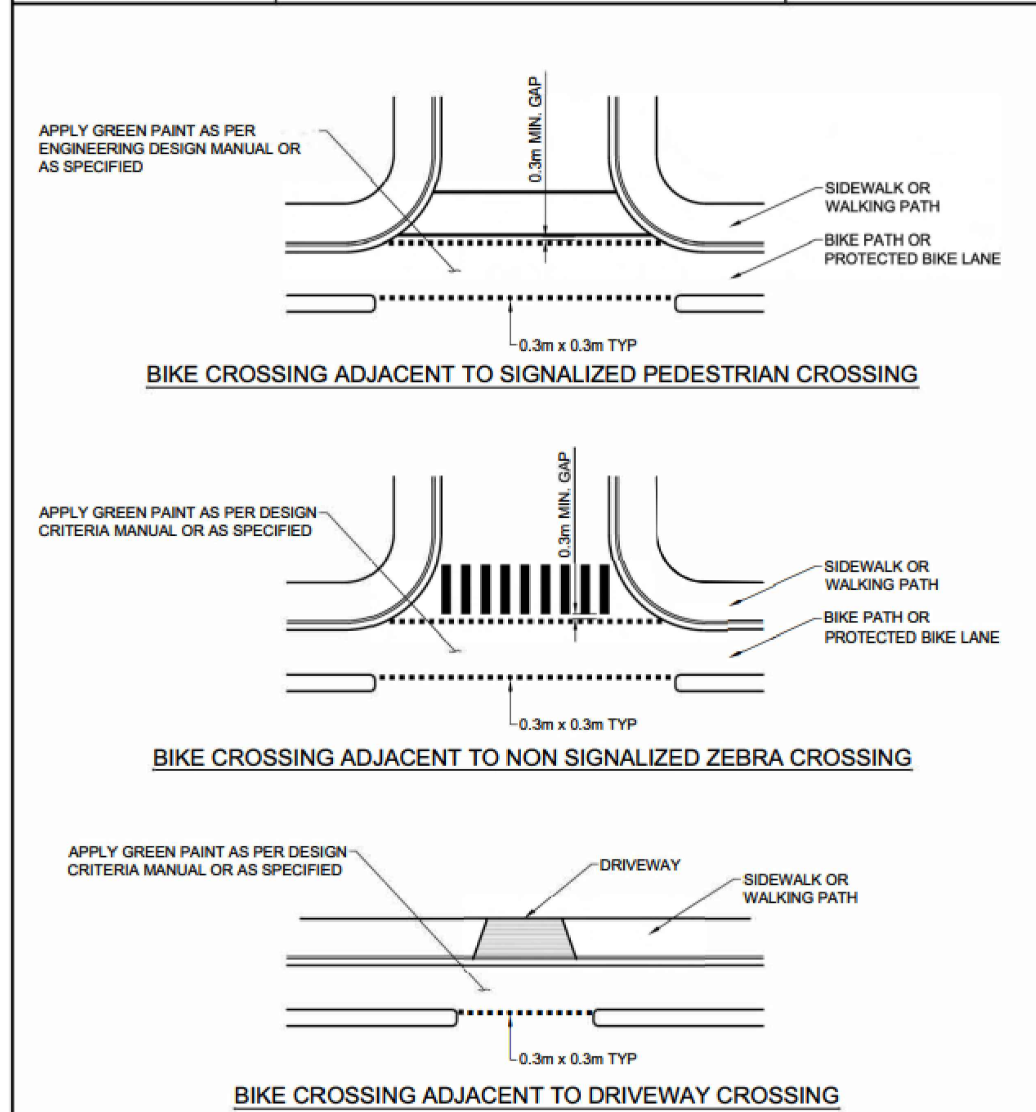
| DESIGNED | Joshua Chong | DATE | 2022-03-26 |
| QUALITY CONTROL | Alvin Lok | DATE | 2022-03-26 |
| QUALITY ASSURANCE | Josh Bian | DATE | 2022-03-26 |
| DRAWN | Joshua Chong | DATE | 2022-03-26 |

SENIOR DESIGNER
DATE 2022-03-26

WESBROOK MALL REDESIGN
PHASE 4
Standard Detail Geometric Drawings

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 20 | B |

STANDARD DETAIL DRAWINGS
ENGINEERING SERVICES - VANCOUVER, B.C.
CITY OF VANCOUVER
DRAWING No. R8.9

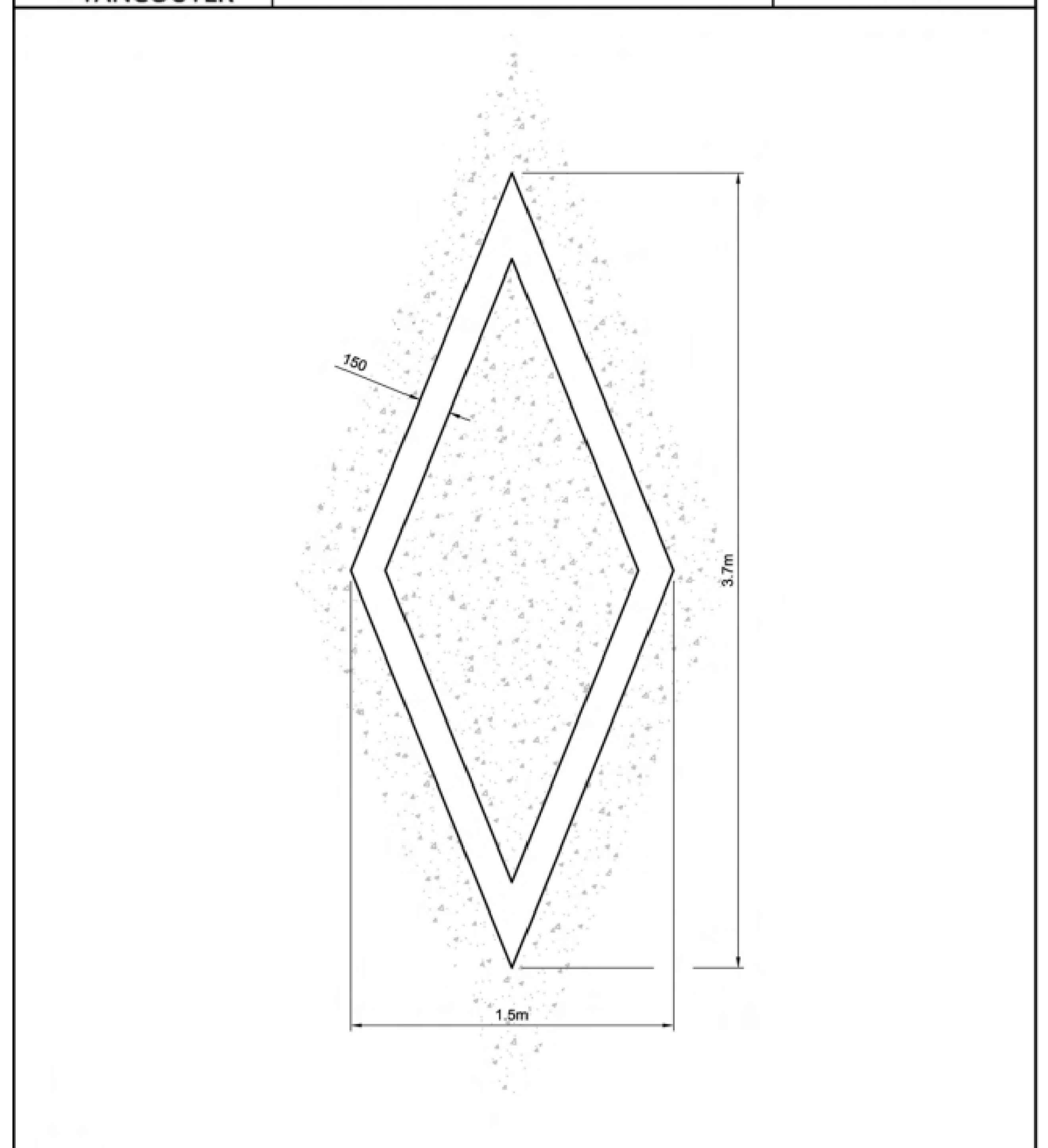



NOTES:
1. INSIDE EDGE OF ELEPHANT'S FEET TYPICALLY ALIGNED WITH OUTSIDE EDGE OF BIKE PATH.
2. ELEPHANT'S FEET TYPICALLY NOT APPLIED WHERE THERE IS A CONCRETE EDGE THROUGH THE CROSSING.

SCALE: N.T.S.

MARKINGS & SIGNAGE
ELEPHANT'S FEET DETAILS
ISSUE DATE: SEPTEMBER 2018
APPROVED BY: R. KENNY

STANDARD DETAIL DRAWINGS
ENGINEERING SERVICES - VANCOUVER, B.C.
DRAWING No. R8.8

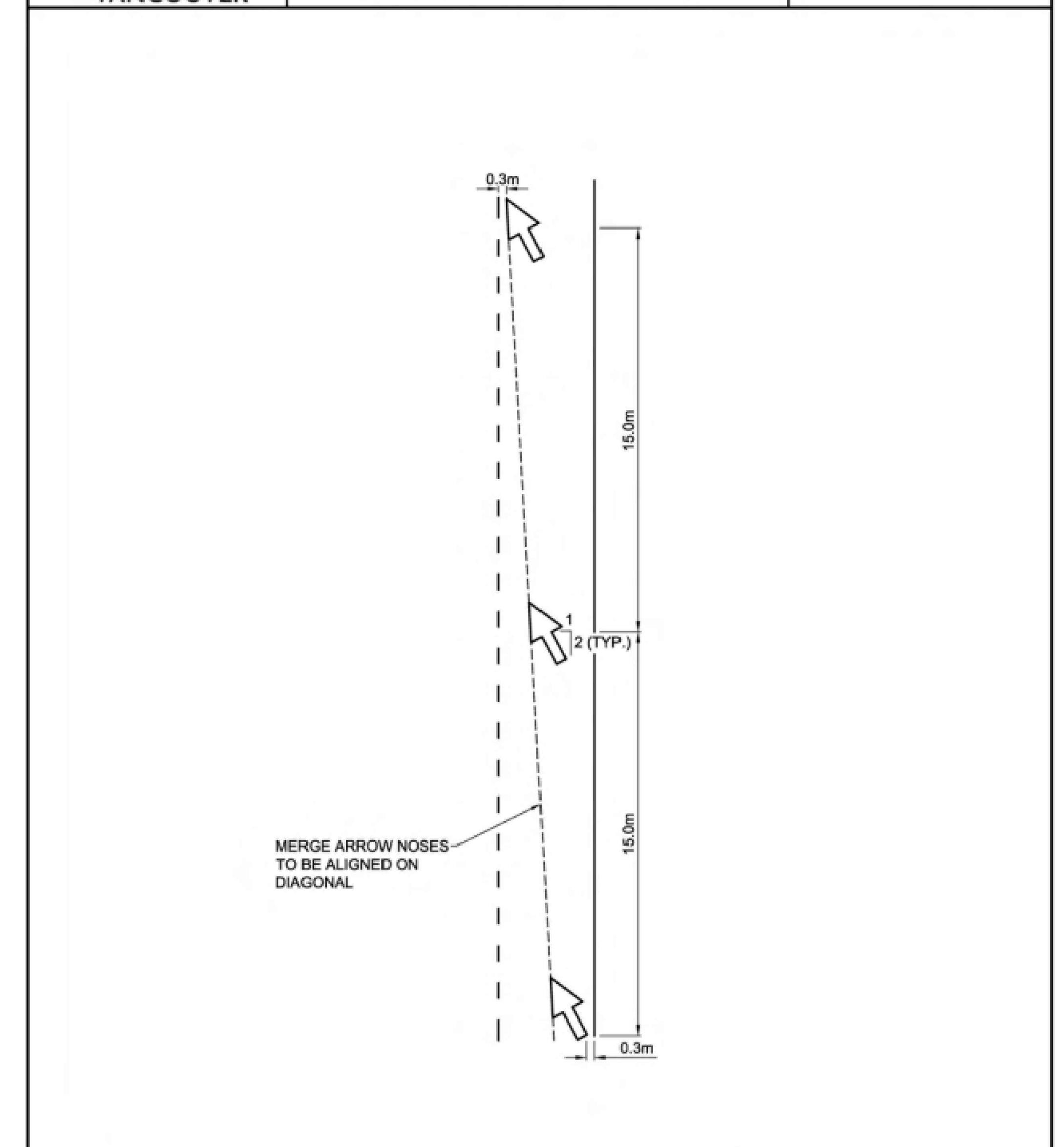



NOTES:
1. BUS LANE MARKINGS - WHITE
2. ALL DIMENSIONS IN MILLIMETERS UNLESS STATED OTHERWISE.

SCALE: N.T.S.

MARKINGS & SIGNAGE
TYPICAL BUS LANE PAVEMENT MARKING
ISSUE DATE: SEPTEMBER 2018
APPROVED BY: R. KENNY

STANDARD DETAIL DRAWINGS
ENGINEERING SERVICES - VANCOUVER, B.C.
DRAWING No. R8.6

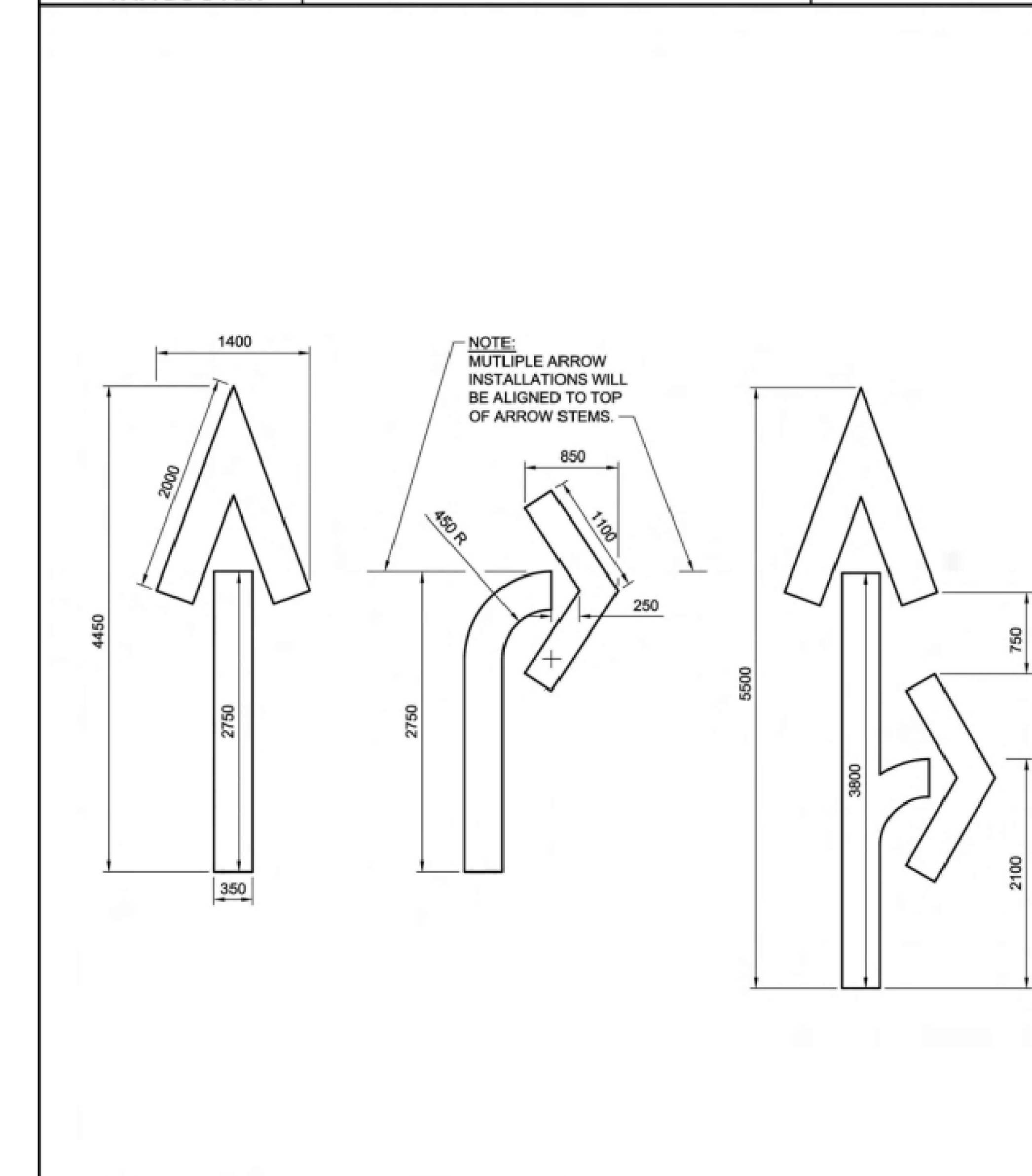



NOTE:
1. WHEN MORE OR LESS THAN 3 ARROWS ARE REQUIRED, ALL ARROWS ARE TO BE PLACED IN THE CENTER OF THE LANE.

SCALE: N.T.S.

MARKINGS & SIGNAGE
TYPICAL MERGE ARROW PLACEMENT
ISSUE DATE: SEPTEMBER 2018
APPROVED BY: R. KENNY

STANDARD DETAIL DRAWINGS
ENGINEERING SERVICES - VANCOUVER, B.C.
DRAWING No. R8.5

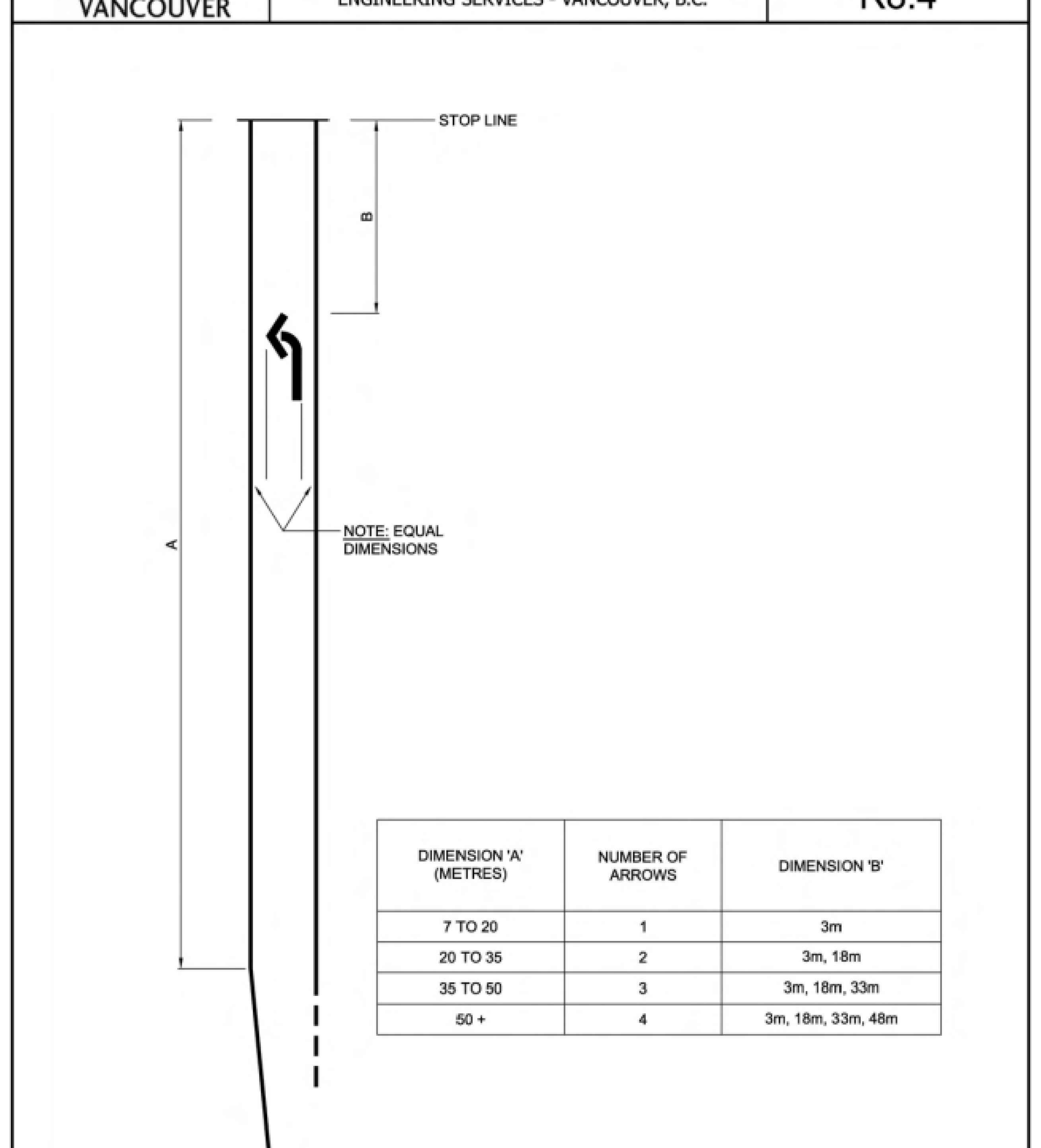



NOTE:
1. ALL DIMENSIONS IN MILLIMETERS UNLESS STATED OTHERWISE.

SCALE: N.T.S.

MARKINGS & SIGNAGE
TURN ARROWS
ISSUE DATE: SEPTEMBER 2018
APPROVED BY: R. KENNY

STANDARD DETAIL DRAWINGS
ENGINEERING SERVICES - VANCOUVER, B.C.
DRAWING No. R8.4

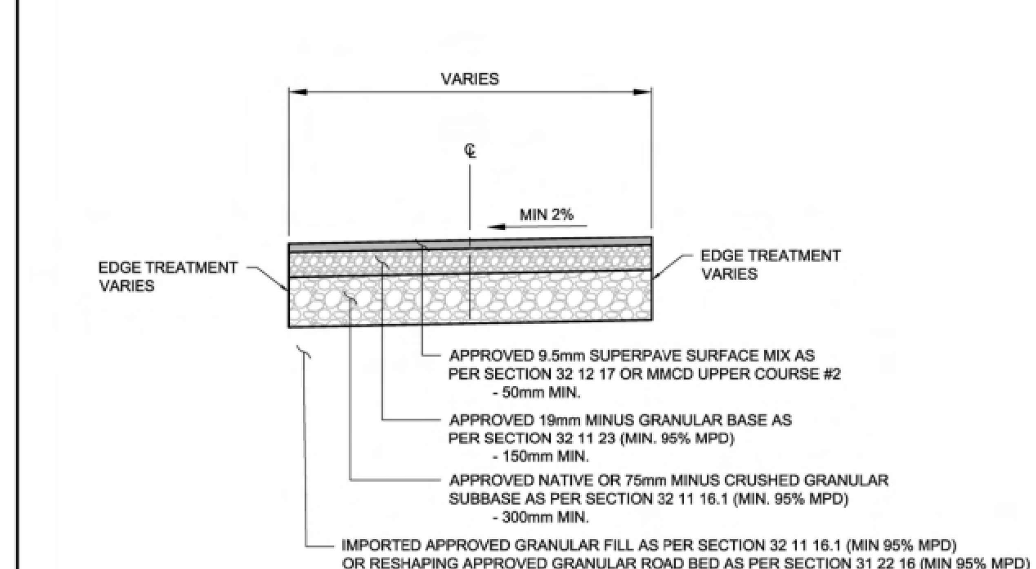



| DIMENSION 'A' (METRES) | NUMBER OF ARROWS | DIMENSION 'B' |
|---|---|---|
| 7 TO 20 | 1 | 3m |
| 20 TO 35 | 2 | 3m, 18m |
| 35 TO 50 | 3 | 3m, 18m, 33m |
| 50 + | 4 | 3m, 18m, 33m, 48m |

SCALE: N.T.S.

MARKINGS & SIGNAGE
LEFT TURN BAY ARROW INSTALLATION
ISSUE DATE: SEPTEMBER 2018
APPROVED BY: R. KENNY

STANDARD DETAIL DRAWINGS
ENGINEERING SERVICES - VANCOUVER, B.C.
DRAWING No. R3.3

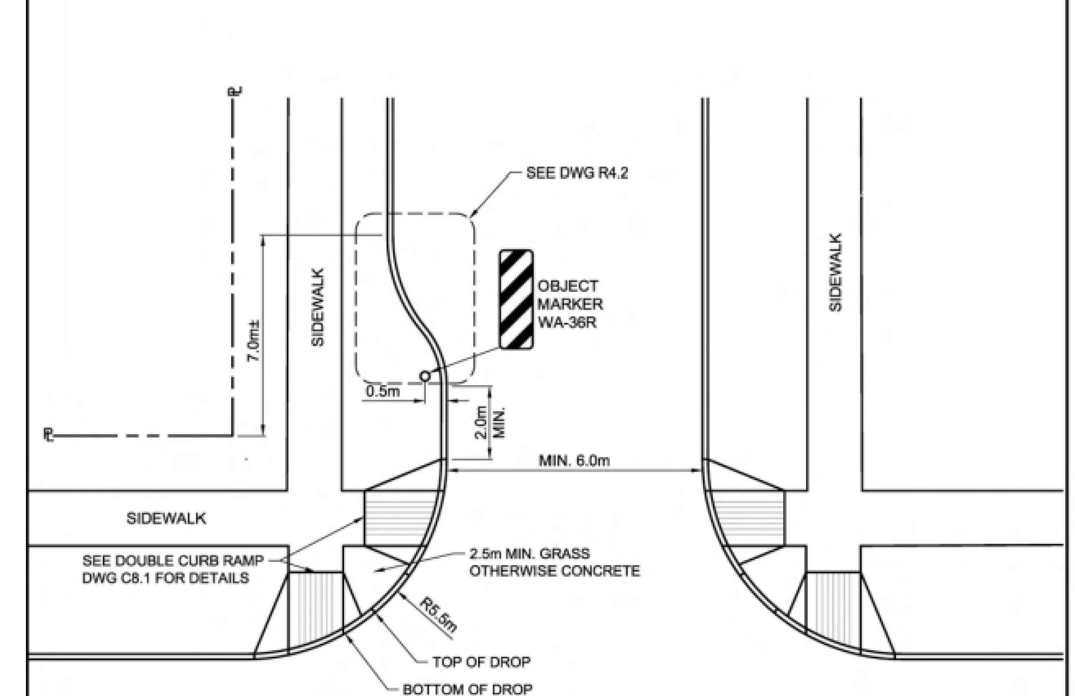



NOTES:
1. FOR SUBGRADE SOIL CLASS SC, ML, OR CL ONLY. OTHER SOIL CLASSES REQUIRE SPECIAL TREATMENT GEOTECHNICAL ENGINEER REQUIRED TO DETERMINE SUBGRADE SOIL CLASSIFICATION.

SCALE: N.T.S.

TYPICAL CROSS SECTION
PROTECTED/RAISED BIKE LANE
ISSUE DATE: SEPTEMBER 2018
APPROVED BY: J. LEE

STANDARD DETAIL DRAWINGS
ENGINEERING SERVICES - VANCOUVER, B.C.
DRAWING No. R4.1




NOTES:
1. NOTIFY TRANSPORTATION BRANCH PRIOR TO DESIGN OF COMPLEX DESIGNS, NON RESIDENTIAL, BUS ROUTES ETC.
2. STREET DESIGN REQUIRED FOR DRAINAGE.
3. INFILTRATION BULGE SHOULD BE CONSIDERED AS AN ALTERNATIVE DESIGN.
4. FOR STANDARD BULGE DESIGN INTERIM GUIDELINES, REFER TO THE DESIGN CRITERIA MANUAL AND DWG R4.2.

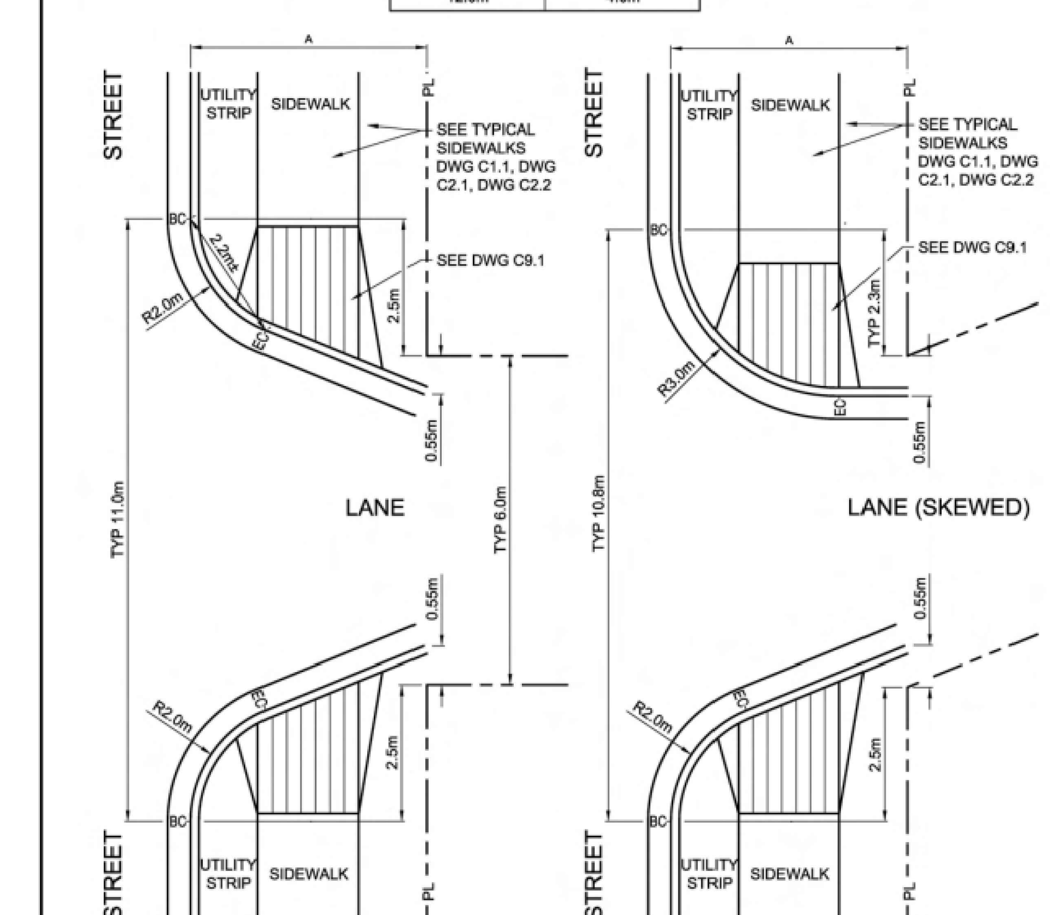
SCALE: N.T.S.

ROADS
RESIDENTIAL ROAD
ISSUE DATE: SEPTEMBER 2018
APPROVED BY: R. KENNY

STANDARD DETAIL DRAWINGS
ENGINEERING SERVICES - VANCOUVER, B.C.
DRAWING No. R7.1

FOR TYP. 20m STREET ALLOWANCE

| ROAD WIDTH | BLVD A |
|---|---|
| 8.5m | 5.75m |
| 10.0m | 5.0m |
| 11.0m | 4.5m |
| 12.0m | 4.0m |




SCALE: N.T.S.

LANEWAYS
LANEWAY ENTRANCE
ISSUE DATE: SEPTEMBER 2018
APPROVED BY: R. KENNY

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SCALE 0 2 1:200 10m
CAD FILENAME Wesbrook Mall Phase 4
DATE 2022-03-26

| REV | DATE | REVISIONS | SIGNATURE |
|---|---|---|---|

TEAM 11 CONSULTANTS

SENIOR DESIGNER
DATE 2022-03-26

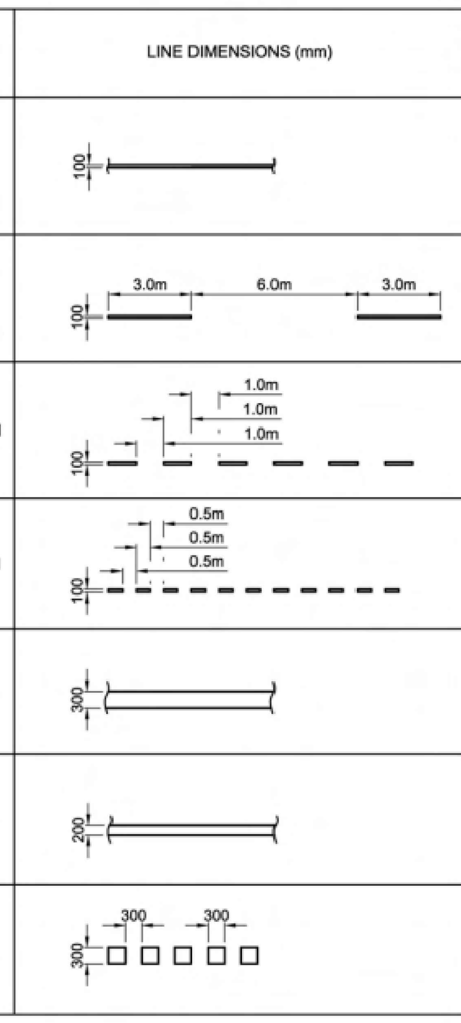
DESIGNED Joshua Chong DATE 2022-03-26
QUALITY CONTROL Alvin Lok DATE 2022-03-26
QUALITY ASSURANCE Josh Bian DATE 2022-03-26
DRAWN Joshua Chong DATE 2022-03-26

WESBROOK MALL REDESIGN
PHASE 4
Standard Detail Geometric Drawings

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 21 | B |

## CITY OF VANCOUVER — STANDARD DETAIL DRAWINGS — ENGINEERING SERVICES - VANCOUVER, B.C. — DRAWING No. R8.1

### INSTALLATION OF PAVEMENT MARKINGS

| TYPE | LINE DIMENSIONS (mm) | COLOR: WHITE | COLOR: YELLOW |
|---|---|---|---|
| SOLID |  | 1. EDGELINES ON THE RIGHT<br>2. LANE LINES PROHIBITING LANE CHANGES | 1. EDGELINES ON THE LEFT<br>2. DIRECTIONAL DIVIDING LINES |
| BROKEN | 3.0m 6.0m 3.0m | 1. LANE LINES | 1. DIRECTIONAL DIVIDING LINES |
| SHORT BROKEN | 1.0m 1.0m 1.0m | 1. CONTINUITY LINES IN MERGING AND DIVERGING AREAS<br>2. LEFT TURN BAYS | |
| DENSE BROKEN | 0.5m 0.5m 0.5m | 1. GUIDE LINES FOR INTERSECTION MOVEMENTS | 1. GUIDE LINES FOR INTERSECTION MOVEMENTS |
| STOP | 300 | 1. STOP LINES | |
| CROSSWALK | 200 | 1. CROSSWALKS | |
| ELEPHANT'S FEET | 300 300 300 | 1. BIKE CROSSINGS | |

NOTE:
1. ALL DIMENSIONS IN MILLIMETERS UNLESS STATED OTHERWISE.

SCALE: N.T.S.

MARKINGS & SIGNAGE — INSTALLATION OF PAVEMENT MARKINGS — ISSUE DATE: SEPTEMBER 2018 — APPROVED BY: R. KENNY

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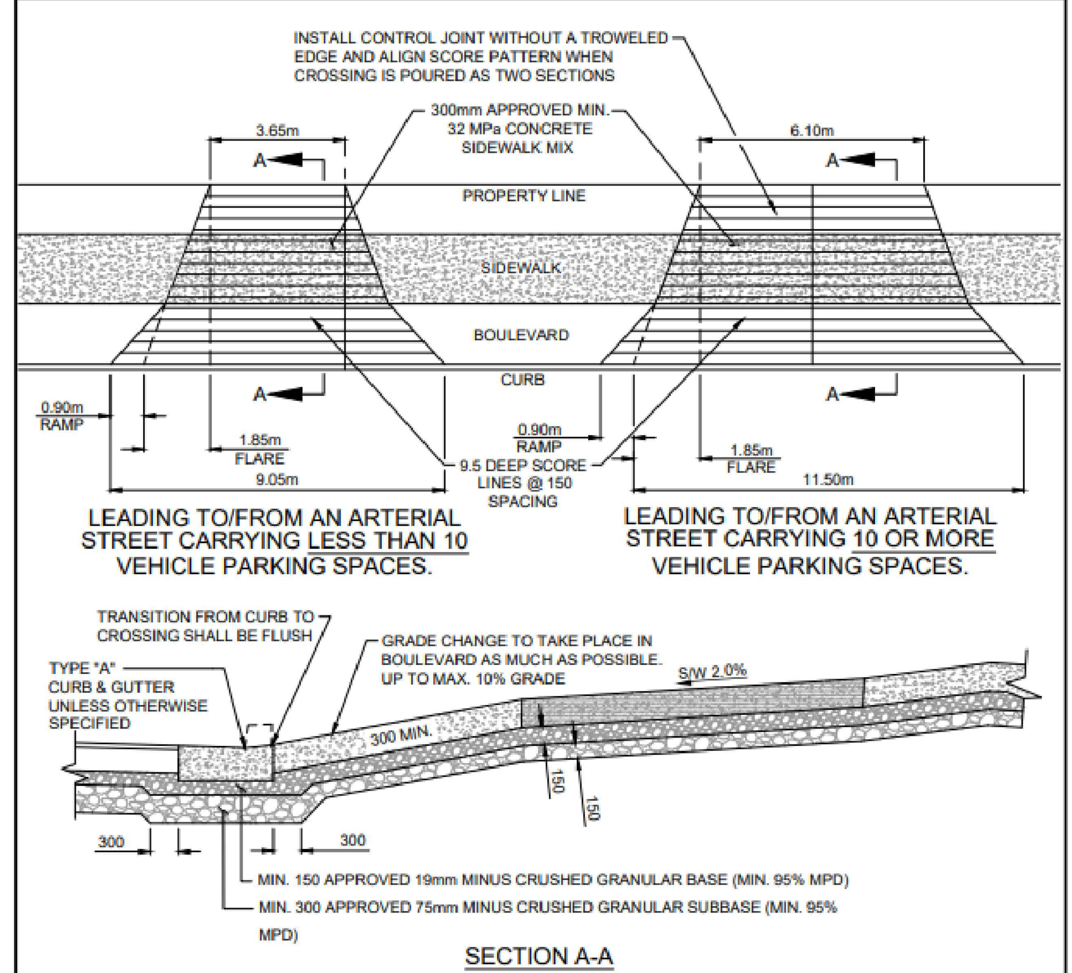
## CITY OF VANCOUVER — STANDARD DETAIL DRAWINGS — ENGINEERING SERVICES - VANCOUVER, B.C. — DRAWING No. C7.2




NOTES:
1. FOR WIDER CROSSINGS, RAMP AND FLARE WIDTHS SHALL REMAIN AS ABOVE.
2. CONTRACTOR SHALL ENSURE THAT CROSSING LAYOUT IS APPROVED BY CITY INSPECTORS PRIOR TO POURING OF CONCRETE.
3. CURB AND GUTTER AS PER DWG C4.1 (TYPE "A") UNLESS OTHERWISE SPECIFIED.
4. CONCRETE MIX:
   A) CITY MIX NO. 1503 OR EQUIVALENT MIX APPROVED BY THE CITY CAN BE USED AS LONG AS NO TRAFFIC OR WEIGHT LOAD PUT ON THE CROSSING FOR 3 DAYS AFTER POUR.
   B) STRENGTH OF 20MPa IN 24 HRS. OR EQUIVALENT MIX APPROVED BY THE CITY CAN BE USED AS LONG AS NO TRAFFIC OR WEIGHT LOAD IS PUT ON THE CROSSING FOR 24 HOURS AFTER POUR.
5. ARTIFICIAL TURF IS NOT A SUPPORTED TREATMENT ON PUBLIC PROPERTY.
6. ALL DIMENSIONS IN MILLIMETERS UNLESS STATED OTHERWISE.

SCALE: N.T.S.

DRIVEWAYS — COMMERCIAL DRIVEWAY CROSSING — ISSUE DATE: AUGUST 2019 — APPROVED BY: J. LEE

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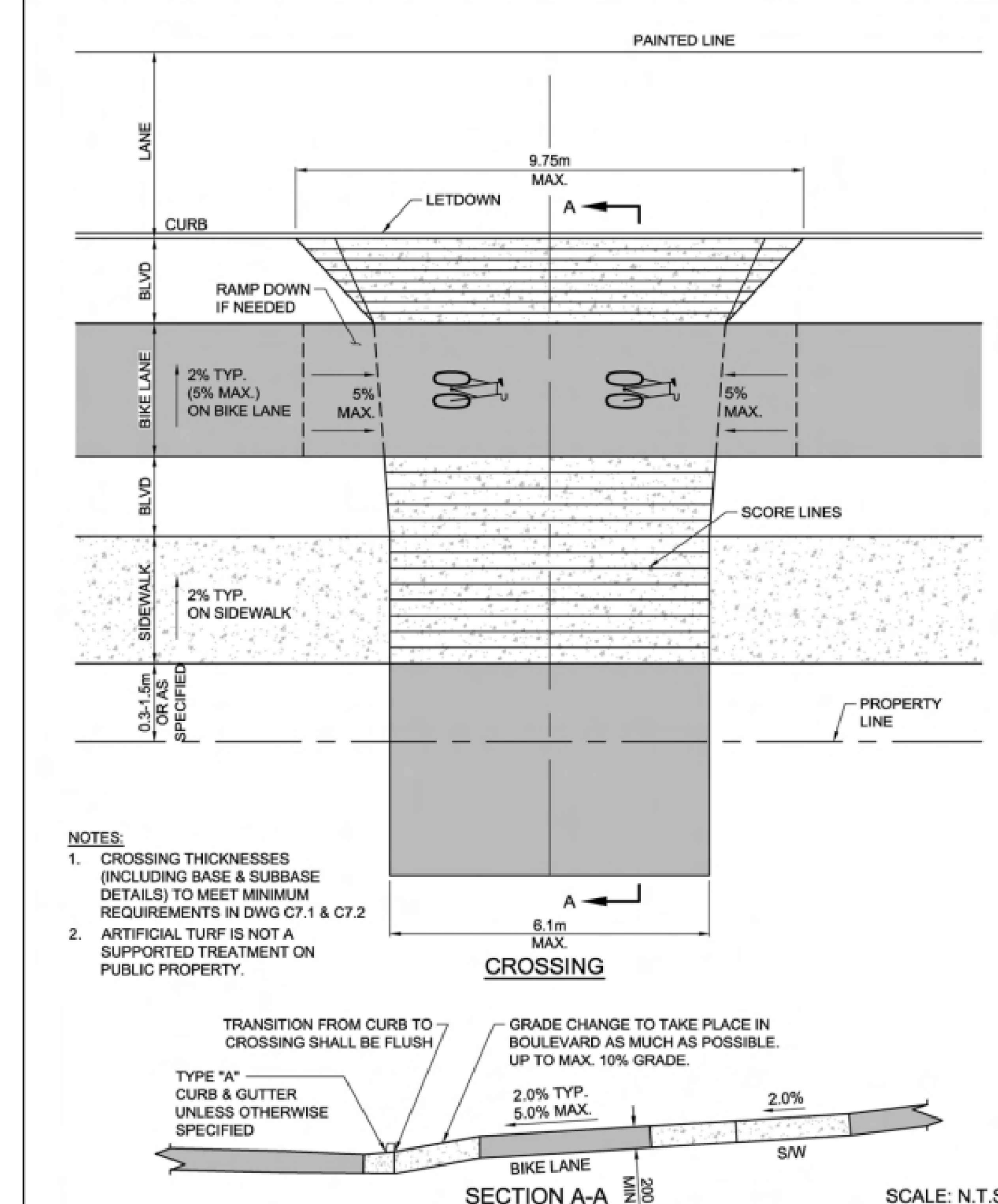
## CITY OF VANCOUVER — STANDARD DETAIL DRAWINGS — ENGINEERING SERVICES - VANCOUVER, B.C. — DRAWING No. C7.3




NOTES:
1. CROSSING THICKNESSES (INCLUDING BASE & SUBBASE DETAILS) TO MEET MINIMUM REQUIREMENTS IN DWG C7.1 & C7.2
2. ARTIFICIAL TURF IS NOT A SUPPORTED TREATMENT ON PUBLIC PROPERTY.

SCALE: N.T.S.

DRIVEWAYS — BIKE LANE DRIVEWAY CROSSING — ISSUE DATE: SEPTEMBER 2018 — APPROVED BY: J. LEE

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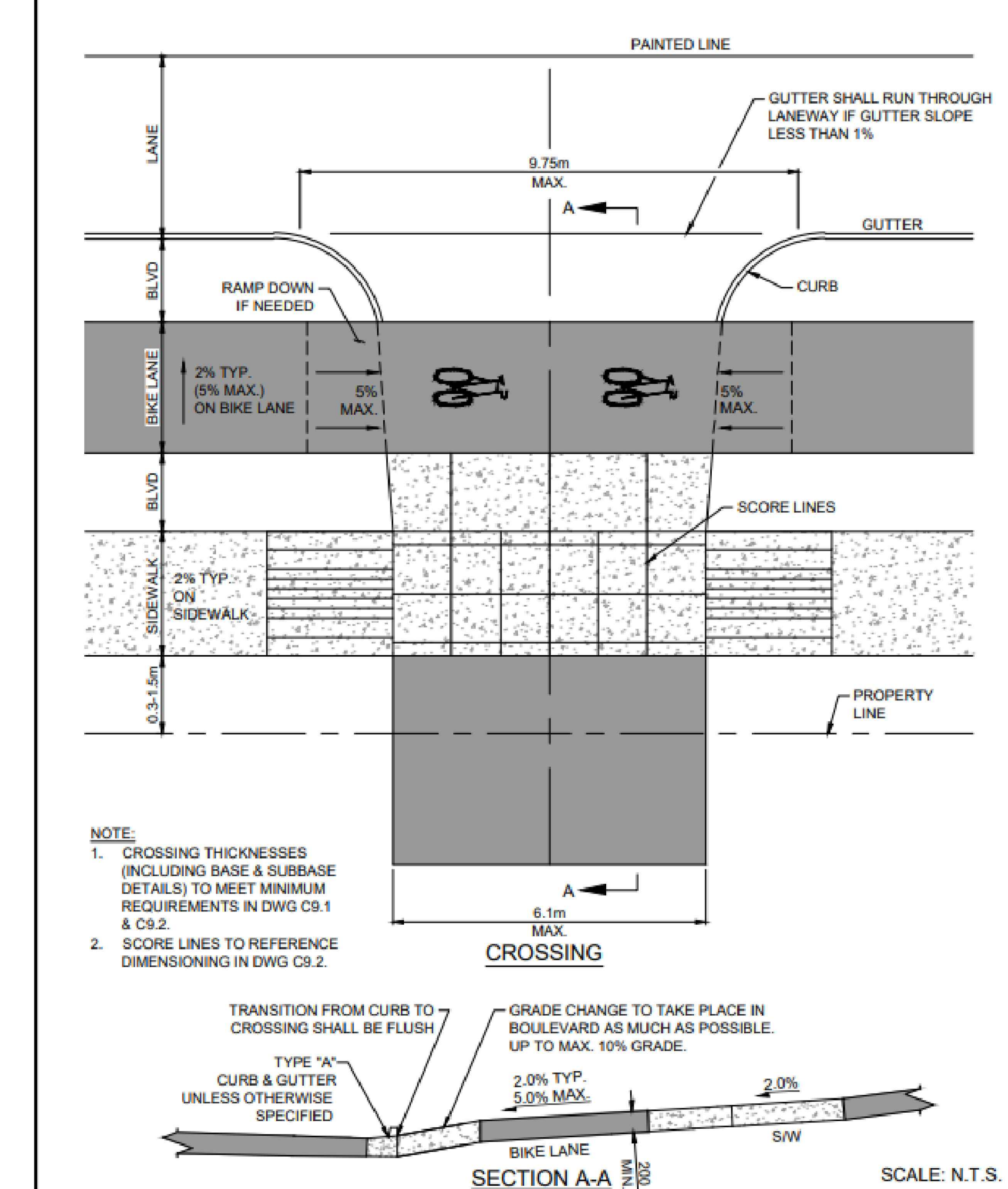
## CITY OF VANCOUVER — STANDARD DETAIL DRAWINGS — ENGINEERING SERVICES - VANCOUVER, B.C. — DRAWING No. C9.3




NOTE:
1. CROSSING THICKNESSES (INCLUDING BASE & SUBBASE DETAILS) TO MEET MINIMUM REQUIREMENTS IN DWG C9.1 & C9.2
2. SCORE LINES TO REFERENCE DIMENSIONING IN DWG C9.2.

SCALE: N.T.S.

LANEWAYS — BIKE LANE LANEWAY CROSSING — ISSUE DATE: JUNE 2019 — APPROVED BY: J. LEE

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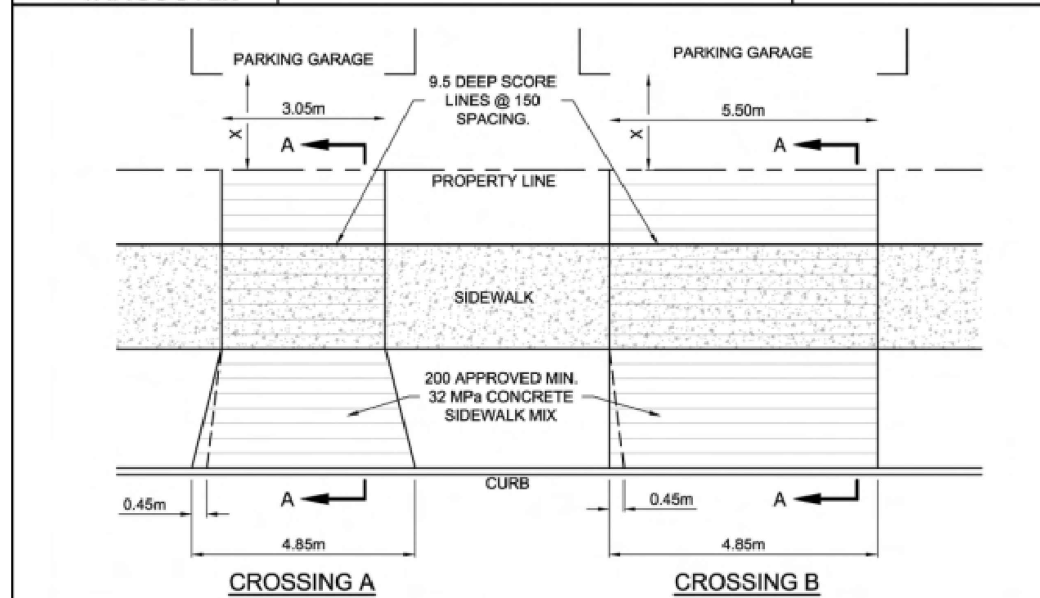
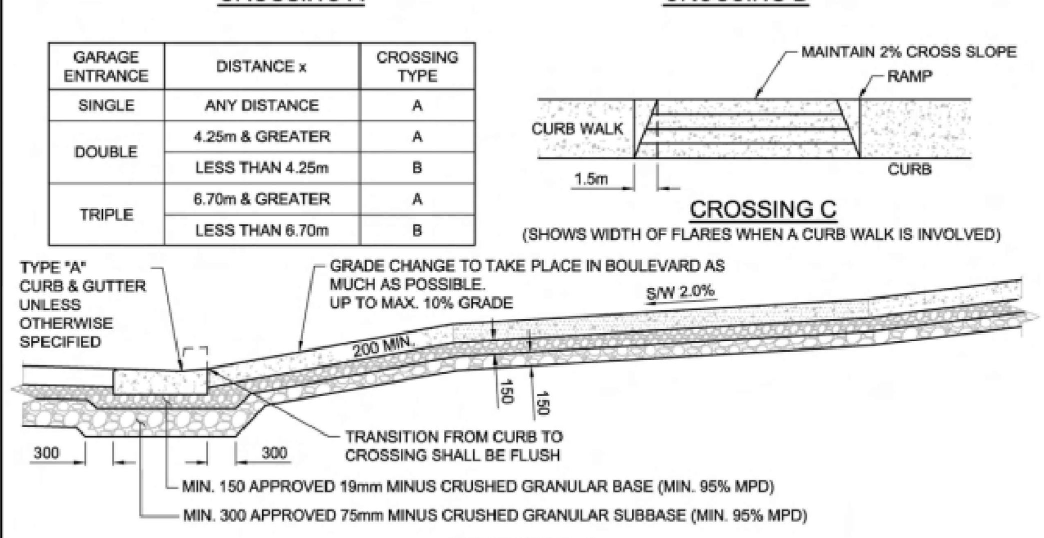
## CITY OF VANCOUVER — STANDARD DETAIL DRAWINGS — ENGINEERING SERVICES - VANCOUVER, B.C. — DRAWING No. C7.1




| GARAGE ENTRANCE | DISTANCE x | CROSSING TYPE |
|---|---|---|
| SINGLE | ANY DISTANCE | A |
| DOUBLE | 4.25m & GREATER | A |
| | LESS THAN 4.25m | B |
| TRIPLE | 6.70m & GREATER | A |
| | LESS THAN 6.70m | B |




NOTES:
1. CONTRACTOR SHALL ENSURE THAT CROSSING LAYOUT IS APPROVED BY CITY INSPECTORS PRIOR TO POURING OF CONCRETE.
2. CONCRETE MIXES AS PER DWG C7.2.
3. ARTIFICIAL TURF IS NOT A SUPPORTED TREATMENT ON PUBLIC PROPERTY.
4. ALL DIMENSIONS IN MILLIMETERS UNLESS STATED OTHERWISE.

SCALE: N.T.S.

DRIVEWAYS — RESIDENTIAL DRIVEWAY CROSSING — ISSUE DATE: SEPTEMBER 2018 — APPROVED BY: J. LEE

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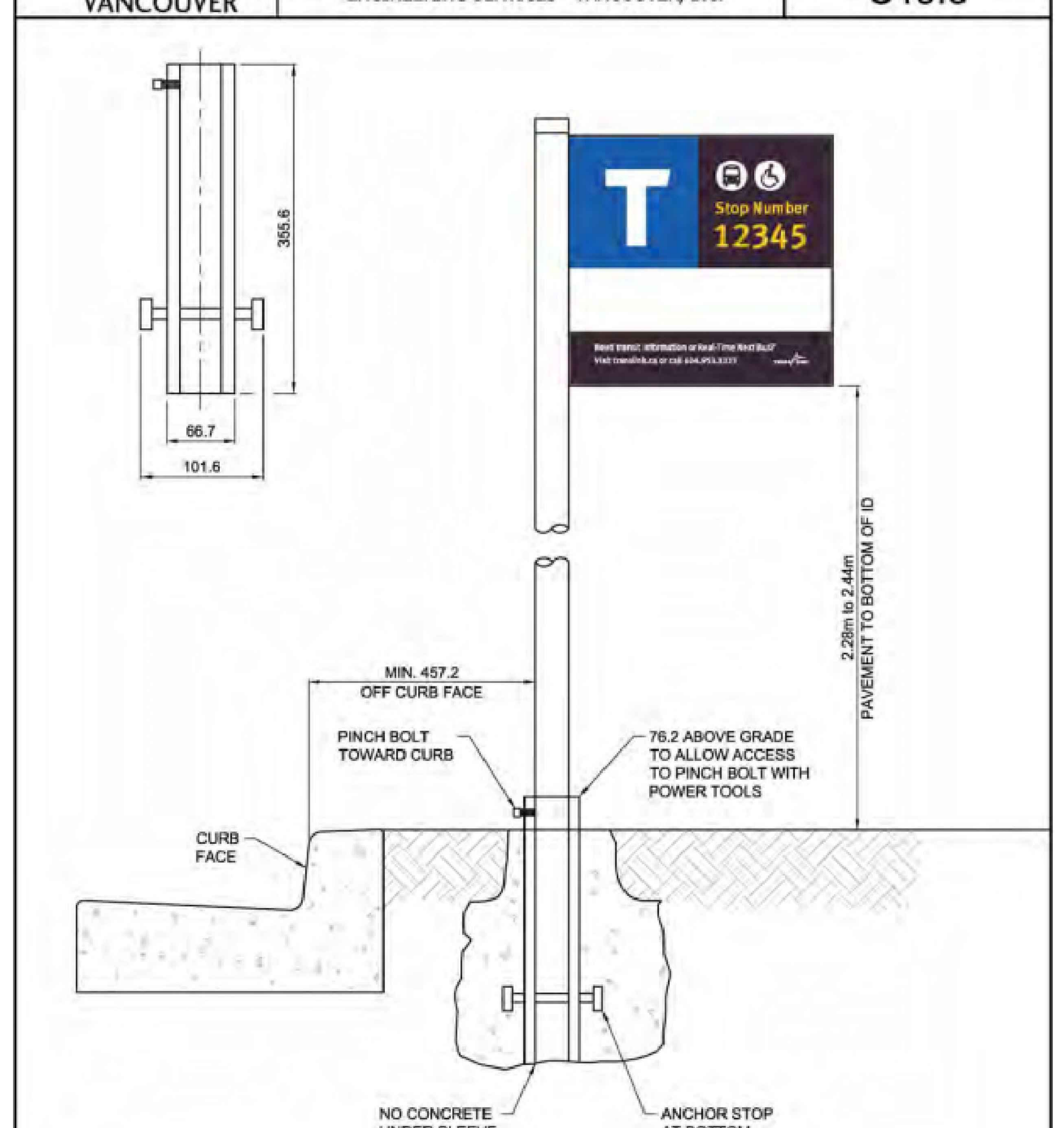
## CITY OF VANCOUVER — STANDARD DETAIL DRAWINGS — ENGINEERING SERVICES - VANCOUVER, B.C. — DRAWING No. C19.3




NOTES:
1. CAUTION MUST BE TAKEN TO ENSURE THAT NO CONCRETE OR DEBRIS GET INSIDE THE SLEEVE.
2. THE SLEEVE IS TO BE ABSOLUTELY PLUMB.
3. BUS STOP ID SIGN SLEEVES FROM COAST MOUNTAIN BUS COMPANY.

SCALE: N.T.S.

SIGNAGE — BUS STOP SIGN SLEEVE — ISSUE DATE: SEPTEMBER 2018 — APPROVED BY: C. DARWENT

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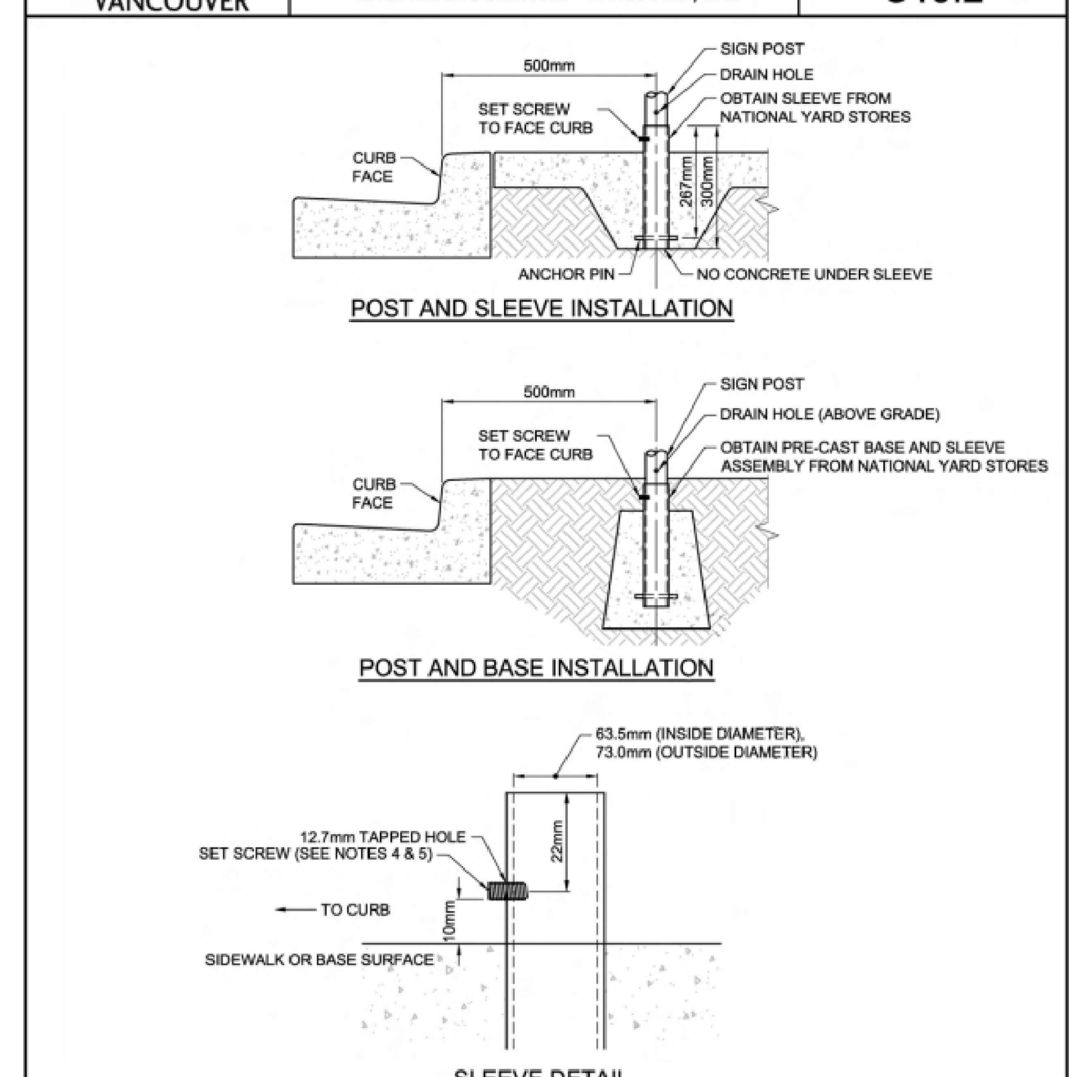
## CITY OF VANCOUVER — STANDARD DETAIL DRAWINGS — ENGINEERING SERVICES - VANCOUVER, B.C. — DRAWING No. C19.2




NOTES:
1. CAUTION MUST BE TAKEN TO ENSURE THAT NO CONCRETE OR DEBRIS GET INSIDE THE SLEEVE.
2. THE SLEEVE IS TO BE ABSOLUTELY PLUMB.
3. ALTERNATIVE SIGN LOCATIONS MAY BE NECESSARY IN INSTANCES OF CONFLICT WITH UNDERGROUND UTILITIES.
4. POST AND SLEEVE: 12.7mm DIAMETER x 12.7mm LENGTH CUP POINT STAINLESS STEEL ALLEN KEY SET SCREW.
5. POST AND BASE: 12.7mm DIAMETER x 19.1mm LENGTH CUP POINT STAINLESS STEEL ALLEN KEY SET SCREW.

SCALE: N.T.S.

SIGNAGE — TRAFFIC SIGN SLEEVE — ISSUE DATE: SEPTEMBER 2018 — APPROVED BY: C. DARWENT

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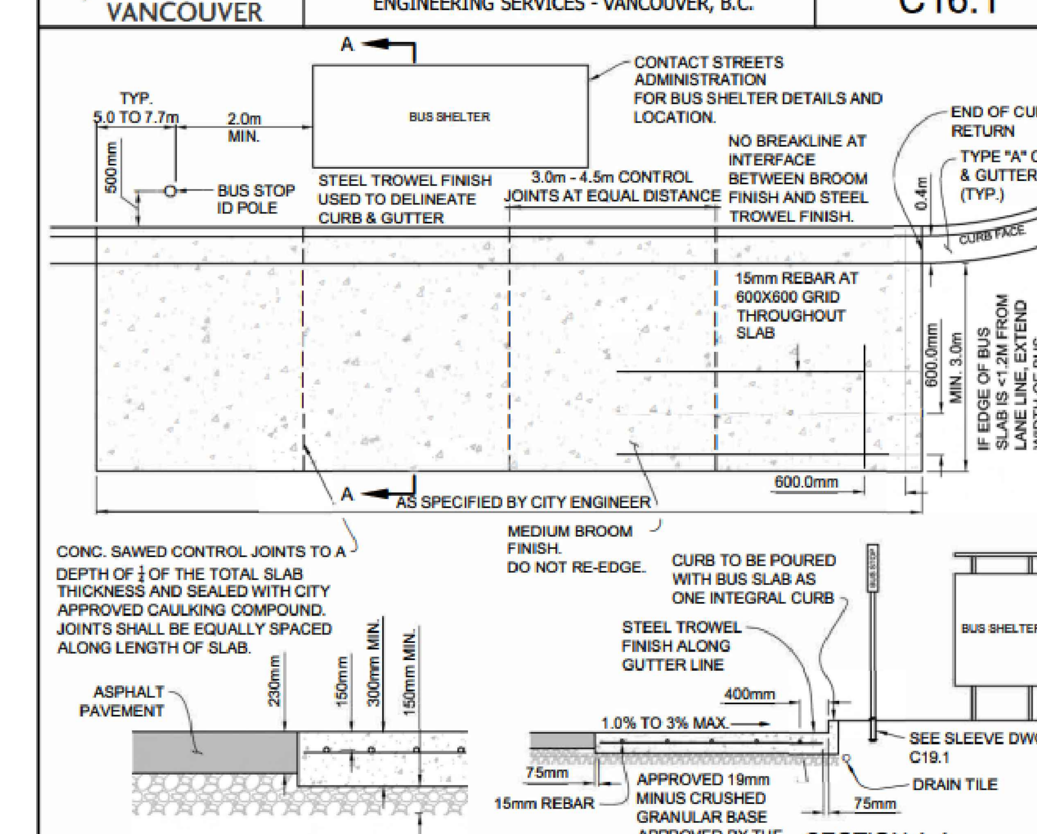
## CITY OF VANCOUVER — STANDARD DETAIL DRAWINGS — ENGINEERING SERVICES - VANCOUVER, B.C. — DRAWING No. C16.1




NOTES:
1. THE BUS SLAB SHOULD BE INSTALLED AS A CONTINUOUS POUR. IF THE BUS SLAB IS INSTALLED IN NO MORE THAN TWO SEPARATE POURS, THEN THE EDGE OF THE POUR MUST BE KEYED OR REBAR INSERTS USED TO TIE BOTH PADS TOGETHER.
2. ALL CUT JOINTS ARE TO RUN PERPENDICULAR TO THE CURB. THE CUT JOINTS MUST RUN FROM OUTSIDE EDGE OF BUS SLAB TO BACK OF INTEGRAL CURB.
3. CUT JOINTS SHOULD BE SAWED INTO THE BUS SLAB WITHIN 24 HOURS AFTER THE POUR TO MINIMIZE ANY CRACKING.
4. BUS SLABS THAT CONTAIN MAINTENANCE HOLES, CATCH BASINS, VALVE BOXES, CHAMBERS OR OTHER UTILITY COVERS MUST HAVE CONTROL CUT JOINTS ON BOTH SIDES OF THE UTILITY COVER.
5. CUT JOINTS MUST MAINTAIN EQUAL DISTANCE OF 3.0m-4.5m FROM ANY CONSTANTS (I.E., MAINTENANCE HOLE, CATCH BASIN, VALVE BOX, CHAMBERS) WITHIN THE BUS SLAB.
6. INTERNAL VIBRATOR OR POWER SCREED SHALL BE USED WHEREVER PRACTICABLE TO CONSOLIDATE THE CONCRETE. ANY OTHER CONSOLIDATION METHODS MUST BE APPROVED BY THE CITY ENGINEER PRIOR TO THE CONCRETE POUR.
7. CONCRETE MIX:
   A) CITY MIX NO. 1503 OR EQUIVALENT MIX APPROVED BY THE CITY CAN BE USED AS LONG AS NO TRAFFIC OR WEIGHT LOAD IS PUT ON THE BUS SLAB FOR 3 DAYS AFTER POUR.
   B) STRENGTH OF 20MPa IN 24 HRS OR EQUIVALENT MIX APPROVED BY THE CITY CAN BE USED AS LONG AS NO TRAFFIC OR WEIGHT LOAD IS PUT ON THE BUS SLAB FOR 24 HOURS AFTER POUR.
   C) NO CHLORIDE BASED ADDITIVES SHALL BE USED IN CONCRETE SLAB WITH EMBEDDED STEEL.
8. USE 15mm REBAR WITH MINIMUM 75mm COVER.
9. PLACE REBAR MAT AT 150mm BELOW TOP OF CONCRETE.
10. PLACE REBAR IN A 600mm X 600mm GRID.
11. MILL AND RE-CONTOUR AC TO MATCH CONCRETE BUS SLAB CROSS FALL.

SCALE: N.T.S.

BUS — REINFORCED BUS SLAB — ISSUE DATE: SEPTEMBER 2018 — APPROVED BY: J. LEE

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"BY SEALING AND SIGNING THIS DRAWING, I CERTIFY THAT THE INFORMATION CONTAINED IN THESE ACCURATELY REFLECTS THE ORIGINAL DESIGN, ADDENDA, CHANGE ORDERS AND MATERIAL DESIGN CHANGES MADE DURING CONSTRUCTION AND FIELD REVIEWED BY ME, OR MY REPRESENTATIVE, AND THAT THE AS-CONSTRUCTED WORKS SUBSTANTIALLY COMPLY WITH THE ORIGINAL DESIGN INTENT, HOWEVER, I DO NOT ACCEPT RESPONSIBILITY OF THE ACCURACY OR COMPLETENESS OF THE AS-CONSTRUCTED INFORMATION SUPPLIED BY OTHERS CONTAINED IN THESE DRAWINGS."

ISSUED FOR CONSTRUCTION
2022-03-26

UBC sustainability

SCALE 0 2 1:200 10m

CAD FILENAME Wesbrook Mall Phase 4
DATE 2022-03-26

| REV | DATE | REVISIONS | SIGNATURE |
|---|---|---|---|

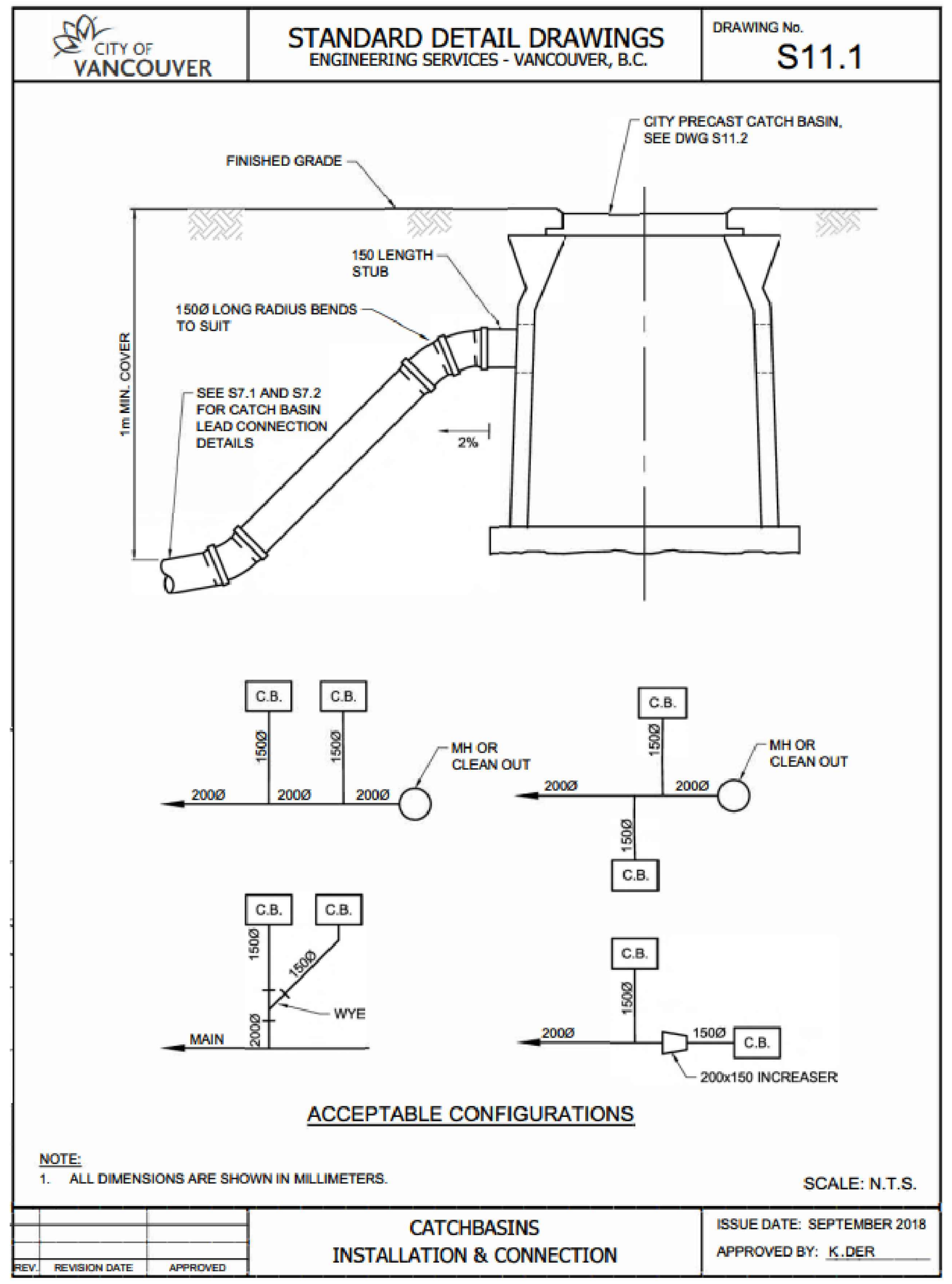
TEAM 11 CONSULTANTS

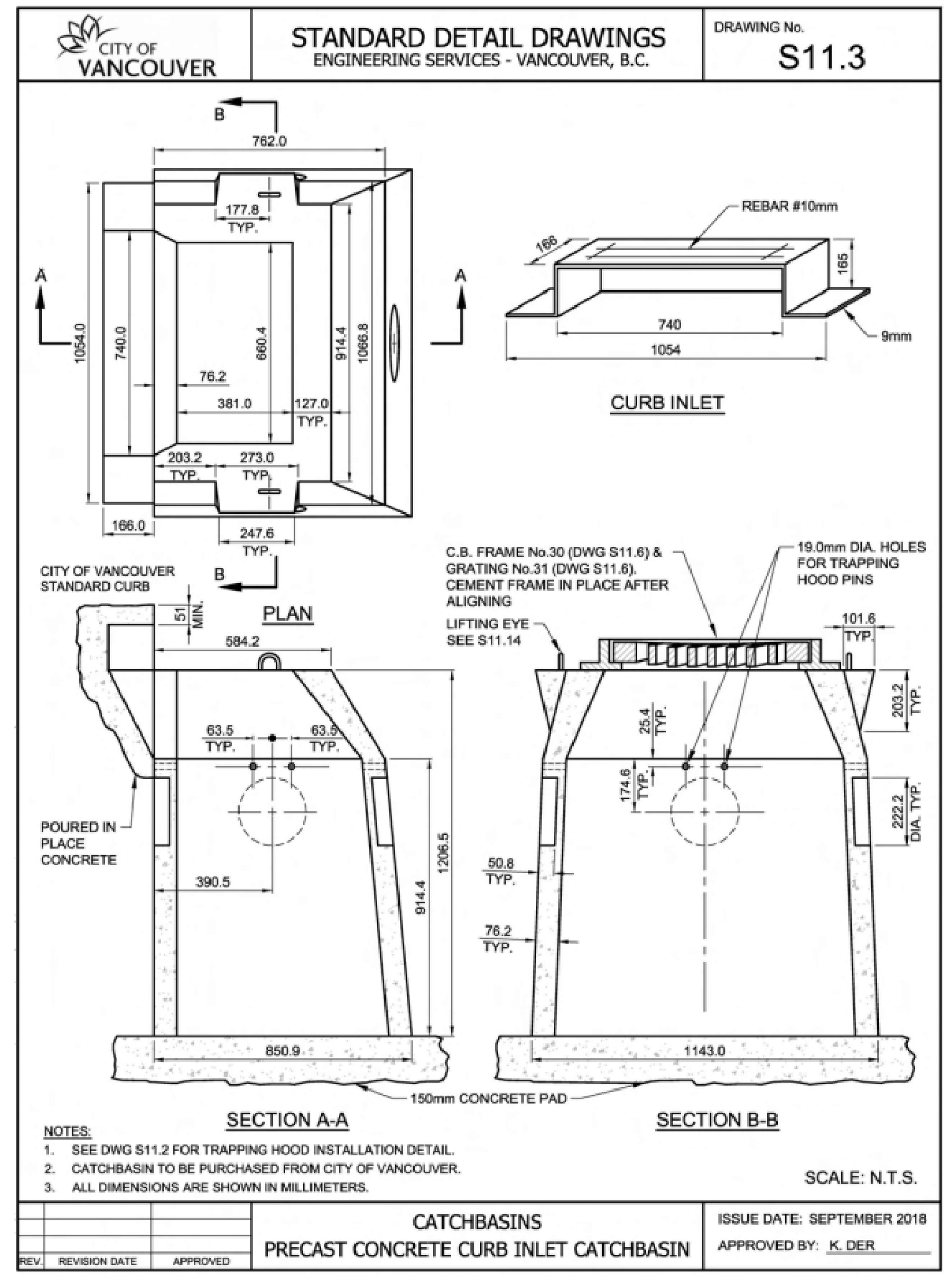
SENIOR DESIGNER
DATE 2022-03-26

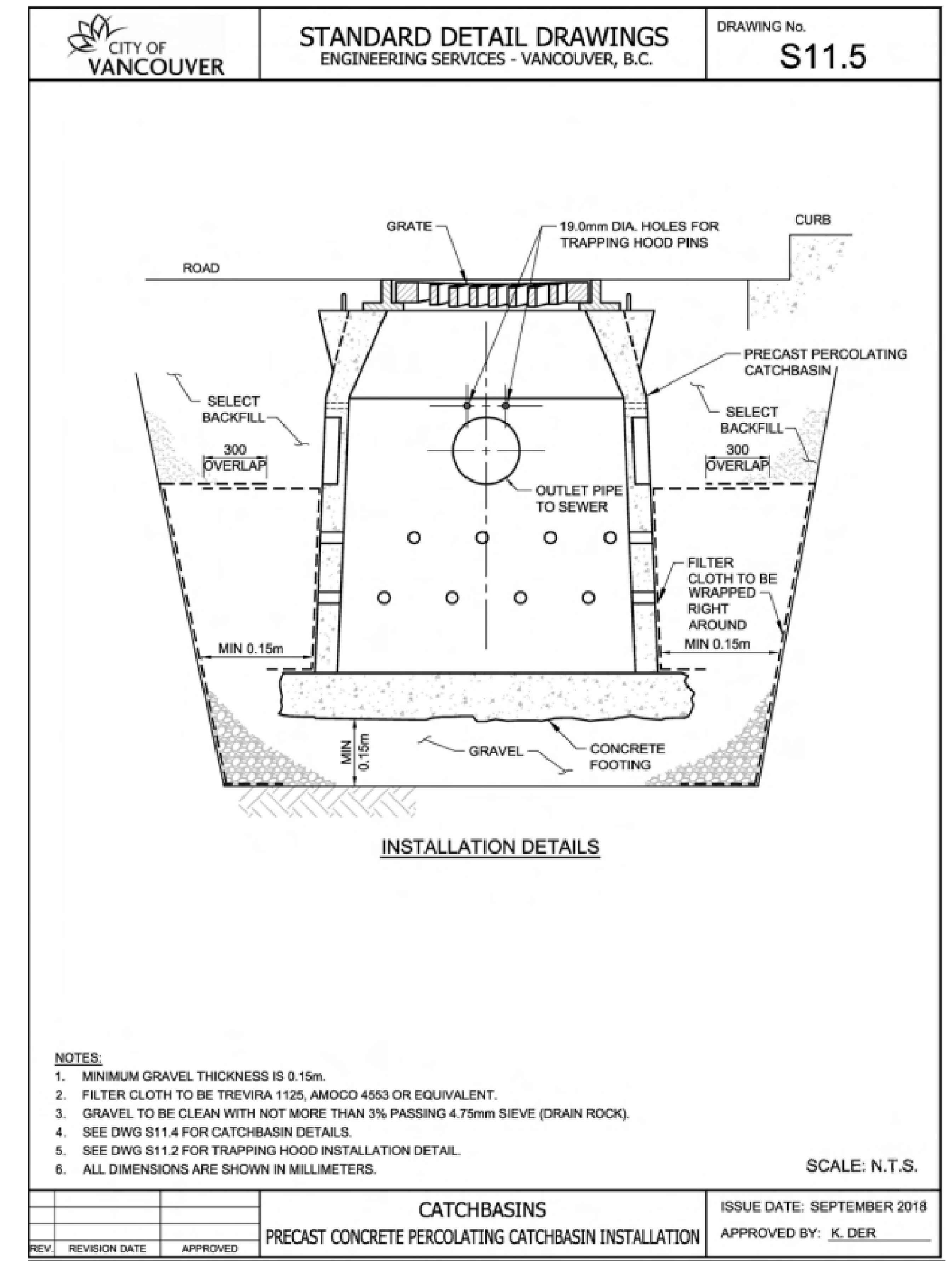
DESIGNED Joshua Chong DATE 2022-03-26
QUALITY CONTROL Alvin Lok DATE 2022-03-26
QUALITY ASSURANCE Josh Bian DATE 2022-03-26
DRAWN Joshua Chong DATE 2022-03-26

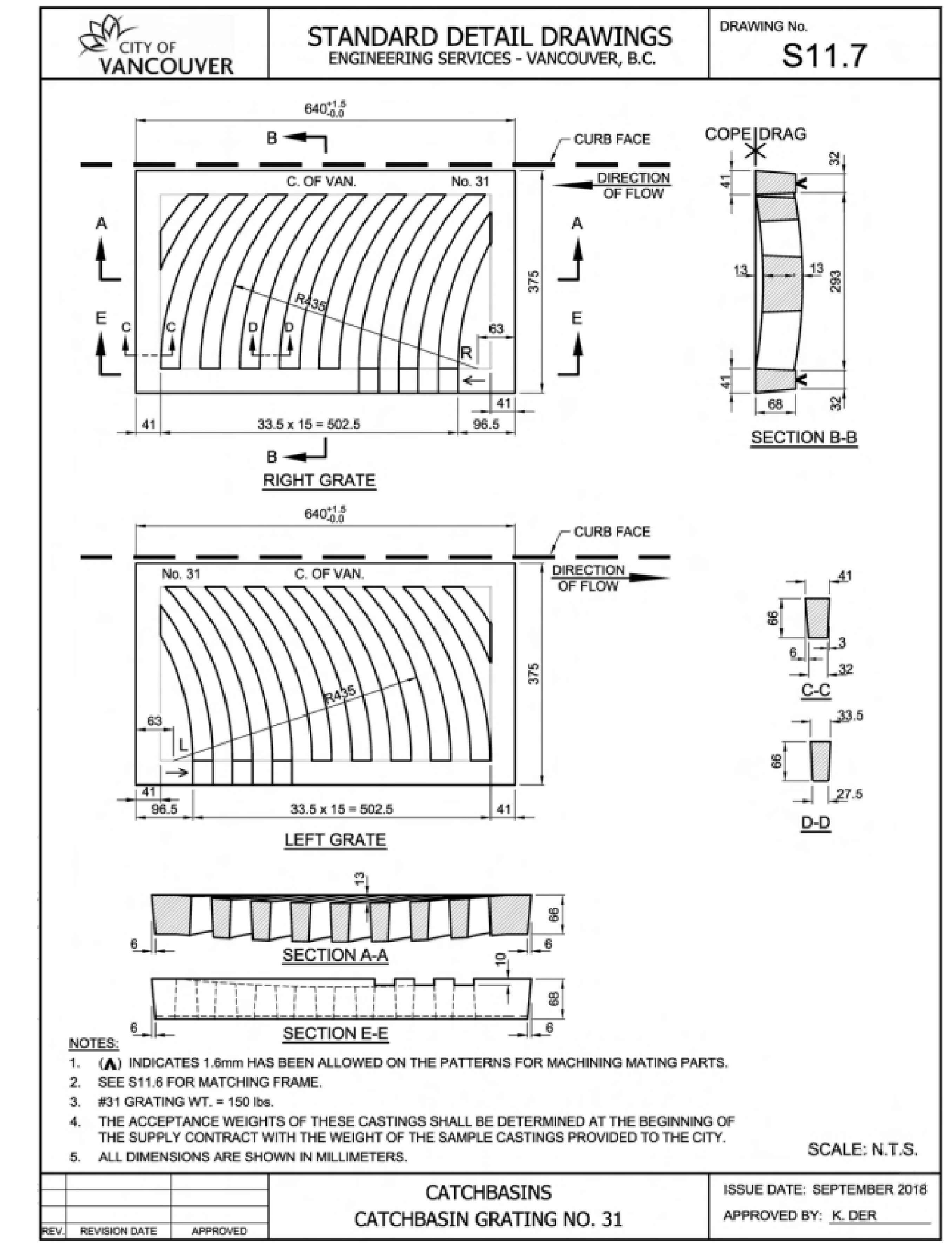
WESBROOK MALL REDESIGN
PHASE 4
Standard Detail Geometric Drawings

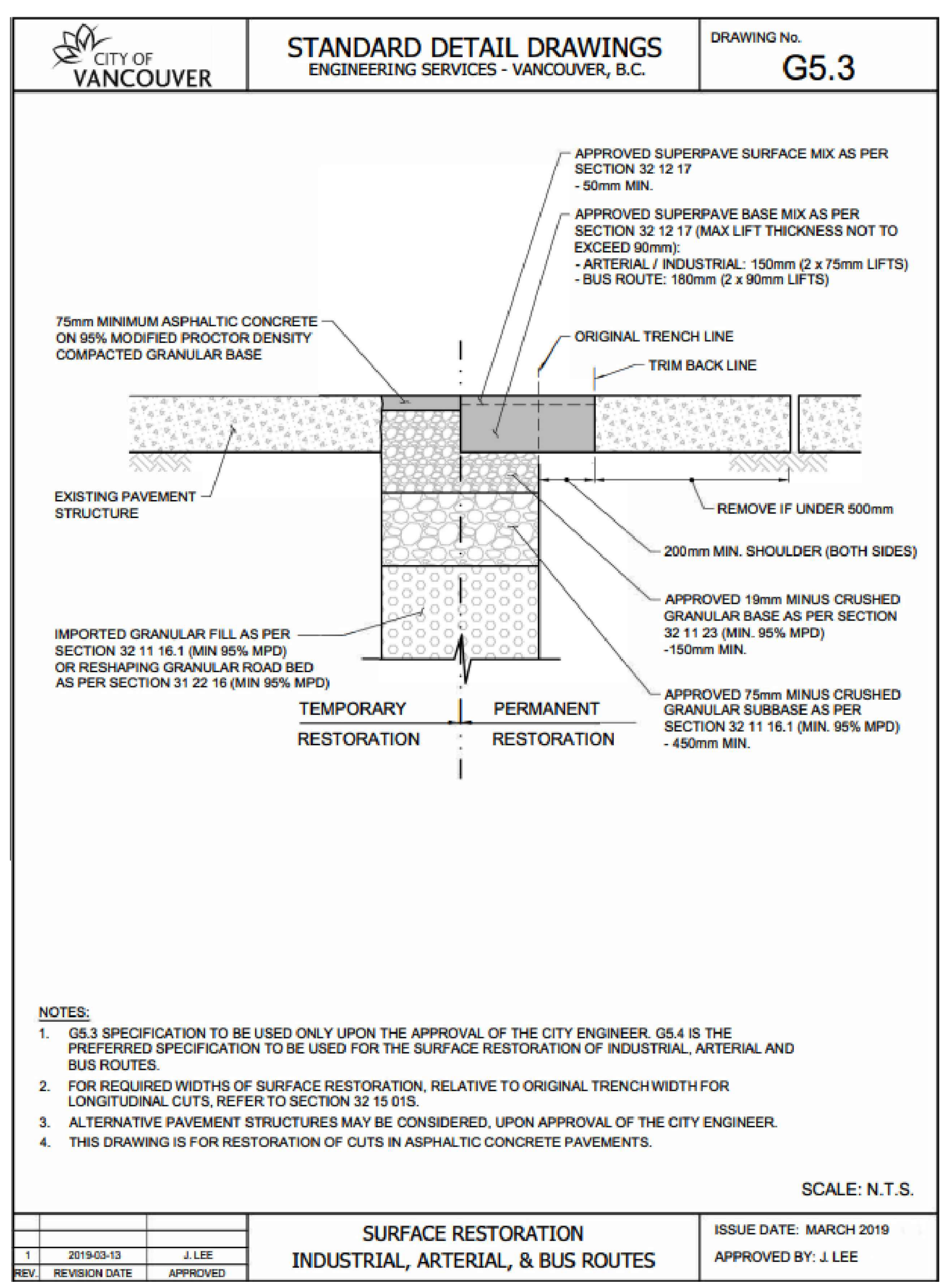
| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 22 | B |

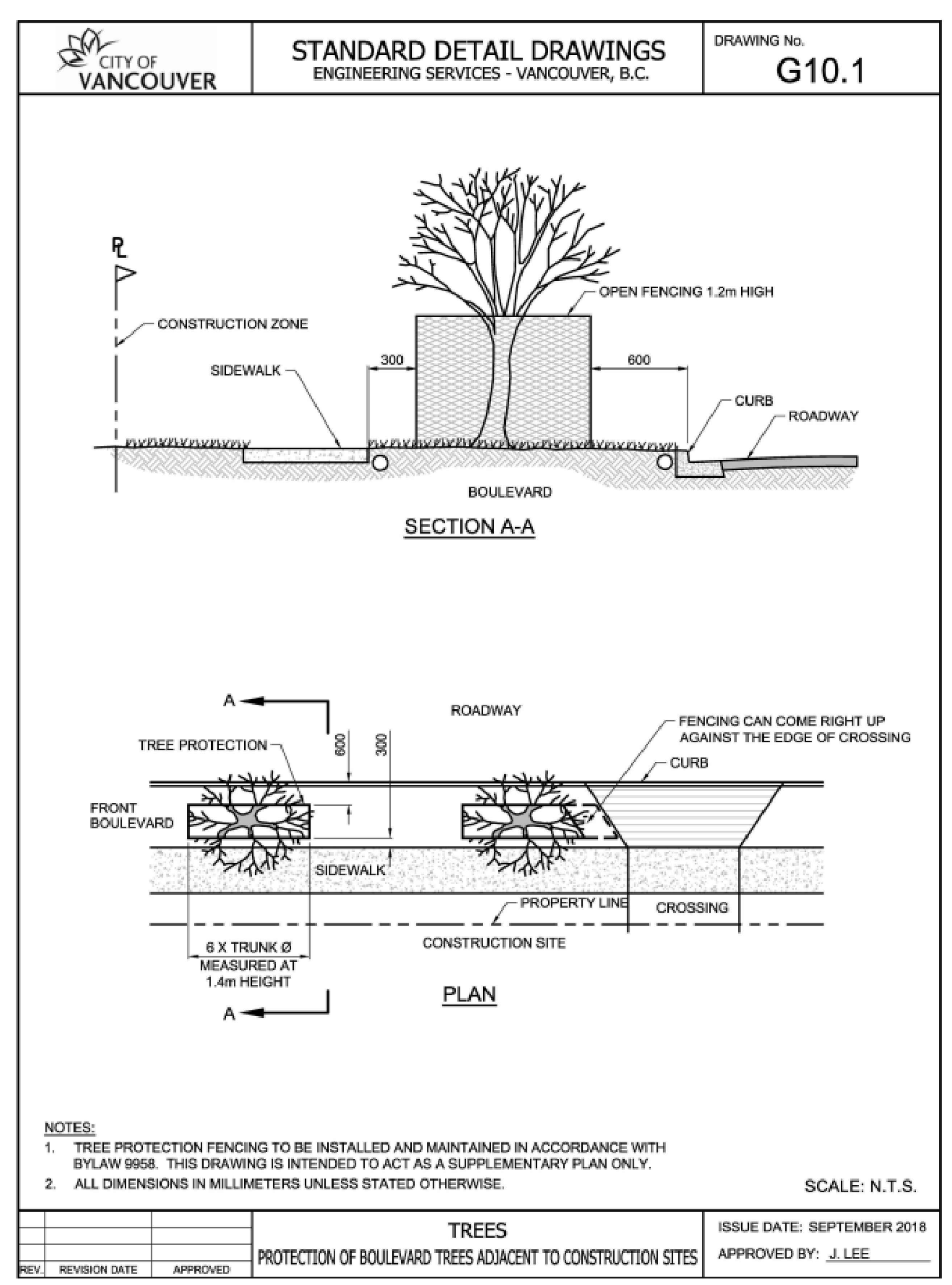


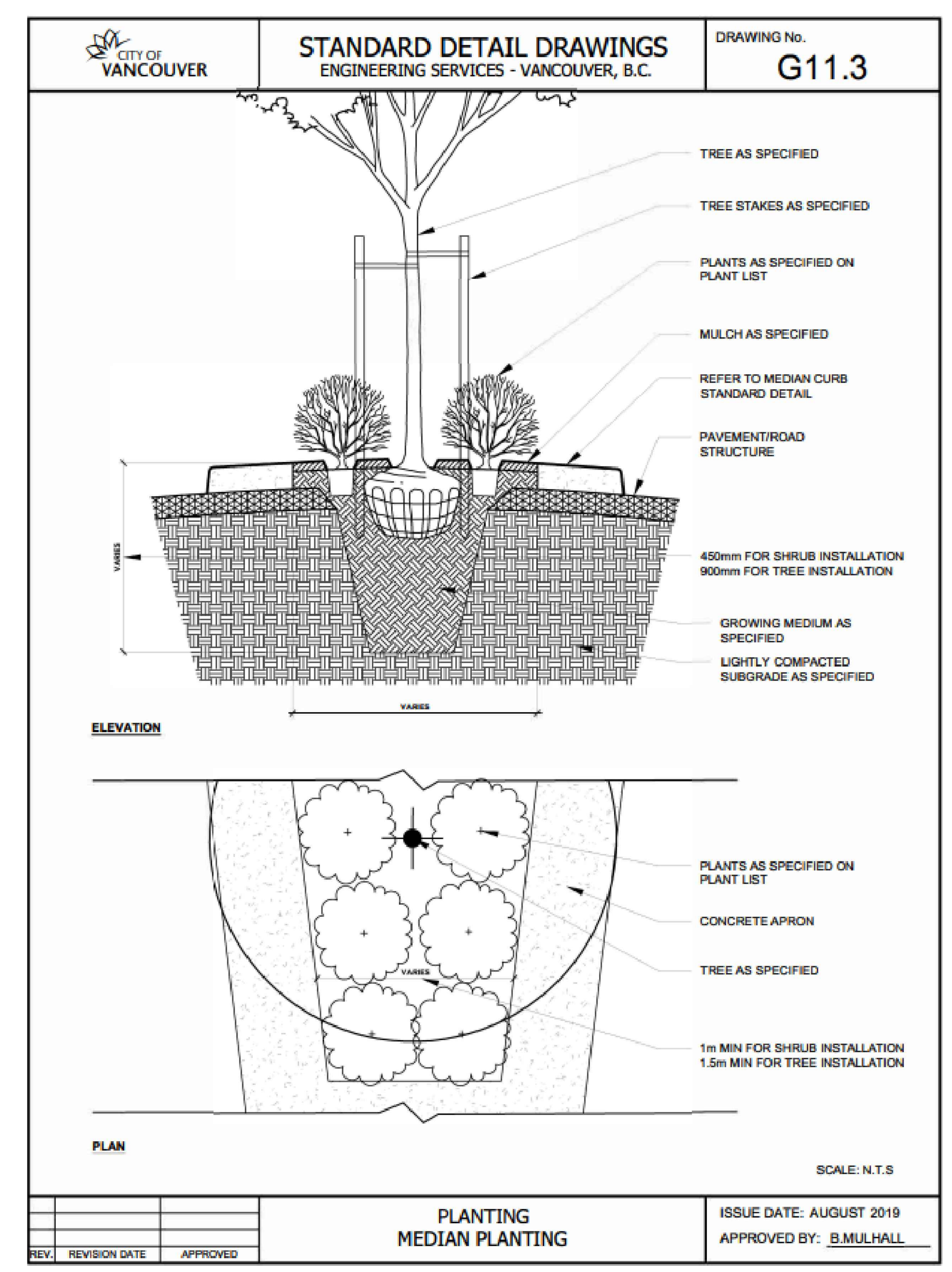




"BY SEALING AND SIGNING THIS DRAWING, I CERTIFY THAT THE INFORMATION CONTAINED IN THESE ACCURATELY REFLECTS THE ORIGINAL DESIGN, ADDENDA, CHANGE ORDERS AND MATERIAL DESIGN CHANGES MADE DURING CONSTRUCTION AND FIELD REVIEWED BY ME, OR MY REPRESENTATIVE, AND THAT THE AS-CONSTRUCTED WORKS SUBSTANTIALLY COMPLY WITH THE ORIGINAL DESIGN INTENT, HOWEVER, I DO NOT ACCEPT RESPONSIBILITY OF THE ACCURACY OR COMPLETENESS OF THE AS-CONSTRUCTED INFORMATION SUPPLIED BY OTHERS CONTAINED IN THESE DRAWINGS."

ISSUED FOR CONSTRUCTION
2022-03-26

UBC sustainability

SCALE 0 2 1:200 10m

CAD FILENAME Wesbrook Mall Phase 4
DATE 2022-03-26

| REV | DATE | REVISIONS | SIGNATURE |
|---|---|---|---|
| | | | |

TEAM 11 CONSULTANTS

SENIOR DESIGNER
DATE 2022-03-26

| | | | |
|---|---|---|---|
| DESIGNED | Joshua Chong | DATE | 2022-03-26 |
| QUALITY CONTROL | Alvin Lok | DATE | 2022-03-26 |
| QUALITY ASSURANCE | Josh Bian | DATE | 2022-03-26 |
| DRAWN | Joshua Chong | DATE | 2022-03-26 |

WESBROOK MALL REDESIGN
PHASE 4
Standard Detail Geometric Drawings

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
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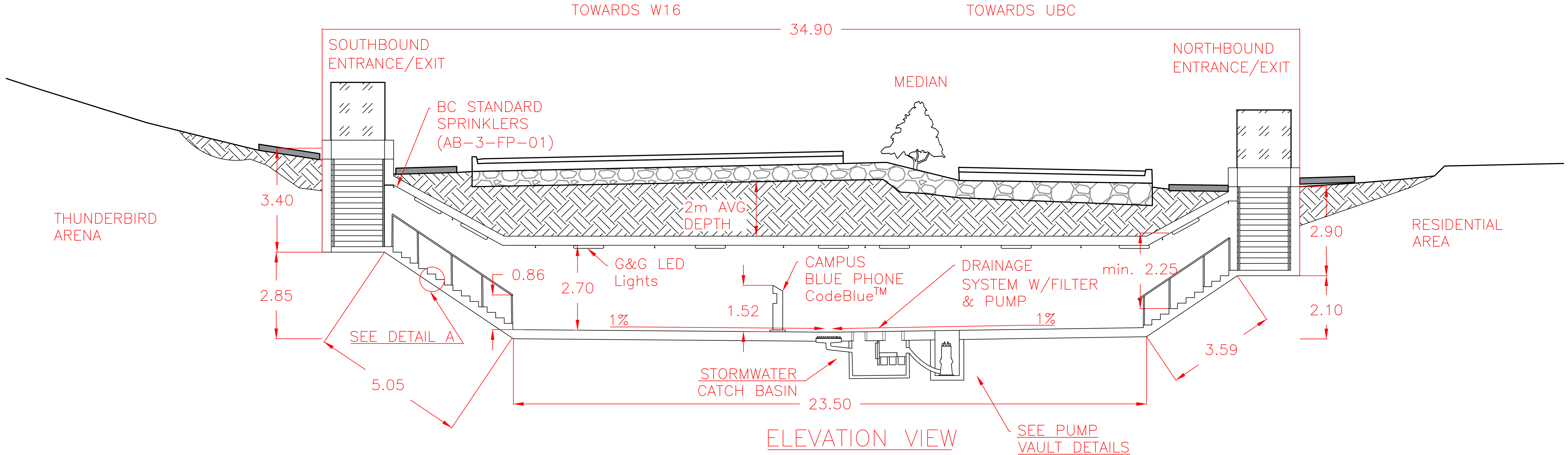
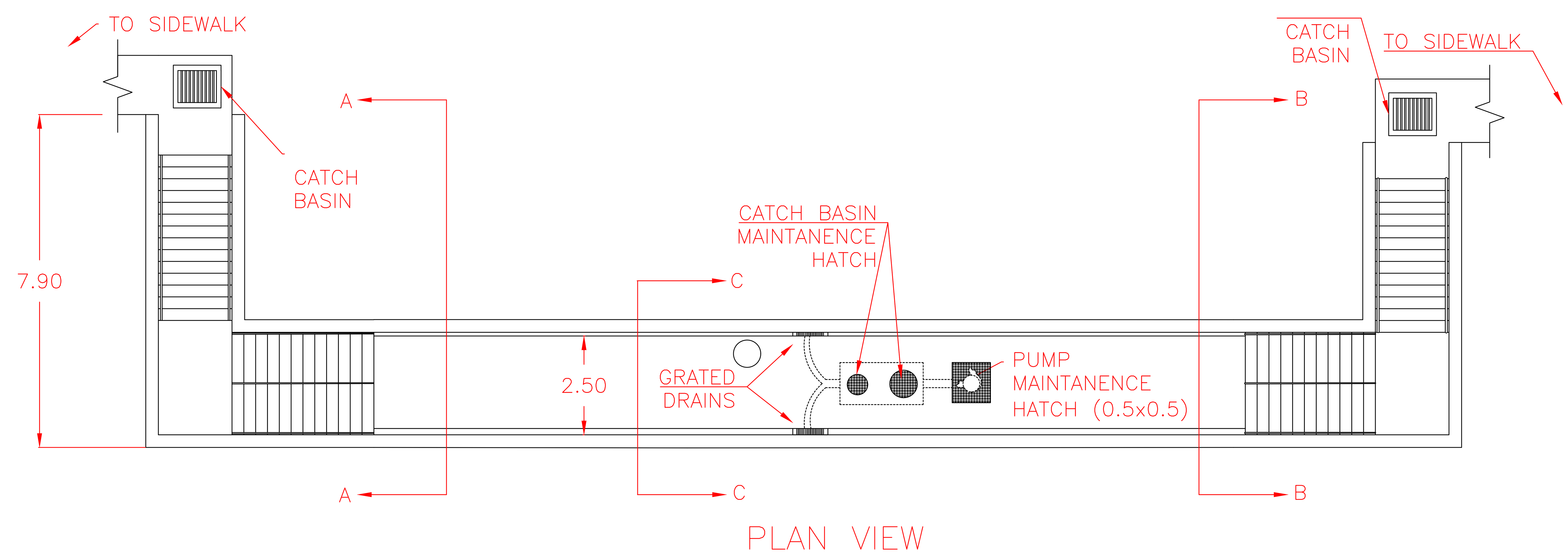
| 01 | 1228 | R | 23 | B |




NOTES:
- ALL UNITS IN METERS (M) UNLESS OTHERWISE SPECIFIED
- DIMENSIONS ARE SUBJECT TO CHANGE IN DETAILED DESIGN PHASE

"BY SEALING AND SIGNING THIS DRAWING, I CERTIFY THAT THE INFORMATION CONTAINED IN THESE ACCURATELY REFLECTS THE ORIGINAL DESIGN, ADDENDA, CHANGE ORDERS AND MATERIAL DESIGN CHANGES MADE DURING CONSTRUCTION AND FIELD REVIEWED BY ME, OR MY REPRESENTATIVE, AND THAT THE AS-CONSTRUCTED WORKS SUBSTANTIALLY COMPLY WITH THE ORIGINAL DESIGN INTENT, HOWEVER, I DO NOT ACCEPT RESPONSIBILITY OF THE ACCURACY OR COMPLETENESS OF THE AS-CONSTRUCTED INFORMATION SUPPLIED BY OTHERS CONTAINED IN THESE DRAWINGS."

ISSUED FOR CONSTRUCTION
2022-04-01

SCALE 1:75

CAD FILENAME Westbrook Mall Phase 4
DATE 2021-11-30

| REV | DATE | REVISIONS | SIGNATURE |
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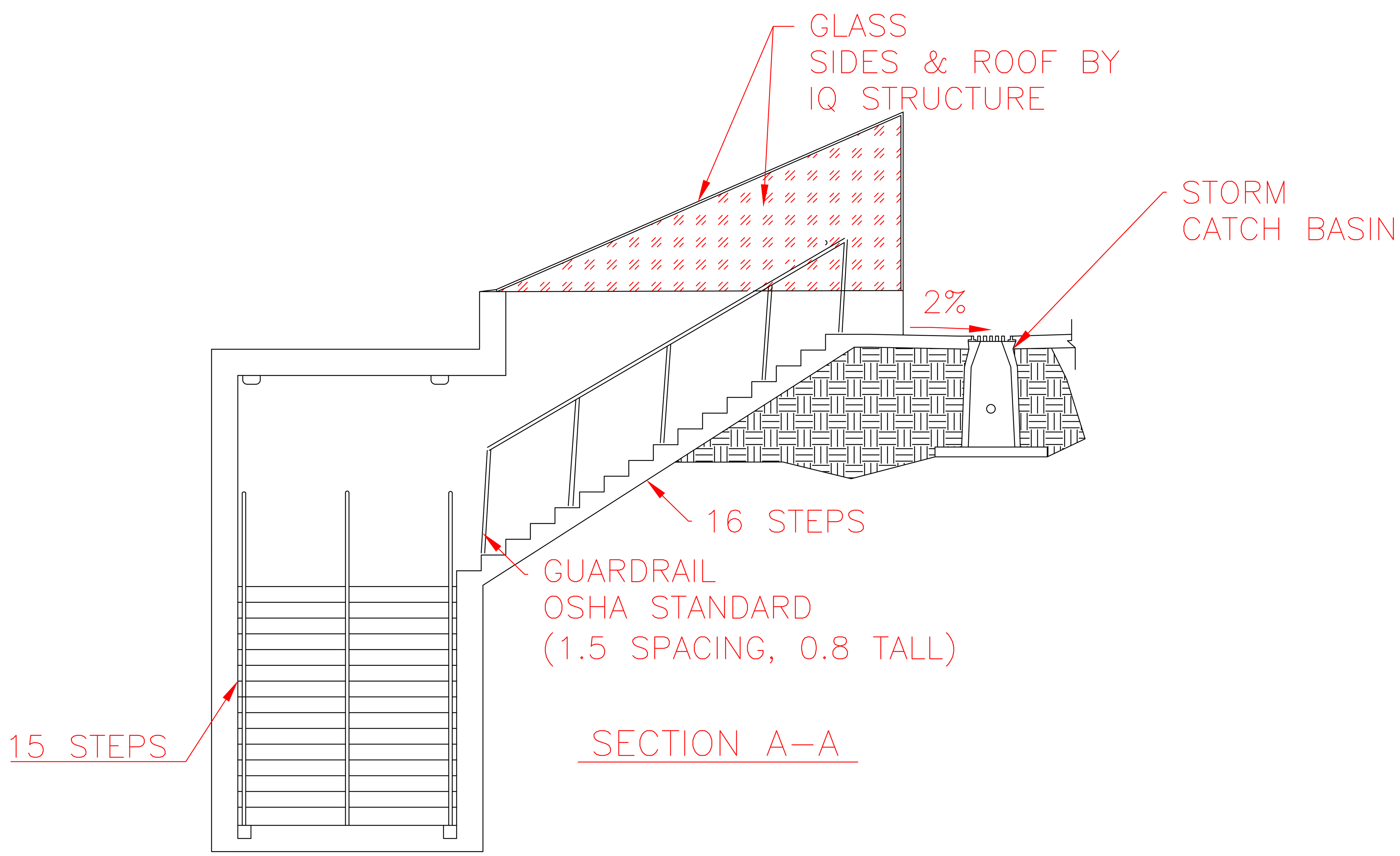
MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE
REGION_NAME
BRANCH

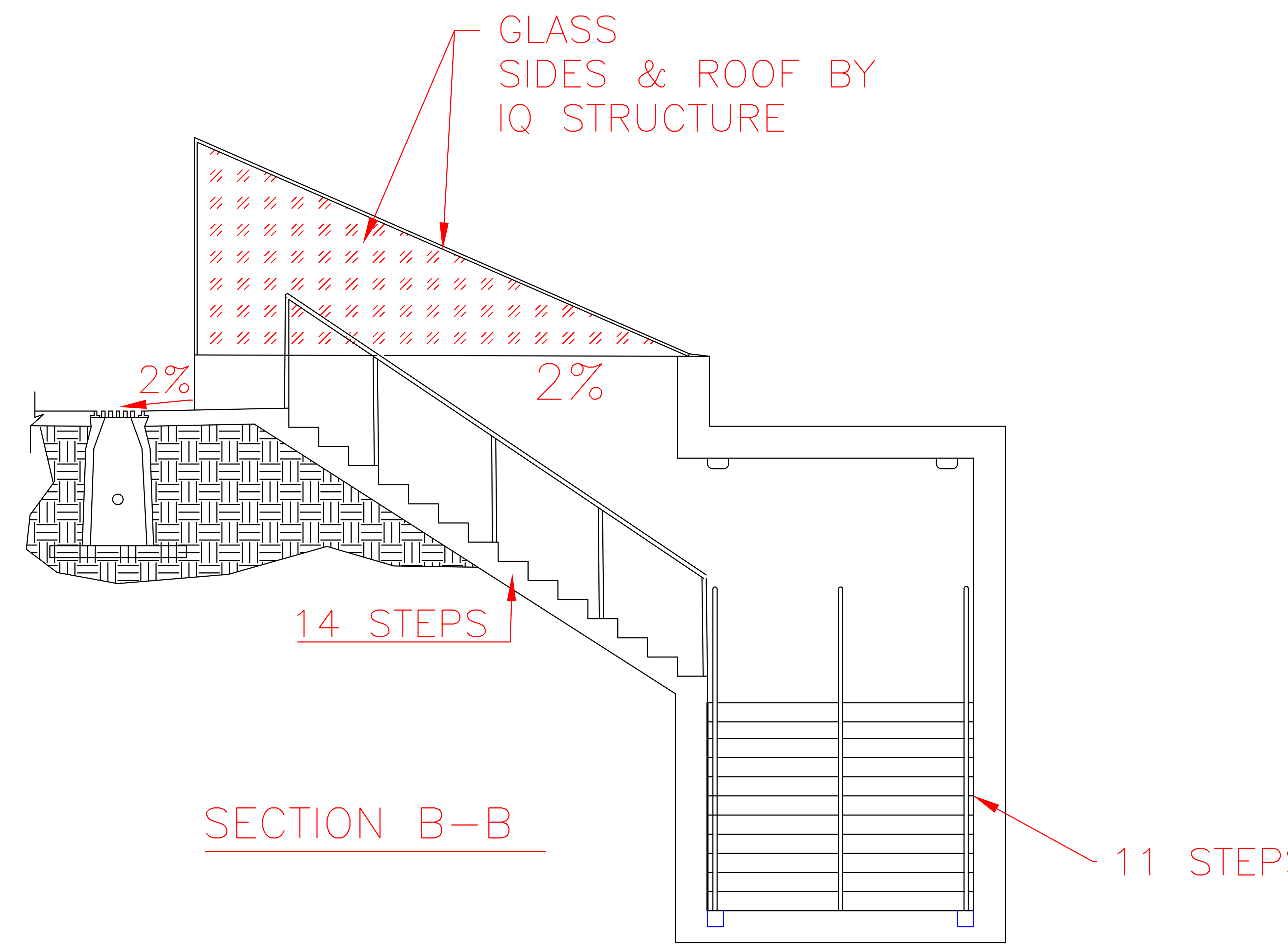
SENIOR DESIGNER
DATE 2021-11-30

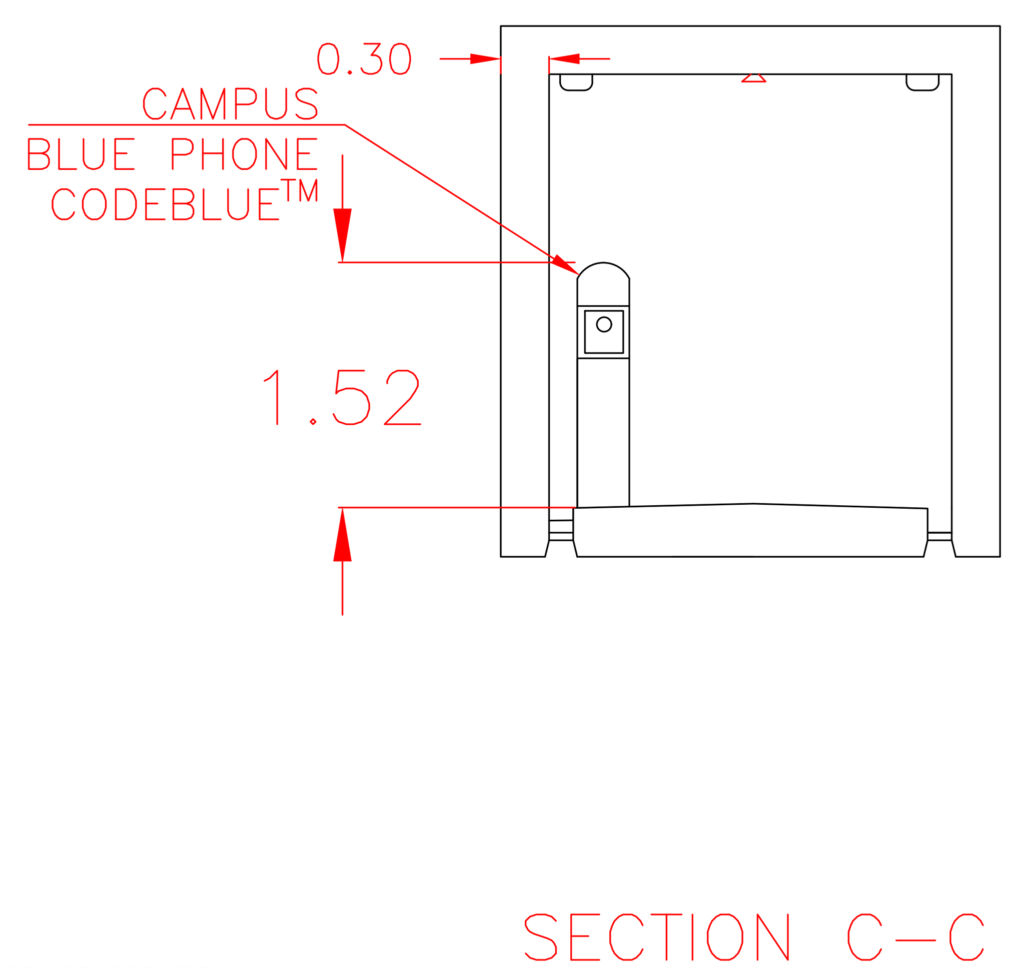
DESIGNED Josh Bian DATE 2021-11-30
QUALITY CONTROL George Gu DATE 2021-11-30
QUALITY ASSURANCE George Gu DATE 2021-11-30
DRAWN Josh Bian DATE 2021-11-30

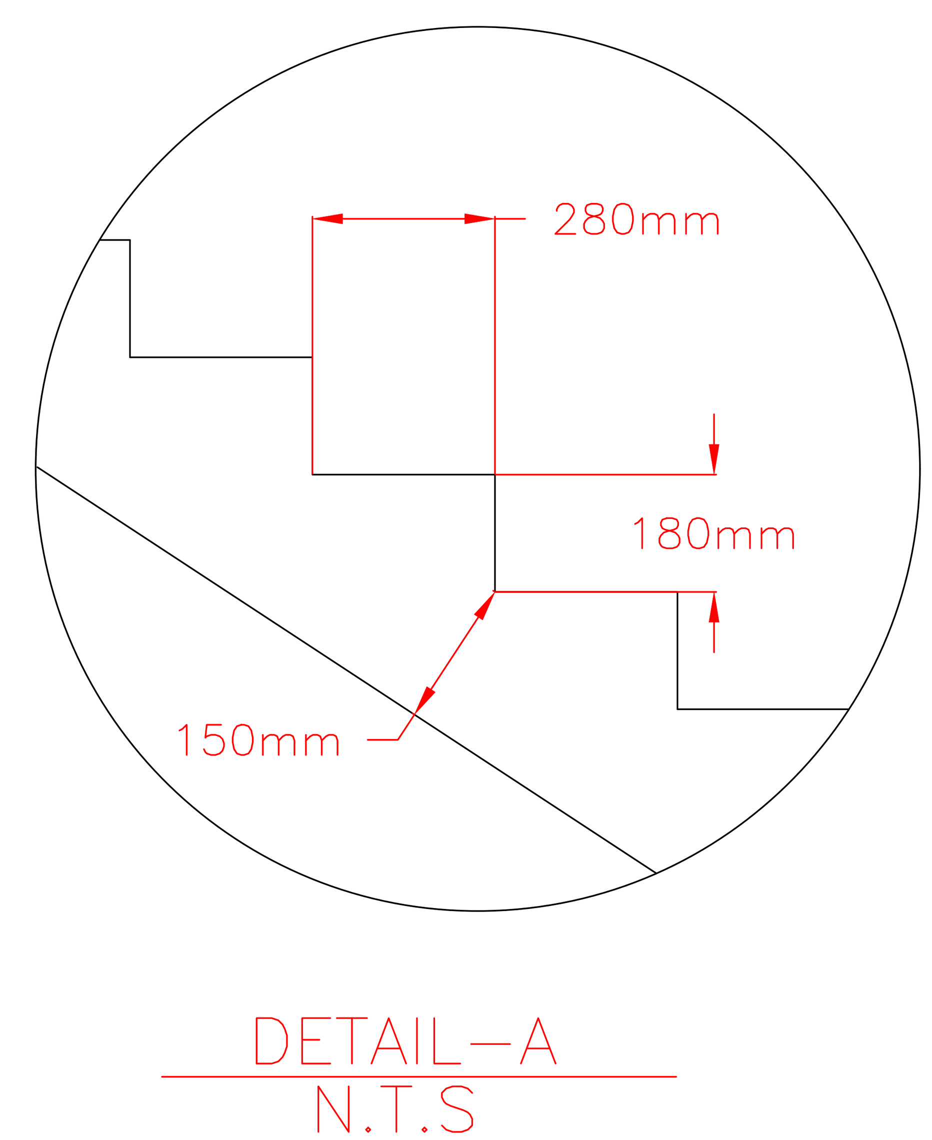
WESBROOK MALL REDESIGN
PHASE 4
Pedestrian Underpass Details

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 24 | A |




NOTES:
- ALL UNITS IN METERS (M) UNLESS OTHERWISE SPECIFIED
- DIMENSIONS ARE SUBJECT TO CHANGE IN DETAILED DESIGN PHASE
- DRAINAGE PIPES TO BE SIZED AFTER DETAILED ANALYSES

"BY SEALING AND SIGNING THIS DRAWING, I CERTIFY THAT THE INFORMATION CONTAINED IN THESE ACCURATELY REFLECTS THE ORIGINAL DESIGN, ADDENDA, CHANGE ORDERS AND MATERIAL DESIGN CHANGES MADE DURING CONSTRUCTION AND FIELD REVIEWED BY ME, OR MY REPRESENTATIVE, AND THAT THE AS-CONSTRUCTED WORKS SUBSTANTIALLY COMPLY WITH THE ORIGINAL DESIGN INTENT, HOWEVER, I DO NOT ACCEPT RESPONSIBILITY OF THE ACCURACY OR COMPLETENESS OF THE AS-CONSTRUCTED INFORMATION SUPPLIED BY OTHERS CONTAINED IN THESE DRAWINGS."

ISSUED FOR CONSTRUCTION
2022-04-01

SCALE 1:45

CAD FILENAME Westbrook Mall Phase 4
DATE 2021-11-30

| REV | DATE | REVISIONS | SIGNATURE |
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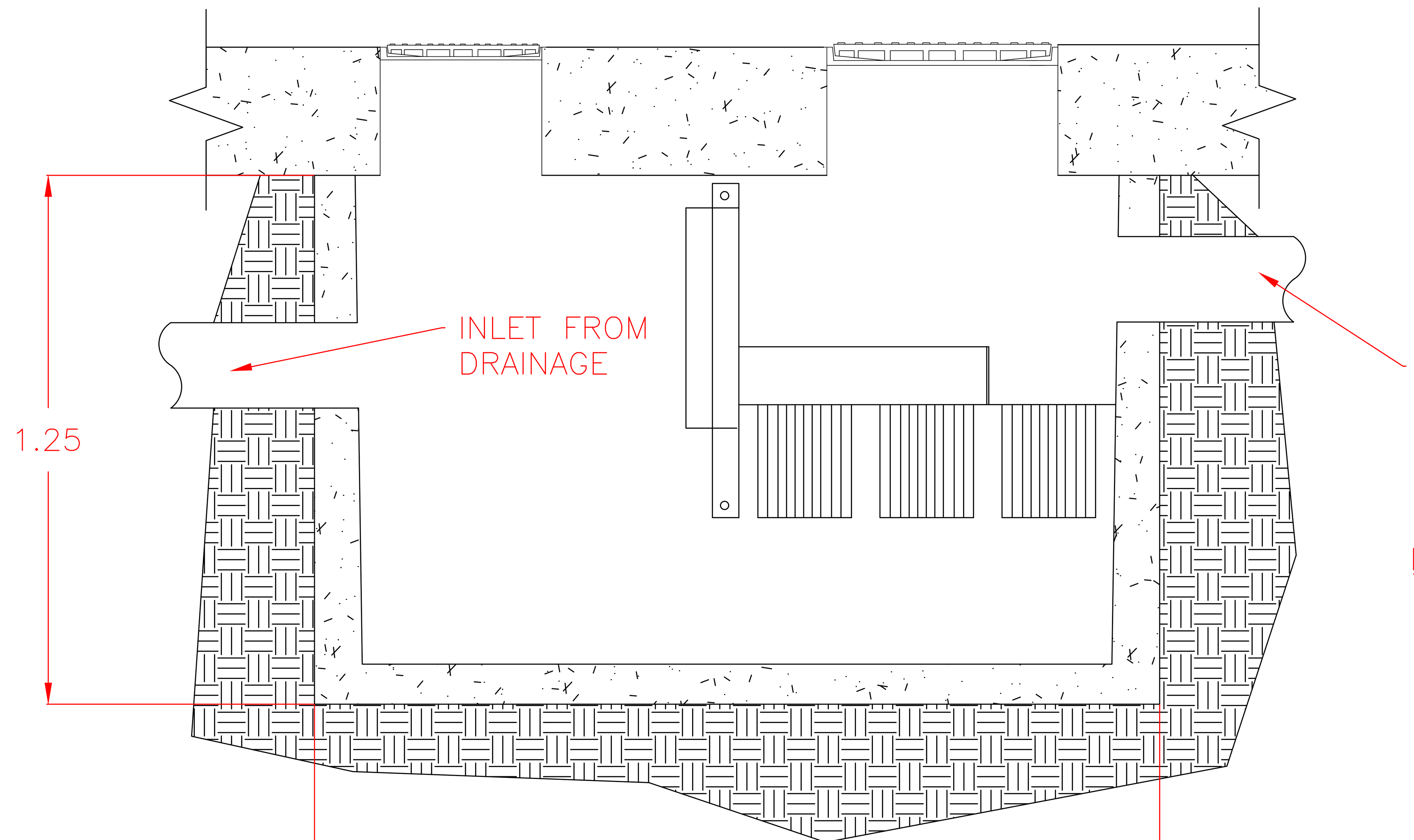
MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE
REGION_NAME
BRANCH

SENIOR DESIGNER
DATE 2021-11-30

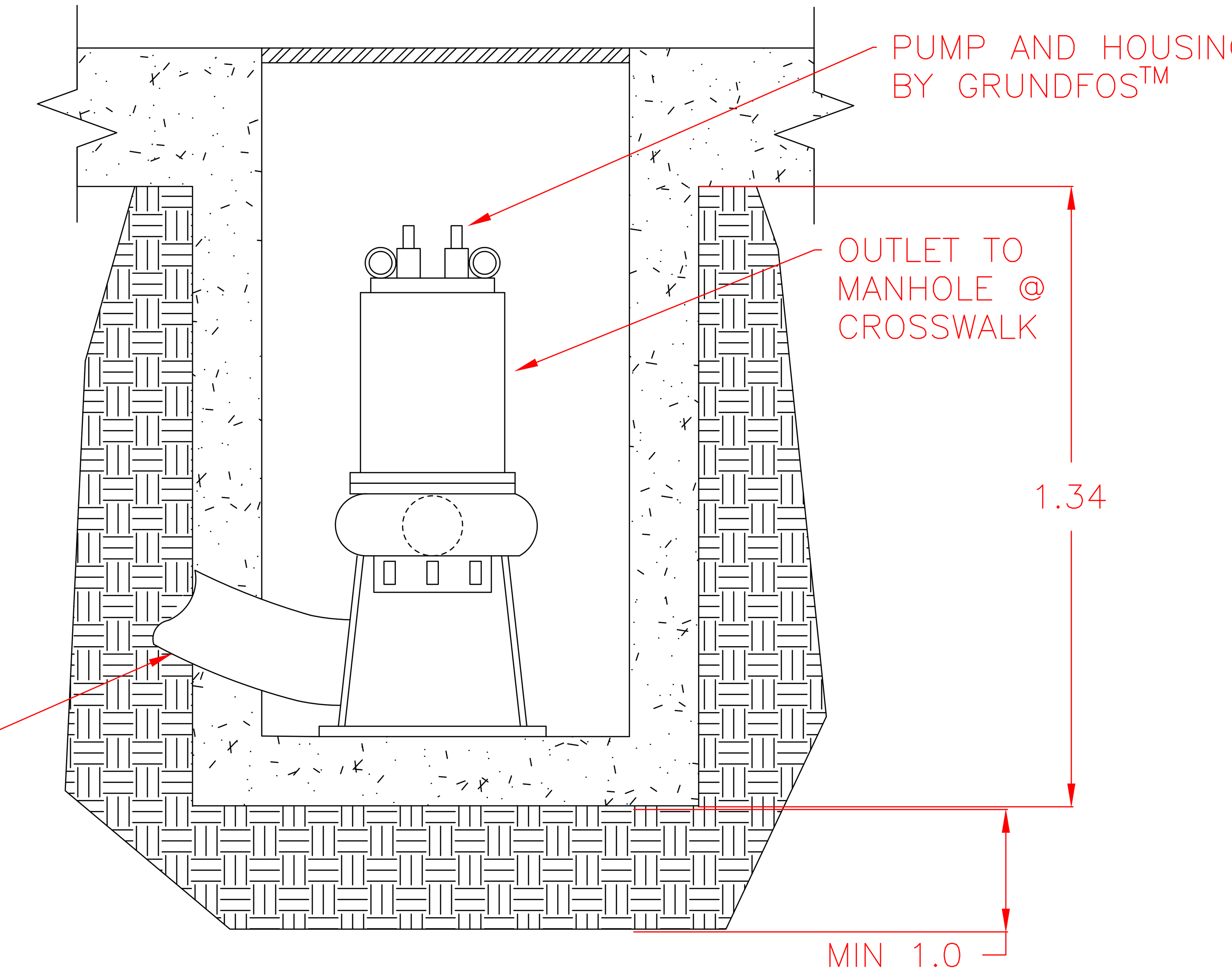
DESIGNED Josh Bian DATE 2021-11-30
QUALITY CONTROL George Gu DATE 2021-11-30
QUALITY ASSURANCE George Gu DATE 2021-11-30
DRAWN Josh Bian DATE 2021-11-30

WESBROOK MALL REDESIGN
PHASE 4
Pedestrian Underpass Details

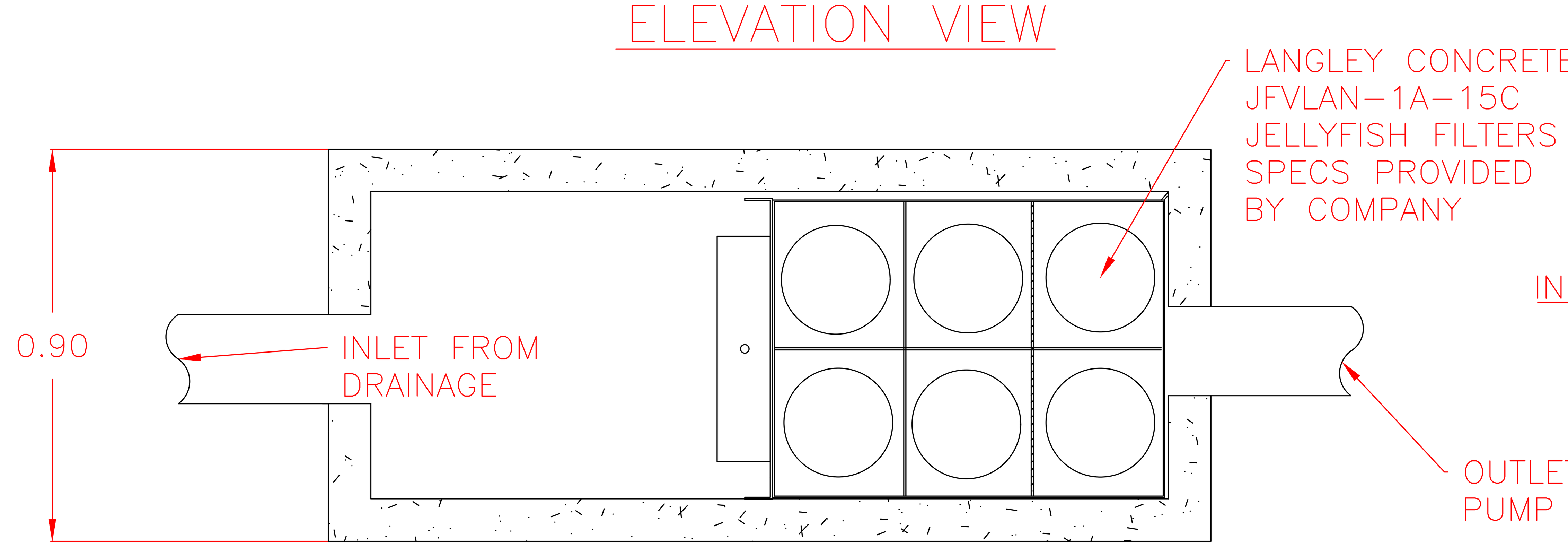
| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 25 | A |



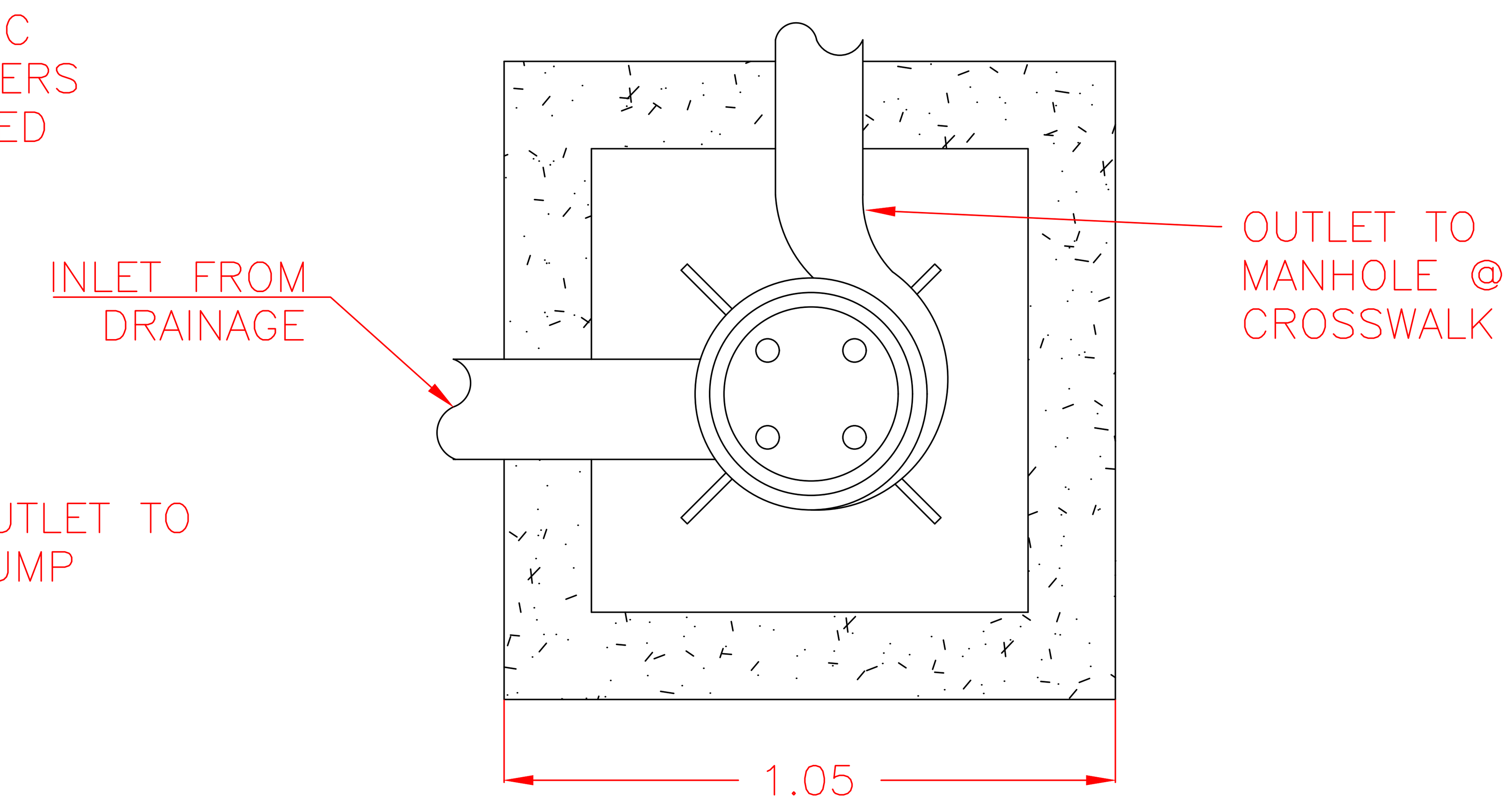

ELEVATION VIEW




ELEVATION VIEW




PLAN VIEW




PLAN VIEW

NOTES:

- ALL UNITS IN METERS (M) UNLESS OTHERWISE SPECIFIED
- DIMENSIONS ARE SUBJECT TO CHANGE IN DETAILED DESIGN PHASE
- ALL PUMPS, FILTERS, PIPES, AND VAULT SIZES TO BE RE–SIZED DURING FROM DETAILED ANALYSES

"BY SEALING AND SIGNING THIS DRAWING, I CERTIFY THAT THE INFORMATION CONTAINED IN THESE ACCURATELY REFLECTS THE ORIGINAL DESIGN, ADDENDA, CHANGE ORDERS AND MATERIAL DESIGN CHANGES MADE DURING CONSTRUCTION AND FIELD REVIEWED BY ME, OR MY REPRESENTATIVE, AND THAT THE AS–CONSTRUCTED WORKS SUBSTANTIALLY COMPLY WITH THE ORIGINAL DESIGN INTENT, HOWEVER, I DO NOT ACCEPT RESPONSIBILITY OF THE ACCURACY OR COMPLETENESS OF THE AS–CONSTRUCTED INFORMATION SUPPLIED BY OTHERS CONTAINED IN THESE DRAWINGS."

ISSUED FOR CONSTRUCTION
2022-04-01

SCALE 1:05

CAD FILENAME Westbrook Mall Phase 4
DATE 2021-11-30

| REV | DATE | REVISIONS | SIGNATURE |
|---|---|---|---|
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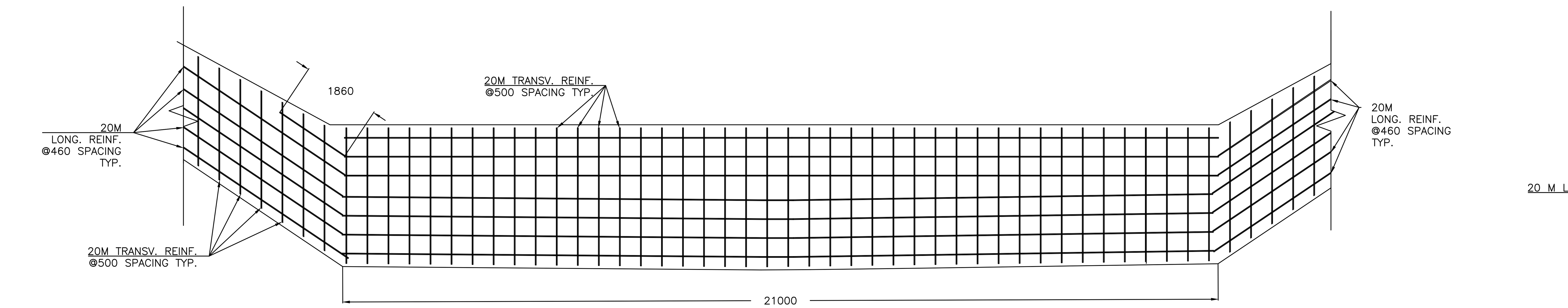
MINISTRY OF TRANSPORTATION
AND INFRASTRUCTURE
REGION_NAME
BRANCH

SENIOR DESIGNER
DATE 2021-11-30

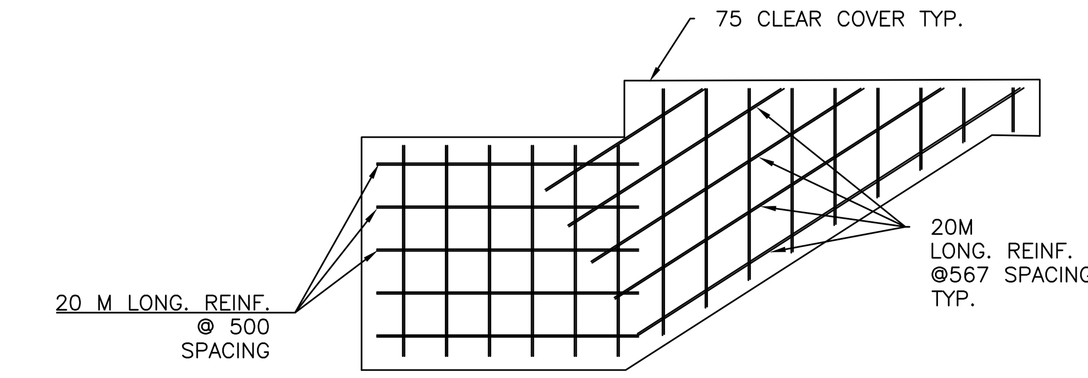
DESIGNED Josh Bian DATE 2021-11-30
QUALITY CONTROL George Gu DATE 2021-11-30
QUALITY ASSURANCE George Gu DATE 2021-11-30
DRAWN Josh Bian DATE 2021-11-30

WESBROOK MALL REDESIGN
PHASE 4
Pedestrian Underpass Details

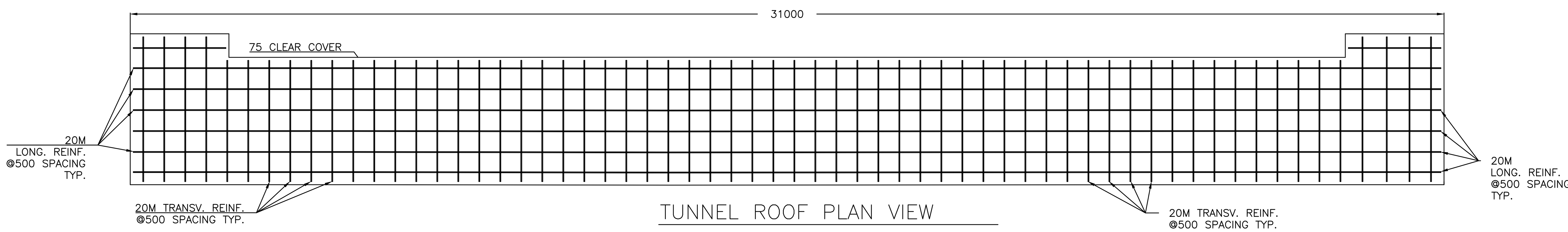
| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 26 | A |



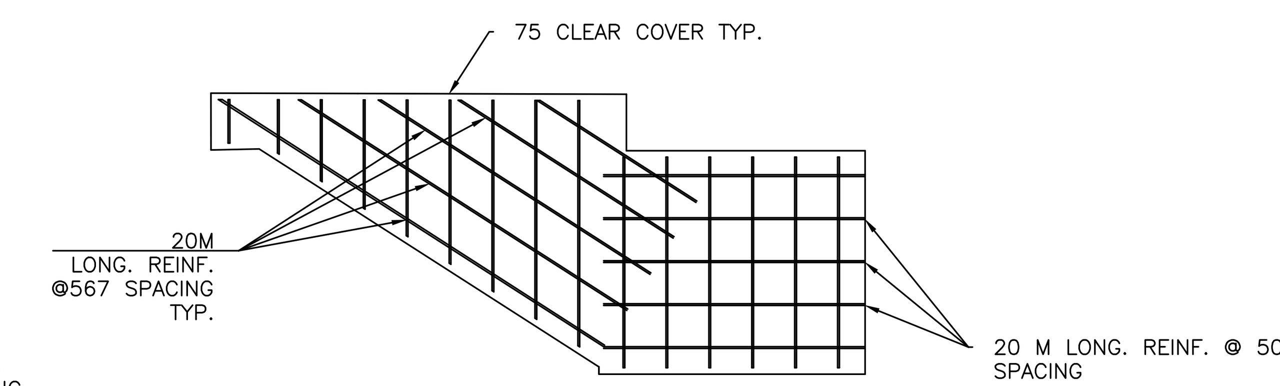

TUNNEL WALLS ELEVATION VIEW



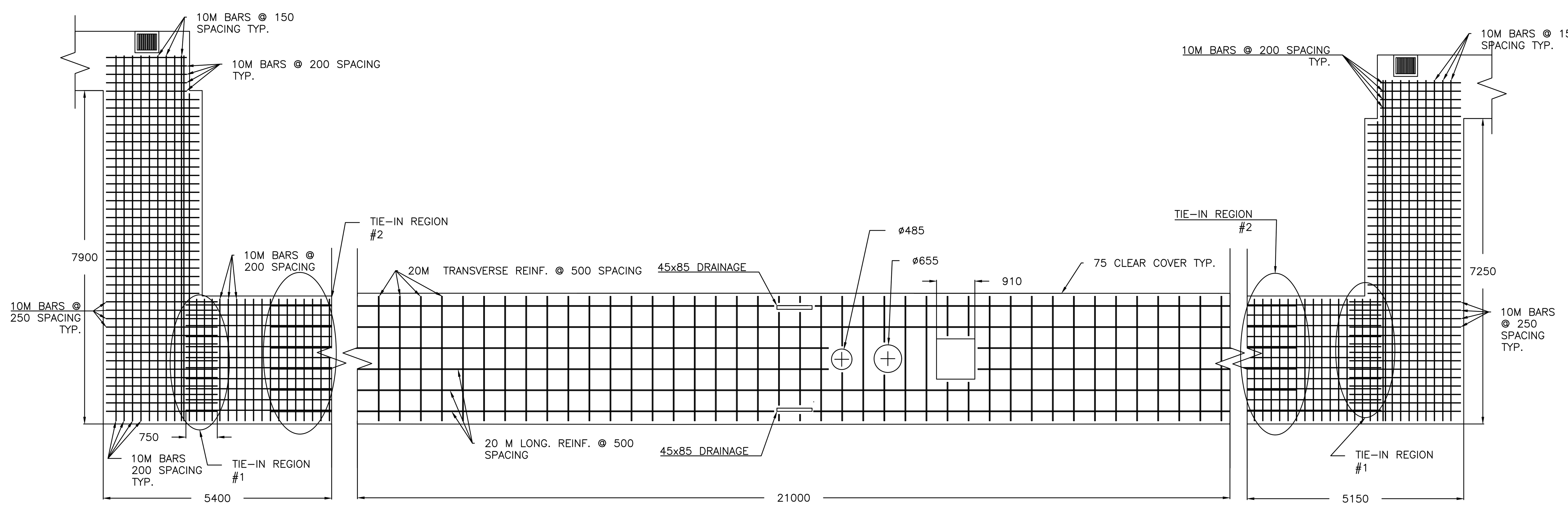

NORTHBOUND ENTRANCE WALL PLAN VIEW




TUNNEL ROOF PLAN VIEW



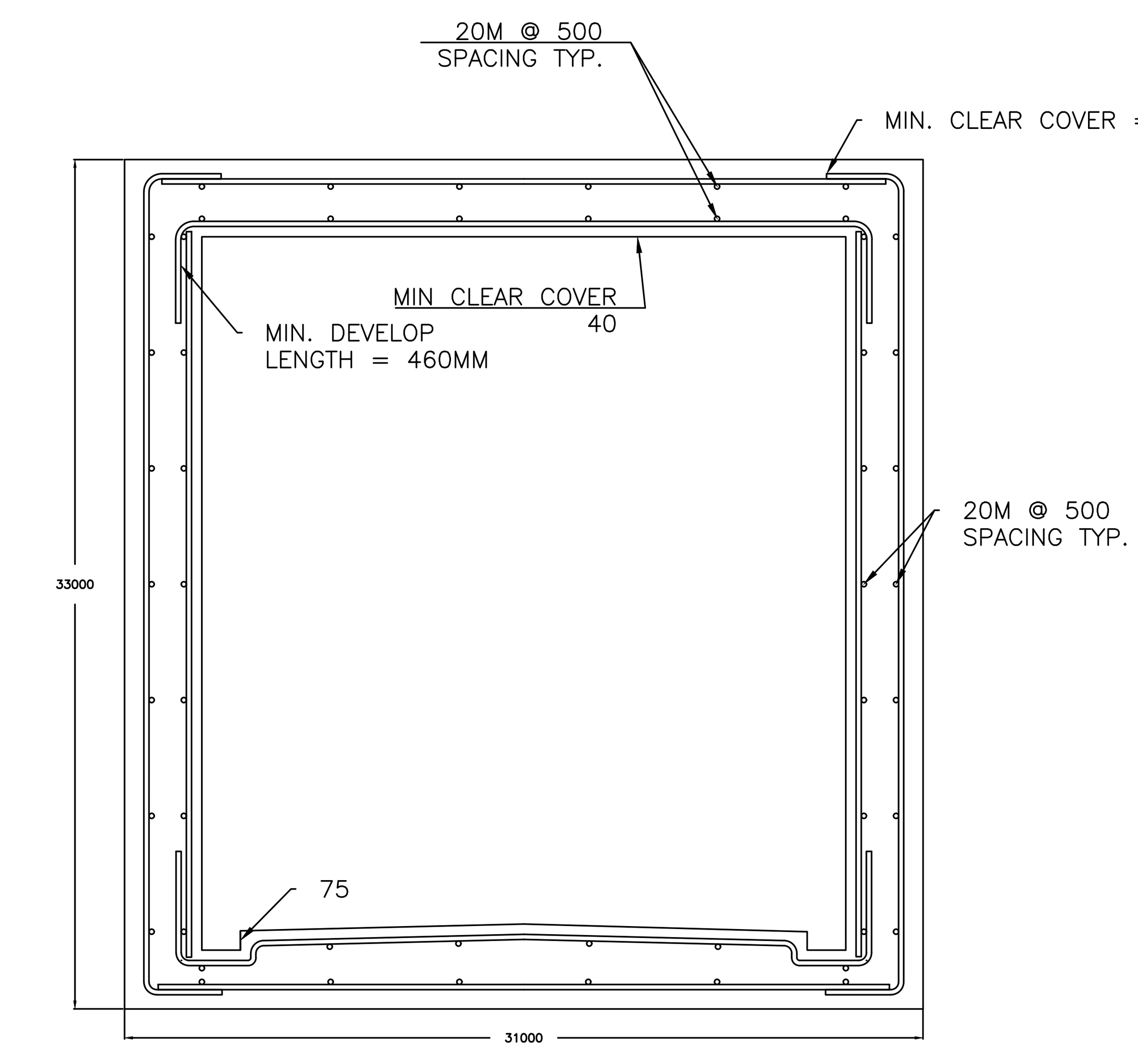

SOUTHBOUND ENTRANCE WALL PLAN VIEW




ENTRANCE TUNNEL

MAIN TUNNEL

TUNNEL BASE PLAN VIEW




TUNNEL CROSS SECTION

NOTES:
- ALL UNITS IN METERS (M) UNLESS OTHERWISE SPECIFIED
- DIMENSIONS ARE SUBJECT TO CHANGE IN DETAILED DESIGN PHASE

"BY SEALING AND SIGNING THIS DRAWING, I CERTIFY THAT THE INFORMATION CONTAINED IN THESE ACCURATELY REFLECTS THE ORIGINAL DESIGN, ADDENDA, CHANGE ORDERS AND MATERIAL DESIGN CHANGES MADE DURING CONSTRUCTION AND FIELD REVIEWED BY ME, OR MY REPRESENTATIVE, AND THAT THE AS-CONSTRUCTED WORKS SUBSTANTIALLY COMPLY WITH THE ORIGINAL DESIGN INTENT. HOWEVER, I DO NOT ACCEPT RESPONSIBILITY OF THE ACCURACY OR COMPLETENESS OF THE AS-CONSTRUCTED INFORMATION SUPPLIED BY OTHERS CONTAINED IN THESE DRAWINGS."

ISSUED FOR CONSTRUCTION
2022-04-01

SCALE 1:75

CAD FILENAME Westbrook Mall Phase 4
DATE 2021-11-30

| REV | DATE | REVISIONS | SIGNATURE |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

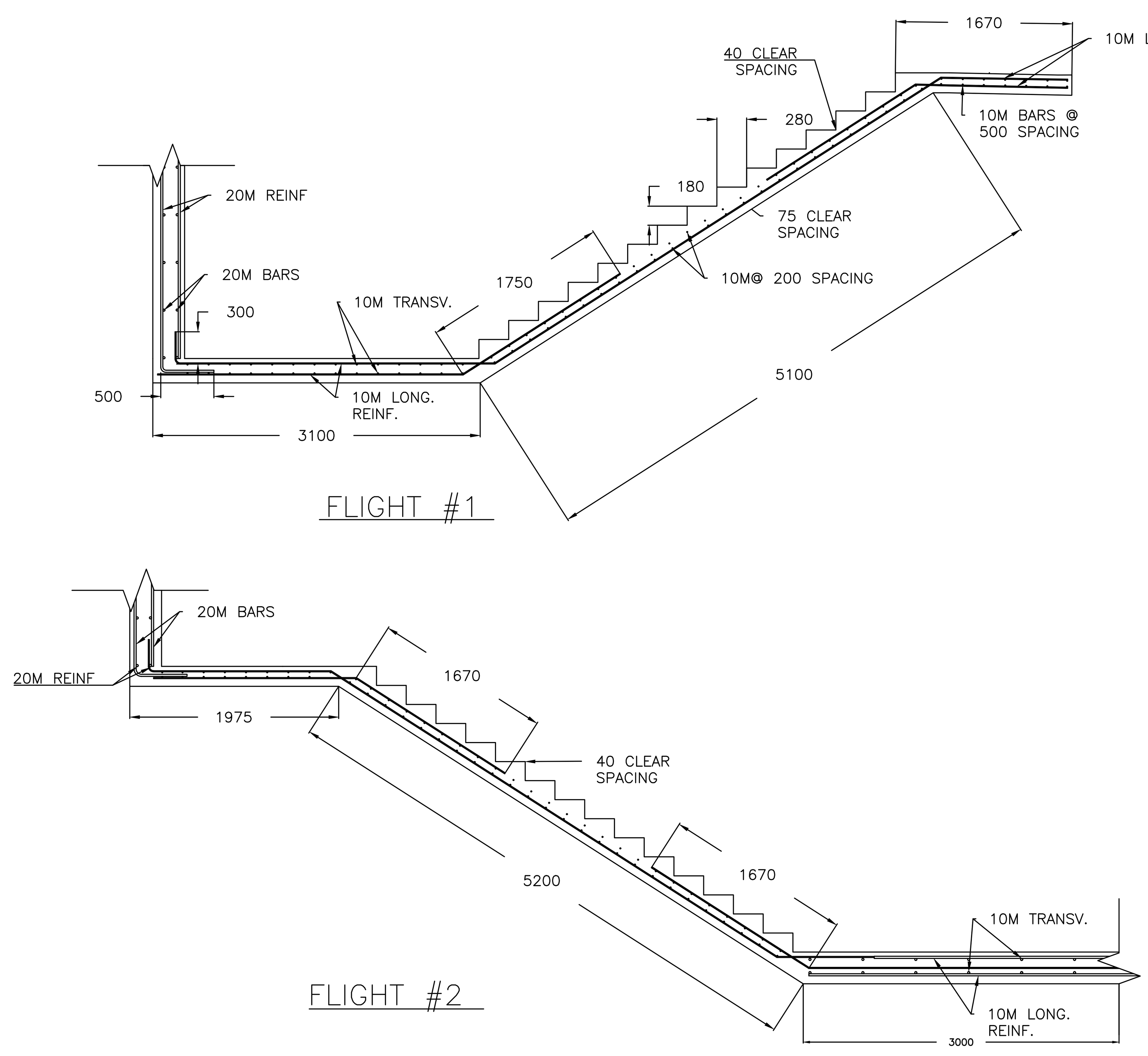
MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE
REGION_NAME
BRANCH

SENIOR DESIGNER
DATE 2021-11-30

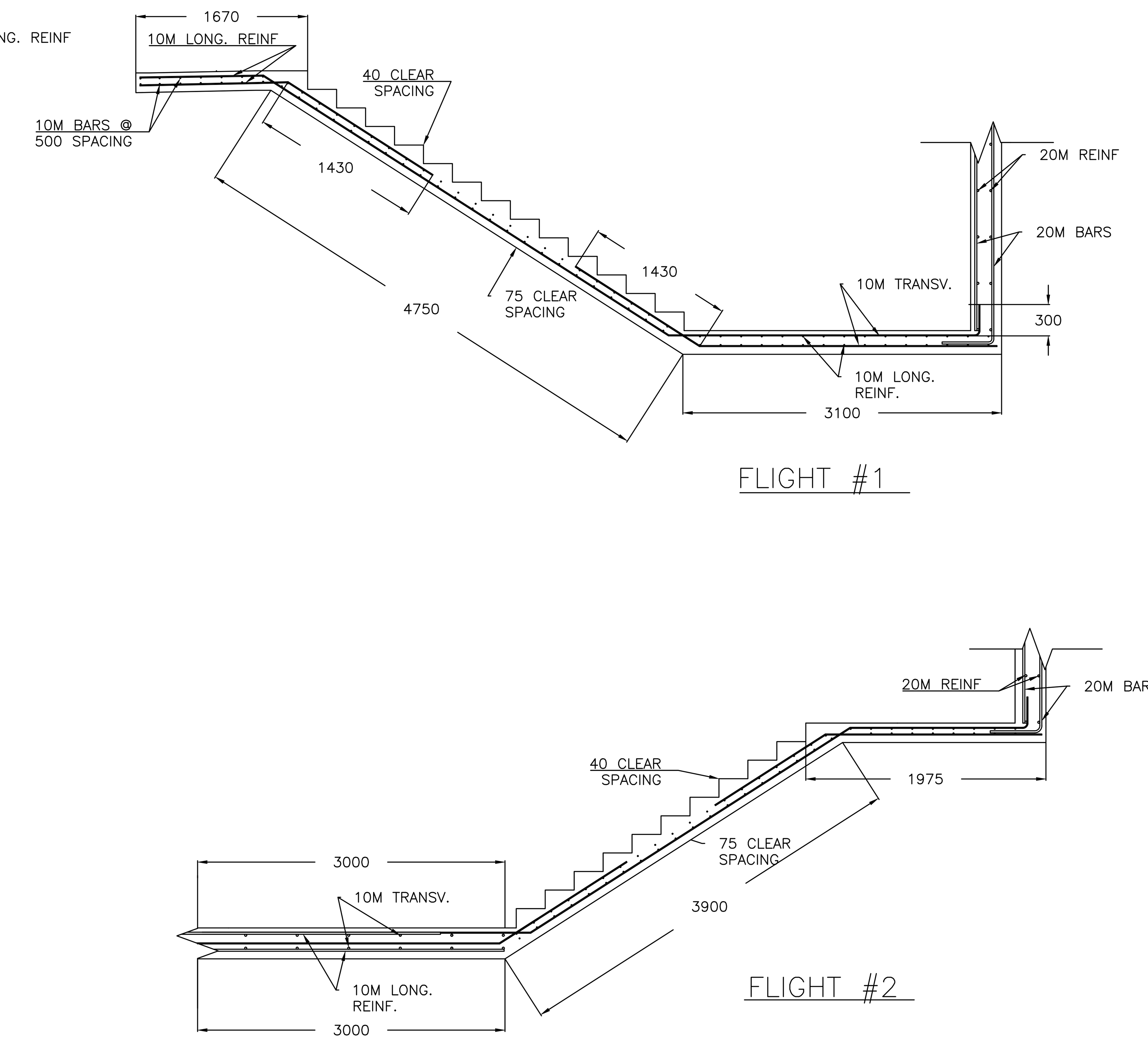
| | | | |
|---|---|---|---|
| DESIGNED | Josh Bian | DATE | 2021-11-30 |
| QUALITY CONTROL | George Gu | DATE | 2021-11-30 |
| QUALITY ASSURANCE | George Gu | DATE | 2021-11-30 |
| DRAWN | Josh Bian | DATE | 2021-11-30 |

WESBROOK MALL REDESIGN
PHASE 4
Pedestrian Underpass Details

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 27 | A |




SOUTHBOUND ENTRANCE STAIRS




NORTHBOUND ENTRANCE STAIRS

NOTES:
- ALL UNITS IN METERS (M) UNLESS OTHERWISE SPECIFIED
- DIMENSIONS ARE SUBJECT TO CHANGE IN DETAILED DESIGN PHASE

"BY SEALING AND SIGNING THIS DRAWING, I CERTIFY THAT THE INFORMATION CONTAINED IN THESE ACCURATELY REFLECTS THE ORIGINAL DESIGN, ADDENDA, CHANGE ORDERS AND MATERIAL DESIGN CHANGES MADE DURING CONSTRUCTION AND FIELD REVIEWED BY ME, OR MY REPRESENTATIVE, AND THAT THE AS-CONSTRUCTED WORKS SUBSTANTIALLY COMPLY WITH THE ORIGINAL DESIGN INTENT, HOWEVER, I DO NOT ACCEPT RESPONSIBILITY OF THE ACCURACY OR COMPLETENESS OF THE AS-CONSTRUCTED INFORMATION SUPPLIED BY OTHERS CONTAINED IN THESE DRAWINGS."

ISSUED FOR CONSTRUCTION
2022-04-01

SCALE 1:75

CAD FILENAME Westbrook Mall Phase 4
DATE 2021-11-30

| REV | DATE | REVISIONS | SIGNATURE |
|---|---|---|---|
| | | | |
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| | | | |

MINISTRY OF TRANSPORTATION
AND INFRASTRUCTURE
REGION_NAME
BRANCH

SENIOR DESIGNER
DATE 2021-11-30

DESIGNED Josh Bian DATE 2021-11-30
QUALITY CONTROL George Gu DATE 2021-11-30
QUALITY ASSURANCE George Gu DATE 2021-11-30
DRAWN Josh Bian DATE 2021-11-30

WESBROOK MALL REDESIGN
PHASE 4
Pedestrian Underpass Details

| FILE NUMBER | PROJECT NUMBER | REG | DRAWING NUMBER | REV |
|---|---|---|---|---|
| 01 | 1228 | R | 28 | A |

# Appendix A - Construction Specifications

# 1. Concrete Walks, Curbs and Gutters

## 1.1. GENERAL

### 1.1.1. Related Work

1.1.1.1. Storm Sewers

## 1.2. PRODUCTS

1.2.1. Polyvinyl Chloride (PVC) or Acrylonitrile Butadiene-Styrene (ABS) plastics shall meet the requirements of the latest revision of CAN / CSA 182.1. Pipe shall be available in 3m lengths with nominal diameter of 100mm and perforations as detailed in Section 4.1.4 of CAN / CSA 182.1 for leach field pipe. The pipe will include bell and spigot design suitable for solvent welding, where required. The pipe shall have an SDR of 28 or lower and 700kPa at 5% deflection.

## 1.3. EXECUTION

### 1.3.1. Formwork

1.3.1.1. At lanes, crossings and other similar locations, formwork shall be left in place until the concrete has attained sufficient strength to bear traffic loads without edge damage. Sufficient strength generally means minimum 20MPa in concrete strength

### 1.3.2. Driveway Crossings and Wheel Chair Ramp

1.3.2.1. Wheel Chair Ramps

1.3.2.1.1. Ramps shall land wheelchair and other users safely in the crosswalk and in the desired direction of travel.

1.3.2.1.2. The ramp and the directional score lines shall lead into the crosswalk, lining up with the ramp across the Street and be parallel with the crossing or marked crosswalk.

1.3.2.2. Double Curb Ramp

1.3.2.2.1. Minimum 1.0m full curb is required between the two ramps as per Standard Detail Drawing C8.1. Double curb ramps are preferred, and shall be implemented whenever possible, over large single curb ramps

1.3.2.3. Large Single Curb Ramp

1.3.2.3.1. The ramp must adequately land a pedestrian in both crosswalks as per Standard Detail Drawing C8.2.

1.3.2.4. Lane Curb Ramp

1.3.2.4.1. The ramp and the directional score lines shall line up with the ramp across the lane and be parallel with the crossing as per Standard Detail Drawing C9.1.

1.3.2.4.2. The minimum thickness of all residential concrete driveway crossings shall be 200mm as per Standard Detail Drawing C7.1. The minimum thickness for commercial crossings is 300mm as per Standard Detail Drawing C7.2.

1.3.3. Control Joints

1.3.3.1. Walks 1.5m, 1.8m, and 2.0m in width shall be marked off in panels 1.5m, 1.8m, or 2.0m long respectively unless otherwise directed by the Owner Representative. Control joints to control and minimize cracking shall be installed to the satisfaction of the Owner Representative. The scoring pattern of the sidewalk is governed by the distance between features such as tree pits and water valve boxes. Keep the scoring pattern as square as possible for the sidewalk panels.

1.3.4. Isolation Joints

1.3.4.1. Carefully fit, cut, and mark the sidewalk around all features such as water valve boxes, lamp standards, poles, and hydrants to prevent cracking of the slabs, to the satisfaction of the Owner Representative.

1.3.5. Finishing

1.3.5.1. Cutting and marking tools shall have a cutting edge not less than 25mm in depth and the edge of the panel shall be rounded to a 6mm radius. Trowel edge to be as close to flush as possible with broom finish. The broom finish shall extend to the edge of the panel.

1.3.5.2. Finished curb and gutter shall have a smooth and uniform surface, true to line, grade, and section and shall be free from voids, sags, bumps, or other irregularities to the satisfaction of the Owner Representative.

1.3.5.3. All control joints are to be sawcut only (no trowel marks) and shall be done 24 hours after the pour to avoid any cracking.

1.3.5.4. All score lines are to be trowelled only.

1.3.6. Acceptance

1.3.6.1. Any portion marked or damaged by vandalism, rain, frost, equipment, traffic, or other, to be replaced at the Contractor's cost.

1.3.6.2. The Contractor shall be responsible for any damage to existing concrete walks, curbs, and gutters at their Site or any damages at adjacent sites, and shall make all necessary repairs, at their cost, to any damage caused from their construction activities to the satisfaction of the Owner Representative.

# 2. Cast-in-Place Concrete

## 2.1. PRODUCTS

2.1.1. Materials

2.1.1.1. All concrete used under this specification shall be ready-mixed concrete, proportioned and mixed in an approved mixing plant.

2.1.2. Concrete Mixes

2.1.2.1. All concrete supplied shall meet the requirements of CAN / CSA-A23.1 and City-specified mix requirements unless otherwise allowed by the Owner Representative. Concrete shall be normal weight, and the Contractor and its supplier shall assume responsibility for the quality and performance of the concrete as per

CAN / CSA-A23.1 Table 5 Alternative 1. Submit mix designs to the Contract Administrator for review and record upon request.

## 2.2. EXECUTION

### 2.2.1. Cold Weather Placement

2.2.1.1. Cold weather requirements apply when the air temperature is at or below 5˚C, or is forecast to fall below 5˚C within 24 hours of placing. Do not schedule or place concrete during periods that have a high probability of rain or snow. Protect concrete against potential rain and frost until it has cured sufficiently to the satisfaction of the Owner Representative.

2.2.1.2. When concrete is to be placed in cold weather, have all materials and equipment needed for adequate protection and curing on hand and ready for use before concrete placement is started. Obtain prior authorization from the Owner Representative for the proposed enclosures, equipment, and procedures for cold weather concreting.

2.2.1.3. Do not place concrete against any surface that has a temperature of less than 5˚C. Remove all snow and ice. Preheat such surfaces for 24 hours or as required to obtain surface temperatures of 5˚C minimum, whichever is longer, prior to placing concrete.

2.2.1.4. Design and construct heating and hoarding protection measures including heated enclosures, coverings, insulation, or a suitable combination of these methods in accordance with CAN / CSA-A23.1.

2.2.1.5. Inspect heating and hoarding measures at least every four hours and verify that enclosures, coverings, and insulation are in place, there is adequate heater fuel, and the specified temperatures are being maintained.

2.2.1.6. Provide a sufficient number of adequately sized and properly vented heaters. Do not place heaters at locations that may cause rapid drying of freshly placed concrete. Use fans to constantly circulate warm air within the enclosure. Do not use tiger torches or other open flame burners as heaters.

2.2.2. Hot Weather Placement

2.2.2.1. Hot weather requirements apply when the air temperature is at or above 25˚C, or is forecast to rise to 25˚C within 24 hours of placement.

2.2.2.2. Protect formwork, reinforcement, and concrete equipment from the direct rays of the sun, or cool by fogging and evaporation. Dampen subgrade surfaces prior to concrete placement.

2.2.2.3. Provide adequate personnel and equipment to transport, place, consolidate, and finish the concrete at the fastest possible rate. Obtain prior authorization from the Owner Representative for the proposed equipment and procedures for hot weather concreting.

2.2.2.4. Provide protection from drying in accordance with CAN / CSA-A23.1.

# 3. Excavating, Trenching and Backfilling

## 3.1. GENERAL

3.1.1. Limitations of Open Trench

3.1.1.1. All backfilling procedures shall be carried out as promptly as possible behind pipe laying. Under no circumstances shall an inactive open trench be open for more than 5 Days unless otherwise approved by the Contract Administrator. In addition, no more than one Block may remain un-backfilled at any given time, unless approved in advance by the Contract Administrator.

3.1.1.2. The use of road plates to cover excavations and restore travel lanes is generally not permitted. Where construction necessitates their use, a letter signed by an Engineer must be submitted ensuring the installation is safe and that the plate will support H-20 traffic loading. Plates need to be properly secured (either pinned or recessed into the pavement) and feathered a minimum 300mm with existing road asphalt. Plates need to extend a minimum 300mm beyond the trench, and any pavement damage related to the plate installation will need to be repaired.

3.1.2. Permits and Approvals

3.1.2.1. Conduct a Condition Survey with the Contract Administrator prior to commencing any excavation unless otherwise directed by the Owner Representative.

3.1.3. Measurement and Payment

3.1.3.1. Unless otherwise noted in the Contract Documents, payment for trench excavation by hand (hand dig) or hydro-vacuum excavation will be incidental to payment for Work described in other Sections.

3.1.3.2. Unless otherwise noted in the Contract Documents, payment for all charges or fees related to inspection from third-party utility companies and / or external authorities / agencies will be incidental to payment for Work described in other Sections

3.1.3.3. Payment for additional paving, including saw-cutting, removal of existing asphalt and base, and preparation of new base shall be made as per the relevant unit price item as indicated in the Schedule of Quantities and Prices.

Payment for additional paving connected to mainline trench pavement repair shall be paid using the lowest unit rate in the Schedule of Quantities and Prices.

3.1.3.4. Unless otherwise noted in the Contract Documents, payment for all costs incurred to obtain professional geotechnical services will be incidental to payment for Work described in other Sections.

3.1.3.5. Unless otherwise noted in the Contract Documents, payment for all costs of vertical trench timbering or sheeting protection will be incidental to payment for Work described in other Sections.

3.1.4. Inspection and Testing

3.1.4.1. Sources and gradation curves for backfill materials must be submitted to the Contract Administrator at least two weeks prior to construction. Material samples are required if requested by the Owner Representative.

3.1.4.2. Compaction tests will be performed as outlined in the Contract Documents and approved by the Owner Representative. Separate compaction tests at each depth are not required at the same station if storm and sanitary sewers are in a common trench.

3.1.4.3. The Contractor shall ensure all compaction test results (for all failed and passed tests) and test certificates are submitted to the Contract Administrator within 48 hours. Compaction test results shall be submitted by third parties to the Contract Administrator.

3.2. PRODUCTS

3.2.1. Use of Specified Materials

3.2.1.1. Backfill for over-excavated trench to be one of the following, as indicated in the Contract Documents or as directed by the Owner Representative:

3.2.1.1.1. 75mm Minus Crushed Tailings (City of Vancouver Aggregate #13).

3.2.1.1.2. 19mm Minus Combined Crushed Aggregate Fill (Mulch) (City of Vancouver Aggregate #9).

3.2.1.1.3. 19mm Clear Drain Rock (City of Vancouver Aggregate #7) (for waterworks only – only where approved by the Owner Representative).

3.2.1.1.4. 20mm Clear Crushed Aggregate (City of Vancouver Aggregate #15) (for waterworks only – only where approved by the Owner Representative).

3.2.1.1.5. 25mm Minus Combined Crushed Recycled Aggregate (City of Vancouver Aggregate #30) (for sewers only).

3.2.1.2. Backfill for trenches and excavations to be one of the following, as indicated in the Contract Documents or as directed by the Owner Representative:

3.2.1.2.1. Approved granular native material:

3.2.1.2.1.1. Native silts and / or clay materials shall not be used

3.2.1.2.1.2. Native granular materials (primarily sand) are permissible for backfilling up to 1.2m below the finished grade. All approved native granular materials shall be compacted to the minimum densities in 3.5.4 of this Section. In addition to the compaction requirements, the granular native material must be proven to be stable enough to provide a good foundation for the lifts of granular base on top. The acceptance of certain native granular materials will be at the sole discretion of the Owner Representative. The Owner Representative may also impose additional acceptance requirements as deemed necessary for the use of approved native granular material.

3.2.1.2.2. Granular or Sand Backfill:

3.2.1.2.2.1. Use imported granular fill materials as per SECTION 31 05 17 of the City of Vancouver Construction Specifications unless otherwise specified or approved by the Owner Representative.

3.2.1.2.3. Controlled Density Fill

3.2.1.2.3.1. Controlled density fill shall meet the requirements in Section 31 23 23 Controlled Density Fill.

3.2.1.2.3.2. Backfill material shall be free of large stones and or frozen material.

3.3. EXECUTION

3.3.1. Site Preparation

3.3.1.1. The Contractor shall continuously cut existing pavement to its full depth along neat straight lines with a cutting tool to confine the width of the pavement to be disturbed. The Contractor shall not disturb the pavement beyond the maximum trench width defined on the Drawings or contained herein, or unless approved otherwise by the Owner Representative.

3.3.2. Stockpiling

3.3.2.1. Do not block curb and gutter drainage with granular materials.

3.3.3. Excavation

3.3.3.1. Excavations shall be to the alignment and grades shown on the Drawings and as set in the field by the construction survey. Vertical walls on all trenches shall be maintained. If, in the opinion of the Contract Administrator, it is impossible or impractical to maintain vertical walls for certain sewer trenches, a "Y" type of excavation will be permitted to a point 300mm above the top of the pipe; trench walls below this point shall be maintained vertical using appropriate shoring methods.

3.3.3.2. For pipe bedding, the Contractor shall over excavate the trench as per Standard Detail Drawing G4.2, G4.3 and G4.4 or as specified herein or on the Drawings. If the bottom of the excavation extends beyond the required depth, the over-excavation shall be refilled at the Contractor's expense with approved compacted granular material. The use of trench digging machinery will be permitted except where its operations will cause damage to trees, buildings, existing utilities, or existing structures above or below ground. At such locations, hand methods shall be employed to avoid such damage.

3.3.3.3. Vertical trench timbering or sheeting shall be placed in accordance with the requirements of WorkSafeBC or as may be necessary to protect life and property adjacent to or on the Site. The Contractor shall be responsible for the adequacy of such bracing and shoring. Unless otherwise accepted by the Contract Administrator, or as WorkSafeBC Rules and Regulations dictate, vertical trench timbering or sheeting shall be placed so as not to extend below the springline of the largest pipe. No timbering or sheeting shall be left in without the written approval of the Owner Representative, and when removed, the void left by the raised sheeting shall be backfilled and thoroughly compacted.

3.3.4. Backfill and Compaction

3.3.4.1. Care must be exercised in selecting compaction equipment. In City Streets, there are many utilities with service connections that are susceptible to damage. The use of drop hammer type compactors and large vibrating rollers shall not be allowed, except under special conditions approved by the Owner Representative. The Contractor shall assume all responsibility for costs / damages caused to any existing utility.

3.3.4.2. All backfilling shall be controlled. The final acceptance to use the backfill method shall be at the sole discretion of the Owner Representative. No claim shall be made for the proposed backfill method being unaccepted.

3.3.4.3. Backfill materials shall be placed in uniform lifts not exceeding 300mm in loose thickness, 200mm for approved granular native material, and compacted to specified densities unless otherwise specified or allowed by the Owner Representative.

# 4. Aggregates and Granular Materials

## 4.1. PRODUCTS

### 4.1.1. General

4.1.1.1. Approved Granulars, as referenced in the Standard Detail Drawings, refers to 2.2, 2.3, 2.5, 2.6, 2.7, 2.9, 2.10, 2.11, and 2.13 of this Section.

### 4.1.2. Native Material

4.1.2.1. Granular native material may be used only with the express written permission of the Owner Representative, and provided it can be compacted to the requirement stated. All costs for Quality Control testing of granular native materials shall be covered by the Contractor.

4.1.2.2. The Owner Representative may require analytical laboratory confirmation that the native materials meet the applicable BC Ministry of Environment land use standards (residential or industrial).

### 4.1.3. Native Material

# 5. Granular Subbase

## 5.1. PRODUCTS

### 5.1.1. Specified Materials

5.1.1.1. Pit Run Gravel as per SECTION 31 05 17 of the City of Vancouver Construction Specifications.

5.1.1.2. 75mm Minus Crushed Tailings as per SECTION 31 05 17 of the City of Vancouver Construction Specifications.

5.1.1.3. Granular Native Material as per SECTION 31 05 17 of the City of Vancouver Construction Specifications.

5.1.1.4. Sand Fill as per SECTION 31 05 17 of the City of Vancouver Construction Specifications.

# 6. Granular Base

## 6.1. PRODUCTS

### 6.1.1. Granular Base

6.1.1.1. 19mm Minus Combined Crushed Aggregate Fill as per SECTION 31 05 17 of the City of Vancouver Construction Specifications.

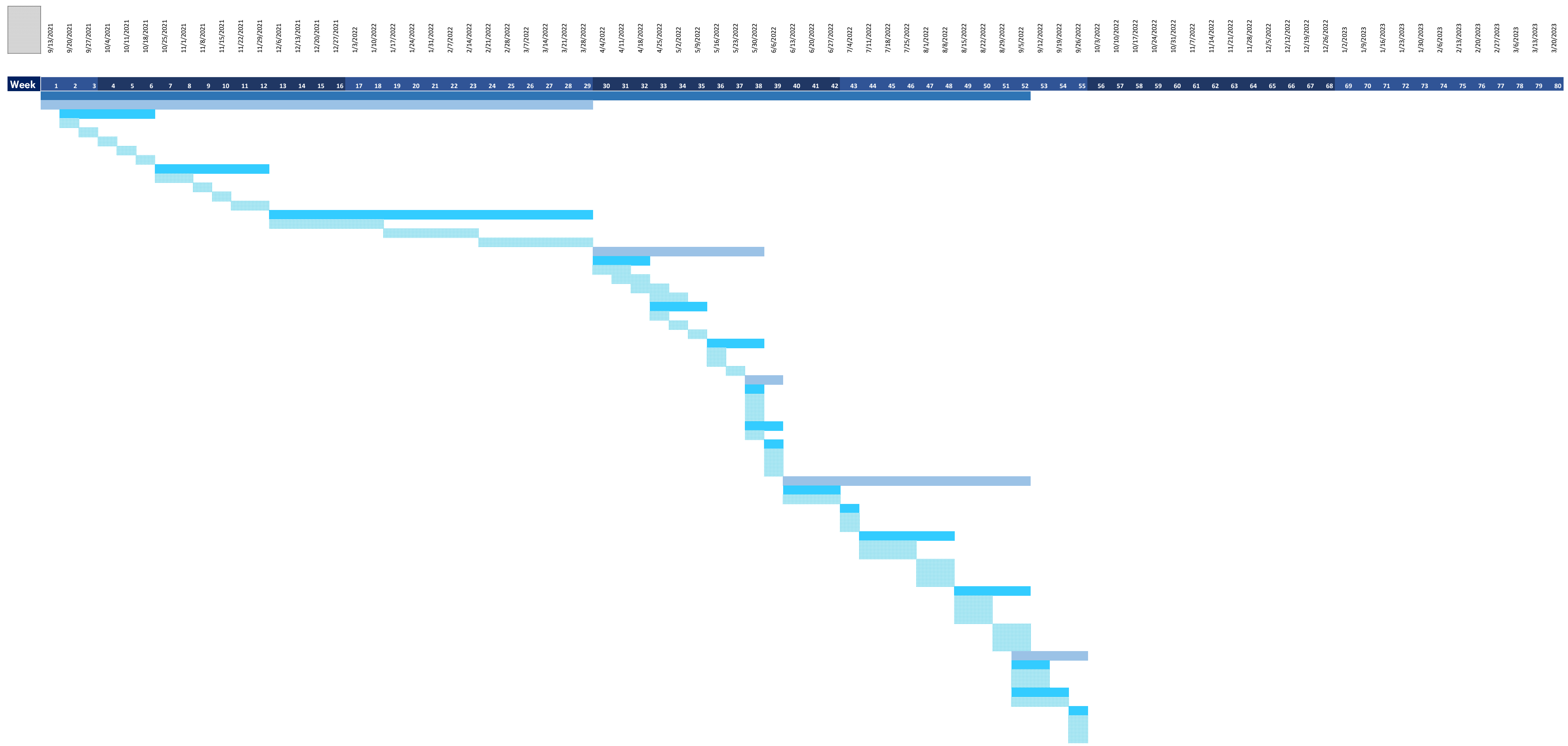
# Appendix B - Scheduling

## WESBROOK MALL REDESIGN - PHASE 4

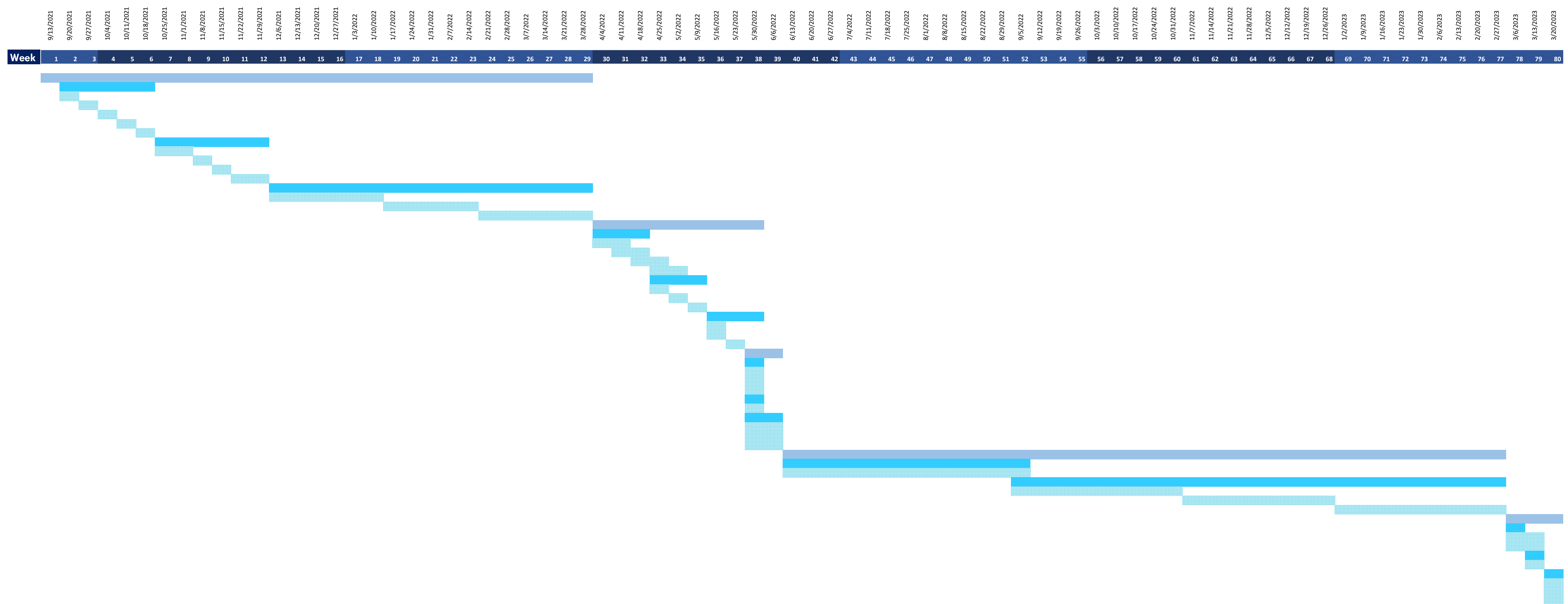
| | |
|---|---|
| Project Start | 13-Sep-21 |
| Project End | 21-Mar-23 |

### ID's

| Schedule ID | Component | WBS # | WBS Line Item | Complete | Duration (days) | Start | End |
|---|---|---|---|---|---|---|---|
| 1 | Underpass | 1 | Tunnel | | 361 | 13-Sep-21 | 9-Sep-22 |
| 2 | Underpass | 1.1 | **Site Delivery** | yes | 200 | 13-Sep-21 | 1-Apr-22 |
| 3 | Underpass | 1.1.1 | *Survey* | yes | 39 | 14-Sep-21 | 23-Oct-21 |
| 4 | Underpass | 1.1.1.1 | Subsurface Investigation | yes | 7 | 14-Sep-21 | 21-Sep-21 |
| 5 | Underpass | 1.1.1.2 | Geotechnical Report | yes | 7 | 22-Sep-21 | 29-Sep-21 |
| 6 | Underpass | 1.1.1.3 | Ground Behavior, Control | yes | 7 | 30-Sep-21 | 7-Oct-21 |
| 7 | Underpass | 1.1.1.4 | Third-Party Impacts | yes | 7 | 8-Oct-21 | 15-Oct-21 |
| 8 | Underpass | 1.1.1.5 | Hazards Investigation | yes | 7 | 16-Oct-21 | 23-Oct-21 |
| 9 | Underpass | 1.1.2 | *Preliminary Design* | yes | 40 | 24-Oct-21 | 3-Dec-21 |
| 10 | Underpass | 1.1.2.1 | Project Layout | yes | 8 | 25-Oct-21 | 2-Nov-21 |
| 11 | Underpass | 1.1.2.2 | Excavation Planning | yes | 7 | 3-Nov-21 | 10-Nov-21 |
| 12 | Underpass | 1.1.2.3 | Construction Method Selection | yes | 7 | 11-Nov-21 | 18-Nov-21 |
| 13 | Underpass | 1.1.2.4 | Mapping and Engineering | yes | 14 | 19-Nov-21 | 3-Dec-21 |
| 14 | Underpass | 1.1.3 | *Detailed Design* | no | 118 | 4-Dec-21 | 1-Apr-22 |
| 15 | Underpass | 1.1.3.1 | Finalize Design | no | 39 | 4-Dec-21 | 12-Jan-22 |
| 16 | Underpass | 1.1.3.2 | Final Feasibility Study | no | 39 | 12-Jan-22 | 20-Feb-22 |
| 17 | Underpass | 1.1.3.3 | Preconstruction Engineering | no | 39 | 20-Feb-22 | 1-Apr-22 |
| 18 | Underpass | 1.2 | **Drawings Approval** | no | 56 | 4-Apr-22 | 30-May-22 |
| 19 | Underpass | 1.2.1 | *Documents* | no | 19 | 4-Apr-22 | 22-Apr-22 |
| 20 | Underpass | 1.2.1.1 | Design Memo | no | 7 | 4-Apr-22 | 11-Apr-22 |
| 21 | Underpass | 1.2.1.2 | Construction Documents | no | 7 | 11-Apr-22 | 18-Apr-22 |
| 22 | Underpass | 1.2.1.3 | Engineering Review | no | 7 | 18-Apr-22 | 25-Apr-22 |
| 23 | Underpass | 1.2.1.4 | Specifications | no | 7 | 25-Apr-22 | 2-May-22 |
| 24 | Underpass | 1.2.2 | *Public Engagement* | no | 19 | 22-Apr-22 | 11-May-22 |
| 25 | Underpass | 1.2.2.1 | Environmental Review | no | 7 | 22-Apr-22 | 29-Apr-22 |
| 26 | Underpass | 1.2.2.2 | Stakeholder Consultation | no | 7 | 29-Apr-22 | 6-May-22 |
| 27 | Underpass | 1.2.2.3 | Public Hearings | no | 5 | 6-May-22 | 11-May-22 |
| 28 | Underpass | 1.2.3 | *Bidding* | no | 19 | 11-May-22 | 30-May-22 |
| 29 | Underpass | 1.2.3.1 | Bid packages | no | 7 | 11-May-22 | 18-May-22 |
| 30 | Underpass | 1.2.3.2 | Project Information Systems | no | 4 | 14-May-22 | 18-May-22 |
| 31 | Underpass | 1.2.3.3 | Bid Review and Selection | no | 11 | 18-May-22 | 29-May-22 |
| 32 | Underpass | 1.3 | **Mobilization** | no | 7 | 30-May-22 | 6-Jun-22 |
| 33 | Underpass | 1.3.1 | *Procurement* | no | 2 | 30-May-22 | 1-Jun-22 |
| 34 | Underpass | 1.3.1.1 | Bill of Quantities | no | 2 | 30-May-22 | 1-Jun-22 |
| 35 | Underpass | 1.3.1.2 | Machinery | no | 2 | 30-May-22 | 1-Jun-22 |
| 36 | Underpass | 1.3.1.3 | Utility and Safety Equipment | no | 2 | 30-May-22 | 1-Jun-22 |
| 37 | Underpass | 1.3.2 | *Fabricate Structural Elements* | no | 7 | 30-May-22 | 6-Jun-22 |
| 38 | Underpass | 1.3.2.1 | Fabricate Floor Slab | no | 2 | 30-May-22 | 1-Jun-22 |
| 39 | Underpass | 1.3.3 | *Site Preparation* | no | 2 | 6-Jun-22 | 8-Jun-22 |
| 40 | Underpass | 1.3.3.1 | Utility Relocation | no | 2 | 6-Jun-22 | 8-Jun-22 |
| 41 | Underpass | 1.3.3.2 | Staging Area | no | 2 | 6-Jun-22 | 8-Jun-22 |
| 42 | Underpass | 1.3.3.3 | Backup Systems | no | 2 | 6-Jun-22 | 8-Jun-22 |
| 43 | Underpass | 1.4 | **Construction** | no | 88 | 9-Jun-22 | 5-Sep-22 |
| 44 | Underpass | 1.4.1 | *Excavation* | no | 21 | 9-Jun-22 | 30-Jun-22 |
| 45 | Underpass | 1.4.1.1 | Cut and Cover | no | 21 | 9-Jun-22 | 30-Jun-22 |
| 46 | Underpass | 1.4.2 | *Support* | no | 7 | 30-Jun-22 | 7-Jul-22 |
| 47 | Underpass | 1.4.2.1 | Support Columns | no | 7 | 30-Jun-22 | 7-Jul-22 |
| 48 | Underpass | 1.4.2.2 | Temporary Lining | no | 7 | 30-Jun-22 | 7-Jul-22 |
| 49 | Underpass | 1.4.3 | *Lining* | no | 38 | 7-Jul-22 | 14-Aug-22 |
| 50 | Underpass | 1.4.3.1 | Lining Segments Staged | no | 19 | 7-Jul-22 | 26-Jul-22 |
| 51 | Underpass | 1.4.3.2 | Floor Slab Installed | no | 19 | 7-Jul-22 | 26-Jul-22 |
| 52 | Underpass | 1.4.3.3 | Support Walls Installed | no | 19 | 26-Jul-22 | 14-Aug-22 |
| 53 | Underpass | 1.4.3.4 | Ceiling Slab Installed | no | 19 | 26-Jul-22 | 14-Aug-22 |
| 54 | Underpass | 1.4.3.5 | Entrance/Exit Staircase Installed | no | 19 | 26-Jul-22 | 14-Aug-22 |
| 55 | Underpass | 1.4.4 | *Finishing* | no | 21 | 15-Aug-22 | 5-Sep-22 |
| 56 | Underpass | 1.4.4.1 | Concrete Protective Coating Applied | no | 13 | 15-Aug-22 | 28-Aug-22 |
| 57 | Underpass | 1.4.4.2 | Guardrail Cast In | no | 13 | 15-Aug-22 | 28-Aug-22 |
| 58 | Underpass | 1.4.4.3 | Stormwater Drainage System Installed | no | 13 | 15-Aug-22 | 28-Aug-22 |
| 59 | Underpass | 1.4.4.4 | Lighting System Installed | no | 7 | 29-Aug-22 | 5-Sep-22 |
| 60 | Underpass | 1.4.4.5 | Fire Suppression System Installed | no | 7 | 29-Aug-22 | 5-Sep-22 |
| 61 | Underpass | 1.4.4.6 | Security System Installed | no | 7 | 29-Aug-22 | 5-Sep-22 |
| 62 | Underpass | 1.5 | **Closing** | no | 25 | 5-Sep-22 | 30-Sep-22 |
| 63 | Underpass | 1.5.1 | *Testing* | no | 7 | 5-Sep-22 | 12-Sep-22 |
| 64 | Underpass | 1.5.1.1 | Test Safety Systems | no | 7 | 5-Sep-22 | 12-Sep-22 |
| 65 | Underpass | 1.5.1.2 | Certifications | no | 7 | 5-Sep-22 | 12-Sep-22 |
| 66 | Underpass | 1.5.2 | *Training* | no | 17 | 5-Sep-22 | 22-Sep-22 |
| 67 | Underpass | 1.5.2.1 | Emergency Operations Training | no | 17 | 5-Sep-22 | 22-Sep-22 |
| 68 | Underpass | 1.5.3 | *Demobilization* | no | 7 | 23-Sep-22 | 30-Sep-22 |
| 69 | Underpass | 1.5.3.1 | Decommission Staging Site | no | 7 | 23-Sep-22 | 30-Sep-22 |
| 70 | Underpass | 1.5.3.2 | Remove Equipment | no | 7 | 23-Sep-22 | 30-Sep-22 |
| 71 | Underpass | 1.5.3.3 | Final Paving | no | 7 | 23-Sep-22 | 30-Sep-22 |



| Schedule ID | Component | WBS # | WBS Line Item | Complete | Duration (days) | Start | End |
|---|---|---|---|---|---|---|---|
| 72 | Roadworks | 2 | Roadworks, Sidewalk, Multi Use Pathway | no | 553 | 13-Sep-21 | 20-Mar-23 |
| 73 | Roadworks | 2.1 | **Site Delivery** | no | 200 | 13-Sep-21 | 1-Apr-22 |
| 74 | Roadworks | 2.1.1 | *Survey* | no | 39 | 14-Sep-21 | 23-Oct-21 |
| 75 | Roadworks | 2.1.1.1 | Subsurface Investigation | no | 7 | 14-Sep-21 | 21-Sep-21 |
| 76 | Roadworks | 2.1.1.2 | Geotechnical Report | no | 7 | 22-Sep-21 | 29-Sep-21 |
| 77 | Roadworks | 2.1.1.3 | Ground behavior, Control | no | 7 | 30-Sep-21 | 7-Oct-21 |
| 78 | Roadworks | 2.1.1.4 | Third-Party Impacts | no | 7 | 8-Oct-21 | 15-Oct-21 |
| 79 | Roadworks | 2.1.1.5 | Hazards Investigation | no | 7 | 16-Oct-21 | 23-Oct-21 |
| 80 | Roadworks | 2.1.2 | *Preliminary Design* | no | 40 | 24-Oct-21 | 3-Dec-21 |
| 81 | Roadworks | 2.1.2.1 | Project Layout | no | 8 | 25-Oct-21 | 2-Nov-21 |
| 82 | Roadworks | 2.1.2.2 | Excavation Planning | no | 7 | 3-Nov-21 | 10-Nov-21 |
| 83 | Roadworks | 2.1.2.3 | Construction Method Selection | no | 7 | 11-Nov-21 | 18-Nov-21 |
| 84 | Roadworks | 2.1.2.4 | Mapping and Engineering | no | 14 | 19-Nov-21 | 3-Dec-21 |
| 85 | Roadworks | 2.1.3 | *Detailed Design* | no | 118 | 4-Dec-21 | 1-Apr-22 |
| 86 | Roadworks | 2.1.3.1 | Finalize Design | no | 39 | 4-Dec-21 | 12-Jan-22 |
| 87 | Roadworks | 2.1.3.2 | Final Feasibility Study | no | 39 | 12-Jan-22 | 20-Feb-22 |
| 88 | Roadworks | 2.1.3.3 | Preconstruction Engineering | no | 39 | 20-Feb-22 | 1-Apr-22 |
| 89 | Roadworks | 2.2 | **Drawings Approval** | no | 56 | 4-Apr-22 | 30-May-22 |
| 90 | Roadworks | 2.2.1 | *Documents* | no | 19 | 4-Apr-22 | 22-Apr-22 |
| 91 | Roadworks | 2.2.1.1 | Design Memo | no | 7 | 4-Apr-22 | 11-Apr-22 |
| 92 | Roadworks | 2.2.1.2 | Construction Documents | no | 7 | 11-Apr-22 | 18-Apr-22 |
| 93 | Roadworks | 2.2.1.3 | Engineering Review | no | 7 | 18-Apr-22 | 25-Apr-22 |
| 94 | Roadworks | 2.2.1.4 | Specifications | no | 7 | 25-Apr-22 | 2-May-22 |
| 95 | Roadworks | 2.2.2 | *Public Approval* | no | 19 | 22-Apr-22 | 11-May-22 |
| 96 | Roadworks | 2.2.2.1 | Environmental Review | no | 7 | 22-Apr-22 | 29-Apr-22 |
| 97 | Roadworks | 2.2.2.2 | Stakeholder Consultation | no | 7 | 29-Apr-22 | 6-May-22 |
| 98 | Roadworks | 2.2.2.3 | Public Hearings | no | 5 | 6-May-22 | 11-May-22 |
| 99 | Roadworks | 2.2.3 | *Bidding* | no | 19 | 11-May-22 | 30-May-22 |
| 100 | Roadworks | 2.2.3.1 | Bid packages | no | 7 | 11-May-22 | 18-May-22 |
| 101 | Roadworks | 2.2.3.2 | Project Information Systems | no | 4 | 14-May-22 | 18-May-22 |
| 102 | Roadworks | 2.2.3.3 | Bid Review and Selection | no | 11 | 18-May-22 | 29-May-22 |
| 103 | Roadworks | 2.3 | **Mobilization** | no | 7 | 30-May-22 | 6-Jun-22 |
| 104 | Roadworks | 2.3.1 | *Procurement* | no | 4 | 30-May-22 | 2-Jun-22 |
| 105 | Roadworks | 2.3.1.1 | Bill of Quantities | no | 4 | 30-May-22 | 2-Jun-22 |
| 106 | Roadworks | 2.3.1.2 | Machinery | no | 4 | 30-May-22 | 2-Jun-22 |
| 107 | Roadworks | 2.3.1.3 | Utility and Safety Equipment | no | 4 | 30-May-22 | 2-Jun-22 |
| 108 | Roadworks | 2.3.2 | *Fabricate Elements* | no | 4 | 30-May-22 | 2-Jun-22 |
| 109 | Roadworks | 2.3.2.1 | Construct Planters | no | 4 | 30-May-22 | 2-Jun-22 |
| 110 | Roadworks | 2.3.3 | *Site Preparation* | no | 7 | 30-May-22 | 6-Jun-22 |
| 111 | Roadworks | 2.3.3.1 | Utility Relocation | no | 9 | 30-May-22 | 8-Jun-22 |
| 112 | Roadworks | 2.3.3.2 | Staging Area | no | 9 | 30-May-22 | 8-Jun-22 |
| 113 | Roadworks | 2.3.3.3 | Backup Systems | no | 9 | 30-May-22 | 8-Jun-22 |
| 114 | Roadworks | 2.4 | **Construction** | no | 264 | 9-Jun-22 | 28-Feb-23 |
| 115 | Roadworks | 2.4.1 | *Earthworks* | no | 88 | 9-Jun-22 | 5-Sep-22 |
| 116 | Roadworks | 2.4.1.1 | Excavation and Ripping | no | 88 | 9-Jun-22 | 5-Sep-22 |
| 117 | Roadworks | 2.4.2 | *Fill* | no | 176 | 5-Sep-22 | 28-Feb-23 |
| 118 | Roadworks | 2.4.2.1 | Subbase Pavement | no | 59 | 5-Sep-22 | 2-Nov-22 |
| 119 | Roadworks | 2.4.2.2 | Base Pavement | no | 59 | 2-Nov-22 | 31-Dec-22 |
| 120 | Roadworks | 2.4.2.3 | Geotextile Placement | no | 59 | 31-Dec-22 | 28-Feb-23 |
| 121 | Roadworks | 2.5 | **Closing** | no | 21 | 28-Feb-23 | 21-Mar-23 |
| 122 | Roadworks | 2.5.1 | *Testing* | no | 6 | 28-Feb-23 | 6-Mar-23 |
| 123 | Roadworks | 2.5.1.1 | Asphalt and Concrete Compaction Testing | no | 7 | 6-Mar-23 | 13-Mar-23 |
| 124 | Roadworks | 2.5.1.2 | Certifications | no | 7 | 6-Mar-23 | 13-Mar-23 |
| 125 | Roadworks | 2.5.2 | *Training* | no | 6 | 7-Mar-23 | 13-Mar-23 |
| 126 | Roadworks | 2.5.2.1 | Emergency Operations Training | no | 6 | 7-Mar-23 | 13-Mar-23 |
| 127 | Roadworks | 2.5.3 | *Demobilization* | no | 7 | 14-Mar-23 | 21-Mar-23 |
| 128 | Roadworks | 2.5.3.1 | Decommission Staging Site | no | 7 | 14-Mar-23 | 21-Mar-23 |
| 129 | Roadworks | 2.5.3.2 | Remove Equipment | no | 7 | 14-Mar-23 | 21-Mar-23 |
| 130 | Roadworks | 2.5.3.3 | Final Paving | no | 7 | 14-Mar-23 | 21-Mar-23 |



# Appendix C - Class A Cost Estimate

## WB Mall Estimate

| Qty | Line Number | Group | Description | Crew | Unit | Labor Hours | Daily Output | Extended Material | Extended Labor | Extended Equipment | Extended Total | Extended Total O&P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3727 | 321123230301 | Sidewalk | Base course drainage layers, aggregate base course for roadways and large paved areas, crushed stone base, compacted, crushed 1-1/2" stone base, to 4" deep | B36B | S.Y | 0.011 | 6,000.00 | $ 19,007.70 | $ 1,229.91 | $ 2,497.09 | $ 22,734.70 | $ 25,679.03 |
| 2748 | 320116715320 | Raised Bike Lane | Cold milling asphalt paving, asphalt pavement, 1” to 3" deep, removal from concrete base, rip, load and sweep, excludes hauling | B70 | S.Y | 0.007 | 8,000.00 | | $ 577.08 | $ 522.12 | $ 1,099.20 | $ 1,538.88 |
| 2748 | 321216130200 | Raised Bike Lane | Plant-mix asphalt paving, for highways and large paved areas, binder course, 4" thick, no hauling included | B25 | S.Y | 0.021 | 4,140.00 | $ 38,197.20 | $ 1,703.76 | $ 1,648.80 | $ 41,549.76 | $ 46,661.04 |
| 3 | 311313201600 | General | Selective felling trees and piling, large tract clearing & piling, firm level terrain, no boulders, softwood, per tree, 300 H.P. dozer, 12" to 24” diameter | B10M | Ea. | 0.04 | 200.00 | | $ 4.20 | $ 24.15 | $ 28.35 | $ 33.39 |
| 3 | 311313202100 | General | Selective clearing and grubbing, 1-1/2 C.Y. excavator, 14” to 24" diameter, stump removal on site by hydraulic excavator | B30 | Ea. | 0.96 | 25.00 | | $ 85.50 | $ 235.50 | $ 321.00 | $ 399.00 |
| 1386 | 24113176000 | Site Prep | Demolish, remove pavement & curb, remove concrete curbs, plain, excludes hauling and disposal fees | B6 | L.F. | 0.067 | 360.00 | | $ 2,661.12 | $ 1,233.54 | $ 3,894.66 | $ 5,779.62 |
| 38 | 334413131582 | Site Prep | RELOCATION: Utility Area Drains, catch basins or manholes curb inlet frame, grate, and curb box, large, heavy duty, 24” x 36", excludes footing, excavation, and backfill | B24 | Ea. | | | | $ 13,870.00 | | $ 13,870.00 | $ 47,880.00 |
| 38 | 24113420400 | Site Prep | Selective demolition, manholes & catch basins, manhole top, precast 8" thick, 4’-6' dia, excludes excavation | B6 | Ea. | 3 | 8.00 | | $ 3,287.00 | $ 1,520.00 | $ 4,807.00 | $ 7,106.00 |
| 3000 | 312316130050 | Multiuse Path/Si | Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering | B11C | B.C.Y. | 0.107 | 150.00 | | $ 9,810.00 | $ 6,420.00 | $ 16,230.00 | $ 23,250.00 |
| 3350 | 321723130020 | General | Painted pavement markings, acrylic waterborne, white or yellow, 4" wide | B78 | L.F. | 0.002 | 20,000.00 | $ 636.50 | $ 167.50 | $ 67.00 | $ 871.00 | $ 1,105.00 |
| 1 | 2 | General | Bus Shelter Relocation | A1F | Ea. | | | | $ 2,000.00 | $ 2,000.00 | $ 4,000.00 | $ 4,000.00 |
| 45000 | 320610100450 | Multiuse Path/Si | Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick bank run gravel base, add | B18 | S.F. | 0.01 | 2,500.00 | $ 22,950.00 | $ 11,700.00 | $ 900.00 | $ 35,550.00 | $ 45,900.00 |
| 2005 | 321613130404 | Roadworks | Cast-in place concrete curbs & gutters, concrete, wood forms, straight 6" x 18", incudes concrete | C2A | L.F. | 0.096 | 500.00 | $ 9,624.00 | $ 6,235.55 | | $ 15,859.55 | $ 20,952.25 |
| 1 | 265613103000 | General | REMOVAL: Light poles, anchor base, aluminum, 20' high, excluding concrete bases | R3 | Ea. | | | $ 930.00 | $ 273.00 | $ 44.50 | $ 1,247.50 | $ 1,519.00 |
| 4320 | 329226130300 | Green Infrastruct | Sprigging, stolonizing, broadcast, 6 bushels per M.S.F., hydro Green Infrastructure | B64 | M.S.F. | 0.16 | 100.00 | $ 40,500.00 | $ 9,136.80 | $ 6,523.20 | $ 56,160.00 | $ 66,268.80 |
| 1370 | 312316130050 | Sidewalk | Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering | B11C | B.C.Y. | 0.107 | 150.00 | | $ 4,479.90 | $ 2,931.80 | $ 7,411.70 | $ 10,617.50 |
| 1600 | 320116715200 | Sidewalk | Cold milling asphalt paving, 1" to 3" asphalt pavement, over 25,000 S.Y., cold planing & cleaning | B71 | S.Y. | 0.009 | 6,000.00 | | $ 448.00 | $ 1,744.00 | $ 2,192.00 | $ 2,672.00 |
| 1600 | 321123230301 | Sidewalk | Base course drainage layers, aggregate base course for roadways and large paved areas, crushed stone base, compacted, crushed 1-1/2" stone base, to 4” deep | B36B | S.Y. | 0.011 | 6,000.00 | $ 8,160.00 | $ 528.00 | $ 1,072.00 | $ 9,760.00 | $ 11,024.00 |
| 1600 | 321123230304 | Sidewalk | Base course drainage layers, aggregate base course for roadways and large paved areas, crushed stone base, compacted, crushed 1-1/2" stone base, to 12" deep | B36B | S.Y. | 0.017 | 3,800.00 | $ 24,480.00 | $ 832.00 | $ 1,696.00 | $ 27,008.00 | $ 30,192.00 |
| 1600 | 334626100188 | Sidewalk | Geotextile Subsurface Drainage Filtration, soil drainage mat on vertical wall, 0.25" thick | 2 Clab | S.Y. | 0.053 | 300.00 | $ 2,464.00 | $ 2,256.00 | | $ 4,720.00 | $ 6,480.00 |
| 1600 | 334626100188 | Sidewalk | Geotextile Subsurface Drainage Filtration, soil drainage mat on vertical wall, 0.25" thick | 2 Clab | S.Y. | 0.053 | 300.00 | $ 2,464.00 | $ 2,256.00 | | $ 4,720.00 | $ 6,480.00 |
| 14410 | 321416100620 | Sidewalk | Brick paving, bedding, mortar, 2” thick | D1 | S.F. | 0.08 | 200.00 | $ 18,877.10 | $ 35,016.30 | | $ 53,893.40 | $ 78,246.00 |
| 4000 | 24113175200 | Sidewalk | Demolish, remove pavement & curb, remove concrete, mesh reinforced, to 150 mm thick, hydraulic hammer, excludes hauling and disposal fees | B38 | S.Y. | 0.188 | 213.00 | | $ 29,200.00 | $ 21,400.00 | $ 50,600.00 | $ 67,600.00 |
| 189 | 347113170900 | Green Infrastruct | Security vehicle barriers, concrete Green Infrastructure, exposed aggregate finish, rectangle, 96" long x 24” wide x 30" high, excludes filling material | B11M | Ea. | 2 | 8.00 | $ 67,567.50 | $ 5,811.75 | $ 4,110.75 | $ 77,490.00 | $ 88,338.60 |
| 14210 | 321123230302 | Roadworks | Base course drainage layers, aggregate base course for roadways and large paved areas, crushed stone base, compacted, crushed 1-1/2" stone base, to 6" deep | B36B | S.Y. | 0.012 | 5,400.00 | $ 108,706.50 | $ 5,257.70 | $ 10,515.40 | $ 124,479.60 | $ 139,417.15 |
| 14210 | 320116715280 | Roadworks | Cold milling asphalt paving, 1" to 3" asphalt pavement, 5,000 to 10,000 S.Y., cold planing & cleaning | B71 | S.Y. | 0.014 | 4,000.00 | $ - | $ 6,110.30 | $ 23,304.40 | $ 29,414.70 | $ 35,591.79 |
| 14210 | 321123230302 | Roadworks | Base course drainage layers, aggregate base course for roadways and large paved areas, crushed stone base, compacted, crushed 1-1/2" stone base, to 6" deep | B36B | S.Y. | 0.012 | 5,400.00 | $ 108,706.50 | $ 5,257.70 | $ 10,515.40 | $ 124,479.60 | $ 139,417.15 |
| 14210 | 321126130550 | Roadworks | Asphalt Paving, plant mixed asphaltic base courses for roadways and large paved areas, bituminous concrete, 6" thick | B25 | S.Y. | 0.024 | 3,700.00 | $ 298,410.00 | $ 9,804.90 | $ 9,520.70 | $ 317,735.60 | $ 352,686.52 |
| 1 | 3 | Roadworks | Consulting and Engineering Fees for Signal Retiming | ENG | Ea. | | | $ 3,400.00 | $ 1,000.00 | | $ 4,400.00 | $ 4,400.00 |
| | | | | | | | | **$ 775,081.00** | **$ 170,999.97** | **$ 110,446.35** | **$ 1,056,527.32** | **$ 1,271,234.72** |

| | |
|---|---|
| Inflation | 1.28 |
| CPI | 1.31 |
| Currency | 1.28 |
| Contingency | 1.1 |
| Contractor Markup | 1.2 |
| Bonds and Insurance | 1.05 |
| Management and Permitting | 1.085 |
| | $4,103,080 |

# Underpass Cost Estimate

| Qty | Line Number | Group | Description | Crew | Unit | Labor Hours | Daily Output | Extended Material | Extended Labor | Extended Equipment | Extended Total | Extended Total O&P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 55213500020 | | Railing, pipe, aluminum, satin finish, 2 rails, 3'-6" high, posts @ 5' O.C., 1-1/4" dia, shop fabricated | E4 | L.F. | 0.2 | 160 | $ 1,890.00 | $ 444.00 | $ 40.80 | $ 2,374.80 | $ 2,958.00 |
| 2223 | 312316420200 | | Excavating, bulk bank measure, 1 C.Y. capacity = 75 C.Y./hour, backhoe, hydraulic, crawler mounted, excluding truck loading | B12A | B.C.Y | 0.02 | 800 | | $ 1,378.26 | $ 2,022.93 | $ 3,401.19 | $ 4,512.69 |
| 1 | 282323500400 | | CB 9-S GATEKEEPER ENCLOSURE: Video surveillance, internet protocol (IP) network, day/night, color, includes power supply | | Ea. | | | $ 3,000.00 | $ 124.00 | | $ 3,124.00 | $ 1,376.00 |
| 100 | 33053401900 | | Structural concrete, in place, elevated slab (4000 psi), flat slab with drop panels, 125 psf superimposed load, 20' span, includes forms(4 uses), WTIHOUT REINFORCING STEEL, concrete, placing and finishing | C14B | C.Y. | | | $ 23,400.00 | $ 18,100.00 | $ 1,985.00 | $ 43,485.00 | $ 58,400.00 |
| 112 | 33053406800 | | Structural concrete, in place, stairs (3500 psi), 3'-6" wide, free standing, includes forms(4 uses), reinforcing steel, concrete, placing and finishing, WITH safety treads | C14H | LF Nose | | | $ 560.00 | $ 2,576.00 | $ 31.36 | $ 3,167.36 | $ 4,234.72 |
| 170 | 312514160060 | | Synthetic erosion control, nylon, 3 dimensional geomatrix, 9 mil thick | B80A | S.Y. | 0.034 | 700 | $ 289.00 | $ 154.70 | $ 52.70 | $ 496.40 | $ 634.10 |
| 7 | 32110500200 | | Reinforcing Steel, average price, cut, bent and delivered, A615, grade 40, material only | | Ton | | | $ 6,160.00 | | | $ 6,160.00 | $ 6,790.00 |
| 251 | 321123230304 | | Base course drainage layers, aggregate base course for roadways and large paved areas, crushed stone base, compacted, crushed 1-1/2" stone base, to 12" deep | B36B | S.Y. | 0.017 | 3800 | $ 3,840.30 | $ 130.52 | $ 266.06 | $ 4,236.88 | $ 4,736.37 |
| 20 | 265623101190 | | Metal halide fixture, exterior, wall pack, 250 Watt, incl lamps | 1 ELEC | Ea. | 2 | 4 | $ 5,800.00 | $ 1,610.00 | | $ 7,410.00 | $ 9,020.00 |
| 79 | 24113176000 | | Demolish, remove pavement & curb, remove concrete curbs, plain, excludes hauling and disposal fees | B6 | L.F. | 0.067 | 360 | | $ 151.68 | $ 70.31 | $ 221.99 | $ 329.43 |
| 1 | 210523506320 | | Sprinkler System Valve Alarm, 8" size, incl. retard chamber, trim, gauges & alarm line strainer | Q13 | Ea. | 10.667 | 3 | $ 1,825.00 | $ 375.00 | | $ 2,200.00 | $ 2,615.00 |
| 1 | 221123111020 | | Pump, turbine pump, cast iron, 100 GPM, 3 H.P., 4" discharge | Q2 | Ea. | 25 | 0.96 | $ 8,225.00 | $ 860.00 | | $ 9,085.00 | $ 7,150.00 |
| 1 | 330516130050 | | Utility structures, utility vaults precast concrete, excludes excavation and backfill | B13 | Ea. | | | $ 2,425.00 | $ 680.00 | $ 375.00 | $ 3,480.00 | $ 4,210.00 |
| 2 | 221319130440 | | Drain, deck, auto park, cast iron, 13" top, 3", 4", 5" and 6" pipe size | Q1 | Ea. | 2 | 8 | $ 2,250.00 | $ 143.00 | | $ 2,393.00 | $ 2,734.00 |
| 3767 | 321123230302 | | Base course drainage layers, aggregate base course for roadways and large paved areas, crushed stone base, compacted, crushed 1-1/2" stone base, to 6" deep | B36B | S.Y. | 0.012 | 5400 | $ 28,817.55 | $ 1,393.79 | $ 2,787.58 | $ 32,998.92 | $ 37,029.61 |
| 3767 | 320116715280 | | Cold milling asphalt paving, 1" to 3" asphalt pavement, 5,000 to 10,000 S.Y., cold planing & cleaning | B71 | S.Y. | 0.014 | 4000 | | $ 1,619.81 | $ 6,177.88 | $ 7,797.69 | $ 9,417.50 |
| 3767 | 321123230302 | | Base course drainage layers, aggregate base course for roadways and large paved areas, crushed stone base, compacted, crushed 1-1/2" stone base, to 6" deep | B36B | S.Y. | 0.012 | 5400 | $ 28,817.55 | $ 1,393.79 | $ 2,787.58 | $ 32,998.92 | $ 37,029.61 |
| 3767 | 321126130550 | | Asphalt Paving, plant mixed asphaltic base courses for roadways and large paved areas, bituminous concrete, 6" thick | B25 | S.Y. | 0.024 | 3700 | $ 79,107.00 | $ 2,599.23 | $ 2,523.89 | $ 84,230.12 | $ 93,722.96 |
| 3000 | 312323200044 | | Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 C.Y. truck, cycle 4 miles, 25 MPH, excludes loading equipment | B34A | L.C.Y. | 0.042 | 192 | | $ 3,390.00 | $ 4,920.00 | $ 8,310.00 | $ 11,070.00 |
| | | | | | | | | **$ 196,406.40** | **$ 37,123.78** | **$ 24,041.09** | **$ 257,571.27** | $ 297,969.99 |

| | |
|---|---|
| Inflation | 1.376 |
| Currency | 1.28 |
| Contingency | 1.2 |
| Contractor Markup | 1.2 |
| Bonds and Insurance | 1.05 |
| Management and Permitting | 1.085 |
| | |
| Adjusted Cost | **$ 860,958.98** |

# Appendix D - Traffic Modeling

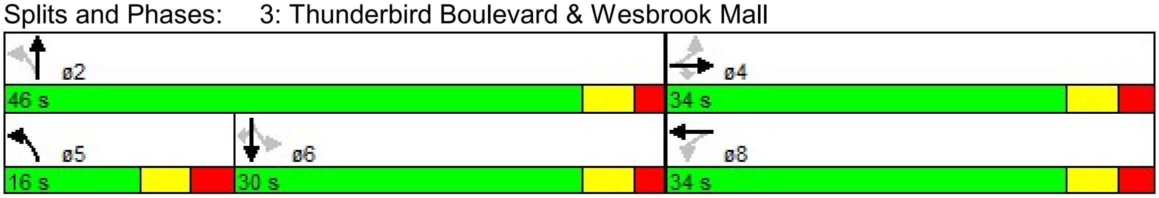
| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Lane Width (m) | 2.9 | 3.3 | 3.3 | 3.5 | 4.0 | 3.5 | 3.5 | 4.0 | 3.5 | 3.1 | 3.5 | 3.3 |
| Storage Length (m) | 60.0 | | 40.0 | 0.0 | | 30.0 | 110.0 | | 0.0 | 50.0 | | 12.0 |
| Storage Lanes | 1 | | 1 | 1 | | 0 | 1 | | 0 | 1 | | 1 |
| Total Lost Time (s) | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Leading Detector (m) | 6.5 | 6.5 | 1.5 | 6.5 | 6.5 | | 6.5 | 6.5 | | 6.5 | 6.5 | 1.5 |
| Trailing Detector (m) | 1.5 | 1.5 | 0.0 | 1.5 | 1.5 | | 1.5 | 1.5 | | 1.5 | 1.5 | 0.0 |
| Turning Speed (k/h) | 25 | | 15 | 25 | | 15 | 25 | | 15 | 25 | | 15 |
| Lane Util. Factor | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Ped Bike Factor | 0.89 | | 0.79 | 0.84 | 0.97 | | 0.94 | 0.87 | | | | 0.82 |
| Frt | | | 0.850 | | 0.982 | | | 0.932 | | | | 0.850 |
| Flt Protected | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (prot) | 1632 | 1801 | 1531 | 1750 | 1853 | 0 | 1750 | 1574 | 0 | 1671 | 1842 | 1531 |
| Flt Permitted | 0.449 | | | 0.680 | | | 0.247 | | | 0.154 | | |
| Satd. Flow (perm) | 684 | 1801 | 1210 | 1056 | 1853 | 0 | 428 | 1574 | 0 | 271 | 1842 | 1250 |
| Right Turn on Red | | | Yes | | | Yes | | | Yes | | | Yes |
| Satd. Flow (RTOR) | | | 88 | | 10 | | | 78 | | | | 106 |
| Headway Factor | 1.11 | 1.04 | 1.04 | 1.01 | 0.94 | 1.01 | 1.01 | 0.94 | 1.01 | 1.08 | 1.01 | 1.04 |
| Link Speed (k/h) | | 50 | | | 50 | | | 50 | | | 50 | |
| Link Distance (m) | | 153.9 | | | 112.5 | | | 755.2 | | | 92.2 | |
| Travel Time (s) | | 11.1 | | | 8.1 | | | 54.4 | | | 6.6 | |
| Volume (vph) | 101 | 79 | 52 | 129 | 150 | 33 | 359 | 417 | 229 | 45 | 339 | 211 |
| Confl. Peds. (#/hr) | 133 | | 193 | 193 | | 133 | 92 | | 100 | 100 | | 92 |
| Confl. Bikes (#/hr) | | | 39 | | | 42 | | | 52 | | | 7 |
| Peak Hour Factor | 0.69 | 0.66 | 0.59 | 0.64 | 0.55 | 0.86 | 0.86 | 0.84 | 0.56 | 0.75 | 0.83 | 0.81 |
| Parking (#/hr) | | | | | | | | | 0 | | | |
| Adj. Flow (vph) | 146 | 120 | 88 | 202 | 273 | 38 | 417 | 496 | 409 | 60 | 408 | 260 |
| Lane Group Flow (vph) | 146 | 120 | 88 | 202 | 311 | 0 | 417 | 905 | 0 | 60 | 408 | 260 |
| Turn Type | Perm | | Perm | Perm | | | pm+pt | | | Perm | | Perm |
| Protected Phases | | 4 | | | 8 | | 5 | 2 | | | 6 | |
| Permitted Phases | 4 | | 4 | 8 | | | 2 | | | 6 | | 6 |
| Detector Phases | 4 | 4 | 4 | 8 | 8 | | 5 | 2 | | 6 | 6 | 6 |
| Minimum Initial (s) | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | | 6.0 | 10.0 | | 10.0 | 10.0 | 10.0 |
| Minimum Split (s) | 31.3 | 31.3 | 31.3 | 33.3 | 33.3 | | 12.5 | 21.9 | | 28.9 | 28.9 | 28.9 |
| Total Split (s) | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 0.0 | 16.0 | 46.0 | 0.0 | 30.0 | 30.0 | 30.0 |
| Total Split (%) | 42.5% | 42.5% | 42.5% | 42.5% | 42.5% | 0.0% | 20.0% | 57.5% | 0.0% | 37.5% | 37.5% | 37.5% |
| Maximum Green (s) | 27.7 | 27.7 | 27.7 | 27.7 | 27.7 | | 9.5 | 40.1 | | 24.1 | 24.1 | 24.1 |
| Yellow Time (s) | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | | 3.4 | 3.6 | | 3.6 | 3.6 | 3.6 |
| All-Red Time (s) | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | | 3.1 | 2.3 | | 2.3 | 2.3 | 2.3 |
| Lead/Lag | | | | | | | Lead | | | Lag | Lag | Lag |
| Lead-Lag Optimize? | | | | | | | Yes | | | Yes | Yes | Yes |
| Vehicle Extension (s) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | | 2.5 | 4.0 | | 4.0 | 4.0 | 4.0 |
| Recall Mode | None | None | None | None | None | | None | C-Min | | C-Min | C-Min | C-Min |
| Walk Time (s) | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | | | 7.0 | | 7.0 | 7.0 | 7.0 |
| Flash Dont Walk (s) | 18.0 | 18.0 | 18.0 | 20.0 | 20.0 | | | 9.0 | | 16.0 | 16.0 | 16.0 |
| Pedestrian Calls (#/hr) | 0 | 0 | 0 | 0 | 0 | | | 0 | | 0 | 0 | 0 |
| Act Effct Green (s) | 22.8 | 22.8 | 22.8 | 22.8 | 22.8 | | 49.2 | 49.2 | | 28.6 | 28.6 | 28.6 |
| Actuated g/C Ratio | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | | 0.62 | 0.62 | | 0.36 | 0.36 | 0.36 |

| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| v/c Ratio | 0.75 | 0.23 | 0.22 | 0.67 | 0.58 | | 0.78 | 0.91 | | 0.62 | 0.62 | 0.50 |
| Control Delay | 47.9 | 21.0 | 5.6 | 35.4 | 27.1 | | 24.5 | 29.9 | | 55.6 | 27.2 | 16.6 |
| Queue Delay | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 |
| Total Delay | 47.9 | 21.0 | 5.6 | 35.4 | 27.1 | | 24.5 | 29.9 | | 55.6 | 27.2 | 16.6 |
| LOS | D | C | A | D | C | | C | C | | E | C | B |
| Approach Delay | | 28.3 | | | 30.4 | | | 28.2 | | | 25.8 | |
| Approach LOS | | C | | | C | | | C | | | C | |
| Queue Length 50th (m) | 20.8 | 14.4 | 0.0 | 28.0 | 40.4 | | 31.2 | 108.5 | | 8.2 | 55.9 | 19.0 |
| Queue Length 95th (m) | 26.3 | 17.1 | 2.5 | 28.8 | 30.7 | | #87.7 | #200.2 | | #22.0 | 78.1 | 35.1 |
| Internal Link Dist (m) | | 129.9 | | | 88.5 | | | 731.2 | | | 68.2 | |
| Turn Bay Length (m) | 60.0 | | 40.0 | | | | 110.0 | | | 50.0 | | 12.0 |
| Base Capacity (vph) | 257 | 675 | 509 | 396 | 701 | | 538 | 998 | | 97 | 659 | 515 |
| Starvation Cap Reductn | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | | 0 | 0 | 0 |
| Spillback Cap Reductn | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | | 0 | 0 | 0 |
| Storage Cap Reductn | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | | 0 | 0 | 0 |
| Reduced v/c Ratio | 0.57 | 0.18 | 0.17 | 0.51 | 0.44 | | 0.78 | 0.91 | | 0.62 | 0.62 | 0.50 |

Intersection Summary

Area Type: Other
Cycle Length: 80
Actuated Cycle Length: 80
Offset: 16 (20%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 90
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 28.0 Intersection LOS: C
Intersection Capacity Utilization 87.9% ICU Level of Service E
Analysis Period (min) 15
# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: Thunderbird Boulevard & Wesbrook Mall



| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Lane Width (m) | 2.9 | 3.3 | 3.3 | 3.5 | 4.0 | 3.5 | 3.5 | 4.0 | 3.5 | 3.1 | 3.5 | 3.3 |
| Storage Length (m) | 60.0 | | 40.0 | 0.0 | | 30.0 | 110.0 | | 0.0 | 50.0 | | 12.0 |
| Storage Lanes | 1 | | 1 | 1 | | 0 | 1 | | 0 | 1 | | 1 |
| Total Lost Time (s) | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Leading Detector (m) | 6.5 | 6.5 | 1.5 | 6.5 | 6.5 | | 6.5 | 6.5 | | 6.5 | 6.5 | 1.5 |
| Trailing Detector (m) | 1.5 | 1.5 | 0.0 | 1.5 | 1.5 | | 1.5 | 1.5 | | 1.5 | 1.5 | 0.0 |
| Turning Speed (k/h) | 25 | | 15 | 25 | | 15 | 25 | | 15 | 25 | | 15 |
| Lane Util. Factor | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Ped Bike Factor | 0.87 | | 0.87 | 0.91 | 0.94 | | | 0.91 | | | | 0.63 |
| Frt | | | 0.850 | | 0.955 | | | 0.966 | | | | 0.850 |
| Flt Protected | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (prot) | 1632 | 1801 | 1531 | 1750 | 1745 | 0 | 1750 | 1709 | 0 | 1671 | 1842 | 1531 |
| Flt Permitted | 0.575 | | | 0.673 | | | 0.138 | | | 0.196 | | |
| Satd. Flow (perm) | 856 | 1801 | 1327 | 1128 | 1745 | 0 | 254 | 1709 | 0 | 345 | 1842 | 960 |
| Right Turn on Red | | | Yes | | | Yes | | | Yes | | | Yes |
| Satd. Flow (RTOR) | | | 17 | | 30 | | | 21 | | | | 41 |
| Headway Factor | 1.11 | 1.04 | 1.04 | 1.01 | 0.94 | 1.01 | 1.01 | 0.94 | 1.01 | 1.08 | 1.01 | 1.04 |
| Link Speed (k/h) | | 50 | | | 50 | | | 50 | | | 50 | |
| Link Distance (m) | | 153.9 | | | 112.5 | | | 755.2 | | | 92.2 | |
| Travel Time (s) | | 11.1 | | | 8.1 | | | 54.4 | | | 6.6 | |
| Volume (vph) | 325 | 71 | 278 | 110 | 57 | 34 | 110 | 359 | 97 | 52 | 539 | 124 |
| Confl. Peds. (#/hr) | 121 | | 113 | 113 | | 121 | 193 | | 149 | 149 | | 193 |
| Confl. Bikes (#/hr) | | | 43 | | | 11 | | | 14 | | | 35 |
| Peak Hour Factor | 0.84 | 0.54 | 0.85 | 0.75 | 0.55 | 0.78 | 0.81 | 0.89 | 0.81 | 0.79 | 0.77 | 0.76 |
| Parking (#/hr) | | | | | | | | | 0 | | | |
| Adj. Flow (vph) | 387 | 131 | 327 | 147 | 104 | 44 | 136 | 403 | 120 | 66 | 700 | 163 |
| Lane Group Flow (vph) | 387 | 131 | 327 | 147 | 148 | 0 | 136 | 523 | 0 | 66 | 700 | 163 |
| Turn Type | pm+pt | | Perm | Perm | | | Perm | | | Perm | | Perm |
| Protected Phases | 7 | 4 | | | 8 | | | 2 | | | 6 | |
| Permitted Phases | 4 | | 4 | 8 | | | 2 | | | 6 | | 6 |
| Detector Phases | 7 | 4 | 4 | 8 | 8 | | 2 | 2 | | 6 | 6 | 6 |
| Minimum Initial (s) | 6.0 | 7.0 | 7.0 | 7.0 | 7.0 | | 10.0 | 10.0 | | 10.0 | 10.0 | 10.0 |
| Minimum Split (s) | 12.5 | 31.3 | 31.3 | 33.3 | 33.3 | | 21.9 | 21.9 | | 28.9 | 28.9 | 28.9 |
| Total Split (s) | 13.0 | 47.0 | 47.0 | 34.0 | 34.0 | 0.0 | 33.0 | 33.0 | 0.0 | 33.0 | 33.0 | 33.0 |
| Total Split (%) | 16.3% | 58.8% | 58.8% | 42.5% | 42.5% | 0.0% | 41.3% | 41.3% | 0.0% | 41.3% | 41.3% | 41.3% |
| Maximum Green (s) | 6.5 | 40.7 | 40.7 | 27.7 | 27.7 | | 27.1 | 27.1 | | 27.1 | 27.1 | 27.1 |
| Yellow Time (s) | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | | 3.6 | 3.6 | | 3.6 | 3.6 | 3.6 |
| All-Red Time (s) | 2.9 | 2.7 | 2.7 | 2.7 | 2.7 | | 2.3 | 2.3 | | 2.3 | 2.3 | 2.3 |
| Lead/Lag | Lead | | | Lag | Lag | | | | | | | |
| Lead-Lag Optimize? | Yes | | | Yes | Yes | | | | | | | |
| Vehicle Extension (s) | 2.5 | 3.0 | 3.0 | 3.0 | 3.0 | | 4.0 | 4.0 | | 4.0 | 4.0 | 4.0 |
| Recall Mode | None | None | None | None | None | | C-Min | C-Min | | C-Min | C-Min | C-Min |
| Walk Time (s) | | 7.0 | 7.0 | 7.0 | 7.0 | | 7.0 | 7.0 | | 7.0 | 7.0 | 7.0 |
| Flash Dont Walk (s) | | 18.0 | 18.0 | 20.0 | 20.0 | | 9.0 | 9.0 | | 16.0 | 16.0 | 16.0 |
| Pedestrian Calls (#/hr) | | 0 | 0 | 0 | 0 | | 0 | 0 | | 0 | 0 | 0 |
| Act Effct Green (s) | 30.1 | 30.1 | 30.1 | 17.1 | 17.1 | | 41.9 | 41.9 | | 41.9 | 41.9 | 41.9 |
| Actuated g/C Ratio | 0.38 | 0.38 | 0.38 | 0.21 | 0.21 | | 0.52 | 0.52 | | 0.52 | 0.52 | 0.52 |

| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| v/c Ratio | 0.95 | 0.19 | 0.64 | 0.61 | 0.37 | | 1.02 | 0.58 | | 0.36 | 0.73 | 0.31 |
| Control Delay | 55.7 | 16.2 | 24.8 | 38.3 | 22.5 | | 112.3 | 17.1 | | 21.5 | 22.3 | 11.5 |
| Queue Delay | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 |
| Total Delay | 55.7 | 16.2 | 24.8 | 38.3 | 22.5 | | 112.3 | 17.1 | | 21.5 | 22.3 | 11.5 |
| LOS | E | B | C | D | C | | F | B | | C | C | B |
| Approach Delay | | 37.6 | | | 30.4 | | | 36.7 | | | 20.3 | |
| Approach LOS | | D | | | C | | | D | | | C | |
| Queue Length 50th (m) | 49.8 | 13.9 | 40.1 | 21.5 | 16.1 | | ~21.6 | 50.9 | | 5.8 | 80.2 | 10.0 |
| Queue Length 95th (m) | #64.6 | 12.3 | 52.8 | 28.7 | 14.9 | | #54.1 | 97.6 | | 16.7 | 114.2 | 21.2 |
| Internal Link Dist (m) | | 129.9 | | | 88.5 | | | 731.2 | | | 68.2 | |
| Turn Bay Length (m) | 60.0 | | 40.0 | | | | 110.0 | | | 50.0 | | 12.0 |
| Base Capacity (vph) | 409 | 968 | 721 | 423 | 673 | | 133 | 905 | | 181 | 965 | 523 |
| Starvation Cap Reductn | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | | 0 | 0 | 0 |
| Spillback Cap Reductn | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | | 0 | 0 | 0 |
| Storage Cap Reductn | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | | 0 | 0 | 0 |
| Reduced v/c Ratio | 0.95 | 0.14 | 0.45 | 0.35 | 0.22 | | 1.02 | 0.58 | | 0.36 | 0.73 | 0.31 |

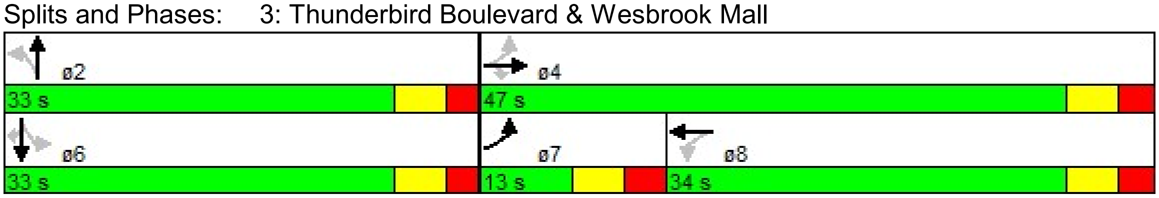
Intersection Summary

Area Type: Other
Cycle Length: 80
Actuated Cycle Length: 80
Offset: 16 (20%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 90
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.02
Intersection Signal Delay: 30.7 Intersection LOS: C
Intersection Capacity Utilization 71.4% ICU Level of Service C
Analysis Period (min) 15

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: Thunderbird Boulevard & Wesbrook Mall



# LANE SUMMARY

## Site: 103 [16th Avenue (Site Folder: 2021_AM_MODEL)]

New Site
Site Category: 2021_AM_BASE
Roundabout



### Lane Use and Performance

| | DEMAND FLOWS [ Total veh/h | HV ] % | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Aver. Delay sec | Level of Service | 95% BACK OF QUEUE [ Veh | Dist ] m | Lane Config | Lane Length m | Cap. Adj. % | Prob. Block. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **South: Wesbrook Mall** | | | | | | | | | | | | | |
| Lane 1[d] | 809 | 2.9 | 1150 | 0.703 | 100 | 3.1 | LOS A | 6.6 | 47.2 | Full | 37 | 0.0 | 12.4 |
| Approach | 809 | 2.9 | | 0.703 | | 3.1 | LOS A | 6.6 | 47.2 | | | | |
| **East: 16th Avenue** | | | | | | | | | | | | | |
| Lane 1 | 118 | 0.0 | 744 | 0.158 | 100 | 11.2 | LOS B | 1.1 | 7.4 | Full | 169 | 0.0 | 0.0 |
| Lane 2[d] | 146 | 13.0 | 923 | 0.158 | 100 | 5.9 | LOS A | 1.2 | 9.0 | Full | 169 | 0.0 | 0.0 |
| Approach | 264 | 7.2 | | 0.158 | | 8.2 | LOS A | 1.2 | 9.0 | | | | |
| **North: Wesbrook Mall** | | | | | | | | | | | | | |
| Lane 1[d] | 319 | 29.7 | 960 | 0.333 | 100 | 7.0 | LOS A | 1.7 | 14.6 | Full | 538 | 0.0 | 0.0 |
| Lane 2 | 168 | 2.9 | 890 | 0.189 | 57[5] | 4.5 | LOS A | 0.8 | 6.0 | Full | 538 | 0.0 | 0.0 |
| Approach | 487 | 20.4 | | 0.333 | | 6.1 | LOS A | 1.7 | 14.6 | | | | |
| **West: 16th Avenue** | | | | | | | | | | | | | |
| Lane 1 | 98 | 0.0 | 1027 | 0.096 | 97[5] | 4.5 | LOS A | 0.6 | 3.9 | Full | 285 | 0.0 | 0.0 |
| Lane 2[d] | 109 | 28.4 | 1105 | 0.098 | 100 | 9.5 | LOS A | 0.6 | 5.1 | Full | 285 | 0.0 | 0.0 |
| Approach | 207 | 14.9 | | 0.098 | | 7.1 | LOS A | 0.6 | 5.1 | | | | |
| Intersection | 1767 | 9.8 | | 0.703 | | 5.2 | LOS A | 6.6 | 47.2 | | | | |

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay per lane.
Intersection and Approach LOS values are based on average delay for all lanes.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

5 Lane under-utilisation found by the program
d Dominant lane on roundabout approach

### Approach Lane Flows (veh/h)

**South: Wesbrook Mall**

| Mov. From S To Exit: | L2 W | T1 N | R2 E | Total | %HV | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Prob. SL Ov. % | Ov. Lane No. |
|---|---|---|---|---|---|---|---|---|---|---|
| Lane 1 | 283 | 344 | 181 | 809 | 2.9 | 1150 | 0.703 | 100 | NA | NA |
| Approach | 283 | 344 | 181 | 809 | 2.9 | | 0.703 | | | |

**East: 16th Avenue**

| Mov. From E To Exit: | L2 S | T1 W | R2 N | Total | %HV | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Prob. SL Ov. % | Ov. Lane No. |
|---|---|---|---|---|---|---|---|---|---|---|
| Lane 1 | 102 | 16 | - | 118 | 0.0 | 744 | 0.158 | 100 | NA | NA |
| Lane 2 | - | 102 | 44 | 146 | 13.0 | 923 | 0.158 | 100 | NA | NA |
| Approach | 102 | 117 | 44 | 264 | 7.2 | | 0.158 | | | |

| North: Wesbrook Mall | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov. From N To Exit: | L2 E | T1 S | R2 W | Total | %HV | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Prob. SL Ov. % | Ov. Lane No. |
| Lane 1 | 51 | 268 | - | 319 | 29.7 | 960 | 0.333 | 100 | NA | NA |
| Lane 2 | - | - | 168 | 168 | 2.9 | 890 | 0.189 | 57 [5] | NA | NA |
| Approach | 51 | 268 | 168 | 487 | 20.4 | | 0.333 | | | |

| West: 16th Avenue | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mov. From W To Exit: | L2 N | T1 E | R2 S | Total | %HV | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Prob. SL Ov. % | Ov. Lane No. |
| Lane 1 | - | 58 | 40 | 98 | 0.0 | 1027 | 0.096 | 97 [5] | NA | NA |
| Lane 2 | 109 | - | - | 109 | 28.4 | 1105 | 0.098 | 100 | NA | NA |
| Approach | 109 | 58 | 40 | 207 | 14.9 | | 0.098 | | | |

| | Total | %HV | Deg.Satn (v/c) |
|---|---|---|---|
| Intersection | 1767 | 9.8 | 0.703 |

Lane flow rates given in this report are based on the arrival flow rates subject to upstream capacity constraint where applicable.

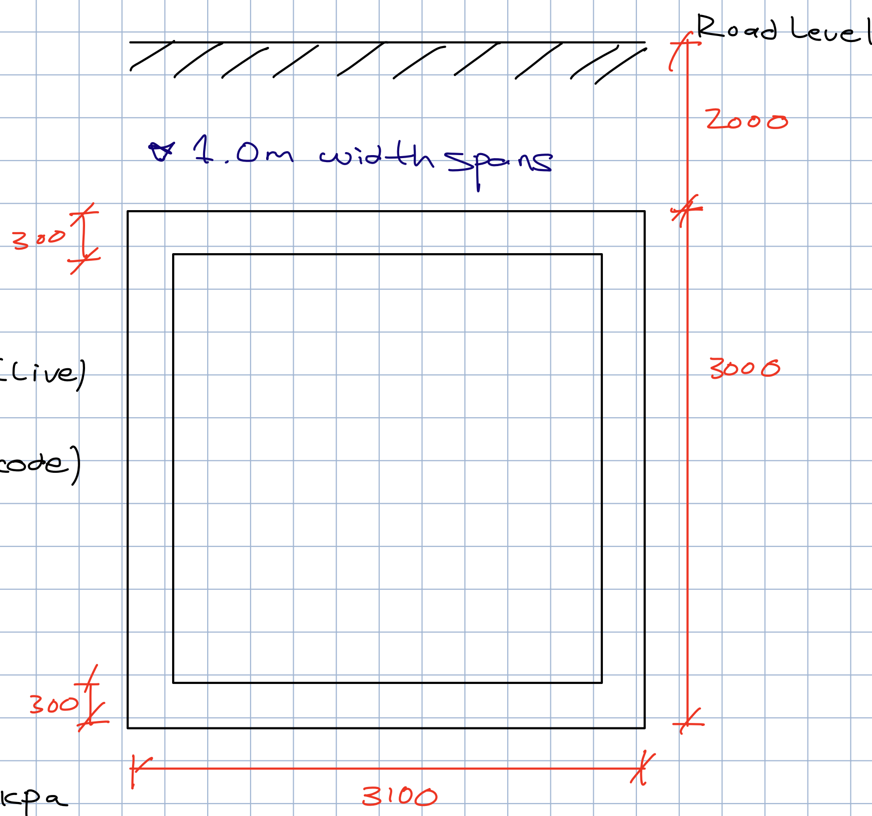
5 Lane under-utilisation found by the program

**Merge Analysis**

| | Exit Lane Number | Short Lane Length m | Percent Opng in Lane % | Opposing Flow Rate veh/h pcu/h | Critical Gap sec | Follow-up Headway sec | Lane Flow Rate veh/h | Capacity veh/h | Deg. Satn v/c | Min. Delay sec | Merge Delay sec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| South Exit: Wesbrook Mall Merge Type: **Not Applied** | | | | | | | | | | | |
| Full Length Lane | 1 | Merge Analysis not applied. | | | | | | | | | |
| East Exit: 16th Avenue Merge Type: **Not Applied** | | | | | | | | | | | |
| Full Length Lane | 1 | Merge Analysis not applied. | | | | | | | | | |
| Full Length Lane | 2 | Merge Analysis not applied. | | | | | | | | | |
| North Exit: Wesbrook Mall Merge Type: **Not Applied** | | | | | | | | | | | |
| Full Length Lane | 1 | Merge Analysis not applied. | | | | | | | | | |
| West Exit: 16th Avenue Merge Type: **Not Applied** | | | | | | | | | | | |
| Full Length Lane | 1 | Merge Analysis not applied. | | | | | | | | | |
| Full Length Lane | 2 | Merge Analysis not applied. | | | | | | | | | |

# Appendix E - Underpass Design Load Calculations

# APPENDIX E: UNDERPASS DESIGN CALCS.




**Soil Parameters:**

Soil angle of friction $\phi = 30^\circ$
Soil unit weight $\gamma_{soil} = 19\ kN/m^3$
Allow. Soil pressure: 144 kpa

**Vehicle loading:** (using CSA S-6) (Live)

wheel load = 72.5 kN (highway code)
2000 mm < 2400 mm ∴ $h_f = 2000$

Loading width = 2000 + 250
= 2250

→ using online calculator:

Linear load on top slab = 7.14 kpa

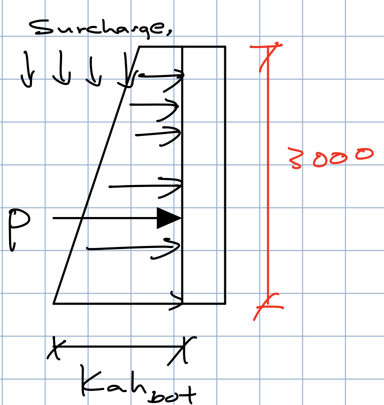
Dynamic Load Allowance $IM = 33(1 - 0.0004(h_f)) = 5.94\%$

$$w_{vehicle} = 7.14 + (7.14 \cdot \frac{IM}{100} \cdot 1.20) = 9.1\ kN/m$$

**Dead Loads from Soil Pressure**

Top slab: $w_{soil} = 2000(19)(1) = 38.0\ kN/m$
$w_{sw_1} = 300(23.5)(1) = 7.05\ kN/m$

Side Slabs:




$K_a = \frac{1 - \sin\phi}{1 + \sin\phi} = 0.33$, Surcharge due to topsoil = 38 kpa

$Kah_{top} = 0.33\ \gamma_{soil}(2.0) = 12.54$

$Kah_{bot} = 0.33\ \gamma_{soil}(3000 + 2000) = 31.7\ kN/m$

$P_{sw_2} = (2)(0.3)(3 - 0.3 - 0.3) \cdot (23.5) = 33.8\ kN$

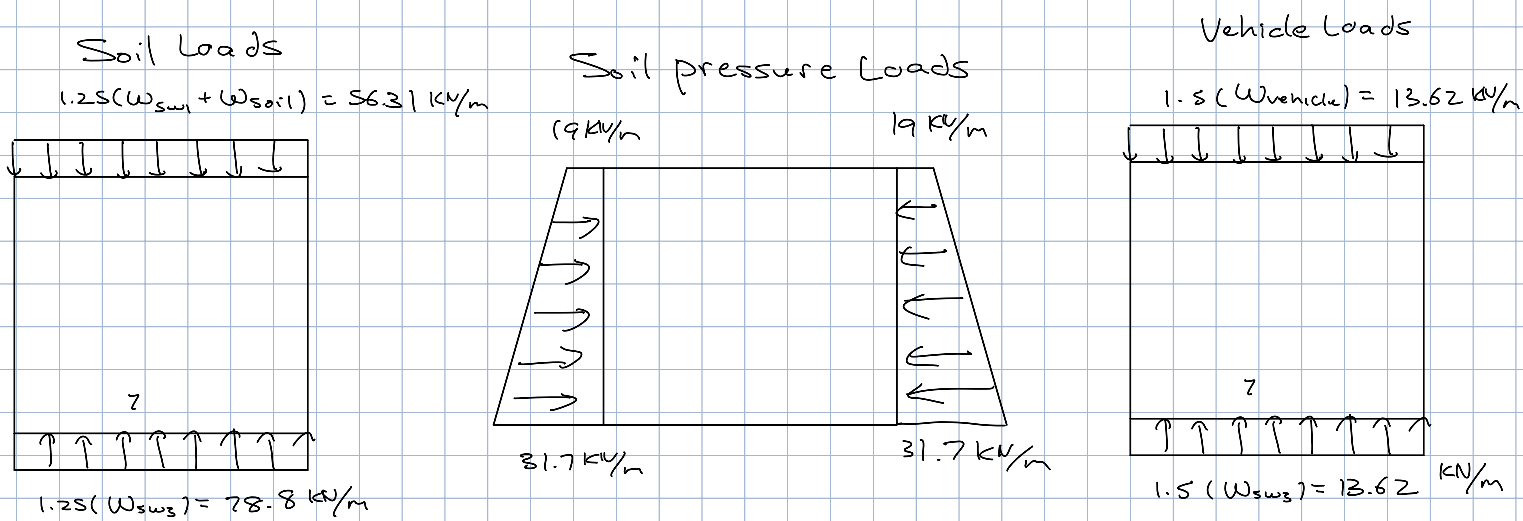
Bottom slabs: $\frac{P_{sw_2}}{3.1} + W_{sw_1} + W_{soil} + \gamma_{concrete}(3.1)(1)$

$W_{sw_3} = 63$ kN/m

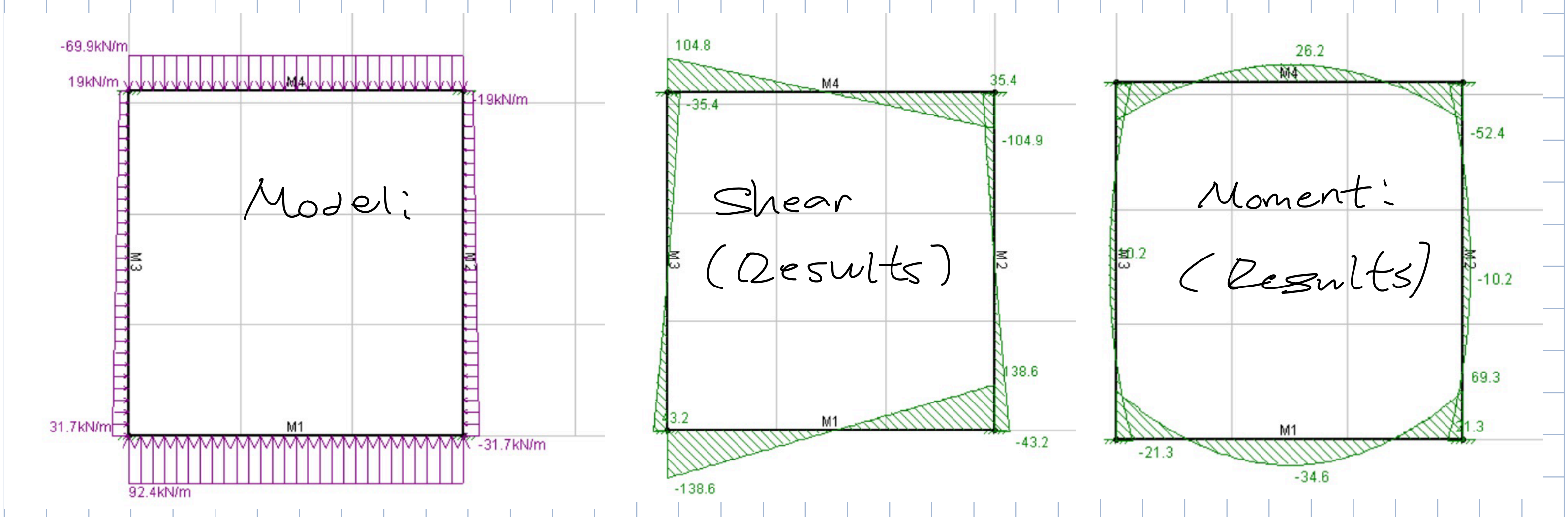
$W_{vehicle} = 9.1$ kN/m

Load Factors: Live = 1.5, Dead = 1.25, horizontal pressure: 1.5

## Final Loading Diagrams:




## Structural Analysis (using Risa 2D)




Max moment = 69.3 kN·m @ bottom slab ends

Max shear = 138.6 kN @ bottom slab ends

To be conservative, use as design forces throughout!

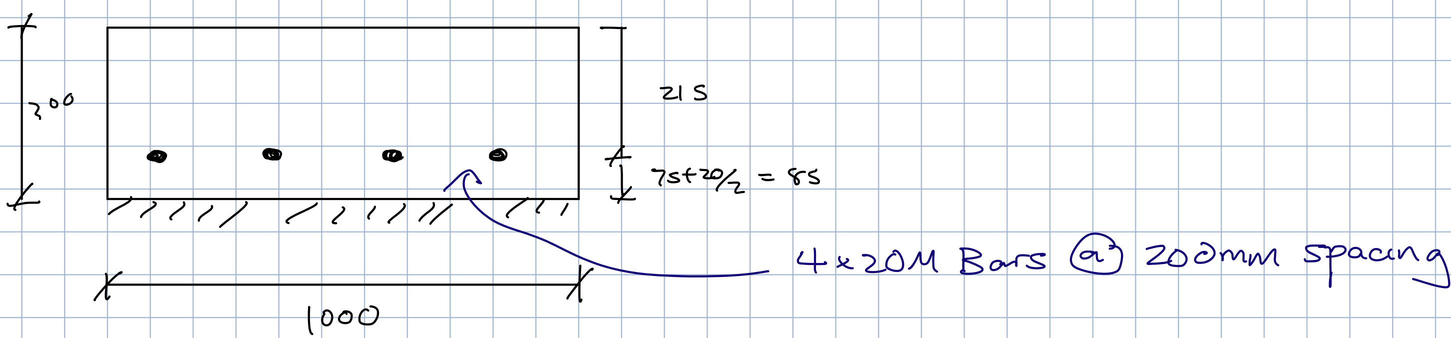
## Reinforcement Detailing:

Concrete touching soil ∴ 75mm required

Concrete not touching soil : 40mm required

### BLL (face touching soil)

Spacing: $\frac{A_s}{st} \geq 0.002$ $S \leq \frac{300}{0.002(300)} = 500$, → Try 200mm



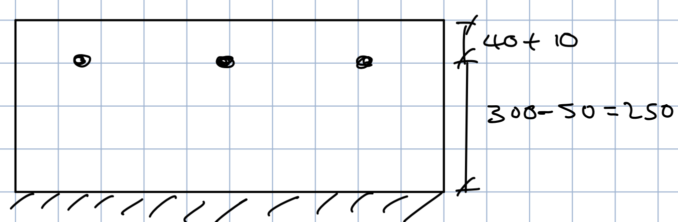

$M_r = \phi_s f_y A_s \left(d - \frac{\phi_s f_y A_s}{2\alpha_1 \phi_c f'_c b}\right)$

$= 340(1200)\left(215 - \frac{(340)(1200)}{2(0.79)(0.85)(40)(1000)}\right) = 84.6 \text{ kN·m} > 69.3$

∴ GOOD

### TUL (face towards inside)

$S \leq 500$ → Try 3×20M Bars ($A_s = 900$)




$M_r = 340(900)\left(250 - \frac{340 \cdot 900}{2(0.79)(0.85)(40)(1000)}\right) = 74.8 > 69.3 \text{ kN·m}$

GOOD

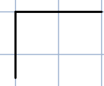
### BUL & TBL

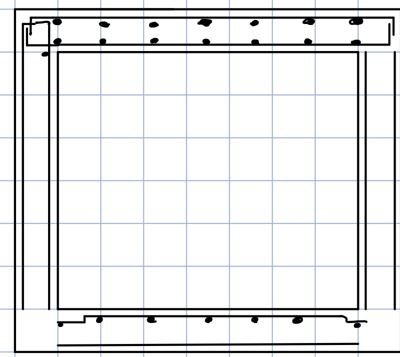
BUL = $\frac{A_b}{st} = 0.002$, $S < 500$ for 20M bars ∴

use 20 M at 500mm spacing

## development length on bars:

$l_d = 23(20) = 460\text{mm} \rightarrow$





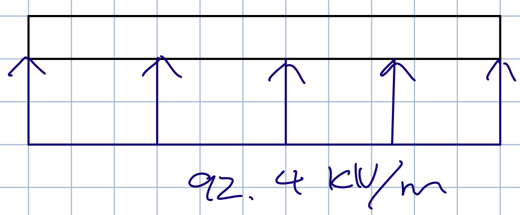
## Shear check Concrete Strength only

$V_c = \phi_c \beta \sqrt{f'_c}\, b_w d_v \qquad d_v = 0.9(215) = 193.5\text{mm}$

$= (0.65)(0.21)(40)^{1/2}(1000)(193.5)$

$= 167.1\text{ kN} > 138.6\text{ kN}$ ✓ GOOD

## Bearing Pressure Check:




$92.4\frac{\text{kN}}{\text{m}} \Big/ 1.0\text{m}$ slab width

$= 92.4$ kPa.

Allowable bearing Pressure $= 150$ kpa

$\therefore\ FOS = \frac{150}{92.4} > 1$ ✓ GOOD ✓

## Summary

| | Moment, M | Shear, V | Bearing |
|---|---|---|---|
| Demand | 69.3 kN·m | 138.8 kN | 92.4 kpa |
| Capacity | 74.9 kN·m | 167.1 kN | 150 kpa |
| Status: | GOOD | GOOD | GOOD |

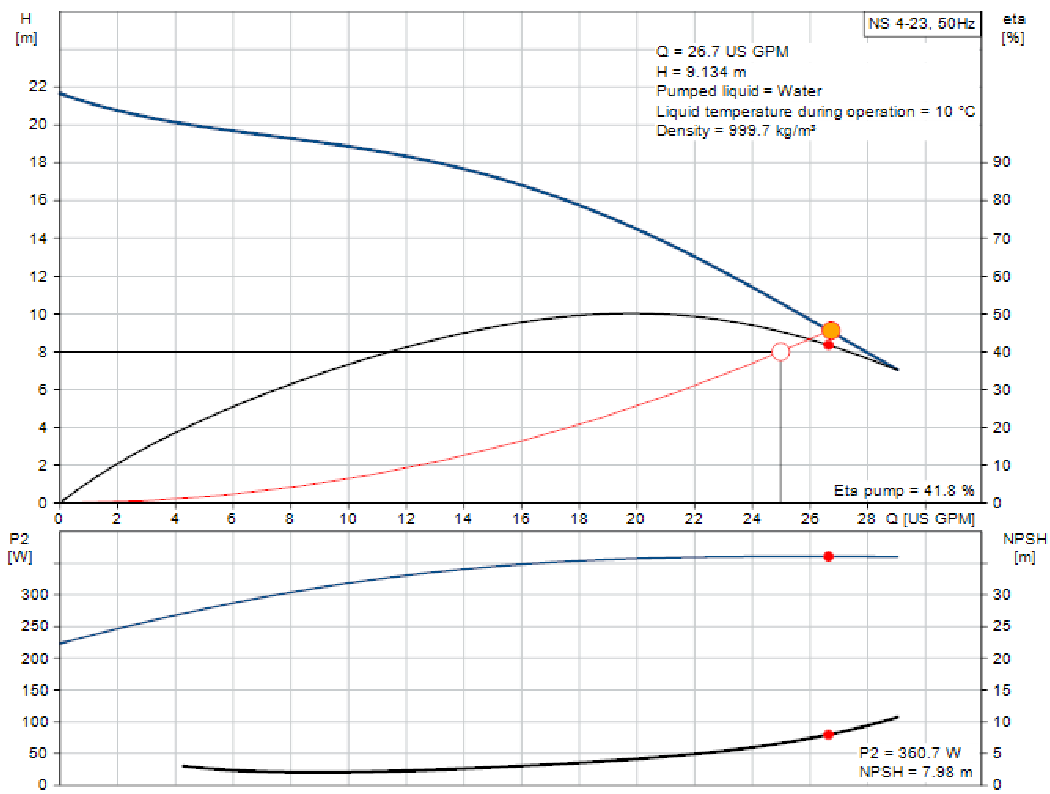
# Appendix F - Pump Design Calculations

Head Requirement - 8 meters

Flow Requirement - 10mm/hr * (4m * 35m) Underpass Plan View Dim. = 25 GPM

- Based on 1 in 100 year hourly rainfall at UBC Vancouver above underpass
- Groundwater water table 45 meters below surface (no influence)

Pump Curve and System Curve - Selected Pump MODEL NS 4-23 CVBP




Source: [https://product-selection.grundfos.com/](https://product-selection.grundfos.com/)

**Operating Point Summary**

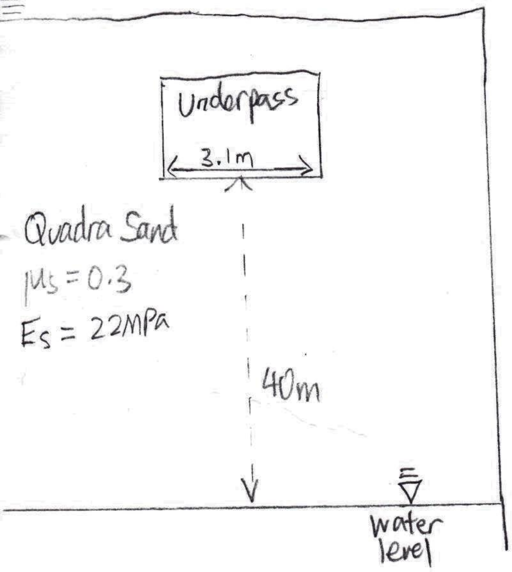
Target Flow = 25 GPM or 1.57 L/s

Target Head Clearance = 7.1 meters

Operating Point = 26.7 GPM at 9.1 meters of head

# Appendix G - Settlement Calculations

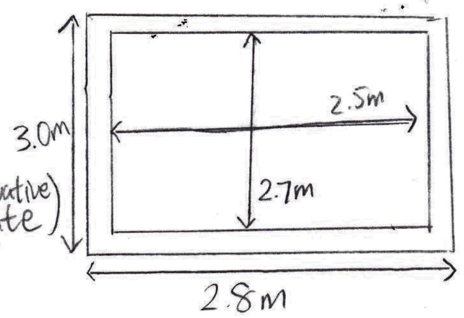
# Underpass Settlement




Assumptions:

1. Shallow foundation
2. Elastic Settlement (Drained sand)
3. No size or depth factors (conservative estimate)

Dimensions (Not to Scale)




Density of concrete

$\rho_{conc} = 2400 kg/m^3$

Equation:

$$\text{Settlement} = q_0(\alpha B')\left((1-\mu_s^2)/E_s\right)$$

- $q_0$ – net pressure
- $\mu_s$ – poisson ratio of soil
- $E_s$ – Average MOE of soil
- $\rho_{conc}$ – density of concrete
- $g = 9.81 m/s^2$
- $A$ = cross section
- $\alpha = 4$
- $B' = \frac{B}{2}$

$q_0$ calculations:

$$q_0 = \rho g A / B$$

$$q_0 = \frac{2400 kg/m^3 \cdot 9.81 m/s^2 \cdot (3\times2.8 - 2.7\times2.8)\,m}{2.8m}$$

$$q_0 = \frac{357 kN}{2.8m}$$

$$q_0 = 127 kN/m$$

Settlement

$$S = q_0(\alpha B')\left((1-\mu_s^2)/E_s\right)$$

$$S = 127\frac{kN}{m}\left(4\times\frac{3.1}{2}\right)\left(\frac{(1-0.3^2)}{22MPa}\right)$$

$$S = 3cm$$

Acceptable settlement for framed structure 5-cm

✓ Pass

Source: Principles of Foundation Engineering
theconstructor.org