UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Stadium Neighborhood Underground Parkade and Water Storage

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Detailed Design Report

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Stadium Road Neighbourhood

Municipal Infrastructure Improvements

UBC SEEDS

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Executive Summary

Our team has been acquired to design municipal infrastructure improvements for the future Stadium Road Neighborhood (the Neighbourhood) in the University of British Columbia (UBC) Vancouver campus. This project targets to reduce stormwater runoff from new impervious area as a result of new development, to mitigate potential overland flooding during major storm events, and to improve quality of stormwater discharge. Our team is taking a natural system approach for stormwater handling through detention facility, bioswales, rain gardens and other green infrastructures as outlined in the UBC Integrated Stormwater Management Plan (ISMP). Stormwater management will be carried out through integration with an underground parkade and transportation improvements on West 16th Avenue. The scope of work is as follows:

1. Create a stormwater management plan for both onsite and offsite;
2. Design a mixed-use underground parkade with stormwater detention; and
3. Include stormwater management into an upgraded road network

The stormwater management plan for the Neighbourhood aims to achieve net zero in pre- and post-development stormwater run-off for a 1/100 year storm. This will be done through an underground detention facility that will prevent stormwater contamination and control flow levels. Rational method was used to calculate the stormwater detention volume and three detention design options were conceptualized.

The preferred option was then developed and features a detention facility designed for small storms located adjacent to the underground parkade beneath the new Thunderbird Stadium and will overflow and accommodate a 1/100 year storm event. The detention facility was designed using EPASWMM and is 470 m^3 with a v-notch weir opening into the parkade. A flow control manhole is located immediately downstream of the detention facility to discharge water back into the storm system at pre-development 1/100 year release rate. An oil/grit separator serves as an additional water treatment method. Onsite stormwater will be collected at the lowest point of the site through gravity flow and conveyed to the detention facility upstream via a pump system. Additionally, a permanent wetland will be built on the southwest corner of the development site to serve as a transfer station for stormwater while mimicking a natural habitat for nearby species and allowing sediments to settle and be treated before being released offsite.

The parkade access is via W 16th Ave. The layout of the parkade is one-way traffic flow with 120 angled parking spaces including spaces for electric vehicle charging and car-share. The parkade is fully accessible with handicap stalls and an elevator. The building envelope of the parkade includes waterproofing and durability measures such as waterproof membrane, capillary break aggregate drainage layer, and a traffic-grade membrane for corrosion. Improvements to the adjacent transportation network include a redesign of W 16th Ave with separated bike lanes and transit/HOV priority lanes to better support sustainable travel modes and accommodate future population and density growth. Bioswales and other green infrastructure are integrated into the design to improve streetscape and achieve further reduction in stormwater runoff.

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1 Introduction

Stadium Road Neighbourhood (the Neighbourhood) is a future mixed-use neighbourhood located at University of British Columbia (UBC) Vancouver campus, bounded by East Mall, W 16th Ave, Stadium Rd and the UBC Botanical Garden. The Neighbourhood will involve relocation of the existing Thunderbird Stadium to accommodate new residential and commercial developments. The project is currently headed by UBC Campus + Community Planning and is in its third phase of public consultation. Under the guiding principles adopted by the UBC Board of Governors in December 2017, neighbourhood planning at UBC will build long-term value, create a green community, enhance ecology, and promote a high efficiency and low impact transportation network.

1.1 Project Objectives

UBC has developed strict water management guidelines for campus development due to strict geographical constraints. The existing stormwater system is traditionally designed with large diameter pipes. UBC's Integrated Stormwater Management Plan (ISMP) proposes innovative opportunities that better manage stormwater [1]. With the future development of the Neighbourhood, UBC Social Ecological Economic Development Studies (UBC SEEDS) has contracted with our team to design a mixed solution of underground parkade and water storage/detention tanks for the Neighbourhood in accordance with the ISMP. A secondary objective of this project is to redesign parts of the adjacent transportation network according to the UBC Transportation Plan, and to integrate stormwater management solutions into the transportation network. The mixed-use solution aims to achieve net zero in both pre- and post-development rainwater run-off for a 1/100 year storm.

1.2 Site Overview

The main design constraint is the proposed site layout, as it needs to be aligned with the evolving Neighbourhood plan. Layout option 1B proposed by the Neighbourhood's public consultation, shown in Figure 1, has been adopted for the designs in this report. A new Thunderbird Stadium will be constructed east of the existing one, and the site of the current stadium will be developed for mixed residential use. The underground parkade provided for commercial units will be located under the stadium with access from W 16th Ave. The site topography includes a 4% slope from north to south. Other site constraints include the surrounding existing developments, underground utilities and transportation network. The design will accommodate these constraints and provide a single solution for all three elements: stormwater management, parkade, and transportation network. The guiding design principles are efficient stormwater management and sustainability in accordance with the ISMP.

Figure 1 - Proposed Neighbourhood Layout Option 1B (Source: UBC)

1.3 Member Contributions

Table 1 - Member Contributions

Member	Main Tasks	Review Tasks
Grace Chiang	Transportation Design - Policy review - AutoCAD drawings Project Management - Stakeholder register - Risk analysis - Report formatting - Internal scheduling/processes - Design and Innovation Day deliverables	- Stormwater integration - Parkade design - Building envelope design - Final consolidation and review of the report
Shanyao Fan	Stormwater Design - Catchment plan - Green infrastructure - Wetland construction	- Transportation design drawings
Jason Ku	Project Management - Cost estimate - Construction methodology - Decision matrix	- Sustainability
Chong Keng (Daniel) Lim	Structural Design - Parkade & Detention Tank - Model & Analysis (SAP2000 & Revit) Project Management - Site Overview & Constraints	- Structural drawings - Cost estimates - Transportation design

Ka Cheng (Kevin) Wong	Transportation Planning and Design - Policy review - Network safety and capacity analysis - Network design - Conceptual drawings - Parking supply management planning	- Stormwater integration - Parkade design - Project management
Peggy Shen	Stormwater Design - Conceptual design options - Sub-catchment plan - Stormwater drainage system - Detention tank in/outflow control Project Management - Risk Analysis - Construction schedule	- Project management - Final consolidation and review of the report
Yan Zhou	Drafting - Site layout - Wetland - Pipe layout - Parkade and detention tank - Construction details of green infrastructure Structural Design - Parkade	- Structural Calculations - Transportation drafting

2 Design Issues/Criteria

2.1 Stormwater

2.1.1 UBC Integrated Stormwater Management Plan (ISMP)

The main design goals are outlined below:

- Reduce the flow of water leaving UBC campus
- Reduce impacts of stormwater that leaves campus through detention and other methods
- Maintain or preferably enhance water quality at campus boundaries so that it meets or exceeds best practices for urbanized municipalities
- Incorporate the natural hydrologic cycle and natural systems approach into the long-term planning and design of the stormwater system
- Build detention facilities with capacities to manage the 1/100 year storm event adjacent to the discharge location at the South Campus
- Include oil/grit separators to minimize particulate matter released into the environment
- Implement low-impact development practices through landscaping, infiltration, and other techniques [1]

2.1.2 Metro Vancouver Stormwater Source Control Design Guidelines 2012

Detailed construction guidelines and calculation methods are taken from the Metro Vancouver Stormwater Source

Control Design Guidelines 2012 which outlines the overall design process for different stormwater source controls

[2]. The guideline is used for design methodology and procedures for natural elements such as infiltration swale systems, pervious paving, and absorbent landscapes.

2.1.3 Geotechnical Conditions

Heavy emphasis is placed on examining the current site condition (i.e. topography, sub-soil structure and condition) to determine a feasible. The site has a 4% slope from north to south which is a physical problem for capturing stormwater runoff via gravity flow into the detention tank which will be located underneath Thunderbird Stadium. The existing Stadium is situated on a basin-like terrain. According to the ISMP, the site sits on top of a perched groundwater aquifer and silty clay [1]. Excessive stormwater infiltration into the ground will increase its water table level and can create erosion issues to the nearby cliffs.

2.2 Underground Structures

The design issues and limitations include uncertainty of loads and sub-grade conditions. The underground structures are designed in accordance with UBC Technical Guidelines (UTG) 2018 Edition which provides structural requirements in Section 03 00 00 Concrete [3]. The structural aspects of the underground parkade is designed with the aid of *Reinforced Concrete Design - A Practical Approach* [4]. British Columbia Building Code (BCBC) [5] was used for the underground structure design and the City of Vancouver Parking and Loading Design Supplement [6] was used for the layout of the parkade. The parkade capacity and design checks are in accordance with the codes from Design of Concrete Structure - CSA A23.3 [7] and Parking Structures - CSA S413 [8] .

Existing soil and groundwater conditions are based on the geotechnical investigation conducted by GeoPacific Consultants Ltd. [9] for an area near W 16th Ave and Wesbrook Mall. The Neighbourhood site condition is assumed to be similar which is stable and safe for construction. However, a follow-up detailed investigation of the actual perimeter of the proposed site should be carried out to verify these assumptions. Geotechnical analysis would determine the geostatic and hydrostatic pressures which may induce lateral or uplift forces on the foundation system. Additionally, the excavation will require shoring due to the limited space of the location. The detailed design of shoring, exterior wall and foundation will be assessed and recommended by the experience geotechnical engineers.

The enclosure of the parkade follows the NIBS design criteria of sub-grade structures [10] below the water table and Section 07 10 00 Dampproofing and Waterproofing of UTG.

2.3 Sustainable Infrastructure and Transportation

Transportation infrastructure improvements are generally guided by these targets outlined in the following plans.

Table 2 Transportation Plan/Policy and Key Guidelines

Plan/Policy	Key Guidelines
Metro Vancouver Regional Growth Strategy [11]	- Encourage land use and transportation infrastructure that improve the ability to withstand climate change impacts and natural hazard risks - Coordinate land use and transportation to encourage transit, multiple-occupancy vehicles, cycling, walking
TransLink Regional Transportation Strategy [12]	- Make early investments to complete the walkway and bikeway networks - Provide more traffic-protected bikeways to support cycling by people of all ages and abilities - Make significant and early investments to complete bikeway and walkway networks - Optimize roads and transit for efficiency, safety and reliability; reallocate road space
UBC Vancouver Campus Plan Design Guidelines [13]	- Walkways minimum 1.8m wide - Vehicular roads paved with asphalt - Minimum cross slope of 0.5% and maximum 2%
UBC Transportation Plan [14]	- Make the campus safer for walking - Restrain automobile use on campus

2.4 Thunderbird Stadium Usage/Attendance

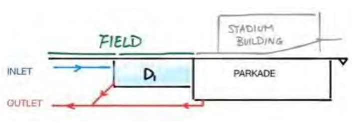
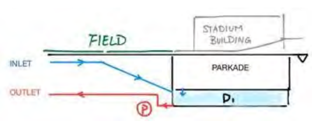
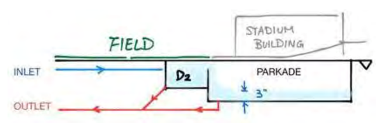
Thunderbird Stadium hosts multiple UBC Recreational programs every year. Approximately four football games with attendance ranging from 1500 - 5000 people and ten soccer games with attendance ranging from 100 - 400 people are hosted. The biggest event that happens annually is UBC Homecoming which brings an average of 10,000 people into the stadium grandstands and open area. Attendance at the existing Thunderbird Stadium is therefore relatively seasonal. The new Thunderbird Stadium will increase in capacity, and small commercial units as well as community facilities will be added in the surrounding area as per the Neighbourhood plan. An increase in daily trips to Thunderbird Stadium can be expected with the new amenities and residences.

3 Conceptual Design Alternatives

3.1 Integrated Underground Parkade and Stormwater Detention Options

In the conceptual design stage, three alternatives were evaluated. All three options were constrained by the same design criteria and had some identical features. Due to the site slope, natural gravity flow cannot convey stormwater upstream to the detention and re-grading the entire site would not be feasible; therefore, a forced pumping system must be implemented to direct water to the detention location. The parkade will be a single storey underground facility with a single access from W 16th Ave. The parkade is designed for optimal parking allocations, which also contains EV charging stations and designated car-share only spots to promote sustainable transportation and reduce single-occupancy vehicle use. The underground parkade will provide 120 parking stalls, which is approximately 50% smaller in area than the existing parkade. Three design ideas for the integrated parkade and detention are shown in Table 3. The main differences among the three options were the size of detention tank and layout of tank with respect to parkade.

Table 3 - Conceptual Design Alternatives for the Parkade and Detention Facility

	OPTION 1	OPTION 2	OPTION 3
			
Size	Detention: 1/100 year (560m^3)	Detention: 1/100 year (560m^3)	Detention: 1/25 year (460m^3)
Layout	Parallel with Parkade	Underneath Parkade	Parallel with Parkade
Note	Detention sits empty most of the time	Pump required for release	Overflow in 1/100 year storm event; max. 3" flood

- *Option 1* is a large detention tank located underneath the new Stadium field and parallel to the parkade. The detention tank has the capacity to hold the volume of a 1/100 year storm, which is approximately 560 m^3.
- *Option 2* is a detention tank located underneath the parkade, but due to the deeper elevation of the outlet, a separate pump is required for discharging water back to the storm system. A more complicated structural design and deeper excavation during construction will be required.
- *Option 3* aims to reduce the size of detention tank, such that it is more economically efficient to construct and maintain. The detention has the capacity to hold a 1/25 year storm, which has the volume of approximately 460 m^3 (about 18% smaller), and any excess stormwater during a 1/100 year event would overflow into the parkade via a weir on the wall. The parkade will be sized so the flooding in the parkade is controlled to be lower than 3" (or 7.5 cm) in height and an emergency

response plan will be developed. A 100 m^3 size reduction in the tank can have a cost saving of approximately $60,000 (100$m^3$ x $600/$m^3$).

3.1.1 Preferred Option – Option 3

Decision matrix analysis was used to select the best option amongst the three alternatives. Each option is given a score on its design/construction cost, constructability, long-term maintenance required and health and safety, where 1 denotes the least favourable and 5 is the most favourable. The decision matrix is shown in Table 4.

Table 4 - Decision Matrix for Conceptual Design Alternatives

Criteria	Weight	Option 1	Option 2	Option 3
Design Cost	1	5	3	3
Construction Cost	4	3	1	5
Constructability	3	5	1	3
Space Utilization	2	1	1	5
Maintenance	5	2	2	5
Health & Safety	3	5	4	3
Total Score:		59	34	**76**

The analysis led to conclude that *Option 3* is the preferred design and will be further detailed in this report. A list of stormwater management solutions was also developed in the conceptual design stage and shown in Table 5.

Table 5 - Stormwater Management Solutions for Stadium Neighbourhood

Stormwater Management Solutions for Stadium Neighbourhood	
Constructed Wetland	● Located at the lowest point of the site and serve as a stormwater transfer station; ● Mimics natural habitat for nearby species; ● An integral part of the recreational area for the development site; ● Provides detention, storage, habitat, and treat stormwater runoff through natural processes prior to discharging it into the downstream drainage system; ● A pump system within the wetland allows for circulation of water in the wetland; hence eliminating stagnation of water which may cause potential environmental and health related issues.
Rain Gardens, Infiltration Bulges, Bioswales	● Placed on boulevards along W 16th Ave and East Mall; ● Reduce runoff volume and improve water quality by infiltrating, capturing, and filtering stormwater; ● Beautiful landscaping feature.
Pervious Paving	● Implemented for the walkway throughout the Neighbourhood; ● reduce runoff volume and improve water quality by infiltrating and treating stormwater while still providing a hard, drivable surface.
Water Quality Structures	● Oil/grit interceptors to be located upstream of the wetland and detention tank; ● capture petroleum hydrocarbons, coarse grit and coarse sediment; ● Install water quality monitoring equipment to collect data for further analysis.

Other Low Impact Development Features	• Such as tree well structures, absorbent landscapes, green roofs, rainwater harvesting, infiltration trenches; • Be examined further depends on site constraints.

3.2 Transportation Improvement Options

The Neighbourhood already has transportation upgrades within its plan on East Mall and Stadium Rd. Transportation network improvements within our team's scope will be to upgrade W 16th Ave between Wesbrook Mall and SW Marine Dr. The main objectives are traffic calming and to encourage multi-modal transportation through road space reallocation. During the conceptual design stage, several options were explored including addition of a transit / HOV lane in anticipation of the W 41st Avenue B-Line service which will begin in September 2019. This can be implemented as a centred transitway (bus stops and transit lane in the centre of the road) or a curbside transit / HOV lane (bus stops and HOV lane at the side of the road). Figure 2 below illustrates schematics of these options for W 16th Ave. Design options of bike and transit lanes were flexible at this stage, and any combination of these options were feasible. It was determined that parkade access from W 16th Ave will require safety features such as signs and highly-visible paint to minimize conflicts between cyclists and vehicles. To further enhance streetscape, pedestrian and cyclist comfort, and stormwater management capability, bioswales, urban trees and other green stormwater management will be implemented along available green space. The preferred design will be further detailed in this report.

Figure 2 - W 16th Ave Upgrade Options

4 Detailed Design

4.1 Stormwater Design Methodology

Since the project site is less than 20 Ha, Rational Method is used for the design of major storm drainage.

$$Q = RAIN$$

where:

Q = Flow in cubic metres per second (m^3/s)

R = Runoff coefficient
A = Drainage area in hectares (Ha)
I = Rainfall intensity in mm/hr
N = Conversion factor 0.00278

4.1.1 Drainage Area

The tributary drainage areas for the storm drainage system is divided based on each pipe segment. The preliminary storm network is designed based on proposed locations of future major walkways, constructed wetland and the integrated underground parkade and stormwater detention facility. The project site is located within the W 16th Ave catchment boundary. Since no data was available for this broader catchment, analysis of the tributary areas is performed for the Neighbourhood only. The sub-catchment area for the project site is approximately 8.85 Ha excluding the trees to be retained along W 16th Ave, which will not be disturbed by this project. The Stadium field will be sloped at 2% from centre toward two longer sides and underlaid by a thin layer of impervious surface so stormwater will sheet flow to the sides and be collected. An illustration for the stormwater catchment plan's drainage areas is shown below.

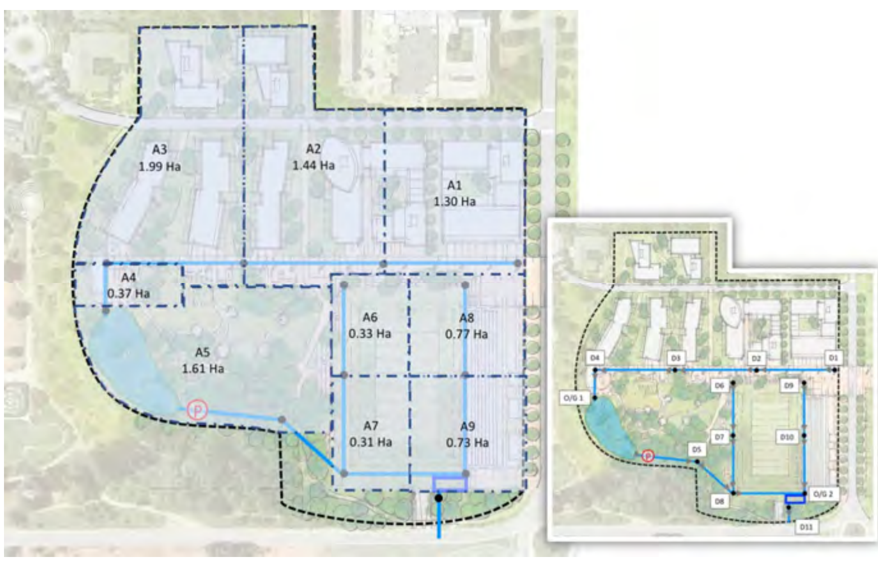


Figure 3 Stormwater Catchment Plan's Drainage Areas

4.1.2 Runoff Coefficients

Considering existing site conditions and proposed mixed-use development for the Neighbourhood, a factored method was used to determine the pre- and post-development runoff coefficients. Since the new Stadium will use artificial turf for the field, a very high runoff is expected and R=0.95 is used for estimation. The calculated 1/100 year runoff coefficients are 0.30 for pre-development and 0.76 for post-development.

Table 6 - Stormwater Runoff Analysis

100-yr Storm Post-Development per Proposed Option 1b Site Plan				
Land Use Type	Area (m^2)	R_{100}	$R_{100, Factored}$	Notes:
Residential-Highrise	13000	0.84	0.13	
Residential-Lowrise	14150	0.72	0.12	
Parks	18700	0.30	0.06	
Walkway	12000	0.95	0.13	
Stadium	22200	0.95	0.24	Artificial Turf, high R.
Road	6600	1.00	0.08	Proposed Stadium Road.
Total Area:	86650		0.76	

100-yr Storm Pre-Development per Existing Condition				
Land Use Type	Area (m^2)	R_{100}	$R_{100, Factored}$	Notes:
Parks (Whit Matthew Field)	23500	0.30	0.08	Cleared and grubbed.
Parks (Forest)	18700	0.13	0.03	Passive Use, reduced R.
Stadium	36200	0.27	0.11	Grass field.
Res (Lot N of Stadium Rd)	5450	0.60	0.04	Cleared w/ some asphalt pvmt.
Road	3000	1.00	0.03	Ex. Stadium Road.
Total Area:	86850		0.30	

4.1.3 Time of Concentration

Time of Concentration (T_c) was used in determining the design rainfall intensity and is defined as the time required for stormwater runoff to travel from the most remote point of the drainage basin to the point of interest. T_c is the cumulative sum of the following, both of which can be calculated as follows:

$$Tc = \text{Overland Flow Time } (T_o) + \text{Travel Time } (T_t)$$

a. Overland Flow Time (T_o):

The Kinematic Wave equation is used to calculate overland flow time:

$$T_o = \frac{6.92L^{0.6}n^{0.6}}{i^{0.4}S^{0.3}}$$

Where:

T_o	=	Overland flow travel time in minutes
L	=	Length of overland flow path in meters
S	=	Slope of overland flow in m/m
N	=	Manning Coefficient
i	=	Design storm rainfall intensity in mm/hr

b. Travel Time (T_t)

Travel time will be calculated as the pipe length divided by the velocity obtained from the Manning's Equation and assuming full pipe conditions. The minimum T_c is 15 minutes.

4.1.4 Rainfall Intensity

The rainfall intensity duration frequency (IDF) curve from Vancouver International Airport (attached in Appendix D) was used to calculate the rainfall intensity for the Project. The 1/100 year IDF curve equation is:

$$I = aT^b$$

Where a = 26.100 and b = -0.558.

4.1.5 Calculations

A sample calculation for 1/100 year storm pre-development flow rate is shown:

$$I_{100-yr} = aT^b = 26.100 \times 15^{-0.558} = 56.6\frac{mm}{hr}$$

$$Q_{100-yr} = RAIN = 0.30 \times 8.85Ha \times 56.6\frac{mm}{hr} \times 0.00278 = 0.418\frac{m^3}{s}$$

Setting the 1/100 year pre-development flow rate (0.418 m^3/s) as the maximum allowable release rate for post-development condition to achieve net-zero in stormwater runoff, the minimum storage volume is 580 m^3 with peak inflow of 0.901 m^3/s for a duration of 20 minutes.

A sample calculation for pipe capacity from MH1 to MH2 is shown:

$$V_{cap} = \left(\frac{d}{4000}\right)^{\frac{2}{3}} \times \frac{\sqrt[2]{\frac{S}{100}}}{n} = \left(\frac{400mm}{4000}\right)^{\frac{2}{3}} \times \frac{\sqrt[2]{\frac{0.5\%}{100}}}{0.0013} = 1.17\frac{m}{s}$$

$$Q_{cap} = \frac{\pi d^2}{4000000} \times V_{cap} = \frac{\pi 400^2}{4000000} \times 1.17\frac{m}{s} = 0.147\frac{m^3}{s}$$

$$Q_{peak} = RAIN = 0.72 \times 1.30Ha \times 54.2\frac{mm}{hr} \times 0.00278 = 0.141\frac{m^3}{s}$$

Since Q_{cap} is greater than Q_{peak}, this pipe segment has enough capacity to convey 1/100 year storm from its catchment area. Detailed calculations are found in Appendix D

4.1.6 Onsite Stormwater Management

The stormwater drainage design for the project site generally follows the proposed walkway from architectural plan Option 1B, which runs through the site and across East Mall to connect to the main recreation facilities. The proposed storm main provides service connections to future developments, collect surface runoff from the entire site and convey all stormwater to the detention facility located underneath the Stadium. The proposed onsite stormwater plan can be found in Appendix E. The constructed wetland and integrated detention facility will be discussed further in this report.

4.1.7 Off-site Stormwater Management

The off-site stormwater management design takes a natural system approach to detain on-site stormwater and incorporates various natural elements such as bio-retention trenches, pervious paving, constructed wetland and other low-impact development features to allow for a post-development environment that mimics that of the pre-development. This approach also allows for circulation of water within the development site, minimizing the potential risk of erosion and flooding of the nearby cliff. Similar approaches have been found near the current site as shown by the site pictures shown in Appendix C.

4.2 Stormwater Detention Facility

4.2.1 Overview

The design of the detention tank facility incorporates numerous design features found in precedent successful example from the Waterplan 2 Rotterdam project located in the Netherlands. To minimize the risk any water leakage, the main structure of the detention tank will be constructed out of a cast-in-place box chamber with inside dimensions of 17m x 10m x 3m (Length x Width x Height), and a detention volume of approximately 470 m^3. Additionally, an overflow v-shape weir is installed on the wall separating the detention tank and the underground parkade to discharge any excess stormwater beyond the 1/25 year storm event into the underground parkade. The water height in the parkade will be approximately 65 mm during a 1/100 year storm event. This is calculated by the taking the difference in the detention volume between a 1/25 and 1/100 year events (110m^3) and dividing by the surface area of the parkade (1700 m^2). Detailed design of the detention tank can be found in Appendix E.

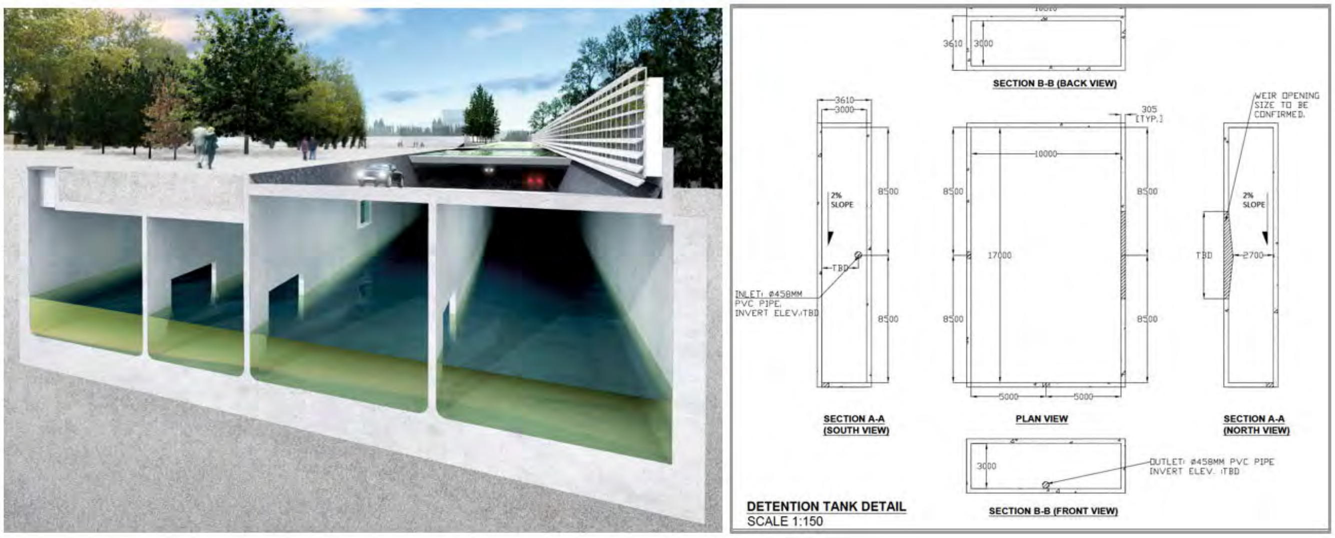


Figure 4 - Precedent Waterplan 2 Rotterdam Project [15] and Proposed Detention Tank

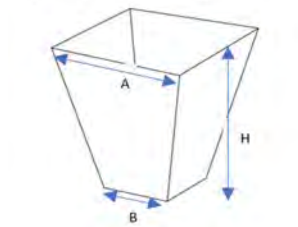
4.2.2 EPASWMM - Hydrograph Method for sizing of Detention Tank

It is assumed that with the source controls installed, the 2-year storm will be adequately mitigated. The detention pond will only be sized for rate control of the 1/100 year storm. The detention facility was designed with EPASWMM, a hydrologic computer program. Post-development hydrographs are determined at the inlet of detention tank for the 1/100 year design storms (2, 6, 12, and 24-hour durations). This process helps identify the most critical event to be used in sizing the detention pond.

With the post-development inflow hydrographs known at the detention tank, an initial surface area was assumed to calculate the initial depth of water assuming the pond is completely dry in the beginning. From there, the total required accumulated storage volume can be determined by taking the difference between the inflow and outflow rates plus the previous storage volume in the last time step. This process continues for every time step in the entire duration. Finally, the required storage volume of the detention tank is determined by taking the highest accumulated storage volume out of all the time steps. For optimization of the system and to reduce the cost of construction, numerous iterations were made by adjusting the two key design parameters: pond surface areas and outflow orifice size while at the same time, ensuring that the pond does not exceed a maximum depth of 1.5 m, side slope of 2:1, and an outflow release rate equal to that of the 1/100 year pre-development release rate. Detailed procedures for sizing of the detention tank is broken down in Table 7. Sizing of the detention tank was completed for each of the design storm durations to ensure all possible design scenarios have been reviewed and accounted for.

Table 7 - Detention Tank Sizing Procedure

Design Step(s)	Description
1. Calculate the maximum post development release rate – equivalent to allowable orifice discharge rate	As per project requirement, allowable post development release rate is 7 L/s/ha $Q_{release} = Q_{allowable}$ * Total Catchment Area $Q_{release}$ = 7 L/s/ha * 10.56 ha = 0.074 cms
2. Calculate inflow volume to detention pond	Q_{in} = outflow hydrograph from EPASWMM * time step Where: Time step = 0.05 hour = 300 seconds
3. Determine the maximum pond volume required	Assume an initial surface area of the pond. a. Calculate the accumulated storage volume in the detention pond. Accumulated volume = [Inflow Volume (@ each time step) – Outflow Volume (@ previous time step)] + Accumulated Volume (from previous step) *Note that the outflow volume (@ previous time step) will be zero until stormwater runoff starts to enter the pond b. Calculate the water depth within pond by taking the accumulated volume divided by the surface area. Determine the net head (h) on the outflow orifice from the calculated water depth h = Water Depth – (Diameter of Orifice/2) If water depth is below half of the diameter of the orifice, partial pipe flow equation will be used to calculate the outflow rate c. Calculate the outflow rate for each time step by using the orifice equation as outlined in the City of Surrey Design Criteria Manual [16]: Outflow Rate = Coefficient of Discharge × Orifice Area × (2 × Gravitational Constant × Net Head on the Orifice Plate)$^{0.5}$ Determine the outflow volume for each time step by multiplying the outflow rate by the time step duration (i.e. 300 seconds). Continue to determine the new surface area and accumulated volume for the next time step using the procedures described above. Each of the design steps above is repeated for the entire durations of the storm event and the required storage volume is the maximum value in the accumulated volume column.
4. Determine the dimensions of the detention pond	Based on the required storage volume calculated, a maximum side slope of 2:1, and the shape of the pond is assumed to be a truncated rectangular pyramid: B (bottom of pond width) = specified by designer initially A (top of pond width) = specified based on the maximum A calculated in step 3

	H (height of pond) = 1.5 m (maximum allowable depth) 
5. Check if overtopping of pond occurs all design storm durations and the orifice outflow rate is within the allowable post-development discharge rate	Allowable orifice outflow rate < 0.074 cms Maximum pond water depth < 1.5 m $$Q = CA(2gh)^{0.5}$$ Where Orifice outflow rate: C (discharge coefficient) = 0.62 A = area of orifice (m^2) D = Diameter of orifice is specified by designer (min. 100mm) H = net head on the orifice g = 9.81 m/s^2
6. Adjust the design parameters to change volume of pond until the conditions in step 5 are satisfied	The two design parameters that can be adjusted and optimize the size of the detention pond are highlighted in red in steps 4 and 5: 1. B – bottom of pond width (dictates the initial pond surface area) 2. D – diameter of orifice (dictates the outflow discharge rate) Volume of pond = = $\frac{1}{3}(a^2 + ab + b^2)h$

The detention pond and outflow orifice were sized to meet the maximum post-development release rate of 7 L/s/ha, and maximum pond depth of 1.5 m. The proposed pond dimensions are listed below in Table 8.

Table 8 - Detention Pond Dimensions

	Design Parameters (Inputs):	
Detention Pond (Rectangular Truncated Pyramid)	B (m)	34
	Bottom Area (m^2)	1156
	Side Slope (#:1)	2
	A (m)	40
	H (m)	1.5
	Top Area (m^2)	1600
	Total Volume (m^3)	2058
Outflow Orifice	D (m)	0.165

	Area of Orifice (m^2)	0.0213
	C_d - Discharge Coefficient	0.62
	g	9.81

Using the above proposed dimensions of the pond, the corresponding inflow and outflow hydrographs as well as the accumulated volume and maximum water depth level for each design storm durations (i.e. 1-hour, 2-hour, 6-hour, 12-hour & 24-hour) were developed as shown below in Figures 5 to 8.

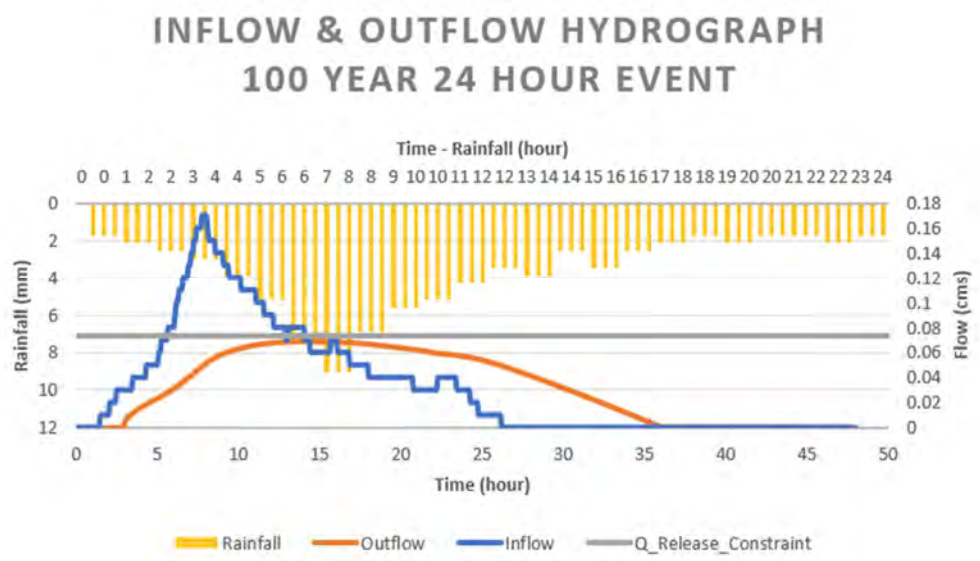


Figure 5 - 100-yr 24-hr Hydrograph

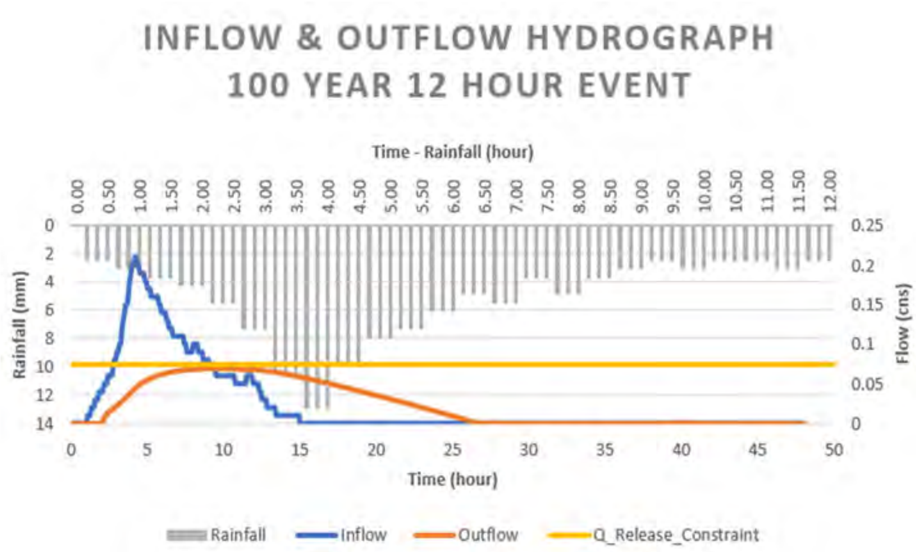


Figure 6 - 100-year 12-hr Hydrograph

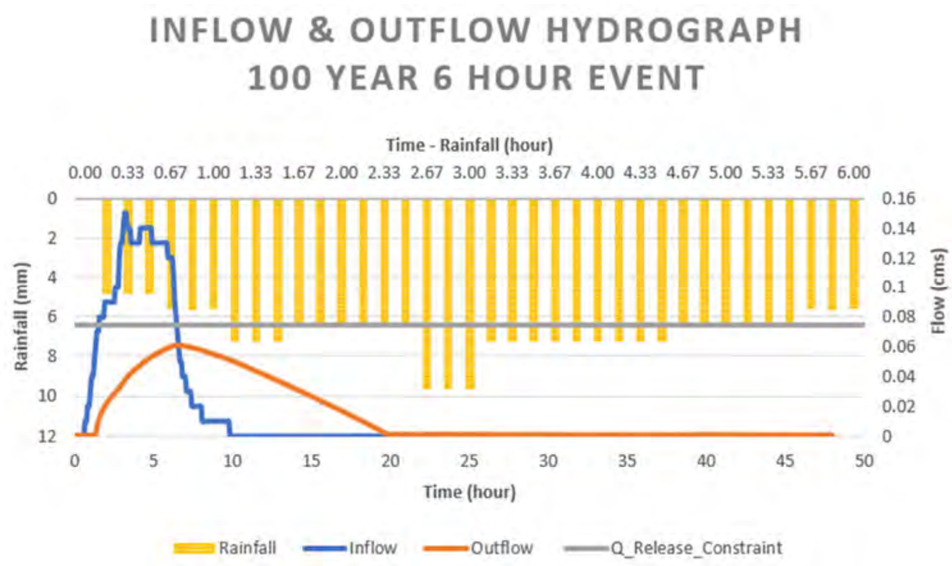


Figure 7 - 100-year 6-hr Hydrograph

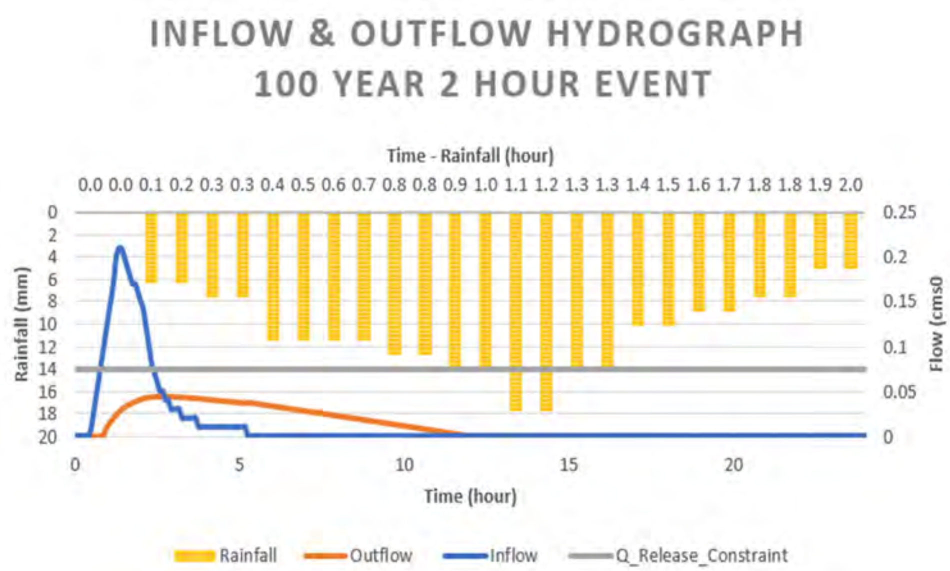


Figure 8- 100-year 2-hr Hydrograph

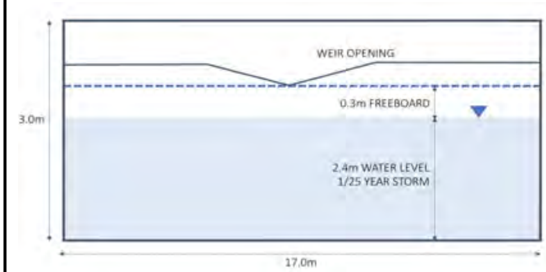
4.2.3 Design Elements

The following three design elements are part of the integrated underground parkade and storm detention facility.

Table 9 -Design Elements of the Integrated Underground Parkade and Stormwater Detention Facility

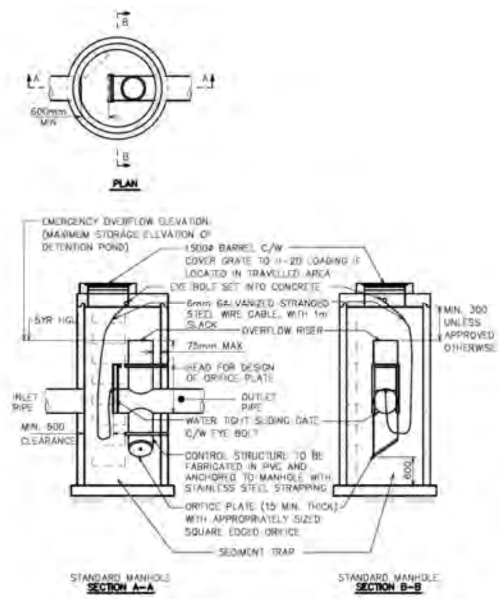
<table>
<tr><th>Elements</th><th>Description</th><th>Sample Illustration</th></tr>
<tr><td>Weir</td><td>

- Controlled release rate of storm water beyond the 1/25 year event;
- 0.3m freeboard of safety factor;
- Excess stormwater will overflow into the parkade through the weir opening.

</td><td>


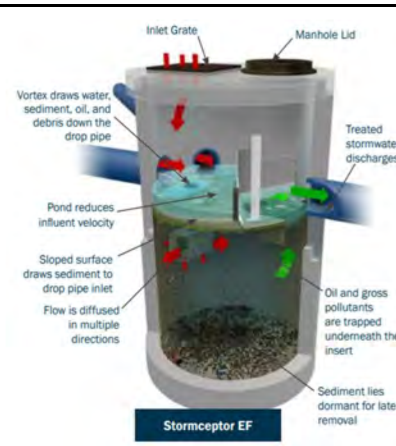
</td></tr>
<tr><td>Flow Control Manhole</td><td>

- Outlet control of the detention facility;
- Located immediately downstream of detention;
- Orifice designed to slowly discharge water back to the storm system at pre-development 1/100 year release rate;
- Can be modified to include stormwater monitoring equipments

</td><td>


Source: City of Surrey [17]
</td></tr>
<tr><td>Stormwater Treatment Manhole (Oil/Grit Interceptor)</td><td>

- Serves as an additional stormwater treatment facility after the wetland;
- Products like Stormceptor EF is cost and space usage efficient in comparison to traditional oil/grit interceptor;
- Requires maintenance once sediments chamber is filled up.

</td><td>


Source: Imbrium Systems [18]
</td></tr>
</table>

4.2.4 Risks and Safety

One major concern over this selected design of stormwater detention facility is that allowing excess stormwater to overflow into the parkade may pose property damage risk to parked vehicles and/or safety risk to parkade users. During the 1/100 year storm event, the maximum flooding level is within a controlled limit of 65 mm, which should present a low safety risk. However, for a major storm event that is greater than 1/100 year occurs, the flooding level in the parkade would be uncontrollable and an Emergency Response Plan must be developed. The emergency plan should have sensor placed to detect water level inside the parkade and ensure the parkade is fully evacuated during a major storm event. Additionally, the detention facility's outlet flow control manhole also has emergency overflow riser to temporarily allow stormwater to discharge at 1/100 year storm release rate.

4.3 Constructed Wetland

As part of the on-site stormwater management plan, a constructed wetland will be built on the southwest corner of the development site to act a "transfer station" for majority of the on-site captured stormwater which will be conveyed into the wetland via gravity flow. During a 1/100 year storm event, any excess stormwater that cannot be detained by the wetland will be diverted into the detention facility located beside the stadium underground parkade through a pump station installed near the outlet flow control structure. The following key components will be constructed as part of the wetland structure to maximize its stormwater contaminants treatment effectiveness, storage capacity as well as the aesthetics aspect which will mimic a natural environment for nearby habitat:

Table 10 - Constructed Wetland Key Components and Functionality

Constructed Wetland	
Rock Armoured Surface with Cobbles	• Geotex non-woven filter fabric underlay to prevent any scouring effect from occurring due to high velocity stormwater discharging at the inlet location.
Meandering Stream	• Meandering stream inside the wetland to allow for sediments contained in stormwater to settle and be treated before being conveyed to the detention tanks.
4m Wide Maintenance Access Road	• A 4m wide maintenance access road will be provided along the perimeter of the wetland to allow for access to the inlet and outlet flow control structures.
Outlet Flow Control Structure	• An outlet flow control structure will be constructed to allow water to discharge a specified release rate during a 1/25 or 1/100 year storm event.
Overflow Concrete Spillway and Pump Station	• In addition to a minimum freeboard water level, an emergency overflow concrete spillway connecting to the pump station is constructed to prevent stormwater from overtopping the wetland during a severe storm event. • An additional secondary pump unit is installed in case the primary pump unit was to fail to function

Rock Lined Channel	● A rock lined channel with geotextile fabric underlay and infilled with sand and gravel will be installed along the east end of the wetland, capturing majority of the overland flow from the park area and diverting them into the wetland.
Edge of Wetland Treatment	● Edge of wetland will receive a vegetated rock-stabilized slope to prevent any slope failure from occurring due to interflow from groundwater table as well as overland flow from the park area. ● The slope will be consisted of large split rocks which are well rounded and possess a flat surface which will allow for placement in consecutive lifts up to the end of slope under the direction of the Geotechnical Engineer. A layer of planting medium will be placed in between any void spaces to facilitate the growth of native plants, as well as serving as a soil stabilizer.

Detailed drawings are found in Appendix E.

4.4 Green Infrastructures/Low Impact Development Features

As part of the off-site stormwater management plan and transportation improvements W 16th Ave, green infrastructures such as bioretention trench and pervious paving will be installed along west side of the road replacing the original shoulder lane. The general structure and composition materials of the constructed wetland and bioretention trench will accommodate design constraints mentioned in Section 2 and minimize groundwater infiltration while maximizing its storage capacity. The intent of low impact development is to provide an alternative to the traditional approach of capturing stormwater and immediately directing it to the storm sewer system. Avoiding this practice by using low impact techniques reduces the load on the natural creek system, dramatically minimizes the potential risk of erosion of nearby cliffs and creates a development that provides hydrology that mimics the pre-development condition. Utilizing these techniques is beneficial to the aquatic habitat and reduces system operating costs.

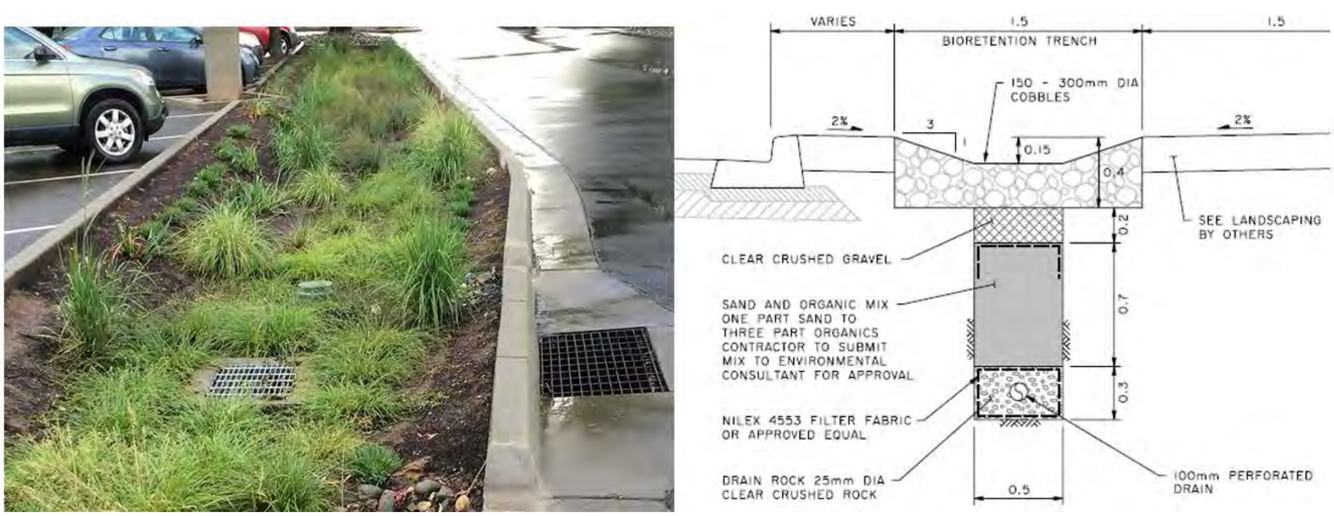


Figure 9 -Typical Bioretention Trench and Cross Section

Table 11 illustrates the functionality of various components that make up a bioretention trench. Detailed drawings are found in Appendix E.

Table 11 - Bioretention Trench Key Components and Functionality

Bioretention Trench	
Top Layer	● A top layer of approximately 250 mm thick of well rounded cobbles will be placed along the surface of the swale, acting as an energy dissipation source during an event of massive rain storm, where high velocity stormwater is expected to discharge via the concrete curb cut along the side of the road and into the bioretention trench.
Secondary Layer underneath Top Layer	● A secondary layer of clear crushed gravel provides a zone of high permeability and rainwater storage capacity, where stormwater is allowed to drain rapidly through and into the “core” of the bioretention trench structure which is consisted of 700 mm of sand and organic mix. This layer mainly functions as an sediment capture and contaminant treatment zone, providing sufficient settling time and storage capacity to separate suspended solids and hydrocarbons typically found in urban stormwater runoff.
Steel Side Inlet Frame	● Steel side inlet frame will be installed at every concrete curb cut location, providing an access point for stormwater runoff from W 16th Ave to enter into the bioretention trench. A minor depression of 25mm will be introduced at the curb line to prevent any sediment accumulation from blocking the inflow stormwater.
Standard Size Catch Basin	● A standard size catch basin will be installed at downstream of the bioretention trench to allow for any excess stormwater runoff that can not be detained by the retention trench to enter straight into the main storm sewer system.
Lawn Basin	● A 600 mm diameter lawn basin is constructed at the end of each bioretention trench to capture any excess stormwater runoff that can not infiltrate fast enough into the ground; it also serves as an emergency spillway during a major storm event where the storage capacity of the subsoil has been exceeded, and the water is directed straight to the main storm sewer system via a service connection.

4.5 Underground Structures

4.5.1 Layout and Logistics

The underground parkade is located beneath the Stadium seating area in the southeast region of the site for easy access to the planned commercial units. Placing the structure underneath the stadium will eliminate the need to remove any trees on site and reduce the amount of impervious surfaces at-grade. Two sets of elevators and stairways in the east corners will provide access for pedestrians from the stadium and commercial units to the parkade. The parkade is constricted to a single entrance from W 16th Ave to reduce traffic on East Mall in order to provide safe pedestrian walkways between the Stadium and other sport facilities. There is a 30 m long ramp with 10% slope going down 3 m to the parkade. The dimensions of the parkade is 82.3 m x 41 m x 3 m to accommodate all mechanical and electrical systems for the stadium. A Revit 3D model was created to showcase the underground tank and detention tank can be found in Appendix K.

The layout of the parkade features a one-way single lane flow (counter-clockwise direction) to 60-degree angled parking slots. Since the parkade is small, the single traffic flow improves the safety and logistics inside the parkade and reduces vehicular conflicts. Diagonal parking spaces increase space efficiency and ease of access; 60-degree angled parking slots are the most efficient use of space when it is designed with a suitable parking slot dimension configuration [19]. Allocation of the 120 parking spaces are as follows: 20% EV, 10% accessibility, 10% car share, 10% commercial reserve, and 50% public use, as well as additional stalls for motorbikes. The dedicated parking stalls for accessibility are provided beside the elevators on the east of parkade for convenience. The stormwater detention tank is placed adjacent to the parkade for the controlled-overflood design system to operate. Capacity of the parking lot of 120 slots is determined through a primitive empirical estimation of existing parking space in the surrounding area. This parking lot is intended for users of the commercial units in the Neighbourhood with some excess for the Stadium; however, it is not intended to satisfy parking demand of large Stadium event. Remote parking, where Stadium visitors who drive will be directed to park at another UBC parkade and then walk or take transit to arrive at the stadium, will be expected. Since Stadium events tend to take place outside of peak periods of student and staff parking, it would be more economical and sustainable to utilize the available capacity at other UBC parkades instead of expanding parking capacity at the new Stadium. An analysis of nearby parkade facilities near Stadium or transit are shown in Table 12.

Table 12 - Remote Parking Capacity of Thunderbird Stadium on UBC Campus

Parkade Name	Parkade Capacity	Access to Stadium
Thunderbird Parkade (existing)	1000	Access via walking or transit on the 41st Avenue B-Line or bus #70, #480
Health Science Parkade (existing)	1000	Access via transit on the 41st Avenue B-Line or bus #70, #480
North Parkade (existing)	1600	Access via transit on the 41st Avenue B-Line or bus #70, #480
MacInnes Field Parkade (under construction)	216	Access via transit on the 41st Avenue B-Line or bus #70, #480
Total Parking Capacity	3816	

Assuming that Stadium events operate when these parkades have an average occupancy rate of 80%, the three parkades above will contribute a total of 3050 parking spaces. Using parking generation rates extracted from the ITE Trip and Parking Generation Manual (0.36 per seat for an urban movie theater, closest category to the UBC stadium) [20], and applying a 50% reduction due to the high walk/bike/transit usage on campus, parking demand for a popular Stadium event is 2160 for a 12,000-seat stadium where every seat is filled. This demand can be met with application of the remote parking strategy.

4.5.2 Structural

Three key structural components are considered for detailed concrete design of the underground parkade: continuous beam, circular column, and one-way slab. Autodesk REVIT renders, SAP2000 analysis and detailed structural calculations of the underground parkade have been provided Appendix K. Detailed geotechnical and seismic designs shall be performed separately by other entities for this project.

4.5.2.1 Loadings

Since the structure is underground and protected from wind load, only gravitational dead, live and snow loads are considered for the design purposes. The underground parkade is assumed to be built under the stadium field and the dead loads for beams and slabs are assumed to be the self-weight, weight of soil cover and miscellaneous components while the columns will follow the loading as specified in the Geotechnical Report. The live loads consist of the pedestrian loads above the underground structure and the occupancy use of the stadium. Further analysis may be performed with seismic loads which requires ground motions data for time-history and response spectrum analysis. The factored loadings are determined using the load factors and combinations as per Table 4.1.3.2A of NBCC 2010. Additionally, CSA A23.3 Cl. 9.2.3.1 arrangement of loads provides additional details regarding load combinations for these specific components. The factored shear and moments for continuous beam and one-way slab may be determined using Table 9.1 from CSA A23.3 9.3.3, however, a more conservative approach has been used for moment force of both beam and slab design which is $w_f \times ln^2/8$ instead.

4.5.2.2 Structural Capacity Design

Although the bearing wall will be designed by geotechnical engineers, it is assumed to be 300 m in this design process which satisfy the minimum thickness of 150 mm as recommended in CSA A23.3 Cl. 14.1.7.1. Due to the rectangular footprint of the underground parkade, a one-way slab design was considered as it can provide the wide space for single lane flow design. The one-way concrete slab was designed in a unit length basis (1000 mm) in accordance with CSA A23.3 Cl. 7.8 and 10.1. The concrete beam was designed as T-beams based on effective flange width as per CSA A23.3 Cl10.3.3. The beam and one-way slab was considered as one unified structural system as many CSA codes are applied to both elements. The thickness of beams and one-way slabs for both ends continuous condition was determined through the minimum thickness stated in Table 9.2 of CSA A23.3 Cl9.8.2.1. The structural columns follow the design specifications of CSA A23.3 Cl.10.9 to Cl.10.19; specifically, the equations in Cl 10.18.1 were used to determine the spiral reinforcement of the concrete columns. The beams and one-way slabs were analyzed for flexure and shear forces while columns are inspected for axial force. All components were found to be adequate in capacity for the selected dimensions of the structural elements with the reinforcement designs. SAP2000 was used to create a model of the parkade and perform structural analysis to verify the induced load and capacity. Both SAP2000 analysis and excel spreadsheet used for detailed hand calculation have undergone several iterations to improve accuracy and optimize the design.

4.5.3 Building Envelope

The building envelope has waterproofing membranes, protection from shocks and corrosion during construction and in-service life, and resistance to earth load thrust forces. The enclosure has aggregate drainage layers and fluid-applied waterproof membrane to control water seepage. Protection boards are used to shield the waterproofing membranes from construction damage. Floor slabs have a capillary break layer composed of granular material to help with drainage. PVC waterstops are used in the connection between floor and wall slabs to prevent water seepage in between assemblies. The parkade floor is also protected by a traffic-grade membrane to protect it from de-icing salts and other corrosive materials brought in by traffic.

4.6 Transportation Network

It is expected that relocation of the Stadium and development of Neighbourhood will lead to changes in traffic pattern as well as possible increases in traffic volume of various modes. The proposed local road network redesign of W 16th Ave will promote sustainable transit modes and introduce new or enhanced safety features for all road users, as well as provide convenient connections to Stadium and the surrounding commercial areas.

4.6.1 W 16th Ave from SW Marine Dr to Wesbrook Mall

This section is currently 850 m long and consists of four lanes with two in each direction. This section of W 16th Ave will undergo "road dieting", or the process of shrinking width of vehicle lanes. In addition, this road section will be retrofitted with bidirectional dedicated transit / HOV lanes as well as separated and buffered bike lanes. A new B-Line will be launched in fall 2019 between Joyce Collingwood Station and UBC via 41st Ave and this stretch of W 16th Ave [21] which will increase transit traffic and ridership along this corridor. The anticipated transit frequency along this section of W 16th Ave by fall 2019 is tabulated below:

Table 13 - Expected Transit Frequency along W 16th Ave by Fall 2019

	Number of transit bus per hour per direction
A.M. Peak	20 (B-Line) + 6 (480) = 26
Midday	10 (B-Line)
P.M. Peak	20 (B-Line) + 6 (480) = 26
Weekday Evenings and Weekends	7.5 (B-Line)

This section of W 16th Ave (and eastwards up to Blanca Street) is owned by the provincial government and managed by the contractor Mainroad. As a result, any planning and roadwork require close collaboration between UBC, the Ministry of Transportation and Infrastructure as well as Mainroad. While this may add complexity to project planning and scheduling, this also presents new opportunities for additional project funding.

4.6.2 W 16th Ave from East Mall to SW Marine Drive

This 450-metre section of W 16th Ave forms the southern boundary of the Neighbourhood. The curb-to-curb width of this section is 32 m. It consists of two 3.8 m general traffic lanes per direction, one 3 m cycling lane per direction and a 10.5 m median which varies throughout the section While there is no sidewalk at each side of the road, mixed-used paths are part of park infrastructure along both sides of the road. These paths are higher in elevation and separated from road section by green drainage strips.

Figure 10 - Current Section View of W 16th Avenue between SW Marine Dr and East Mall

There are also two bus stops (one per direction) located approximately 200 m east of the intersection of W 16th Ave and SW Marine Drive. These stops are currently only used by TransLink's route #49 (Metrotown / UBC) and are inaccessible by wheelchair users. TransLink has proposed to reroute the #49 service onto Wesbrook Mall between W 16th Ave and SW Marine Drive after the introduction of a 41st Avenue B-Line. It is assumed that this set of bus stops will be eliminated in the design process. Designed in the last century with the potential of a ferry terminal at the western end of W 16th Ave in mind, the general traffic lanes on this section of the road are excessively wide with plenty of redundant capacity. This has contributed to some safety issues, most prominently speeding as well as the safety of cyclists and transit riders. In addition, high vehicular speed also deters cyclists from using the bike lanes on this section of the road.

Figure 11 - Proposed W 16th Ave Section View between SW Marine Dr and East Mall

The proposed design is illustrated in Figure 11. All traffic lanes will be reduced to 3.4m, and the outermost lanes will become a designated transit or HOV lane. The cycling lane will be buffered by a 1 m green boulevard 1 m. The curb-to-curb distance as well as the width of the central median along this section of the road will remain unchanged. Since this stretch of the road has very few destinations that will induce pedestrian activity, it is expected that the current mix-used trail-path on either side of the road will be sufficient for pedestrian access.

4.6.3 Stadium Parkade Access

A bi-directional access road to the Stadium Parkade will be on the north side of W 16th Ave, approximately 75 m southwest of the intersection of W 16th Ave and East Mall. This design prevents increasing traffic volume on secondary roadways such as East Mall while providing most drivers with access to the parkade without the need of making a U-turn or circuitous detours via residential streets. Eastbound vehicles along W 16th Ave can access the parkade by turning around at the roundabout at East Mall.

Figure 12 - Stadium Parkade Access from W 16th Ave

4.6.4 W 16th Ave from Wesbrook Mall to East Mall

The current road configuration is illustrated in Figure 13. The curb-to-curb distance along this road section is 23 m with a 3.8 m centred median. Similar to the road section west of East Mall, this section of the road also has wide traffic lanes and inadequate or unsafe walking, cycling and transit infrastructure.

Figure 13 - Current Section View of W 16th Ave between Wesbrook Mall and East Mall

The proposed redesign of this section of the road is shown in Figure 14. Similar to the concept used in redesigning the section west of East Mall, this section of the road will also feature narrower traffic lanes and widened cycling lanes. Cycling lanes will be separated from vehicle traffic by a 3 m strip, which will be the location of bus stops, or a green strip where there is not a bus stop. The farside lanes will become a transit / HOV lanes.

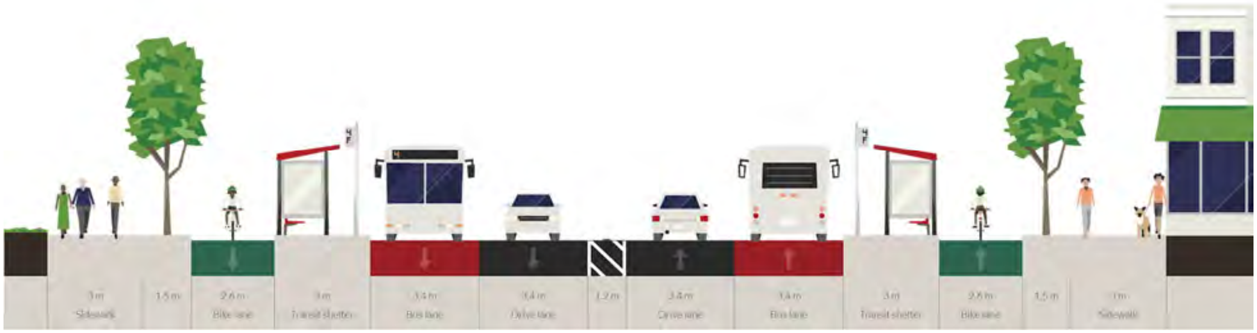


Figure 14 - Proposed W 16th Ave Section View between Wesbrook Mall and East Mall

4.6.5 Intersection of W 16th Ave and SW Marine Drive

This intersection requires a reconfiguration since the westbound approach of W 16th Ave needs to be widened to accommodate an additional right-turn lane and a dedicated cycling lane. The channelized right-turn from W 16th Ave onto SW Marine Dr will be closed to vehicles avoid conflicts between vehicles and cyclists or transit vehicles. The southbound approach of SW Marine Dr will also be moved back to make space for the expanded intersection. The traffic light at this intersection will also need to be adjusted to feature two different phases for the westbound approach from W 16th Ave: a transit and cycling phase for left turns onto SW Marine Dr, as well as a general traffic phase for left or right turns onto SW Marine Dr.

Figure 15 - Proposed Intersection of W 16th Ave and SW Marine Drive

4.7 Construction Methodology

4.7.1 General Construction

Given the large area of the Neighbourhood, three zones are identified based on the scopes of work: the south area including the wetland and the park, the west area comprising of residential buildings, community buildings, and boardwalk, and the east area composing of the stadium and parkade. Except for the stormwater drainage network, these zones behave relatively independently.

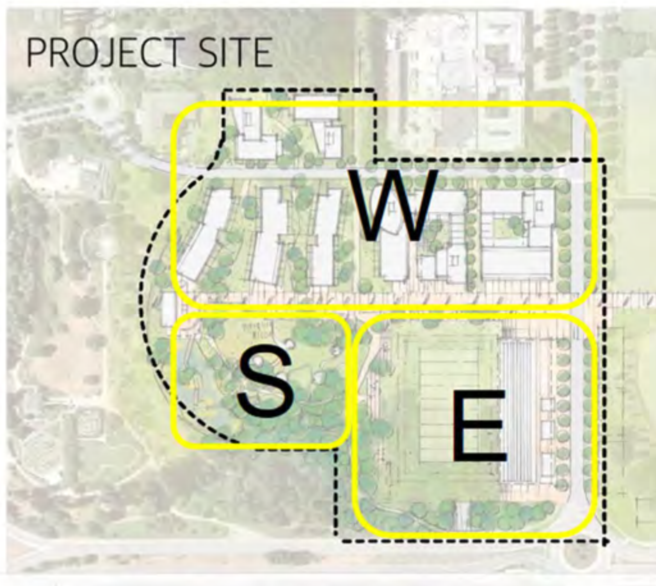


Figure 16 - Construction Zones

Excavated fill and materials typically can be reused; however, the Geotechnical Report has noted that UBC is perched on two aquifers and on two to three meters of low permeability clay. In the preparation of an estimate for this preliminary design, only the layer of topsoil and part of the subsoil will be reused. New earth fill is expected to be sourced in Metro Vancouver easily given the wide range of suppliers in the region. From observing UBC's current projects, Our team noted series of dump trucks are stationed on standby in pull-outs along SW Marine Dr. The trucks await their cue and can arrive at the site within five minutes. These pullouts play a vital role in construction management and logistics reducing construction traffic congestion on campus.

Figure 17 - SW Marine Dr Construction Staging

The start of construction would be to install Erosion and Sediment Controls (ESC) measures, like silt fence and truck wheel wash station, for the clearing and grubbing of the South and East Zones. A temporary sediment pond will be constructed at the lowest point of the site (South end) to collect and treat sediment laden water from the construction site; later, the pond will be converted to the permanent wetland to save excavation cost. Combining with temporary swales and berm, rock access pad, hydroseeding exposed surface and silt sac on catch basin, the ESC plan will keep the site drier to improve productivity and ensure no suspended solids are entering into the storm system and the surrounding water body. Furthermore, because the primary scope of work of the south area is landscaping scheduled towards the end of the project, this would be an ideal location to set up construction offices, crew accommodations, and equipment storage. The west area will be the next area for tree removal because of the extensive buildings to be constructed there.

During excavation for drainage pipe and parkade, any trench deeper than 4' needs to be shored if sloped sides of 3H:4V are not feasible according to WorkSafeBC standards. Since sloped sides cannot be achieved where the parkade is directly adjacent to the road, sheet piles will be used. Sheet piles need to be anchored laterally and will not be removed even after construction. Cost of excavation and refill depends on trucking times, dumping locations and quality of existing soil (if can be reused). West Zone will be cleared and grubbed but covered with straw mulch and hydroseed to prevent erosion of the soil, until developments of residential buildings take place.

4.7.2 Stormwater Management

Trenches will be excavated throughout the site and pipes will be welded and dropped into place by crane. Towards the end of construction, the temporary ESC sediment pond will be reverted to a permanent wetland by laying geotextile fabric and engineered fill at the bottom to secure the foundation. Inlet and outlet headwall structure will have riprap for protection from scouring. The pump station includes a pump placed in a box manhole and a sump to collect sediments before forcing the stormwater to the detention tank.

4.7.3 Structural

The main structural element of this project is the parkade and stormwater detention facility. These two underground structures are to be built from cast-in-place concrete. A large open pit will be excavated, and the pit walls secured with shoring. The current cost estimate assumed that the walls will be sheet-piled; however, provided there is enough space, many sections of excavation show potential for significant savings by using open sloped excavations instead. Given that stadium seating and retail stores are anticipated to be built above the parkade, piles and other foundation stabilizing procedures may be employed; to be designed by geotechnical consultants. Typical cast-in-place concrete and temporary formwork will be installed for the floor before concrete is poured from either an on-site crane or boom truck. The walls and ceiling for both the parkade and detention pond will follow the same process after.

4.7.4 Transportation

Construction staging on W 16th Ave aims to minimize impacts on existing traffic flow including accommodating cyclists, buses and passenger cars. Between East Mall and Wesbrook Mall, 16th Avenue will be reduced to single outer lanes in each direction while the median and inner lanes are redeveloped. Once the buffer and inner lanes are complete, traffic will be directed onto these lanes while the outer lanes are redeveloped to include bus stop shelters and bike lanes. 16th Avenue between Southwest Marine Drive and East Mall will follow a similar procedure. Both the lanes and the median will be narrowed slightly to provide space for the bike lane, bus lane, through lane, and right turn lane into the new stadium. The two lanes towards UBC and opposite the new stadium should be redeveloped first because it has the least anticipated impact on construction activities on site. Following this, the median narrowing and inner lane leaving UBC will be reconstructed. The lane directly adjacent to the new stadium should be rebuilt last because heavy construction traffic would likely damage the road and induce rutting.

4.8 Sustainability Summary

Sustainability of each design aspect outlined in this section is given below:

Stormwater:

- Oil/grit separators remove sediment and metals from stormwater runoff to prevent contamination resulting quality stormwater being discharged into the ocean
- Cost efficiency benefited from smaller sized detention tank (higher utilization for the space)
- Integration of wetland, bioswales and rain gardens, provides natural habitat for local species and contributes to a livable neighbourhood with less carbon emission
- Bioswales allow for the capture and removal of carbons, sediments and other large debris usually found in urban stormwater runoff, hence reducing the total suspended solid percentage being discharged offsite via the main storm sewer system
- Constructed wetland combines the functionality of a storm water treatment facility as well as integrating with the recreational park area, making it both aesthetically pleasing and practical at the same time
- Supports UBC ISMP's plan to re-establish stormwater monitoring with electronic monitoring equipment
- Encourage stormwater to infiltrate back into the ground and help maintain ground water storage level
- Overall reduces stormwater runoff and alleviated the burden for W 16th Ave Stormwater Outfall

Parkade:

- Encourages sustainable travel by limiting parking spaces and providing car-share spaces
- Reduces potential overprovision of parking spaces in expectation of future mode share shifts
- Small size is economically viable
- One way single-lane traffic flow reduces congestion and collision probability

W 16th Ave:

- Optimized lane configuration prioritizes sustainable travel modes and increases safety for cyclists
- Transit priority lanes are characteristic of future road designs on campus and will familiarize users
- Bioswales and grass boulevards help purify stormwater from ground contamination and contributes to stormwater management

5 Service Life and Maintenance

5.1 Stormwater

A maintenance and operation schedule for the stormwater management components are given in Table 14.

Table 14 - Maintenance and Operation Schedule for Stormwater Components

BMP	Description	Maintenance Required When	Operation & Maintenance Action	Timeline
Constructed Wetland	Stormwater basins that include a permanent pool for water treatment and temporary runoff storage	o Vegetation is wilting or dying. o Sediment accumulation is affecting hydraulic capacity. o Undesirable species of plants or insects are present.	Inspect vegetation of pond to ensure healthy growth.	Quarterly
			Inspection of any erosion, flow channelization, bank stability, or sediment/debris accumulation.	Quarterly
			Wetland to be drained and sediment to be removed from forebay.	Every 7 to 10 years
Bio-swale & Rain Gardens	Gravel-filled excavations that temporarily store stormwater and treats runoff by infiltration through soil. Provides detention and reduces peak flows.	o Standing water is visible in the observation well for more than 48 hours after a rain event. o Insects and/or odour problems develop. o There is visible damage to the swale/pond (e.g. sinkholes). o Trash, leaves, and other debris have collected on the surface. o Runoff is conveyed over and across swale/pond and not into the facility. o Vegetation is wilting or dying. o Topsoil is exposed and/or being eroded.	Inlets to be inspected and cleaned.	Annually
			Remove debris from surface to maintain proper function.	Quarterly
			Repair any damage to the facility.	As needed
			Provide temporary diversions and ensure swale/rain garden is protected from sediments during construction phase.	Construction Phase
			Inspect cleanouts of perforated drains.	Quarterly
			Ensure areas of topsoil placement remain un-compacted during the construction phase.	Construction Phase
			Replant and add topsoil.	As needed
Pervious Pavers on Walkways	Provide structure and stability while allowing runoff to infiltrate through to the ground surface.	o Significant amounts of sediment have accumulated between the pavers. o Ponding of water is visible on the surface 48 hours after a rain event.	Surface sweeping to be completed with a commercial vacuum sweeping unit.	Annually
			Inspection to check surface conditions to determine if any remedial work is needed.	Annually
Underground Detention Tank	Underground stormwater tank that stores run-offs, with oil & grit separator at inlet to ensure water quality.	o Cracks on the concrete walls with water infiltration. o Significant amounts of sediment have accumulated at the bottom of the tank. o No reduction in water level after rain events.	Inspect the structural condition and sediment accumulations.	Bi-annually in the first two years; Annually after two years
			Fix any cracks due to subgrade settlement, thermal contraction or drying shrinkage.	As needed
			Inspect and remove debris from oil & grit interceptor.	Annually
			- Inspect outlet flow control manhole.	Annually

The stormwater network will be constructed from High Density Polyethylene (HDPE) and is a common building material for stormwater and water supply pipes in BC. All joints within the network will be butt fused together by heat. The material is homogeneous and does not require the use of steel fasteners and neoprene gasket typical in steel and stainless-steel pipes. As a result, frequent maintenance is not required because leakage is not expected. In the event of soil uplift caused by earthquake and soil deterioration, pipe damage may occur. Most of the storm network is unpressurized and will not rupture explosively. The low-pressure segment after the pump station is exposed to atmospheric pressure at the detention tank and water hammer behavior will dissipate energy in the event of accidents. The pump station will be below grade and susceptible to groundwater infiltration. Yearly inspections of the station should be scheduled. Typically, pump station process piping for projects of this size is constructed using steel, which oxidizes in the presence of water. Although the moisture within the pump station will be controlled, the steel pipe immediately outside the station before coupling to HDPE will be vulnerable to oxidation. Inspections should be scheduled every ten years to test for leakage in this area.

5.2 Underground Structures

As per UBC Technical Guidelines, UBC Energy & Water Services (EWS) and Building Operations are responsible for the operation and maintenance of utilities. The underground structures are designed to have a service life of 100 years as per Section 03 00 00 of UTV. The underground structures consist of reinforced concrete are prone to water damage due to the collected stormwater in the detention tank which may be overflowed into the parkade during intense rainfall event. The durability of concrete structure is greatly influenced by the effectiveness of moisture protection system used to protect it from water and chlorides [22]. Floor drains and pipes should be flushed and cleaned twice a year. De-icing salt should be limited as chlorine attacks will accelerate the deterioration of reinforced concrete. To maintain the structural integrity of the underground structures, it is advised to conduct annual inspection of the building envelope to sustain the waterproofing performance. Additionally, detailed condition assessment should be performed and reviewed by qualified consultants in a three-year cycle during the structure lifetime.

5.3 Roadway

W 16th Ave is owned by the BC Ministry of Transportation and Infrastructure and is assumed that maintenance plans are already in place. The main contractor used for roadways owned by MOTI in the Lower Mainland is

Mainroad Lower Mainland Contracting LP. In the event that maintenance falls under UBC's jurisdiction, Section 32 01 90 Operation and Maintenance of Planting of the UTG is recommended for maintenance of landscaping details on W 16th Avenue. Specific requirements will include lawn mowing of the centre median at minimum once a week, general cultivation, weeds, mulching, fertilizing and general clean-up which begins immediately after installation [3]. UBC will also be responsible for maintaining bus shelters at 16th Avenue and Wesbrook Mall regularly, while TransLink will look after the bus stop signs.

6 Project Management

6.1 Schedule

Our team's scope of work is detailed in Figure 18. Activities are sequenced to provide the most available overlap between other activities. As discussed above, the first step is to establish the site office and temporary wetland. To allow for the extensive work of the new stadium, the parkade and stormwater network around the parkade should begin immediately after. The permanent wetland, pump station and oil grit separators should begin midway through the construction phase in the South zone. At this point, all three zones: East, West, and South should be active as other contractors will be working on the residential buildings in the West. The storm network above the boulevard is not expected to impede on the progress of residential building construction and may be completed at this later phase prior to fill and pavers. The final steps, connection with municipal, testing and commissioning must be synced with the completion of all buildings on site.

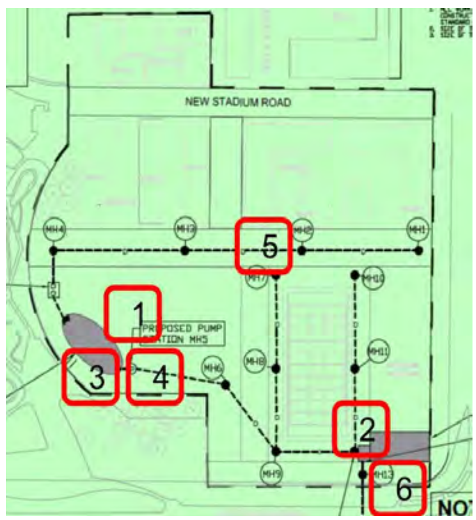


Figure 18 - Site Staging Plan

The work on W 16th Ave between East Mall and Wesbrook Mall will be completed after the Stadium neighborhood is complete starting from south side to north side. This maximizes construction traffic on the existing road and limits potential damage on the new road. The transportation upgrades are staged during the summer when fewer classes are in session and lower traffic volumes are expected. The road improvements should be completed after much of Stadium neighborhood's work is complete to reduce construction activities on new roads. Based on Translink and Metro Vancouver's plan for the Broadway SkyTrain extension UBC and additional bus services, the schedule is subject to high variation. UBC is currently redeveloping the northern segment of Wesbrook Mall with plans to extend activities Southward. Our team's road work schedule should be synced with UBC's plan to avoid alignment and scheduling conflicts. A timeline of the condensed construction schedule is found in Appendix F. Roadwork on W 16th Ave between East Mall to Wesbrook Mall will be mostly carried out in September and October. TransLink has announced that launch of the 41st Avenue B-Line may be postponed due to delays along other segment of the route [21], thus completion of the roadwork may still be in coincide with the introduction of the B-Line in late 2019.

Figure 19 - Roadworks Staging Plan

6.2 Cost Management

6.2.1 Project Cost Plan and Cash Flow

Cost management describes the process of planning and controlling the budget of a project. There are four main sections that are directly involved with cost management: planning, estimating and budgeting, financing and funding, and cost control. These processes, as described in the Project Management Book of Knowledge (PMBOK), span the full life cycle of the project from conceptual planning to project completion [23].

For the cost estimation, unit rate estimate and detailed estimate are used. The unit rate cost estimate was used to provide a very rough idea of the project costs while the detailed cost estimate expanded on the rough estimate. The unit rate estimate will form the basis of the quantity takeoff calculations, work crew sizes, and makeup utilized for tasks, as well as productivity assumptions. These estimates will be further quantified through unit costs for materials, labour, equipment and work crews, productivity and work methods. In addition to these estimates, overhead and profit margins of this project will be included in the report. Furthermore, a proposed contingency was given to the detailed cost estimate.

6.2.2 Unit Cost Estimate

A common means of cost estimation is using a cost database of previously completed projects and breaking the completed project down by a unit rate. By breaking the cost of a completed project down by area or volume, one can establish the unit rate-based cost estimate. In this case, a multi-story parking garage subset was the closest means of estimating the cost of the parkade based on the RS Means Cost Database of Square Foot Costs. The RS Means assigns a multiplicative factor against square footage based on location, size, time, and a base unit cost; these components are also dependent on economic trends. For the wetland, a paper titled "Economic Analysis of Wetlands Mitigation Projects in the Southeastern U.S." [24] was referenced. The paper considered approximately 1000 projects and categorized them by wetland type. The wetlands areas described in the paper were scaled down to suit this project's constructed wetland.

The estimate totaled $11,690,000. A breakdown of the unit cost estimate can be found in Appendix G.

6.2.3 Detailed Cost Estimate

The assumption of the site construction is that it is the summation of sub-elements. The work breakdown structure will outline the sub-elements of the project that must be executed to successfully implement the design. As found in industry standards, each item in the work breakdown structure has been itemized with reference to the MASTERFORMAT. At this design stage, a general breakdown has been completed, which expands on the core components of the project into its detailed activities. Our team has reached out to consultant Dragados Canada for recommendation for installation practice, industry standards, and detailed unit pricing.

Compared to the preliminary unit cost estimate, the detailed cost estimate shows great potential for cost engineering. For example, through consultation with WorkSafe BC, slope limitations in trench excavation were investigated. As a result, our team modified the stormwater pipeline excavation from trench box shoring to open trench. By using a combination of sloped trench and sheet piles for the parkade construction and using only sloped trench for the storm pipe installation, the high costs of excavation were reduced. Furthermore, by using sloped trench excavation instead of trench boxes, the lag time between excavation and pipe laying is increased because trench boxes limited the length of work area. This flexibility will be beneficial in cases of expected weather and construction delays. Many of the savings from excavation were offset; however, from the increased cost of constructing other scopes of the project. As the details of the site are refined, the costs for small, but crucial activities greatly increased the overall project cost. Each activity and their respective material, labour and equipment costs were sourced from local businesses such as Langley Concrete Group, Mainland Sand and Gravel, and BA Blacktop.

The detailed estimate totaled $11,604,000. A breakdown of the unit cost estimate can be found in Appendix G.

6.2.4 Other Costs

According to the RS Means, overhead costs, costs that do not account direct for labour and materials, are set at 5% of the overall project estimate. With respect to profit, it is also suggested that the profit margin be set at 10% of the overall cost. The contingency of given cost estimates is broad considering the uniqueness of the site. The suggested minimum contingency of 20% which is similar to standards for projects of a similar scope. The site work will be noted as the largest source of uncertainty due to site conditions such as topography, location, soil grade, and existing storm services.

6.3 Stakeholder/Public Consultation

The Consultative Areas Database has identified 13 First Nations groups that require consultation and/or notification regarding this project. It is assumed that consultation with these groups and other stakeholders are mostly included in the scope of the Neighbourhood and will be handled by UBC Campus and Community Planning. Redesign of W 16th Ave will require consultation with BC Ministry of Transportation and Infrastructure as they are the property owners. During construction phase, coordination with TransLink will also be required to ensure transit services are accommodated. A stakeholder analysis is provided in Appendix G.

6.4 Risk Analysis

A preliminary risk analysis following Table 15 is provided in Appendix I.

Table 15 - Risk Analysis Criteria

Risk Levels		Impact				
		Negligible	Low	Medium	High	Extreme
Probability	Almost Certain	1	3	4	4	4
	Likely	1	2	3	4	4
	Moderate	1	2	2	3	4
	Unlikely	1	1	2	3	4
	Rare	1	1	2	2	3

Appendix - Table of Contents

Appendix A References

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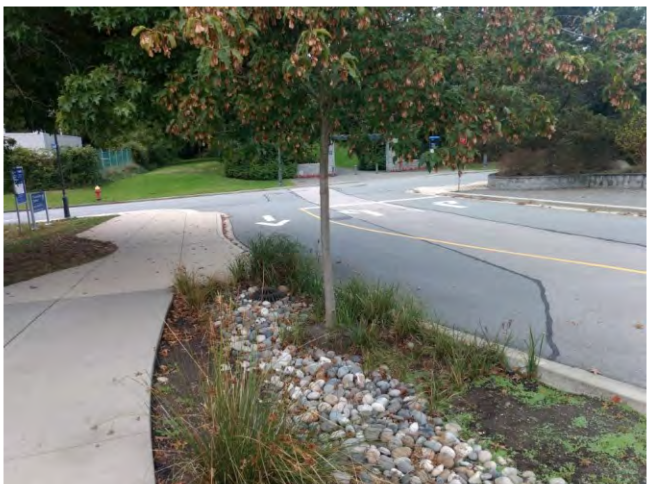
Appendix B *Stadium Road Neighbourhood Plan Option 1B*

Appendix C Site Photos

S1: Outside of Thunderbird Stadium
- Sloped ground for water management

S2: Parking lot at Thunderbird Stadium
- Existing bioswale system to manage runoffs



S3: Parking lot entrance at Thunderbird Stadium
- Bio-retention trenches along the road side

S4: Inside of Thunderbird Stadium
- Current ground condition mimics a basin-like terrain

S5: Proposed location of new Thunderbird Stadium
- Silty clay condition at existing ground

S6: Proposed location of new Thunderbird Stadium
- Existing ground condition

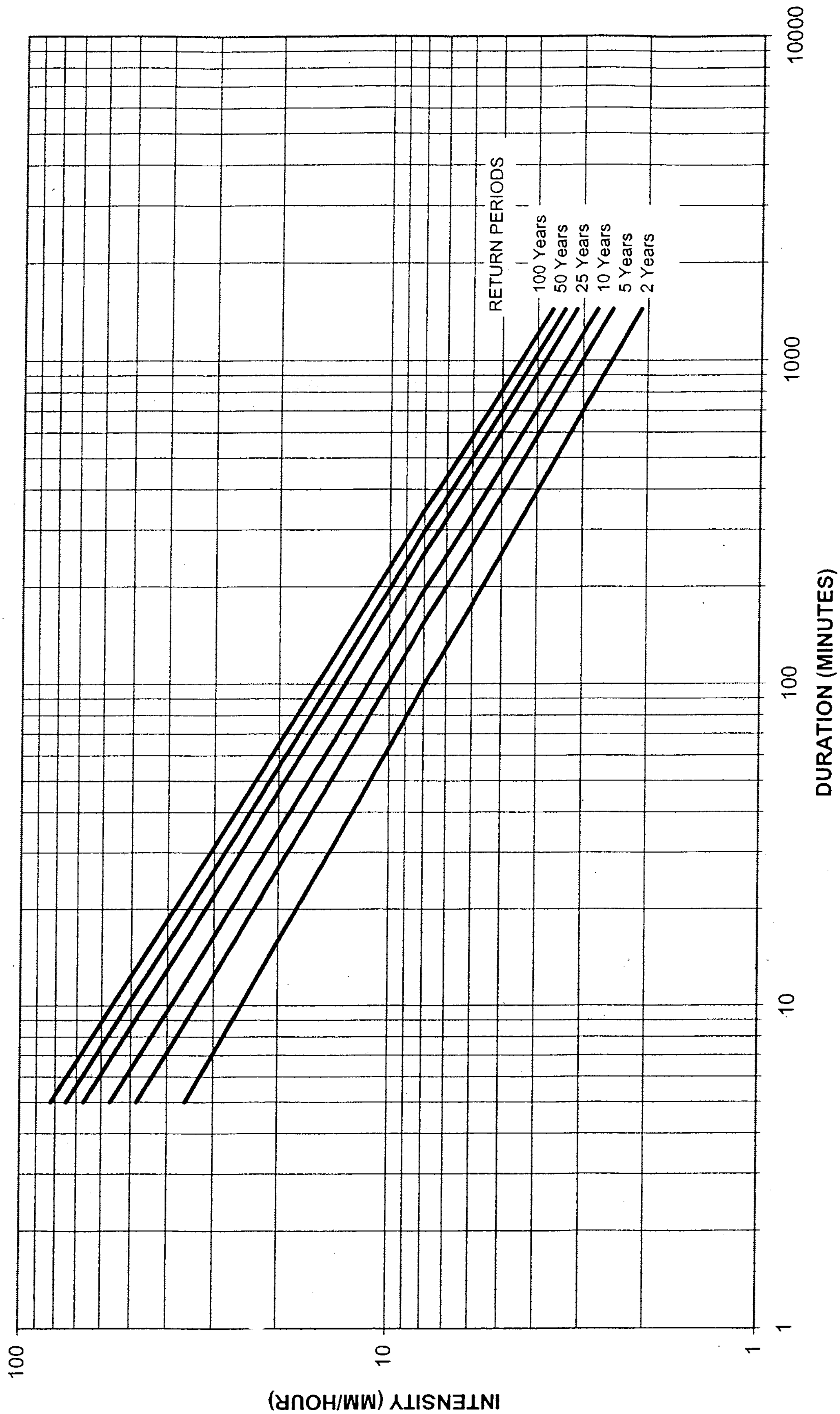


FIGURE 3.1 SHORT DURATION RAINFALL INTENSITY-DURATION-FREQUENCY (IDF) CURVES
(Source: Atmospheric Environment Service - Environment Canada; Vancouver International Airport, 1961 to 1998)

Appendix D-2 Stormwater Detention Volume Calculation (1/25 Year Storm)

DETENTION CALCULATIONS

Client: UBC
Project Location: Stadium Road Neighbourhood
Project No.: CIVL 445

Type of Analysis: 25-yr Post Development Release Rate = 25-yr Pre-development Release Rate

Description: Achieve net-zero with underground storm detention facility.

Date of Analysis: October 18, 2018
IDF Curve Used: Vancouver International Airport

25-yr Post development Parameters:

R (Runofff Coeff.) 0.76
A (Ha) 8.670 Ha
N 0.00278

$I=aT^b$, where I (mm/hr), T (hr), a & b are constants.

$a_{25\text{-yr}}$ = 21.200
$b_{25\text{-yr}}$ = -0.550

25-yr Pre-development Parameters:

R (Runofff Coeff.) 0.30
A (Ha) 8.670 Ha
N 0.00278

Tc (min) 15.0

$I=aT^b$, where I (mm/hr), T (hr), a & b are constants.

$a_{25\text{-yr}}$ = 21.200
$b_{25\text{-yr}}$ = -0.550
I_{25yr} (mm/hr) 45.4
Q_{25yr} = RAIN (m^3/s) 0.32859 [Maximum allowable release rate]

Duration (min)	Intensity (mm/hr)	Peak Inflow (m^3/s)	Inflow Volume (m^3)	Release Rate (m^3/s)	Outflow Volume (m^3)	Storage Volume (m^3)	
5	83.2	1.52322	457.0	0.32859	98.6	358.4	
10	56.8	1.04039	624.2	0.32859	197.2	427.1	
15	45.4	0.83243	749.2	0.32859	295.7	453.5	
20	38.8	0.71061	852.7	0.32859	394.3	458.4	*
30	31.0	0.56856	1023.4	0.32859	591.5	432.0	
40	26.5	0.48536	1164.9	0.32859	788.6	376.2	
50	23.4	0.42930	1287.9	0.32859	985.8	302.1	
60	21.2	0.38834	1398.0	0.32859	1182.9	215.1	
120	14.5	0.26524	1909.8	0.32859	2365.8		
180	11.6	0.21223	2292.0	0.32859	3548.8		
240	9.9	0.18117	2608.8	0.32859	4731.7		
360	7.9	0.14495	3131.0	0.32859	7097.5		
480	6.8	0.12374	3563.7	0.32859	9463.4		
600	6.0	0.10945	3940.2	0.32859	11829.2		
720	5.4	0.09901	4277.1	0.32859	14195.1		
1440	3.7	0.06762	5842.7	0.32859	28390.2		
2000	3.1	0.05645	6773.5	0.32859	39430.8		
3000	2.5	0.04516	8129.3	0.32859	59146.2		
4000	2.1	0.03855	9252.8	0.32859	78861.5		
5000	1.9	0.03410	10230.2	0.32859	98576.9		
6000	1.7	0.03085	11104.9	0.32859	118292.3		
7200	1.5	0.02790	12054.5	0.32859	141950.8		
8400	1.4	0.02564	12920.3	0.32859	165609.2		
10000	1.3	0.02329	13974.9	0.32859	197153.8		
					DETENTION VOLUME =	**458.4**	

/Users/dabao1383/Documents/4 year/CIVL 445 CAPSTONE/Design /[2018-10-14 SRN Detention Calculations.xls]100Yr vs. 100Yr

Appendix D-3 Stormwater Detention Volume Calculation (1/100 Year Storm)

DETENTION CALCULATIONS

Client: UBC SEEDS
Project Location: Stadium Road Neighbourhood, UBC
Project No.: CIVL 445 - Capstone

Type of Analysis: 100-yr Post Development Release Rate = 100-yr Pre-development Release Rate

Description: Achieve net-zero with underground storm detention facility.

Date of Analysis: November 27, 2018
IDF Curve Used: Vancouver International Airport

100-yr Post development Parameters:

R (Runofff Coeff.) 0.76
A (Ha) 8.850 Ha
N 0.00278

$I=aT^b$, where I (mm/hr), T (hr), a & b are constants.

$a100_{-yr}$ = 26.100
$b100_{-yr}$ = -0.558

100-yr Pre-development Parameters:

R (Runofff Coeff.) 0.30
A (Ha) 8.850 Ha
N 0.00278

Tc (min) 15.0

$I=aT^b$, where I (mm/hr), T (hr), a & b are constants.

$a100_{-yr}$ = 26.100
$b100_{-yr}$ = -0.558
I_{100yr} (mm/hr) 56.6
Q_{100yr} = RAIN (m^3/s) 0.41754 [Maximum allowable release rate]

Duration (min)	Intensity (mm/hr)	Peak Inflow (m^3/s)	Inflow Volume (m^3)	Release Rate (m^3/s)	Outflow Volume (m^3)	Storage Volume (m^3)	
5	104.4	1.95265	585.8	0.41754	125.3	460.5	
10	70.9	1.32633	795.8	0.41754	250.5	545.3	
15	56.6	1.05777	952.0	0.41754	375.8	576.2	
20	48.2	0.90090	1081.1	0.41754	501.0	580.0	*
30	38.4	0.71848	1293.3	0.41754	751.6	541.7	
40	32.7	0.61193	1468.6	0.41754	1002.1	466.5	
50	28.9	0.54029	1620.9	0.41754	1252.6	368.2	
60	26.1	0.48803	1756.9	0.41754	1503.1	253.7	
120	17.7	0.33149	2386.7	0.41754	3006.3		
180	14.1	0.26437	2855.2	0.41754	4509.4		
240	12.0	0.22516	3242.3	0.41754	6012.6		
360	9.6	0.17957	3878.7	0.41754	9018.9		
480	8.2	0.15294	4404.6	0.41754	12025.2		
600	7.2	0.13503	4861.2	0.41754	15031.5		
720	6.5	0.12197	5269.2	0.41754	18037.8		
1440	4.4	0.08285	7158.1	0.41754	36075.6		
2000	3.7	0.06897	8276.7	0.41754	50104.9		
3000	2.9	0.05501	9901.2	0.41754	75157.4		
4000	2.5	0.04685	11243.8	0.41754	100209.9		
5000	2.2	0.04136	12409.3	0.41754	125262.4		
6000	2.0	0.03736	13450.7	0.41754	150314.8		
7200	1.8	0.03375	14579.5	0.41754	180377.8		
8400	1.7	0.03097	15607.5	0.41754	210440.7		
10000	1.5	0.02810	16857.8	0.41754	250524.7		
					DETENTION VOLUME =	**580.0**	

/Users/dabao1383/Documents/4 year/CIVL 445 CAPSTONE/Design /2018-11-27 Catchment Plan/2018-11-27 SRN Detention Calculations_1:[2018-11-27 SRN Detention Calculations_1:100.xls]100Yr vs. 100Yr

POST-DEVELOPMENT

STORM SEWER DESIGN - RATIONAL METHOD

Sub-Catchment Plan

LOCATION:	Stadium Road Neighbourhood, UBC	Qpeak=Runoff (m^3/s)	Tc=Ti+Tt	Ø=Pipe Diameter (mm)	Date:	26-Nov-18
REF. No.:		R=Runoff Coefficient	Tc=Time of Concentration (min)	n=Roughness Coefficient	Calc. By:	Peggy Shen
IDF Curve:	Vancouver International Airport	A=Area (ha)	Ti=Inlet Time (min)	S=Slope of Pipe (%)	Sheet:	1 of 1
Return Period	100 year	I=Rainfall Intensity (mm/hr)	Tt=Travel Time (min)	Vcap=Velocity at Capacity (m/s)		
		N=0.00278	I = aTb where I in mm/hr, T in hr	L=Length of Pipe (m)		
			a = 26.100	Qcap=Flow at Capacity (m^3/s)		
			b = -0.558			

Location		Catchment Area	Tributary Area				Run-off					Sewer Design						Adjusted Tt	HGL Condition
From	To		A (ha)	R	RA	Σ(AR)	Ti (min)	Tt (min)	Tc (min)	I (mm/hr)	Qpeak (m^3/s)	Qcap (m^3/s)	Ø (mm)	n	S (%)	Vcap (m/s)	L (m)	(min)	
Stadium Road Neighbourhood																			
MH-1	MH-2	1	1.30	0.72	0.94	0.94	15.00	1.18	16.18	54.2	0.141	0.147	400	0.013	0.500	1.17	83.0	1.18	SURFACE
MH-2	MH-3	2	1.44	0.72	1.04	1.97	16.18	1.00	17.18	52.4	0.288	0.327	500	0.013	0.750	1.67	100.0	1.00	SURFACE
MH-3	MH-4	3	1.99	0.72	1.43	3.41	17.18	0.71	17.89	51.3	0.485	0.499	500	0.013	1.750	2.54	108.3	0.71	SURFACE
MH-4	O/G-1	4	0.37	0.72	0.27	3.67	17.89	0.15	18.04	51.0	0.521	0.534	500	0.013	2.000	2.72	25.0	0.15	SURFACE
O/G 1	WETLAND - IN			-	-	3.67	18.04	0.03	18.07	51.0	0.520	0.534	500	0.013	2.000	2.72	5.0	0.03	SURFACE
WETLAND - IN	WETLAND	5A	1.48	0.30	0.45	4.12	15.00												
WETLAND	Wetland-Out	5B	0.13	1.00	0.13	4.24	15.00												
WETLAND - OUT	PUMP			-	-	4.12	18.07	0.10	18.17	50.8	0.582	0.866	575	0.013	2.500	3.34	20.0	0.10	SURFACE
PUMP	MH-5			-	-	4.12	18.17	0.40	18.57	50.2	0.575	0.866	575	0.013	2.500	3.34	80.0	0.40	SURFACE
MH-5	MH-6			-	-	4.12	18.57	0.34	18.91	49.7	0.569	0.866	575	0.013	2.500	3.34	68.0	0.34	SURFACE
MH-6	MH-7	6	0.33	0.95	0.31	0.33	15.00	0.91	15.91	54.7	0.050	0.097	300	0.013	1.000	1.37	75.0	0.91	SURFACE
MH-7	MH-8	7	0.31	0.95	0.30	0.64	15.91	0.91	16.83	53.1	0.095	0.097	300	0.013	1.000	1.37	75.0	0.91	SURFACE
MH-9	MH-10	8	0.77	0.95	0.73	0.77	15.00	0.75	15.75	55.1	0.117	0.118	300	0.013	1.500	1.68	75.0	0.75	SURFACE
MH-10	O/G-2	9	0.73	0.95	0.69	1.50	15.75	0.53	16.28	54.0	0.225	0.226	350	0.013	2.400	2.35	75.0	0.53	SURFACE
MH-8	O/G-2			-	-	4.76	18.91	0.45	19.36	49.1	0.649	0.686	600	0.013	1.250	2.43	65.0	0.45	SURFACE
O/G-2	DETENTION			-	-	6.26	19.36	0.02	19.38	49.0	0.853	0.868	600	0.013	2.000	3.07	3.0	0.02	SURFACE
DETENTION	MH-11			-	-	6.26	19.38	0.02	19.39	49.0	0.852	0.868	600	0.013	2.000	3.07	3.0	0.02	SURFACE
MH-11	MH-12			-	-	6.26	19.39	0.14	19.53	48.8	0.849	0.868	600	0.013	2.000	3.07	25.0	0.14	SURFACE
		Σ	8.85 ha																

Assuming wetland has surface area of 0.13ha and a depth of 0.45m

Nov-30-2018 - 9:10 AM

/Users/dabao1383/Documents/4 year/CIVL 445 CAPSTONE/Design /2018-11-26 SWCP/[2018-11-26-SWCP.xls]100-YR Flow RM

Appendix D-5 Underground Parkade Load Calculation

Client:	University of British Columbia	Design Analysis:	Parkade Capacity
Project:	Stadium Road Neighborhood	Design Code	CSA A23.3-14 & S413-14
Project No.:	CIVL 446	Date of Analysis:	24-Feb-19

Loading

Formula name	Formula Symbols	Formula		Formula Results	Units
Input					
Resistance Factor of Concrete	ϕ_c, phic	=	=	0.65	
Modification Factor of Concrete	λ	=	=	1	
Compressive Strength of Concrete	f'c	=	=	35	MPa
Tensile Strength of Concrete	f_t	= sqrt(f'c)	=	5.9161	MPa
Alpha Factor of Concrete	α_1, alpha1	= 0.85-0.0015*f'c	=	0.7975	
Beta Factor of Concrete	β_1, beta1	= 0.97-0.0025*f'c	=	0.8825	
Density of Concrete	gamma	=	=	2400	kg/m3
Unit Weight of Concrete	Wc	= gamma*9.81/1000	=	23.544	kN/m3
Resistance Factor of Steel	ϕ_s, phis	=	=	0.85	
Yield Strength of Steel	f_y	=	=	400	MPa
Unit Weight of Soil	Ws	= 1400*9.81/1000	=	13.734	kN/m3
Parkade Length	Lpk	=	=	120	m
Parkade Height	Hpk	=	=	3	m
Parkade Width	Wpk	=	=	40	m
Soil Cover	hs	=	=	0.15	m
Slab Thickness	hf	=	=	0.25	m
Total Slab Area	At	= Lpk*Wpk	=	4800	m2
Wall Thickness	twall	=	=	0.4	m
Beam Height	h	=	=	1.3	m
Beam Width	bw	=	=	0.5	m
Beam Span	ln	=	=	15	m
Tributary Beam Width (beam to beam)	tw	=	=	7.5	m
Tributary Area	Atrb	=	=	112.5	m2
Dead Load					
Concrete Slab Weight	W1	= hf*Wc	=	5.886	kPa
Soil Cover	W2	= hs*Ws	=	2.0601	kPa
Utilities	W3	=	=	1	kPa
Others	W4	=	=	2	kPa
Superimposed Floor Dead Load	Wfloor	= SUM(H38:H41)	=	10.9461	kPa
Concrete Beam Weigt	Wbeam	= (h-hf)*bw*Wc	=	12.3606	kN/m
Live Load					
Stadium (Blechers)	W5	=	=	4.8	kPa
Additional Roof Load (Non-vechicular)	W6	=	=	1	kPa
Live Load	LL	= W5+W6	=	5.8	kPa
Snow Load					
Importance Factor	Is	=	=	1	
1/50 yr Ground Snow Load	Ss	=	=	2.1	kPa
Basic Roof Snow Load Factor	Cb	=	=	0.8	
Wind Exposure Factor	Cw	=	=	1	
Slope Factor	Cs	=	=	1	
Accumulation Factor	Ca	=	=	1	
1/50 yr Associated Rain Load	Sr	=	=	0.4	kPa
Snow Load	SL	= Is*(Ss*(Cb*Cw*Cs*Ca)+Sr)	=	2.08	kPa
Factored Load - Governing Load Combination, Case 3 = 1.25D + 1.5L					
Loading for Slab for 1m strip	Lslab	= (1.25*Wfloor+1.5*LL)*1	=	22.382625	kN/m
Loading for Beam	Lbeam	= 1.25*((Wfloor*tw)+Wbeam)+1.5*(LL*tw)	=	183.3204375	kN/m
Loading for Columns	Lcolumn	= CONVERT(1000,"lbf","N")	=	4448.221615	kN

Continuous Beam Design

Input

Formula name	Formula Symbols		Formula		Formula Results	Units
Resistance Factor of Concrete	ϕ_c, phic	=		=	0.65	
Modification Factor of Concrete	λ	=		=	1	
Compressive Strength of Concrete	f'c	=		=	35	MPa
Tensile Strength of Concrete	f_t	=	sqrt(f'c)	=	5.9161	MPa
Alpha Factor of Concrete	α_1, alpha1	=	0.85-0.0015*f'c	=	0.7975	
Beta Factor of Concrete	β_1, beta1	=	0.97-0.0025*f'c	=	0.8825	
Resistance Factor of Steel	ϕ_s, phis	=		=	0.85	
Yield Strength of Steel	f_y	=		=	400	MPa
Rebar	rebar	=		=	30M	
Diameter of Rebar	db	=		=	29.9	mm
Area of Rebar	Ab	=		=	700	mm2
Number of Rebar per row	Nsr	=		=	6	bars
Number of Row	Nr	=		=	3	rows
Total Number of Rebar	Ns	=	Nsr*Nr	=	18	bars
Spacing of Rebar	sp	=	(bw-2*cover-2*stirrups)/(Ns-1)	=	82	mm
Total Area of Rebar	As	=	Ab*Ns	=	12600	mm2
Max Aggregate Size	Agg	=		=	20	mm
Stirrup Size	ds	=		=	15	mm
Area of Stirrups	Ast	=		=	200	mm2
Number of stirrup legs	Nsl	=		=	2	legs
Spacing of shear reinforcement	s	=		=	150	mm
Clear Cover	cover	=		=	30	mm
Beam Height w/ Slab	h	=		=	1300	mm
Beam Width	bw	=		=	500	mm
Slab Thickness	hf	=		=	250	mm
Clear Span of Beam	ln	=		=	15000	mm
Clear Distance of "T-beam"	lw	=	7500-2*(1/2)bw	=	7000	mm
Overhanging Flange Width	bt	=	min(ln/10,12*hf, lw/2)	=	1500	mm
Effective Flange Width	bf	=	bw+2*bt	=	3500	mm
Tributary Width	tw	=		=	7.5	m
Uniformly Distributed Load	q	=	Lbeam	=	183.3204375	kN/m
Flexural Design Load	Mf	=	q*(ln/1000)^2/8	=	5155.887305	kNm
Shear Design Load	Vf	=	q*(ln/1000)/2	=	1374.903281	kN

Flexural Capacity

Formula name	Formula Symbols		Formula		Formula Results	Units
Effective Depth	d	=	h-cover-stirrups-db/2	=	1240.05	mm
Tension Force in Reinforcement	Tr	=	φs*fy*As/1000	=	4284	kN
Depth of Rectangular Stress Block	a	=	Tr*1000/(alpha*phic*fc*bf)	=	67.46357091	mm
Check - "a" is within flange	Check1	=	IF(a<hf,"Ok","Fail")	=	Ok	
Factored Moment Resistance	Mr	=	Tr*(d-a/2)/1000	=	5167.867231	kNm
Demand/Capacity Ratio	DC_moment	=	Mf/Mr	=	0.997681843	
Check - Flexural is sufficient	Check2	=	IF(DC_moment<1,"Ok","Fail")	=	Ok	

Flexural Requirements Check

Formula name	Formula Symbols		Formula		Formula Results	Units
Neutral Axis Depth	c	=	a/beta	=	76.4459727	mm
c/d ratio	cd	=	c/d	=	0.061647492	
Balanced Condition	balcon	=	700/(700+fy)	=	0.636363636	
Check - Steel has yielded	Check3	=	IF(cd<balcon,"Ok","Fail")	=	Ok	
Minimum Spacing of Rebars	spmin	=	max(1.4*db, 1.4*agg, 30)	=	41.86	mm
Check - Spacing is sufficient	Check4	=	IF(sp>spmin,"Ok","Fail")	=	Ok	
Tension Zone Width	btz	=	bw	=	500	mm
Minimum Steel Required	Asmin	=	0.2*sqrt(fc)/fy*btz*h	=	1922.72593	mm2
Check - Steel is sufficient	Check5	=	IF(As>Asmin,"Ok","Fail")	=	Ok	
Reinforcement Ratio	rhob	=	As/(btz*d)	=	0.020321761	
Balanced Reinforcement Ratio	Pb	=		=	0.03	
Check - Max Steel Allowed	Check6	=	IF(rhob<pb,"Ok","Fail")	=	Ok	

Shear Capacity

Formula name	Formula Symbols		Formula		Formula Results	Units
Effective Shear Depth	dv	=	MAX(0.9*d,0.72*h)	=	1116.045	mm

Formula name	Formula Symbols		Formula		Formula Results	Units
Shear Resistance Factor	β, beta	=		=	0.18	
Shear Resistance of Concrete	Vc	=	phic*beta*SQRT(fc)*bw*dv/1000	=	386.2527588	kN
Area of Shear Reinforcement	Av	=	Nsl*Ast	=	400	mm2
Longitudinal Member Axis	theta	=		=	35	degree
Shear Resistance of Steel	Vs	=	phis*Av*fy*dv*COT(RADIANS(theta))/s/1000	=	1445.115548	kN
Factored Shear Resistance	Vr	=	Vc+Vs	=	1831.368306	kN
Check - Shear is sufficient	Check7	=	IF(Vr>Vf,"Ok","Fail")	=	Ok	

Shear Requirements Check

Formula name	Formula Symbols		Formula		Formula Results	Units
Maximum Shear Resistance	Vrmax	=	0.25*phic*fc*bw*dv/1000	=	3173.752969	kN
Check - Shear resistance limit	Check8	=	if(Vrmax>Vr,"Ok","Fail")	=	Ok	
Maximum Shear Spacing	smax	=	MIN(600,0.7*dv)	=	600	mm
Check - Spacing is within limit	Check9	=	if(smax>s,"Ok","Fail")	=	Ok	
Minimum Area of Shear Reinforcement	Avmin	=	0.06*sqrt(fc)*bw*s/fy	=	66.55589756	mm2
Check - min shear reinforcement	Check	=	if(Av>Avmin,"Ok","Fail")	=	Ok	

One-Way Slab

Input

Formula name	Formula Symbols		Formula		Formula Results	Units
Resistance Factor of Concrete	ϕc, phic	=		=	0.65	
Modification Factor of Concrete	λ	=		=	1	
Compressive Strength of Concrete	f'c	=		=	35	MPa
Tensile Strength of Concrete	ft	=	sqrt(f'c)	=	5.9161	MPa
Alpha Factor of Concrete	α1, alpha1	=	0.85-0.0015*f'c	=	0.7975	
Beta Factor of Concrete	β1, beta1	=	0.97-0.0025*f'c	=	0.8825	
Resistance Factor of Steel	ϕs, phis	=		=	0.85	
Yield Strength of Steel	fy	=		=	400	MPa
Longitudinal and Transverse Rebar	rebars	=		=	20M	
Diameter of Rebar	dbs	=		=	20	mm
Area of Rebar	Abs	=		=	300	mm2
Spacing of Rebar	sps	=		=	250	mm
Total Area of Rebar	Ass	=	Abs*(bws/sps)	=	1200	mm2
Max Aggregate Size	Agg	=		=	20	mm
Clear Cover	covers	=		=	20	mm
Beam Height w/ Slab	h	=		=	1300	mm
Beam Width	bw	=		=	500	mm
Slab Unit Width	bws	=		=	1000	mm
Slab Thickness	hf	=		=	250	mm
Slab Concrete Area for 1m strip	Ags	=	bws*hf	=	250000	mm2
Clear Span of Beam	ln	=		=	15000	mm
Clear Distance of "T-beam"	lw	=	7500-2*(1/2)bw	=	7000	mm
Overhanging Flange Width	bt	=	min(ln/10,12*hf, lw/2)	=	1500	mm
Effective Flange Width	bf	=	bw+2*bt	=	3500	mm
Tributary Width	tw	=		=	7.5	m
Factored uniform load per metre	wf	=	Lslab	=	11.7	kN/m
Shear Force for slab per metre	Vfs	=	wf*(lw/1000)/2	=	40.95	kN/m
Moment Force for slab per metre	Mfs	=	wf*(lw/1000)^2/8	=	71.6625	kNm/m

Flexural Capacity of Slab

Formula name	Formula Symbols		Formula		Formula Results	Units
Effective Depth	dslab	=	hf-covers-1/2*dbs	=	220	mm
Tension Force in Reinforcement	Tr	=	φs*fy*As/1000	=	408	kN
Depth of Rectangular Stress Block	a	=	Tr*1000/(alpha*phic*fc*bws)	=	22.48785697	mm
Check - "a" is within flange	Check1	=	IF(a<hf,"Ok","Fail")	=	Ok	
Factored Moment Resistance	Mr	=	Tr*(d-a/2)/1000	=	85.17247718	kNm
Demand/Capacity Ratio	DC_moment	=	Mf/Mr	=	0.841380953	
Check - Flexural is sufficient	Check2	=	IF(DC_moment<1,"Ok","Fail")	=	Ok	

Shear Capacity of Slab

Formula name	Formula Symbols		Formula		Formula Results	Units
Effective Shear Depth	dvs	=	MAX(0.9*dslab,0.72*hf)	=	198	mm
Shear Resistance Factor	βs, betas	=	230/(1000+dvs)	=	0.191986644	
Shear Resistance of Concrete	Vcs	=	phic*betas*SQRT(fc)*bws*dvs/1000	=	146.1785289	kN/m
Check - Shear steel required?	Check1s	=	IF(Vcs<Vfs,"Yes","No")	=	No	
Longitudinal Member Axis	thetas	=		=		
Shear Resistance of Steel	Vss	=	phis*Ass*fy*dvs*COT(RADIANS(theta))/sps/100(	=	461.4860343	kN/m
Factored Shear Resistance	Vrs	=	Vcs+Vss	=	607.6645632	kN/m
Check - Shear is sufficient	Check7s	=	IF(Vrs>Vfs,"Ok","Fail")	=	Ok	

Design Requirements Check

Neutral Axis Depth	c	= a/beta	= 124.9325387	mm
c/d ratio	cd	= c/dslab	= 0.567875176	
Balanced Condition	balcon	= 700/(700+fy)	= 0.636363636	
Check - Steel has yielded	Check3	= IF(cd<balcon,"Ok","Fail")	= Ok	
Minimum Spacing of Rebars	spmin	= max(1.4*dbs, 1.4*agg, 30)	= 30	mm
Check - Spacing is sufficient	Check4	= IF(sps>spmin,"Ok","Fail")	= Ok	
Tension Zone Width	btz	= bws	= 1000	mm
Minimum Steel Required	Asmin	= 0.2*sqrt(fc)/fy*btz*h	= 739.5099729	mm2
Check - Steel is sufficient	Check5	= IF(Ass>Asmin,"Ok","Fail")	= Ok	
Reinforcement Ratio	rhob	= Ass/(btz*dslab)	= 0.007375892	
Balanced Reinforcement Ratio	Pb	=	= 0.03	
Check - Max Steel Allowed	Check6	= IF(rhob<pb,"Ok","Fail")	= Ok	
Maximum Shear Resistance	Vrmaxs	= 0.25*phic*fc*bws*dvs/1000	= 1126.125	kN
Check - Shear resistance limit	Check2s	= if(Vrmax>Vrs,"Ok","Fail")	= Ok	
Maximum Shear Spacing	smaxs	= MIN(500,3*hf)	= 500	mm
Check - Spacing is within limit	Check9	= if(smaxs>sps,"Ok","Fail")	= Ok	
Minimum Area of Shear Reinforcement	Avmins	= 0.06*sqrt(fc)*bws*sps/fy	= 221.8529919	mm2
Check - min shear reinforcement	Check	= IF(Ass>Avmins,"Ok","Fail")	= Ok	

Spiral Column Design

Input

Formula name	Formula Symbols	Formula	Formula Results	Units
Resistance Factor of Concrete	φc, phic	=	= 0.65	
Modification Factor of Concrete	λ	=	= 1	
Compressive Strength of Concrete	f'c	=	= 35	MPa
Tensile Strength of Concrete	ft	= sqrt(f'c)	= 5.9161	MPa
Alpha Factor of Concrete	α1, alpha1	= 0.85-0.0015*f'c	= 0.7975	
Beta Factor of Concrete	β1, beta1	= 0.97-0.0025*f'c	= 0.8825	
Resistance Factor of Steel	φs, phis	=	= 0.85	
Yield Strength of Steel	fy	=	= 400	MPa
Rebar	rebar	=	= 30M	
Diameter of Rebar	db	=	= 29.9	mm
Area of Rebar	Ab	=	= 700	mm2
Number of Rebar per row	Nsr	=	= 8	bars
Number of Row	Nr	=	= 1	rows
Total Number of Rebar	Ns	= Nsr*Nr	= 8	bars
Total Area of Rebar	As	= Ab*Ns	= 5600	mm2
Max Aggregate Size	Agg	=	= 20	mm
Spiral Bar Size	ds	=	= 15	mm
Area of Spiral Bar	Ast	=	= 200	mm2
Clear Cover	cover	=	= 35	mm
Concrete Column Diameter	dc	=	= 500	mm
Gross Cross-Sectional Area	Ag	= (PI()*dc^2)/4	= 196349.5408	mm2
Axial Load	Pf	= Lcolumn	= 4448.221615	kN

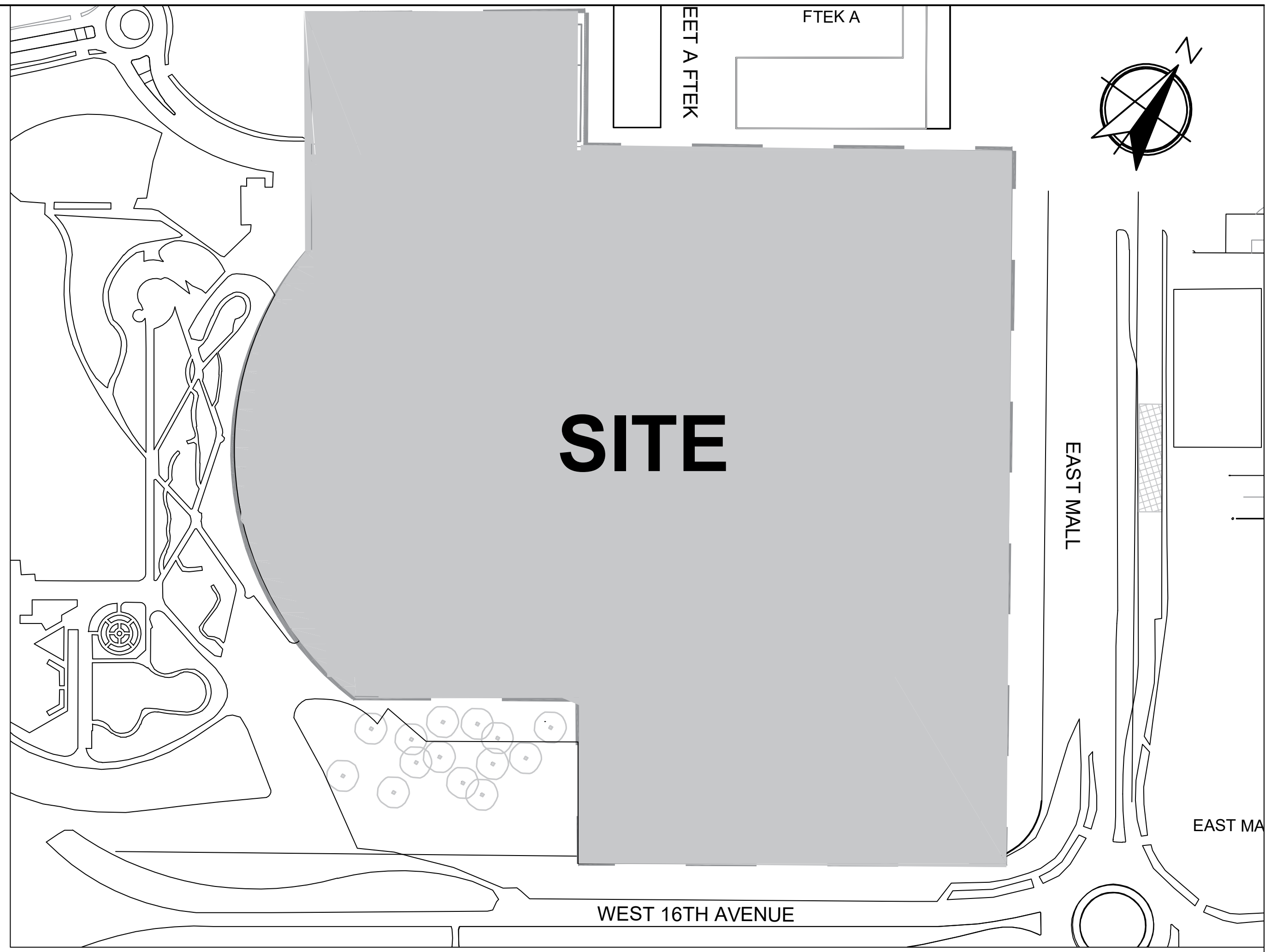
Axial Capacity

Factored Axial Load Resistance	Pro	= (alpha1*phic*fc*(Ag-As)+phis*fy*As)/1000	= 5364.792763	kN
Maximum Axial Load Resistance	Prmax	= 0.85*Pro	= 4560.073849	kN
Check - Axial Capacity	Check1c	= IF(Prmax>Pf,"Ok","Fail")	= Ok	

Spiral Reinforcement

Area of Spiral Reinforcement	Asp	= (PI()*ds^2)/4	= 176.7145868	mm2
Length of one spiral turn	lsp	= PI()*dcsp	= 1460.840584	mm
Diameter within Spiral Reinforcement	dcsp	= dc-cover	= 465	mm
Pitch (Dist b/w successive spiral turns)	pitch	=	= 25	mm
Area of Concrete Core	Acsp	= (PI()*dcsp^2)/4	= 169822.7179	mm2
Spiral Reinforcement Ratio	Ps	= Asp*lsp/(Acsp*pitch)	= 0.060805019	
Minimum Spiral Reinforcement Ratio	Psmin	= 0.45*(Ag/Acsp-1)*(phic/phis)	= 0.053752219	
Check - Sufficient Spiral Reinf.?	Check2c	= IF(Ps>Psmin,"Ok","Fail")	= Ok	
Minimum Rebar Diameter for Spiral	dsmin	=	= 6	mm
Check - Sufficient spiral bar size?	Check3c	= IF(ds>dsmin,"Ok","Fail")	= Ok	
Max Pitch Distance	pitchmax	= MIN(75,1/6*dcsp)	= 75	mm
Min Pitch Distance	pitchmin	=	= 25	mm
Check - Pitch within limit?	Check4c	= IF(AND(pitch>pimin,pitch<pimax),"Ok","Fail")	= Ok	

Appendix E *Detailed Design Drawing Package*



SITE LOCATION PLAN

SCALE: 1:300

DRAWING No. INDEX:

1. COVER
2. GENERAL NOTES
3. KEY PLAN
4. STORMWATER CONTROL PLAN
5. MANHOLES DETAILS
6. CONSTRUCTED WETLAND DETAILS
7. BIOSWALE DETAILS
8. RAIN GARDEN TYPICAL CROSS SECTIOIN
9. UNDERGROUND PARKADE PLAN
10. UNDERGROUND PARKADE ELEVATIONS
11. REINFORCED CONCRETE BEAM DETAILS
12. REINFORCED CONCRETE COLUMNS DETAILS
13. PILE FOUNDATION DETAILS
14. PARKADE BELOW GRADE SLAB WATERPROOF SYSTEM
15. PARKADE FOUNDATION WALL WATERPROOF SYSTEM
16. DETENTION TANK DETAILS
17. W16TH AVE. & SW MARINE DR. ROAD GEOMETRIC
18. W16TH AVE. & EAST MALL ROAD GEOMETRIC
19. W16TH AVE. & WESBROOK MALL ROAD GEOMETRIC
20. TYPICAL SECTION-W16TH AVE.

UBC Sustainability

CLIENT: **UBC SEEDS SUSTAINABILITY PROGRAM**

PROJECT: **UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT**

ISSUE FOR CONSTRUCTION

GENERAL NOTES:

1. ALL CONSTRUCTION SHALL BE PERFORMED IN ACCORDANCE WITH THESE NOTES. THE MASTER MUNICIPAL CONSTRUCTION DOCUMENT (MMCD), AND THE UNIVERSITY OF BRITISH COLUMBIA STANDARDS. IN THE EVENT OF ANY CONFLICTS BETWEEN THEM, THE INFORMATION SHOWN ON THE PLANS AND THESE NOTES SHALL GOVERN. IF THERE ARE ANY CONFLICTS BETWEEN THE MMCD AND UNIVERSITY STANDARDS, THIS SHALL BE POINTED OUT TO THE CONSULTANT AND THE UNIVERSITY STANDARDS SHALL GOVERN. THESE NOTES AND THE PLANS TAKE PRECEDENCE OVER SPECIFICATIONS IN THE CONTRACT BOOKLET IN THE EVENT OF CONFLICT. ALL ALTERNATES SHALL BE APPROVED BY THE CONSULTANT PRIOR TO INSTALLATION. NOTE: IF THE PAVED PORTION OF THE SERVICE ROAD IS IMPACTED/DAMAGED DURING CONSTRUCTION OF THE WORKS, REPAIRS TO THE ROAD ARE TO BE DONE TO UNIVERSITY STANDARDS.

2.THE CONTRACTOR SHALL NOTIFY THE CONSULTANT OF HIS CONSTRUCTION SCHEDULE AND SHALL PROVIDE THE CONSULTANT THE NAME AND CONTACT NUMBER OF HIS ON-SITE SUPERVISOR

3.THE CONTRACTOR' S OPERATION SHALL NOT BLOCK ANY UNIVERSITY ROADWAYS/LANES WITHOUT WRITTEN UNIVERSITY PERMISSION. IF IT IS NECESSARY TO CLOSE A UNIVERSITY LANE, THE CONTRACTOR SHALL CONTACT CONSULTANT AND THE UNIVERSITY OF BRITISH COLUMBIA AND OBTAIN THEIR APPROVAL IN WRITING. A COPY OF THE WRITTEN APPROVAL SHALL BE SUBMITTED TO THE CONSULTANT PRIOR TO THE CLOSING OR BLOCKING OF THE LANE(S). ALTERNATE ROUTES MAY BE REQUIRED. NOTE: IF THE TRAVELLED LANES OF THE SERVICE ENTRY ROAD ARE IMPACTED BY THE WORKS, THE APPLICANT IS RESPONSIBLE TO APPLY TO THE MINISTRY FOR APPROVAL OF A TRAFFIC CONTROL PLAN, AT LEAST TWO WEEKS PRIOR TO BEGINNING CONSTRUCTION.

4.THE CONTRACTOR SHALL CONTACT THE CONSULTANT 72 HOURS PRIOR TO COMMENCING AND ALL CONSTRUCTION SHALL PASS THE INSPECTION OF BOTH THE CONSULTANT AND THE UNIVERSITY

5.THE CONTRACTOR SHALL ENSURE THAT ALL APPROVALS, PERMITS, AGREEMENTS, ETC., THAT ARE REQUIRED FOR THE PROPOSED WORK, AND COPIES OF CONSTRUCTION DRAWINGS ISSUED "FOR CONSTRUCTION" HAVE BEEN OBTAINED PRIOR TO COMMENCEMENT OF CONSTRUCTION

6.THE LOCATION AND SIZE OF EXISTING UTILITIES AND SERVICES, AS SHOWN ON THE DRAWINGS IS APPROXIMATE ONLY. PRIOR TO COMMENCEMENT OF CONSTRUCTION THE CONTRACTOR SHALL EXPOSE AND VERIFY THE EXACT LOCATION AND SIZE OF THESE INSTALLATIONS AND SHALL NOTIFY THE CONSULTANT OF ANY DISCREPANCIES, CONFLICTS OR OMISSIONS

7.THE CONTRACTOR SHALL EXERCISE EXTREME CAUTION WHEN WORKING NEAR EXISTING UTILITIES AND SERVICES. ANY DAMAGES SUFFERED BY THE UTILITIES, WHICH MAY BE ATTRIBUTED TO THE CONTRACTOR' S OPERATIONS, SHALL BE REPAIRED BY THE CONTRACTOR AT HIS EXPENSE AND TO THE SATISFACTION OF THE AUTHORITY HAVING JURISDICTION

8.WHEN WORKING ON EXISTING PAVEMENT WHICH WILL BE RETAINED FOR FUTURE USE, THE CONTRACTOR SHALL EXERCISE CARE NOT TO CAUSE ANY DAMAGE. ANY DAMAGE CAUSED BY THE CONTRACTOR TO EQUIVALENT CONDITION TO THAT EXISTING PREVIOUS AT HIS EXPENSE AND TO THE SATISFACTION OF THE CONSULTANT

9.THE CONTRACTOR SHALL USE ONLY NEW AND APPROVED MATERIALS AND SHALL NOT SUBSTITUTE ANY MATERIALS WITHOUT THE PRIOR WRITTEN APPROVAL OF THE CONSULTANT

10.ALL SURVEY MONUMENTS, PROPERTY PINS AND PROJECT PRIMARY SURVEY CONTROL PINS, SHALL BE PROTECTED DURING ALL STAGES OF CONSTRUCTION. ANY DAMAGE SUFFERED BY THE MONUMENTS OR PINS SHALL BE REPAIRED BY THE CONTRACTOR AT HIS EXPENSE

11.EXISTING PARKING AREAS, ON-SITE AND OFF-SITE ROADS MUST BE KEPT CLEAN. CLEANING SHALL BE DONE BY THE CONTRACTOR AT HIS EXPENSE

12.DISTURBANCE TO EXISTING LANDSCAPING OR SURFACE IMPROVEMENT, ATTRIBUTABLE TO THE CONTRACTOR' S OPERATION SHALL BE CORRECTED BY THE CONTRACTOR AT HIS EXPENSE. SUCH REPAIR SHALL BE CARRIED OUT TO THE SATISFACTION OF THE CONSULTANT AND THE UNIVERSITY

13.CONSTRUCTION AND EXCAVATION WASTES, OVERBURDEN, SOIL, OR OTHER SUBSTANCES DELETERIOUS TO AQUATIC LIFE SHALL BE DISPOSED OF OR PLACED IN SUCH A MANNER SO AS TO PREVENT THEIR ENTRY INTO ANY WATERCOURSE, RAVINE OR STORM WATER SYSTEM

14.ALL WORK SHALL BE UNDERTAKEN IN A MANNER THAT PREVENTS THE RELEASE OF SEDIMENT LADEN WATER INTO ANY DITC, WATERCOURSE OR STORM SEWER

15.THE CONTRACTOR SHALL CONNECT ALL PROPOSED SERVICES INCLUDING CURBS, PAVEMENT, SLOPES, BOULEVARDS AND STORM SEWERS TO THE SATISFACTION OF THE UNIVERSITY OF BRITISH COLUMBIA AND THE CONSULTANT

16.BC HYDRO, FORTIS BC, TELUS, CABLE AND ALL OTHER UTILITY COMPANIES ASSOCIATED WITH THE CONSTRUCTION PROJECT SHOULD BE NOTIFIED BY THE CONTRACTOR BEFORE CONSTRUCTION TO COORDINATE THE INSTALLATION OF THEIR RESPECTIVE SERVICES. ALL INSTALLATIONS SHALL BE CONSTRUCTED TO THE SATISFACTION OF THE AUTHORITY HAVING JURISDICTION

17.THE CONTRACTOR SHALL PROVIDE THE CONSULTANT WITH AS-CONSTRUCTED RECORDS DETAILING THE POSITION OF ALL STORM SERVICES. THE CONTRACTOR SHALL NOTE ON THE RECORDS ANY LOCATION AND/OR ELEVATION CHANGE FROM THE DESIGN DRAWINGS FROM THE SERVICES.

STORM WORKS:

1.TIE-INS AND CONNECTIONS TO EXISTING STORM SEWERS TO BE PERFORMED BY THE DEVELOPER UNDER THE DIRECT SUPERVISION OF THE CITY, AND THE COST CHARGED TO THE DEVELOPER. A MINIMUM 72 HOURS NOTICE TO BE GIVEN FOR ANY TIE-IN.

2.NEW SEWER LINES TIED TO EXISTING LINES MUST BE PLUGGED UNTIL THEY ARE TESTED AND FLUSHED.

3.DELETERIOUS MATERIALS SHALL BE PREVENTED FROM ENTERING THE CITY'S SEWER SYSTEM.

4.MINIMUM SLOPE ON CATCH BASIN LEADS TO BE 2%.

5.ALL STORM SEWER CONNECTIONS SHALL BE MARKED BY ALL OF THE FOLLOWING:
- 75MM STAMP MARK "D" IN THE CURB AT THE TIME OF CURB INSTALLATION, AND
- 50MM X 100MM STAKE (PAINTED GREEN) AT THE END OF THE PIPE.

6.ALL MANHOLES TO BE SIZED IN ACCORDANCE WITH THE MMCD DWG.S-1.

7.ALL TRENCH FOUNDATIONS TO BE APPROVED BY THE GEOGRAPHICAL ENGINEER.

8.CONTRACTOR SHALL KEEP PROPER AS-BUILT INFORMATION DURING CONSTRUCTION AND SUBMIT THE INFORMATION TO THE CONTRACT ADMINISTRATOR.

ROADS/PARKING LOT:

1.SITE PREPARATION FOR THE PROPOSED PARKING AREAS, SIDEWALKS AND ROADS SHALL INCLUDE STRIPPING AND DISPOSAL OF THE VEGETATION, TREES, ANY EXISTING PAVEMENT, HOG FUEL, AND ALL UNSUITABLE SURFACE MATERIAL. ONCE STRIPPING IS COMPLETE AND THE ROADWAY HAS BEEN EXCAVATED TO THE SUB-GRADE ELEVATION, THE REMAINING SURFACE SHALL BE PROOF-ROLLED, THE THE PROOF EXTENDING 3 METERS BEYOND THE EDGES OF THE PROPOSED EDGE OF PAVEMENT. ANY SOFT SPOTS IDENTIFIED SHALL BE OVER-EXCAVATED AND THE MATERIAL REPLACED WITH CLEAN GRANULAR MATERIAL.

2.BEFORE REMOVING ANY PAVEMENT, IT SHALL BE SAW CUT ALONG THE CUT LINE

3.PARKING AREA, SIDEWALK, RAMP AND ROAD FILL SHALL ONLY BE PLACED AFTER THE ACCEPTANCE OF THE PROOF-ROLLING OF THE SUB-GRADE. FILL MATERIALS SHALL BE APPROVED SELECTED GRANULAR MATERIALS, AS DESCRIBED IN THE UNIVERSITY BYLAW OR APPROVED BY THE GEOTECHNICAL ENGINEER

4.ALL MANHOLE COVERS, VALVE BOXES AND COVERS, CATCH BASIN RIMS AND GRATINGS, AND OTHER SUCH FIXTURES (NEW AND EXISTING) SHALL BE ADJUSTED TO FINAL GRADE OF PAVEMENT, GUTTER OR SOIL SURFACE

5.ALL CONNECTIONS TO EXISTING ROAD SURFACES AND EXISTING CONCRETE WORK SHALL BE MADE IN SMOOTH TRANSITION

6.ALL UNDERGROUND SERVICES SHALL BE INSTALLED, TESTED AND ACCEPTED BY THE CONSULTANT PRIOR TO PAVING AND THE BOULEVARD CONSTRUCTION

7.ALL RANDOM FILL AND TOPSOIL MUST BE TRUCKED OFF SITE OR USED AS LANDSCAPE FILL, PROVIDED THE FINISHED GRADES REMAIN AS DESIGNED

FOUNDATIONS:

1.BEARING SURFACES MUST BE APPROVED BY THE SOILS ENGINEER IMMEDIATELY PRIOR TO CONSTRUCTION.

2.REFER TO SOILS REPORT FOR OTHER SPECIFIC DESIGN REQUIREMENTS FOR FOOTING, SOIL SLOPES,FROST PROTECTION, MINIMUM COVER, ETC.

3.UNLESS OTHERWISE SHOWN, CENTER FOOTINGS BELOW COLUMNS AND WALLS.

4.DOWELS SHALL BE PLACED BEFORE CONCRETE IS PLACED. TEMPLATES SHALL BE USED TO ENSURE CORRECT PLACEMENT OF DOWELS.

5.FOOTINGS MAY HAVE TO BE LOWERED TO ACCOMMODATE MECHANICAL OR ELECTRICAL SERVICES. SEE MECHANICAL AND ELECTRICAL DRAWINGS FOR ELEVATIONS. FOOTINGS ARE NOT TO BE UNDERMINED BY EXCAVATIONS FOR SERVICES, PITS, ETC.

6.FOOTINGS ELEVATIONS, IF SHOWN, ARE FOR BIDDING PURPOSES ONLY, ARE NOT FINAL, AND MAY VARY ACCORDING TO SITE CONDITIONS OR AS REQUIRED BY SERVICES. ALL FOOTINGS MUST BE TAKEN TO A BEARING LAYER APPROVED BY THE SOILS ENGINEER.

7.BEARING SURFACES MUST BE PROTECTED FROM FREEZING BEFORE AND AFTER FOOTINGS ARE POURED.

8.SUB-BASE DESIGN OF THE SOIL UNDER THE SLAB ON GRADE SHALL BE IN ACCORDANCE WITH THE SOIL REPORT.

9.CONCRETE PLACED UNDER WATER SHALL CONFORM TO CAN/CSA-A23.1.

CONCRETE:

1.ALL CONCRETE SHALL CONFORM TO CSA STANDARD A23.1 (LATEST EDITION) HAVING A MINIMUM COMPRESSIVE STRENGTH AS SHOWN BELOW (UNLESS NOTED OTHERWISE).

2.ALL CAST-IN-PLACE CONCRETE SHALL CONFORM TO THE LATEST EDITION OF CSA STANDARD A23.1, "CONCRETE MATERIALS AND METHODS OF CONCRETE CONSTRUCTION".

3.SUBMIT CONCRETE MIX DESIGN TO ENGINEER PRIOR TO PRODUCTION. NO WATER SHALL BE ADDED TO THE CONCRETE AT THE SITE.

4.SUBMIT PLACING DRAWINGS AND BAR LISTS FOR ALL REINFORCING STEEL TO RSIO MANUAL SUFFICIENTLY DETAILED AND DIMENSIONED TO PERMIT PLACING OF ALL REINFORCING WITHOUT REFERENCE TO DESIGN DRAWINGS.

5.THE OWNER WILL EMPLOY A TESTING COMPANY TO CONDUCT STRENGTH, SLUMP, MATERIAL AND AIR ENTRAINED TESTS ONCE FOR EVERY DAY CONCRETE IS POURED. STRENGTH TEST SHALL INCLUDE THREE CYLINDERS, ONE TESTED AT 7 DAYS AND TWO TESTED AT 28 DAYS IN ACCORDANCE WITH CAN3-A23.2. SLUMP AND AIR CONTENT TESTS SHALL CONSIST OF ONE SAMPLE EACH IN ACCORDANCE WITH CAN3-23.1 AND CAN3-A23.2.

6.ALL CONCRETE THAT WILL BE EXPOSED TO WEATHER SHALL HAVE A 5 TO 7% AIR ENTRAINMENT AT TIME OF PLACING.

7.BULL FLOAT CONCRETE SURFACES AND PROVIDE A LIGHT TROWEL FINISH TO PRODUCE A SMOOTH NON-SLIP SURFACE FREE FROM RIDGES, VOIDS AND MACHINE MARKS. EXTERIOR CONCRETE WALKING SURFACES SHALL HAVE A LIGHT BROOM FINISH TO CREATE A NON-SLIP SURFACE. PROVIDE ROUGH SURFACE AT COLD JOINTS.

8.KEEP CONTINUOUSLY MOIST ALL EXPOSED NON-FORMED SURFACES FOR A MINIMUM OF SEVEN CONSECUTIVE DAYS AFTER PLACEMENT OF CONCRETE UNLESS NOTED OTHERWISE.

9.ALL EXPOSED CONCRETE EDGES ARE TO HAVE A THREE-QUARTER INCH (3/4") CHAMFER UNLESS NOTED OTHERWISE.

10.WHERE NEW CONCRETE IS TO BE PLACED AGAINST EXISTING CONCRETE, EXISTING CONCRETE MUST BE THOROUGHLY CLEANED TO REMOVE OIL, GREASE AND DIRT AND BE SURFACE 'CHIPPED' A MINIMUM OF ONE-HALF 20.(1/2) INCH PRIOR TO PLACEMENT OF NEW CONCRETE UNLESS NOTED OTHERWISE ON DRAWINGS. APPLICATION OF AN APPROVED BONDING AGENT SHALL BE APPLIED AT ALL INTERFACES BETWEEN NEW AND OLD CONCRETE.

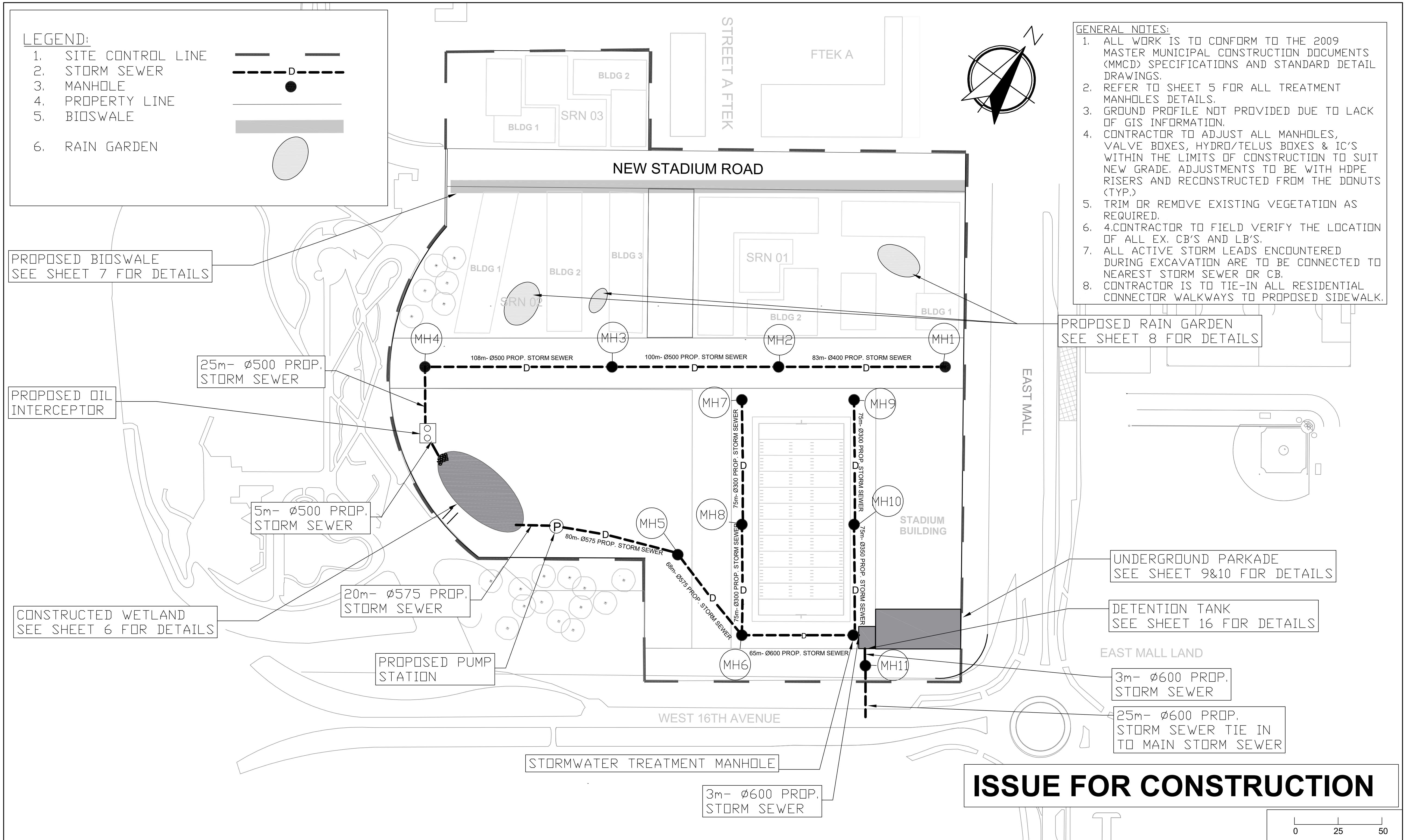
CONSULTANT:	UBC Sustainability	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: General Notes	SCALE: N/A	DATE: 2019.03.29
				DRAWN BY: YZ	DESIGN BY: JK
		PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: JK	DWG NO.: 2 of 20
				REV.	

LEGEND:

1. SITE CONTROL LINE
2. STORM SEWER
3. MANHOLE
4. PROPERTY LINE
5. BIOSWALE
6. RAIN GARDEN

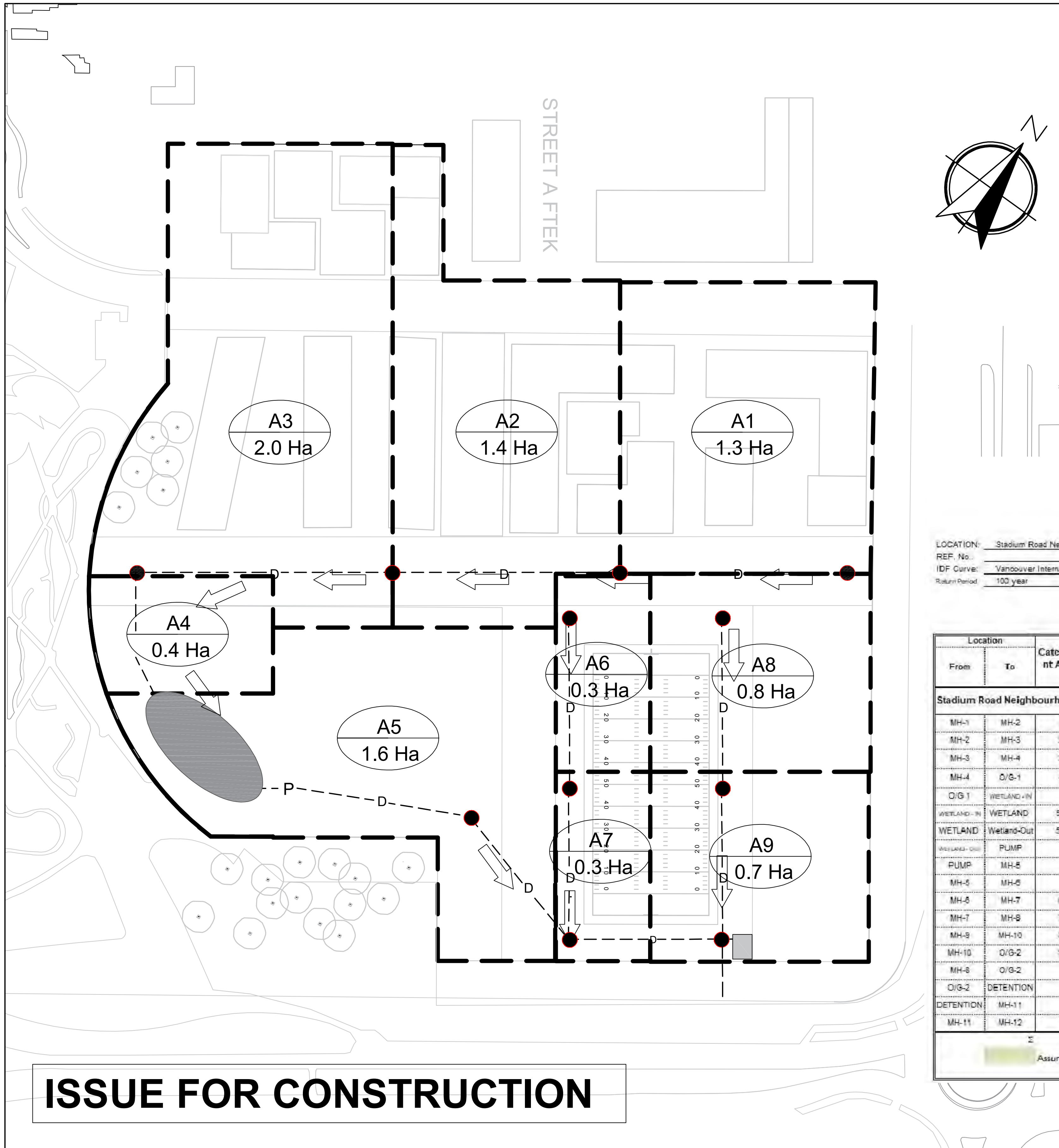
GENERAL NOTES:

1. ALL WORK IS TO CONFORM TO THE 2009 MASTER MUNICIPAL CONSTRUCTION DOCUMENTS (MMCD) SPECIFICATIONS AND STANDARD DETAIL DRAWINGS.
2. REFER TO SHEET 5 FOR ALL TREATMENT MANHOLES DETAILS.
3. GROUND PROFILE NOT PROVIDED DUE TO LACK OF GIS INFORMATION.
4. CONTRACTOR TO ADJUST ALL MANHOLES, VALVE BOXES, HYDRO/TELUS BOXES & IC'S WITHIN THE LIMITS OF CONSTRUCTION TO SUIT NEW GRADE. ADJUSTMENTS TO BE WITH HDPE RISERS AND RECONSTRUCTED FROM THE DONUTS (TYP.)
5. TRIM OR REMOVE EXISTING VEGETATION AS REQUIRED.
6. 4.CONTRACTOR TO FIELD VERIFY THE LOCATION OF ALL EX. CB'S AND LB'S.
7. ALL ACTIVE STORM LEADS ENCOUNTERED DURING EXCAVATION ARE TO BE CONNECTED TO NEAREST STORM SEWER OR CB.
8. CONTRACTOR IS TO TIE-IN ALL RESIDENTIAL CONNECTOR WALKWAYS TO PROPOSED SIDEWALK.



ISSUE FOR CONSTRUCTION

CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: KEY PLAN	SCALE: 1: 500	DATE: 2018.11.07
			DRAWN BY: YZ	DESIGN BY: JF/PS
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: JF/PS	DWG NO.: 3 of 20
			REV.	



LEGEND:

- 100 YEAR FLOW IN PIPE
- SUB CATCHMENT BOUNDARY LINE
- PROPOSED STORM SWER ---D---
- MAHOLE
- CATCHMENT AREA (CATCHMENT #: A1; AREA (Ha): 1.3 Ha)

POST-DEVELOPMENT

STORM SEWER DESIGN - RATIONAL METHOD

Sub-Catchment Plan

LOCATION: Stadium Road Neighbourhood, UBC
REF. No.:
IDF Curve: Vancouver International Airport
Return Period: 100 year

Qpeak=Runoff (m³/s)
R=Runoff Coefficient
A=Area (ha)
I=Rainfall Intensity (mm/hr)
N=0.00278

Tc=Ti+Tt
Tc=Time of Concentration (min)
Ti=Inlet Time (min)
Tt=Travel Time (min)
I = aTb where I in mm/hr, T in hr
a = 26.100
b = -0.558

Ø=Pipe Diameter (mm)
n=Roughness Coefficient
S=Slope of Pipe (%)
Vcap=Velocity at Capacity (m/s)
L=Length of Pipe (m)
Qcap=Flow at Capacity (m³/s)

Date: 26-Nov-18
Calc. By: Peggy Shen
Sheet: 1 of 1

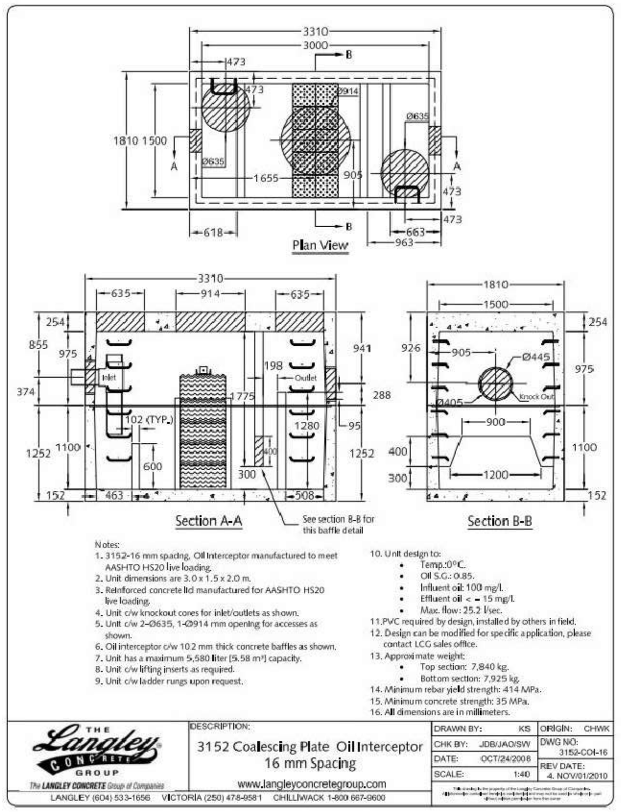
Location		Catchment Area	Tributary Area				Run-off					Sewer Design						Adjusted Tt	HGL Condition
From	To		A (ha)	R	RA	Σ(AR)	Ti (min)	Tt (min)	Tc (min)	I (mm/hr)	Qpeak (m³/s)	Qcap (m³/s)	Ø (mm)	n	S (%)	Vcap (m/s)	L (m)	(min)	
Stadium Road Neighbourhood																			
MH-1	MH-2	1	1.30	0.72	0.94	0.94	15.00	1.18	16.18	54.2	0.141	0.147	400	0.013	0.500	1.17	83.0	1.18	SURFACE
MH-2	MH-3	2	1.44	0.72	1.04	1.97	16.18	1.00	17.18	52.4	0.288	0.327	500	0.013	0.750	1.67	100.0	1.00	SURFACE
MH-3	MH-4	3	1.99	0.72	1.43	3.41	17.18	0.71	17.89	51.3	0.485	0.499	500	0.013	1.750	2.54	108.3	0.71	SURFACE
MH-4	O/G-1	4	0.37	0.72	0.27	3.67	17.89	0.15	18.04	51.0	0.521	0.534	500	0.013	2.000	2.72	25.0	0.15	SURFACE
O/G 1	WETLAND - IN			-	-	3.67	18.04	0.03	18.07	51.0	0.520	0.534	500	0.013	2.000	2.72	5.0	0.03	SURFACE
WETLAND - IN	WETLAND	5A	1.48	0.30	0.45	4.12	15.00												
WETLAND	Wetland-Out	5B	0.13	1.00	0.13	4.24	15.00												
WETLAND - OUT	PUMP			-	-	4.12	18.07	0.10	18.17	50.8	0.582	0.866	575	0.013	2.500	3.34	20.0	0.10	SURFACE
PUMP	MH-5			-	-	4.12	18.17	0.40	18.57	50.2	0.575	0.866	575	0.013	2.500	3.34	80.0	0.40	SURFACE
MH-5	MH-6			-	-	4.12	18.57	0.34	18.91	49.7	0.569	0.866	575	0.013	2.500	3.34	68.0	0.34	SURFACE
MH-6	MH-7	6	0.33	0.95	0.31	0.33	15.00	0.91	15.91	54.7	0.050	0.097	300	0.013	1.000	1.37	75.0	0.91	SURFACE
MH-7	MH-8	7	0.31	0.95	0.30	0.64	15.91	0.91	16.83	53.1	0.095	0.097	300	0.013	1.000	1.37	75.0	0.91	SURFACE
MH-9	MH-10	8	0.77	0.95	0.73	0.77	15.00	0.75	15.75	55.1	0.117	0.118	300	0.013	1.500	1.68	75.0	0.75	SURFACE
MH-10	O/G-2	9	0.73	0.95	0.69	1.50	15.75	0.53	16.28	54.0	0.225	0.226	350	0.013	2.400	2.35	75.0	0.53	SURFACE
MH-8	O/G-2			-	-	4.76	18.91	0.45	19.36	49.1	0.649	0.686	600	0.013	1.250	2.43	65.0	0.45	SURFACE
O/G-2	DETENTION			-	-	6.26	19.36	0.02	19.38	49.0	0.853	0.868	600	0.013	2.000	3.07	3.0	0.02	SURFACE
DETENTION	MH-11			-	-	6.26	19.38	0.02	19.39	49.0	0.852	0.868	600	0.013	2.000	3.07	3.0	0.02	SURFACE
MH-11	MH-12			-	-	6.26	19.39	0.14	19.53	48.8	0.849	0.868	600	0.013	2.000	3.07	25.0	0.14	SURFACE
		Σ	8.85 ha																

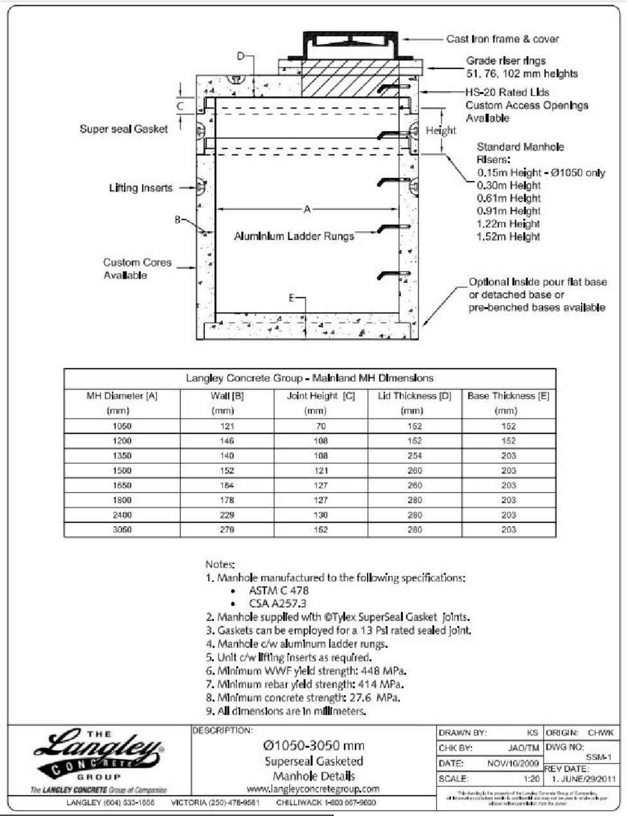
Assuming wetland has surface area of 0.13ha and a depth of 0.45m

ISSUE FOR CONSTRUCTION

CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: STORMWATER CONTROL PLAN	SCALE: 1: 500	DATE: 2018.11.27
			DRAWN BY: YZ	DESIGN BY: PS
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: PS	DWG NO.: 4 of 20
			REV.	

UBC Sustainability

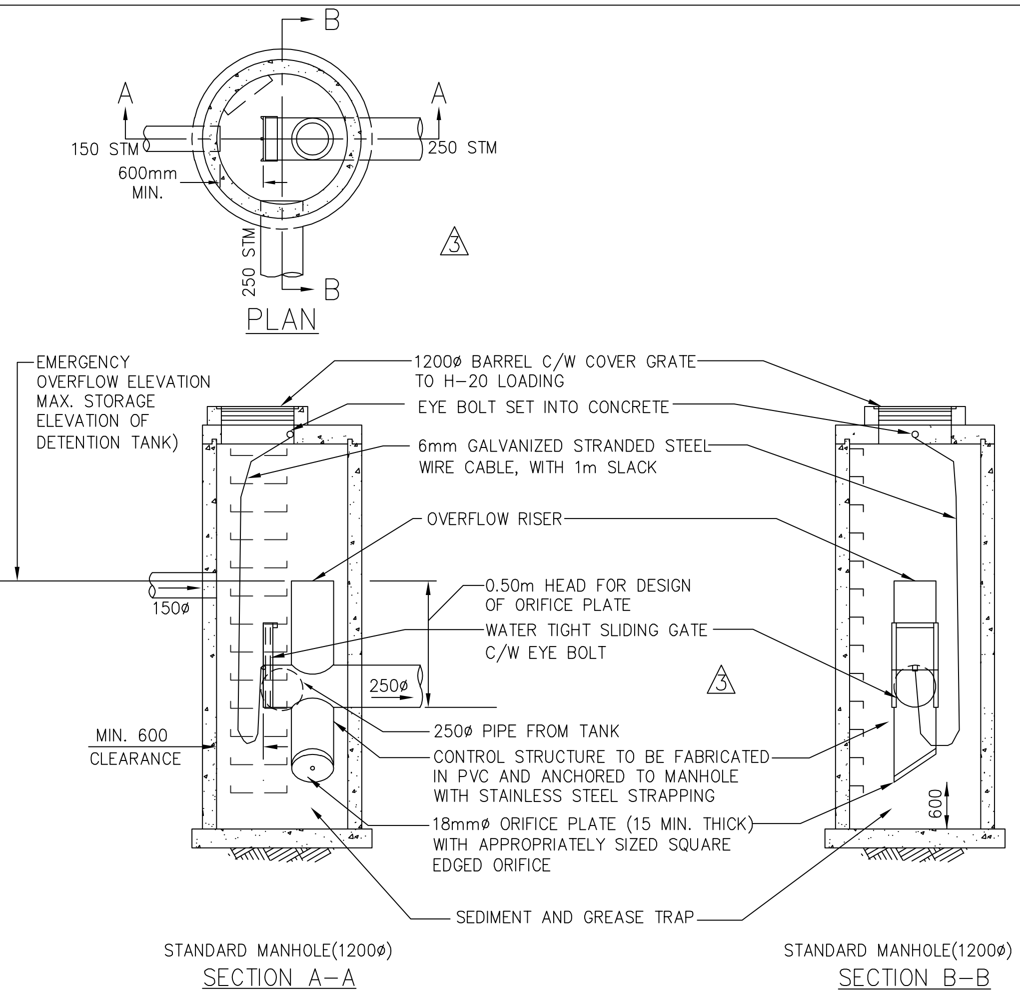




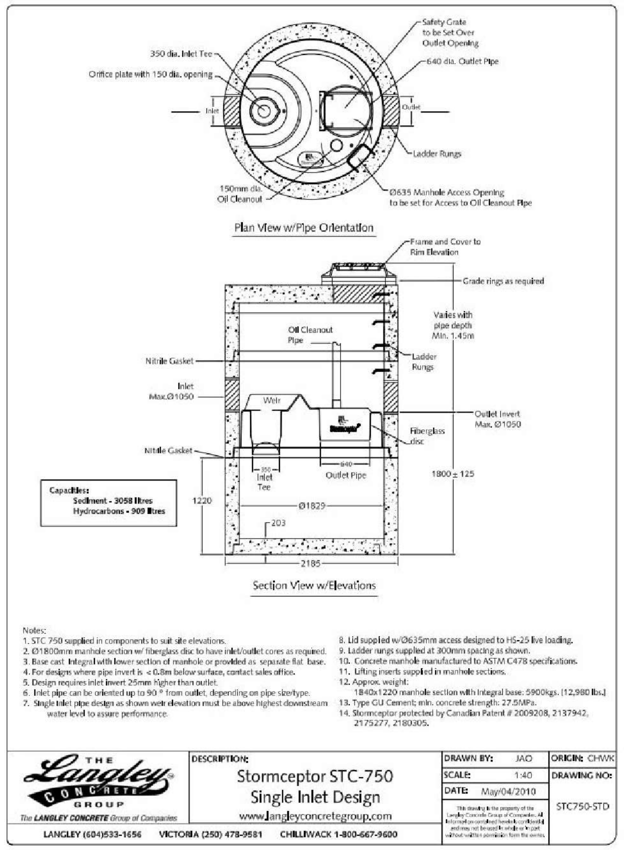
Langley Concrete Group - Mainland MH Dimensions

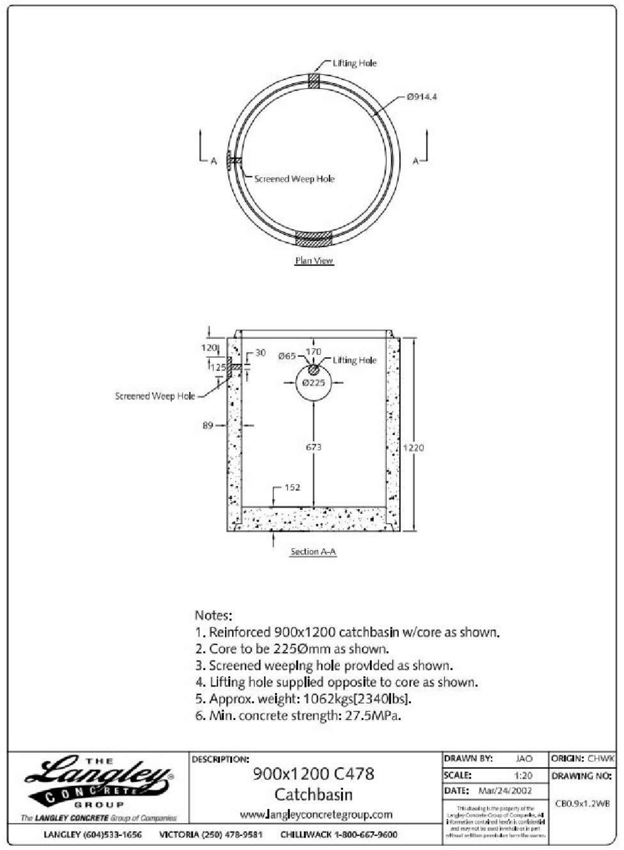
MH Diameter [A] (mm)	Wall [B] (mm)	Joint Height [C] (mm)	Lid Thickness [D] (mm)	Base Thickness [E] (mm)
1050	121	70	152	152
1200	146	108	152	152
1350	140	108	254	203
1500	152	121	260	203
1650	184	127	260	203
1800	178	127	280	203
2400	229	130	280	203
3050	279	152	280	203

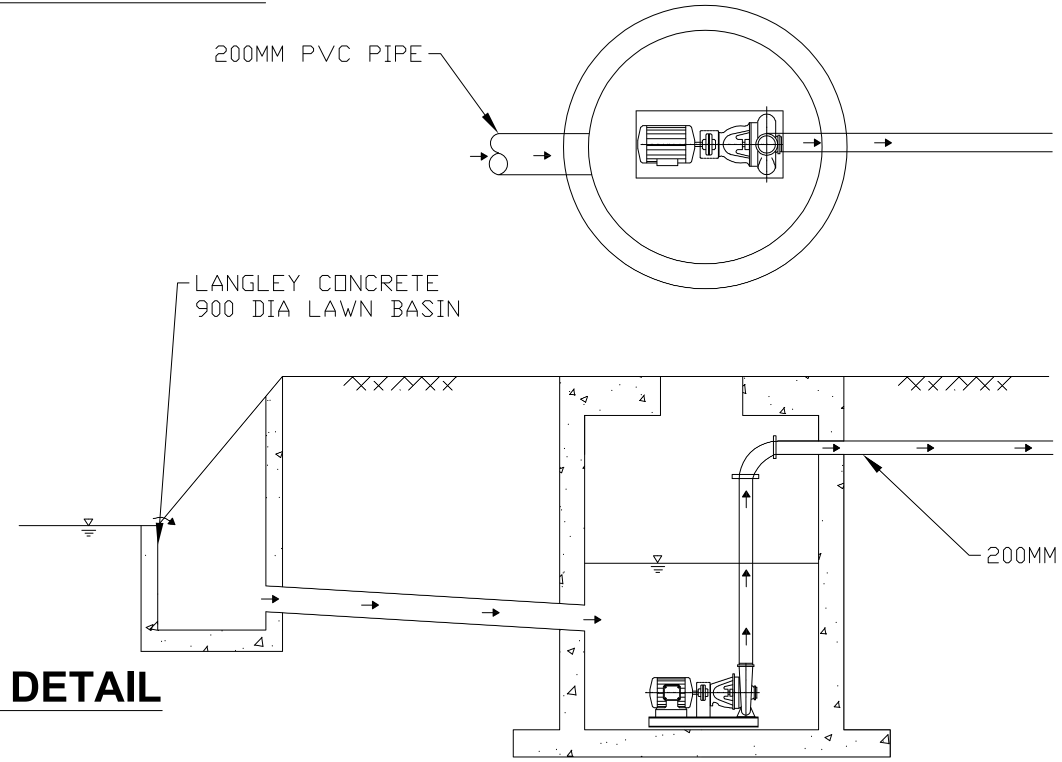
ISSUE FOR CONSTRUCTION



FLOW CONTROL MANHOLE
SCALE 1:200

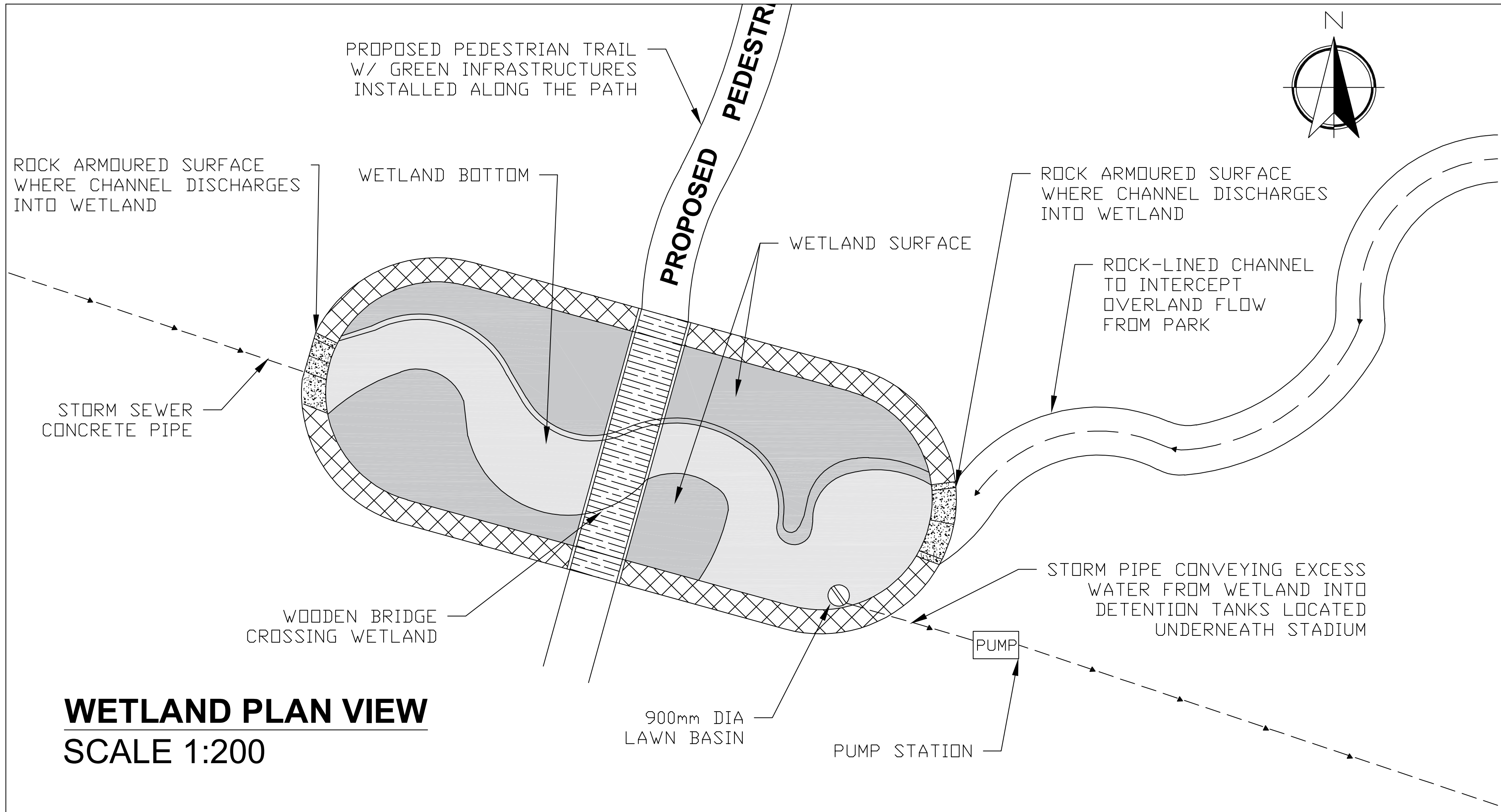






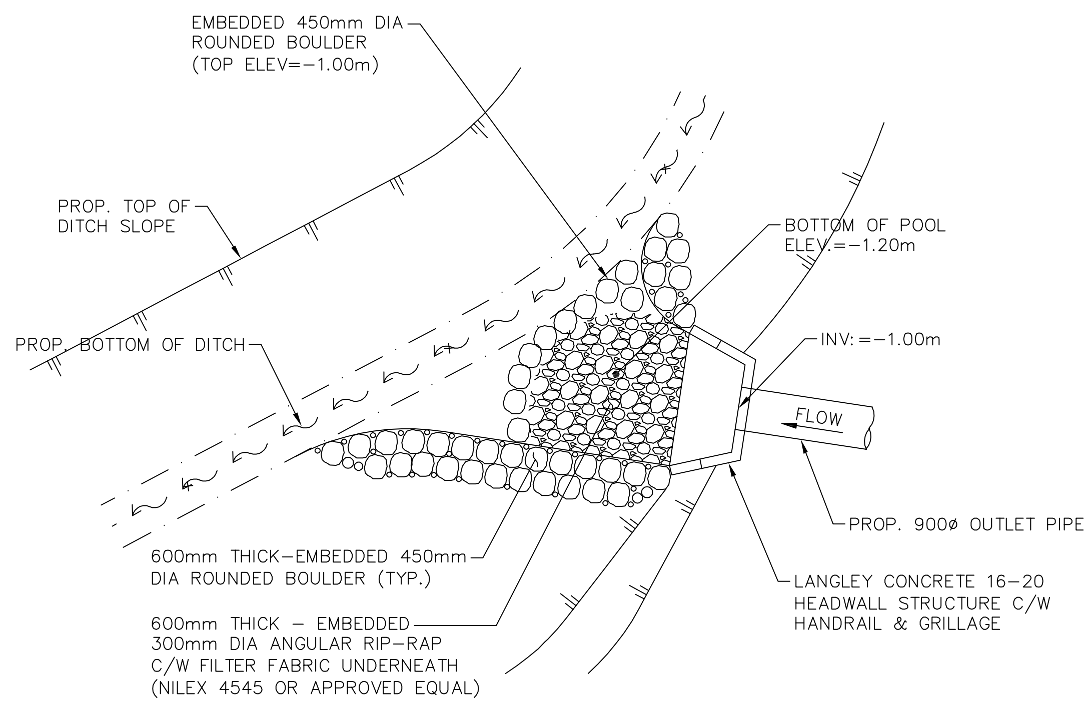
PUMP STATION DETAIL
SCALE 1:100

CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE:	SCALE: N/A	DATE: 2019.03.29
		MANHOLES DETAILS	DRAWN BY: YZ	DESIGN BY: YZ
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: JF	DWG NO.: 5 of 20
			REV.	



WETLAND PLAN VIEW

SCALE 1:200



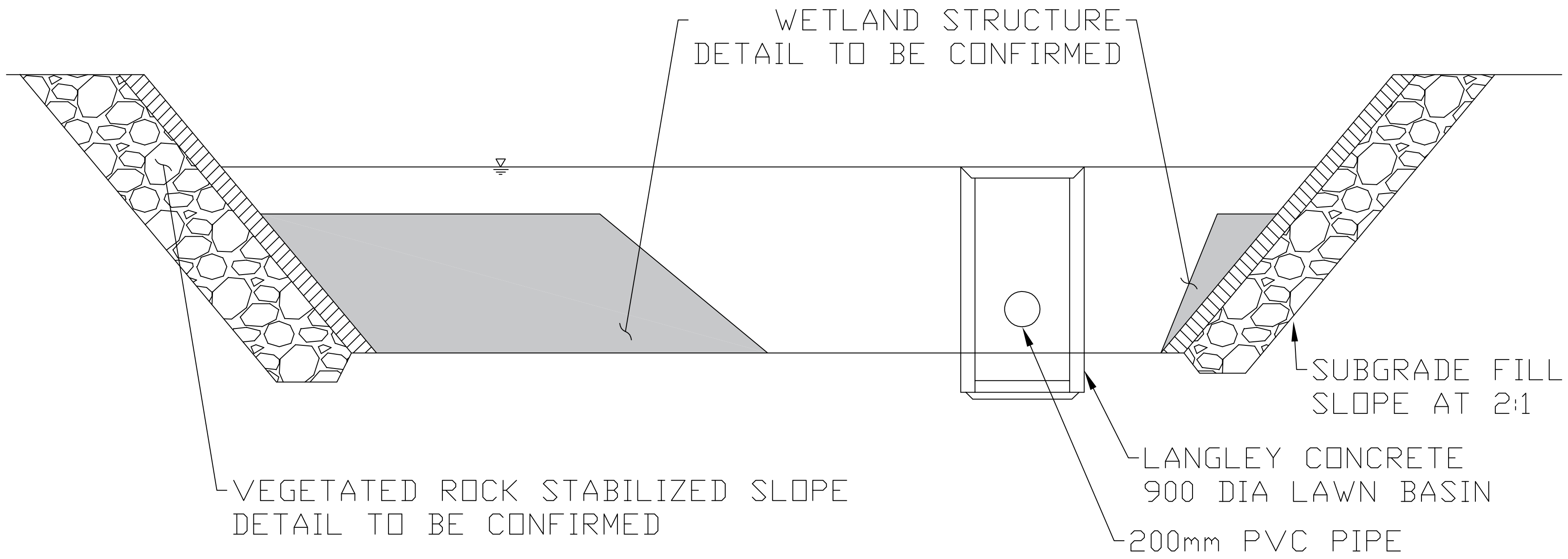
DRAINAGE OUTFALL DETAILS

SCALE 1:100

GENERAL NOTES:

1. PUMP AND PIPE SIZE TO BE DETERMINED AS PER FINAL DESIGN CALCULATION NEXT TERM.
2. SIZE OF WETLAND AND VAULT TO BE DETERMINED BASE ON VOLUME AND CONTROLLED RELEASED RATE.
3. ALL DIMENSIONS ARE IN MILLIMETERS.

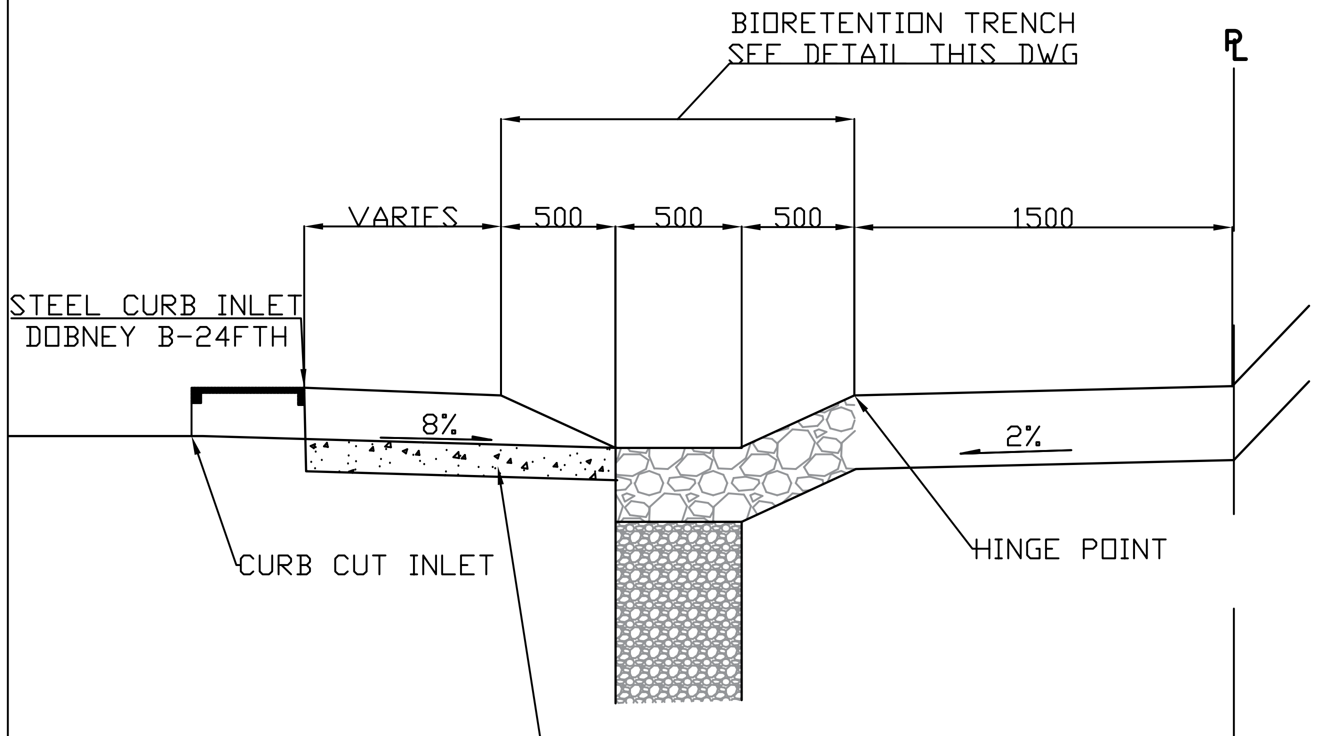
ISSUE FOR CONSTRUCTION



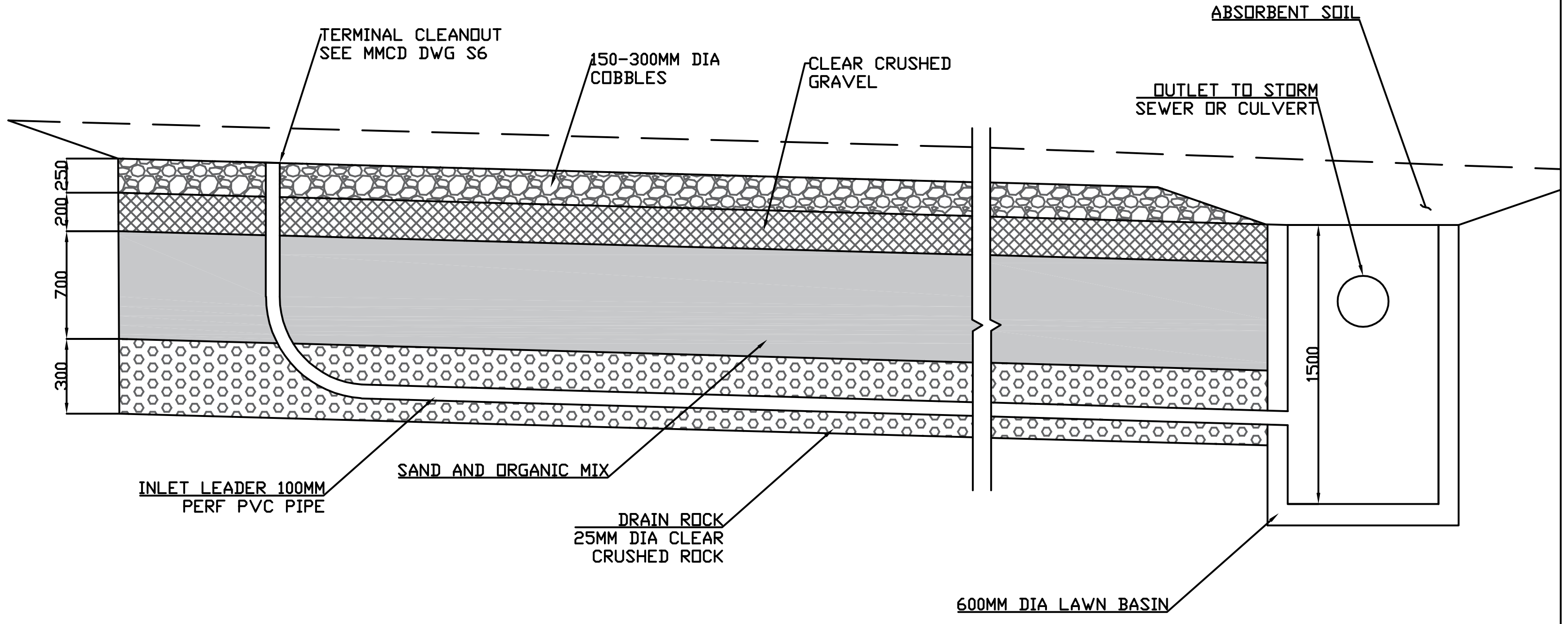
WETLAND SECTION VIEW

SCALE 1:200

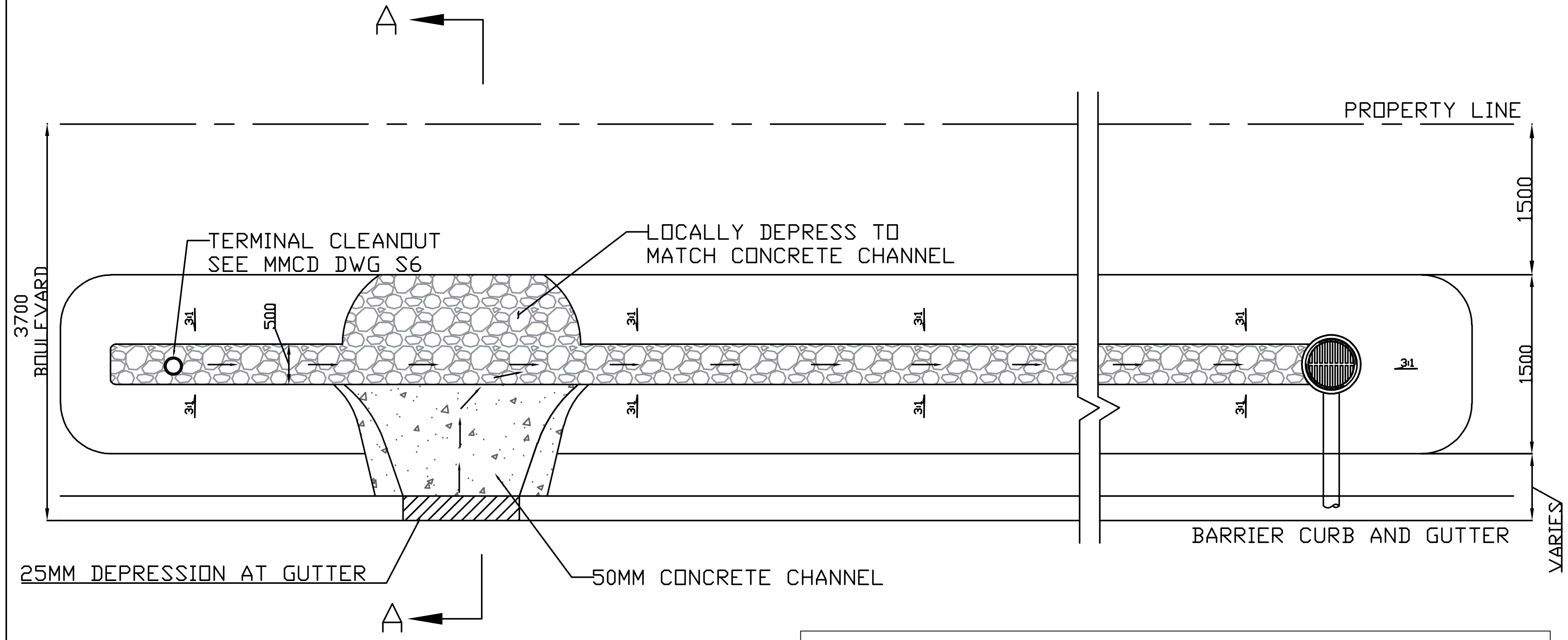
CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: CONSTRUCTED WETLAND DETAILS	SCALE: N/A	DATE: 2019.03.30
			DRAWN BY: YZ	DESIGN BY: JF
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: JF	DWG NO.: 6 of 20
			REV.	

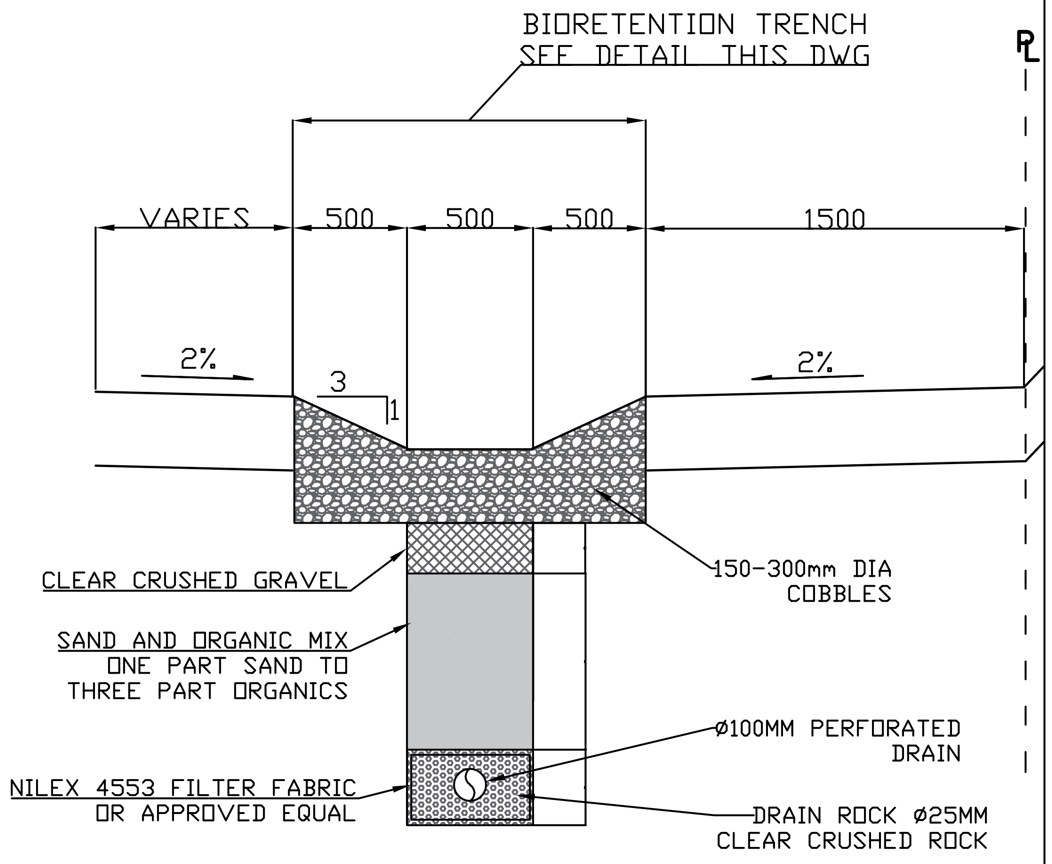


BIORETENTION TRENCH SECTION A
SCALE 1:30



SECTION ALONG BIORETENTION TRENCH
SCALE 1:150





ISSUE FOR CONSTRUCTION

BIORETENTION TRENCH
SCALE 1:60

BIORETENTION TRENCH SECTION VIEW
SCALE 1:30

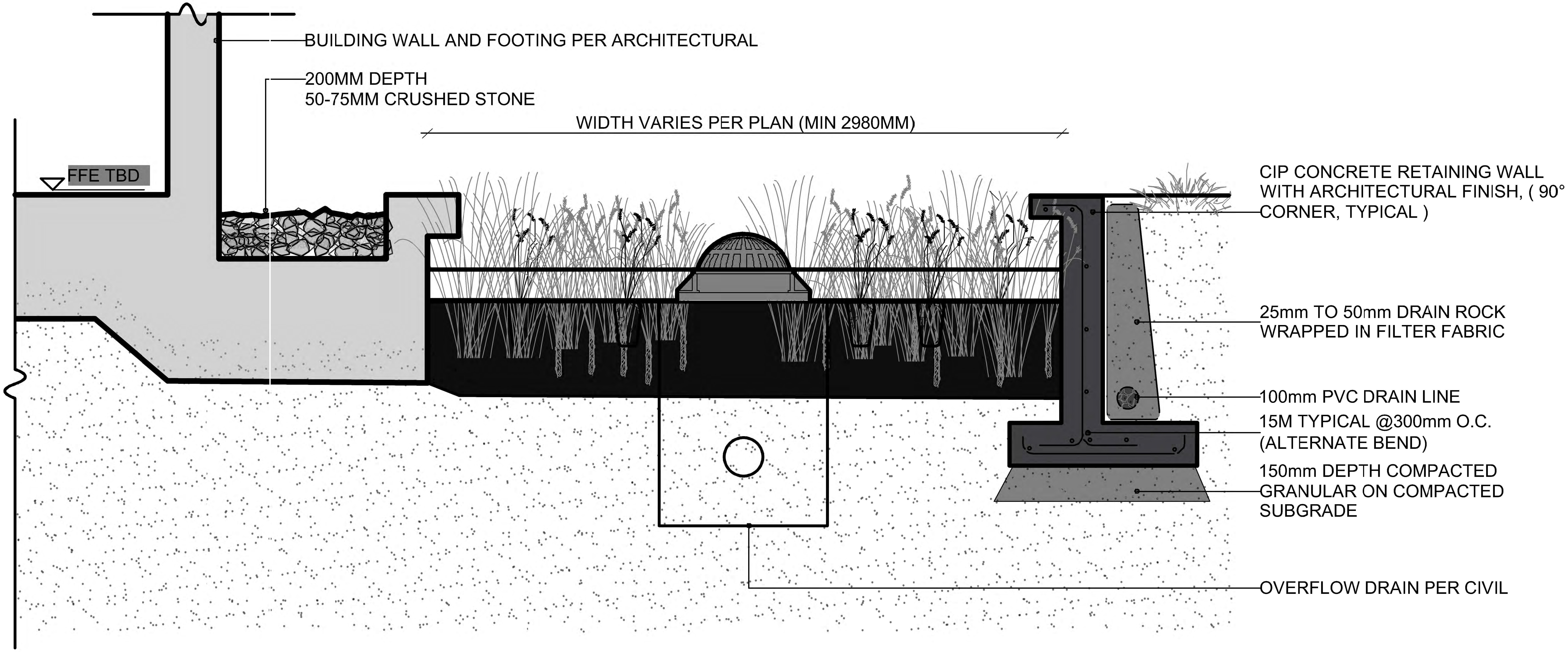
CONSULTANT:

CLIENT:
UBC SEEDS SUSTAINABILITY PROGRAM

PROJECT:
UBC STADIUM ROAD NEIGHBORHOOD
MUNICIPAL INFRASTRUCTURE IMPROVEMENT

SHEET TITLE:
Bio-retention Trench Details

SCALE: N/A
DATE: 2018.11.21
DRAWN BY: YZ
DESIGN BY: JF
REVIEW BY: JF
DWG NO.:
7 of 20
REV.



ISSUE FOR CONSTRUCTION

CONSULTANT:	UBC Sustainability	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: Rain Garden Typical Cross Section	SCALE: 1:20	DATE: 2019.03.29
				DRAWN BY: YZ	DESIGN BY: DL
		PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: DL	DWG NO.: 8 of 20
				REV.	

GENERAL NOTES:

1. PARKING STALL SIZE AND SINGLE LANE WIDTH ARE CONFORM TO CITY OF VANCOUVER PARKING DESIGN APPENDIX A.
2. PARKING STALL LEGEND AND DIMENSION:

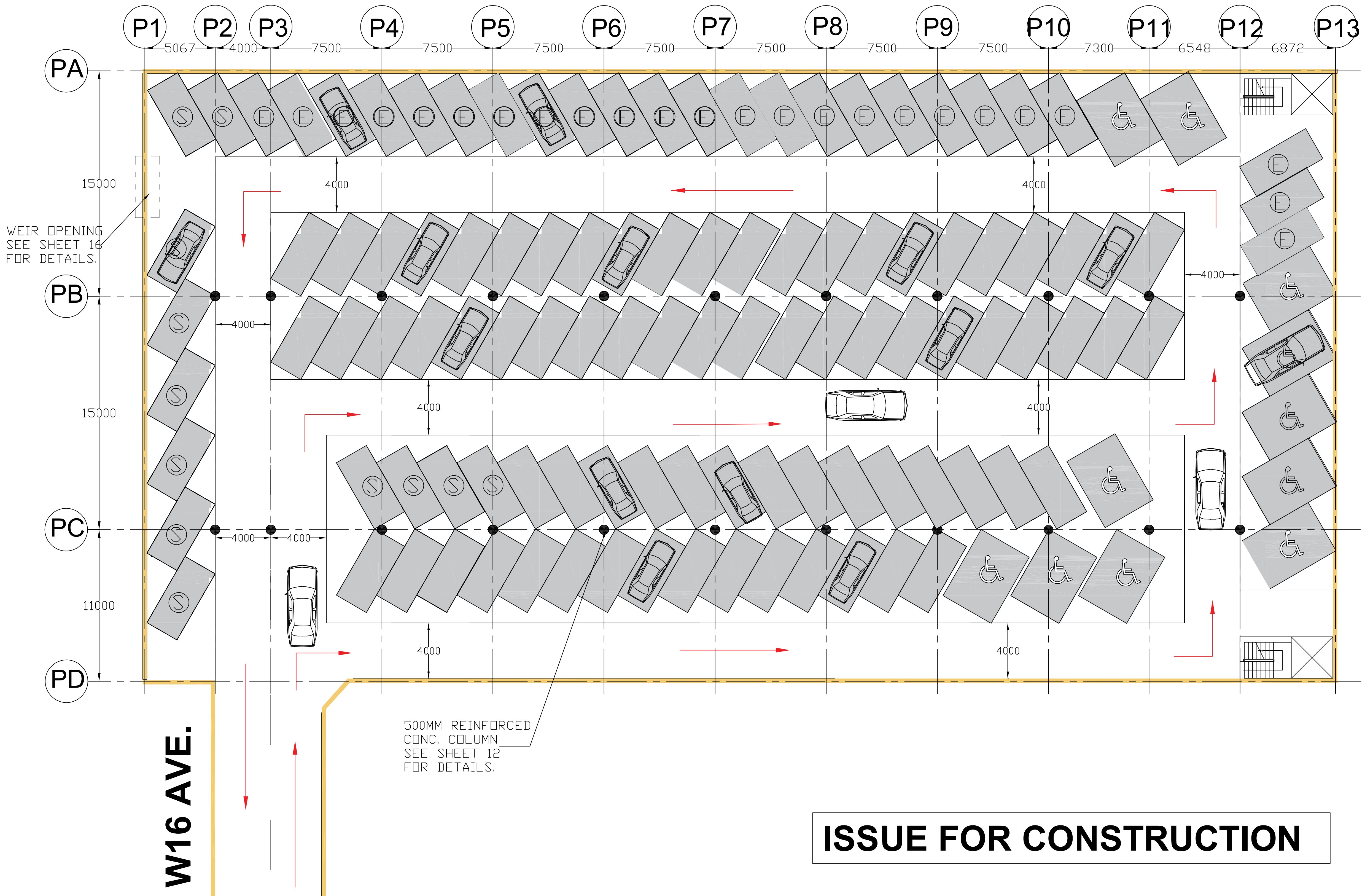
2500 × 5500 — STANDARD CAR: CAR SHARING STALL

2500 × 5500 — STANDARD CAR: ELECTRICAL VEHICLE STALL

2500 × 5500 — STANDARD CAR STALL

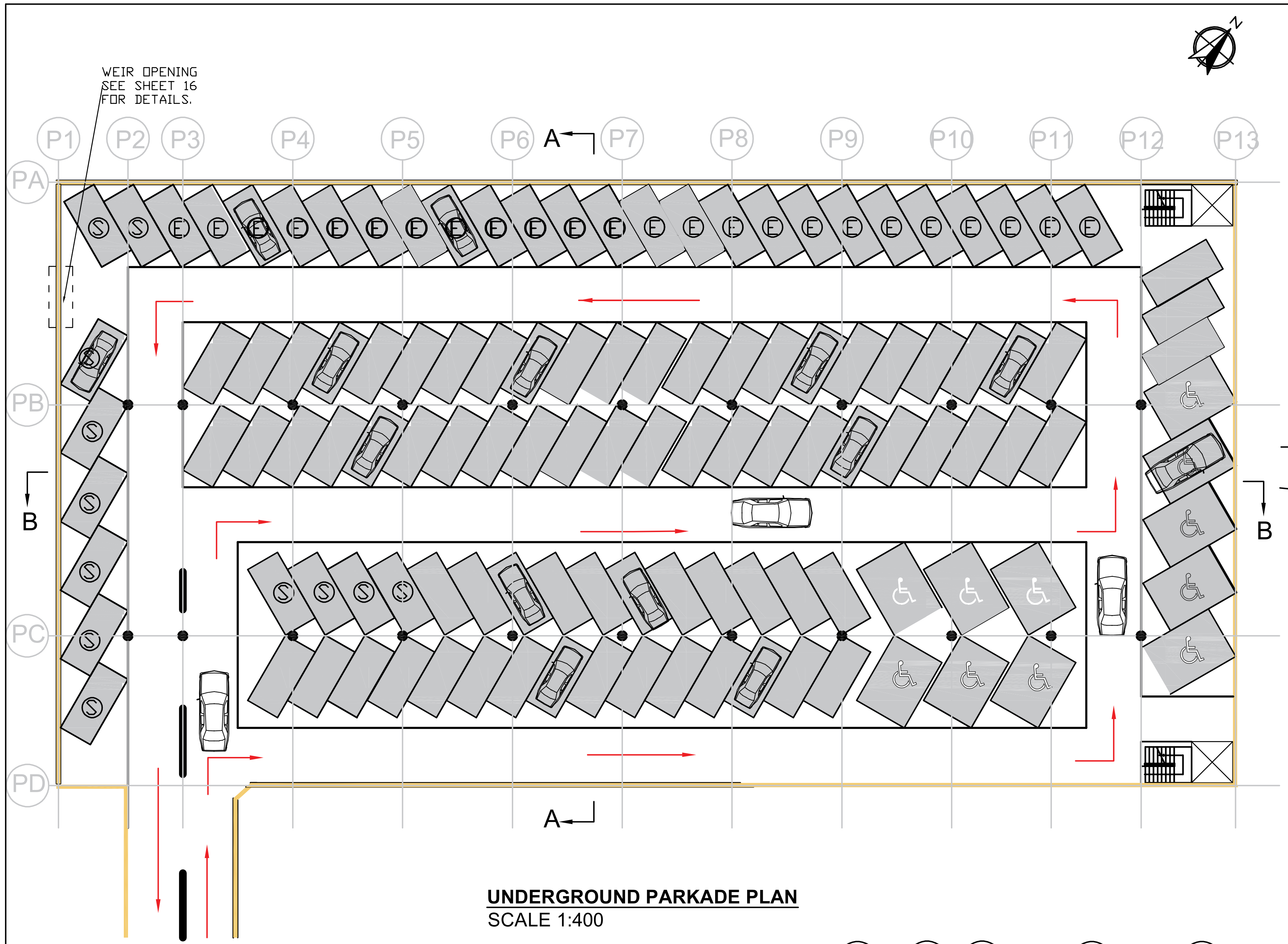
4000 × 5500 — DISABILITY STALL

3. ALL PARKING STALLS ARE ROTATED BY 60 DEGREE.
4. FOR ALL STRUCTURAL COMPONENTS, REFER TO SHEET 11,12&13.
5. ALL DIMENSIONS ARE IN MILLIMETER.



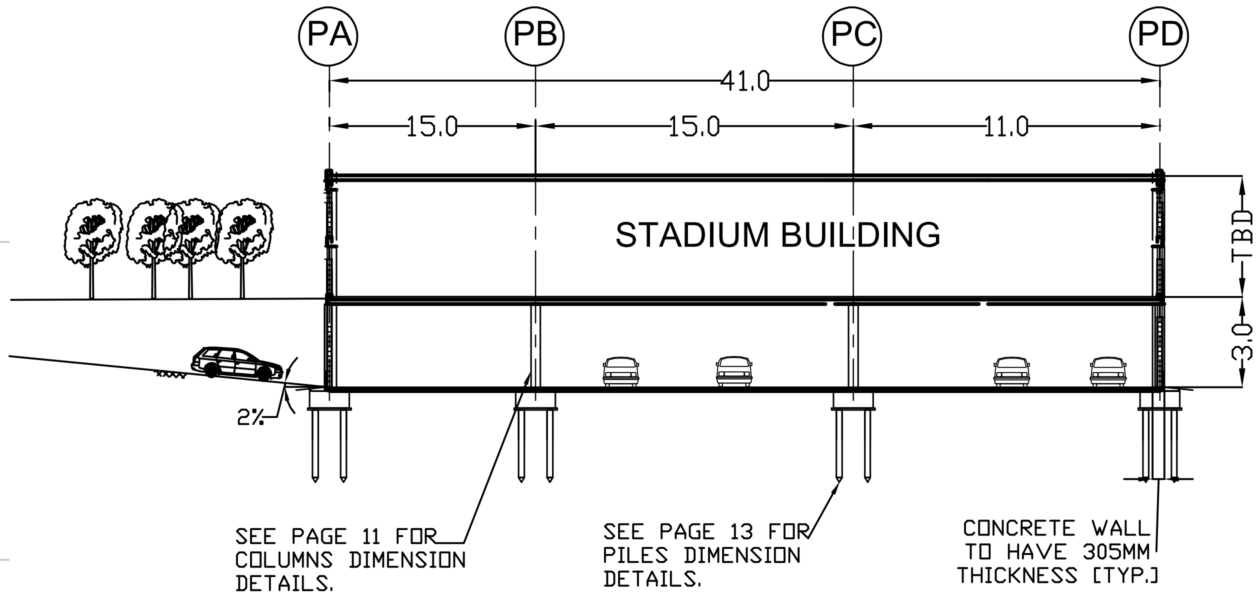
ISSUE FOR CONSTRUCTION

CONSULTANT:	UBC Sustainability	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: UNDERGROUND PARKING PLAN	SCALE: 1:300	DATE: 2018.11.25
		PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		DRAWN BY: YZ	DESIGN BY: DL/KW
				REVIEW BY: DL	DWG NO.: 9 of 20
				REV. A	



UNDERGROUND PARKADE PLAN

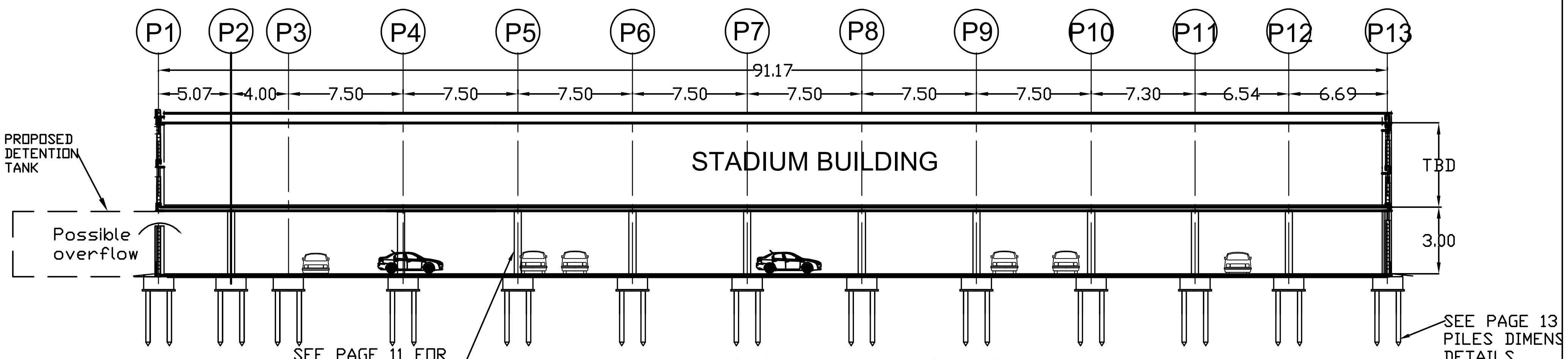
SCALE 1:400



UNDERGROUND PARKADE SECTION A-A

SCALE 1:400

ISSUE FOR CONSTRUCTION



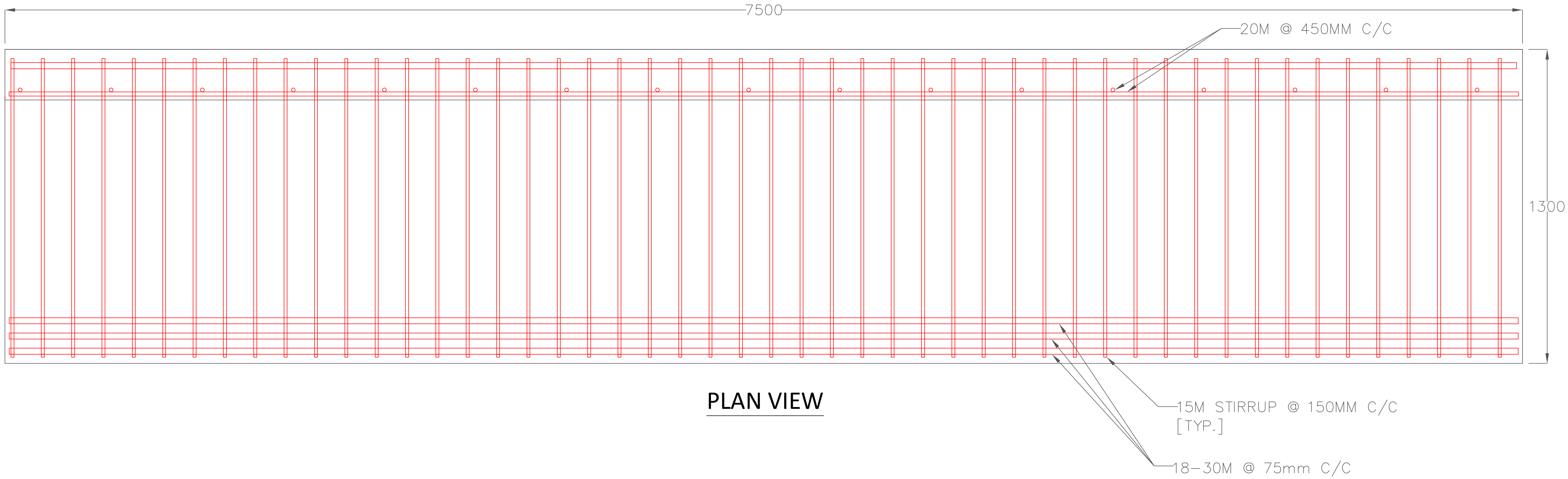
UNDERGROUND PARKADE SECTION B-B

SCALE 1:400

GENERAL NOTES:

1. SITE PREPARATION FOR THE PROPOSED PARKING AREAS, SIDEWALKS AND ROADS SHALL INCLUDE STRIPPING AND DISPOSAL OF THE VEGETATION, TREES, ANY EXISTING PAVEMENT, HOG FUEL, AND ALL UNSUITABLE SURFACE MATERIAL. ONCE STRIPPING IS COMPLETE AND THE ROADWAY HAS BEEN EXCAVATED TO THE SUB-GRADE ELEVATION, THE REMAINING SURFACE SHALL BE PROOF-ROLLED, THE THE PROOF EXTENDING 3 METERS BEYOND THE EDGES OF THE PROPOSED EDGE OF PAVEMENT. ANY SOFT SPOTS IDENTIFIED SHALL BE OVER-EXCAVATED AND THE MATERIAL REPLACED WITH CLEAN GRANULAR MATERIAL.
2. ALL DIMENSIONS ARE IN METRES.

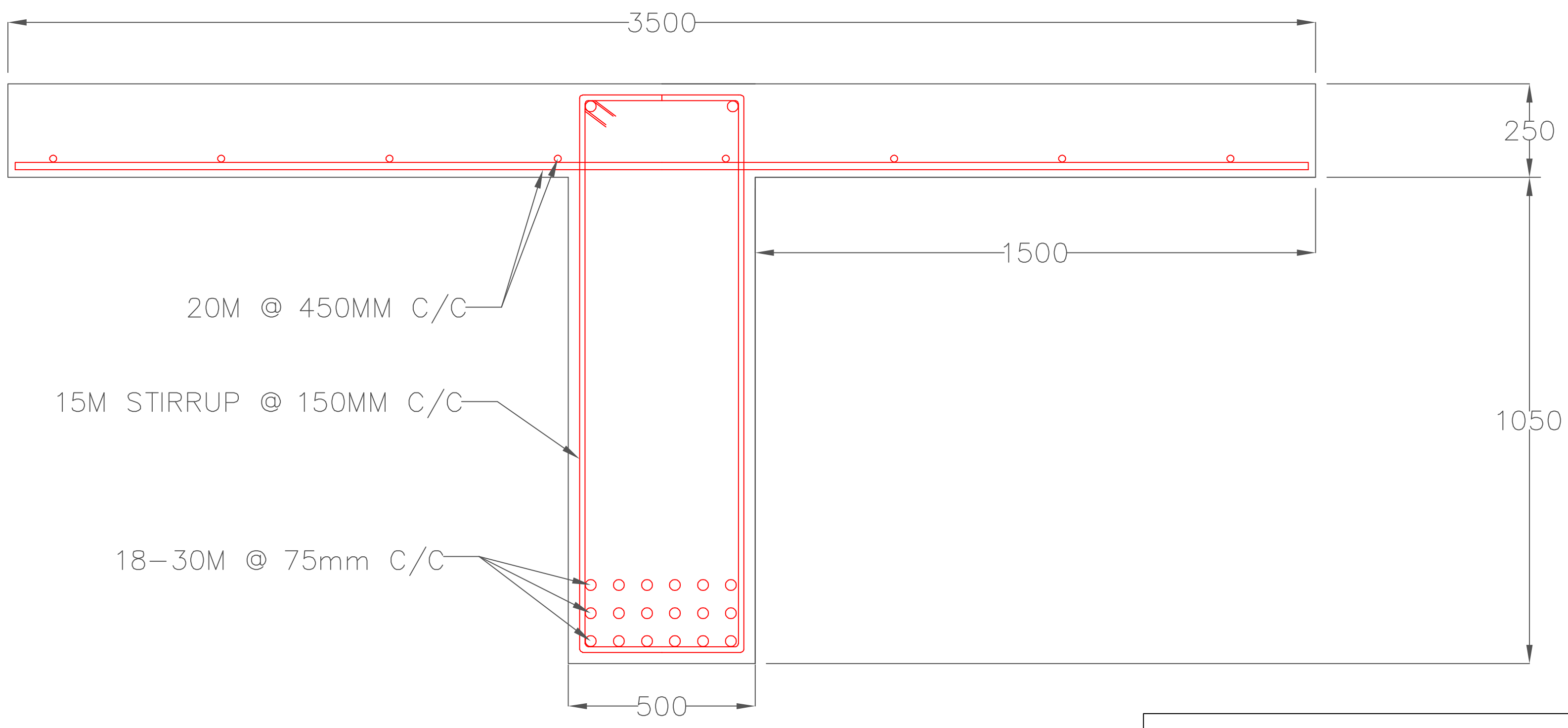
CONSULTANT:	UBC Sustainability	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: UNDERGROUND PARKADE DIMENSIONS	SCALE: N/A
				DATE: 2019.03.29
				DRAWN BY: YZ
				DESIGN BY: DL/YZ
		PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: DL
				REV.
				DWG NO.: 10 of 20



PLAN VIEW

GENERAL NOTES:

1. ALL CONCRETE SHALL CONFORM TO CSA STANDARD A23.1 (LATEST EDITION) HAVING A MINIMUM COMPRESSIVE STRENGTH OF 35MPA.
2. ALL CONCRETE THAT WILL BE EXPOSED TO WEATHER SHALL HAVE A 5 TO 7% AIR ENTRAINMENT AT TIME OF PLACING.
3. KEEP CONTINUOUSLY MOIST ALL EXPOSED NON-FORMED SURFACES FOR A MINIMUM OF SEVEN CONSECUTIVE DAYS AFTER PLACEMENT OF CONCRETE UNLESS NOTED OTHERWISE.
4. MINIMUM REBAR YIELD STRENGTH: 414 MPA.
5. ALL REINFORCING TO HAVE MINIMUM 20MM OF CONCRETE COVER.
6. ALL DIMENSIONS ARE IN MILLIMETERS.



SECTION VIEW

ISSUE FOR CONSTRUCTION

CONSULTANT:

CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM

PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT

SHEET TITLE: REINFORCED CONCRETE BEAM DETAILS

SCALE: 1:20

DATE: 2019.03.29

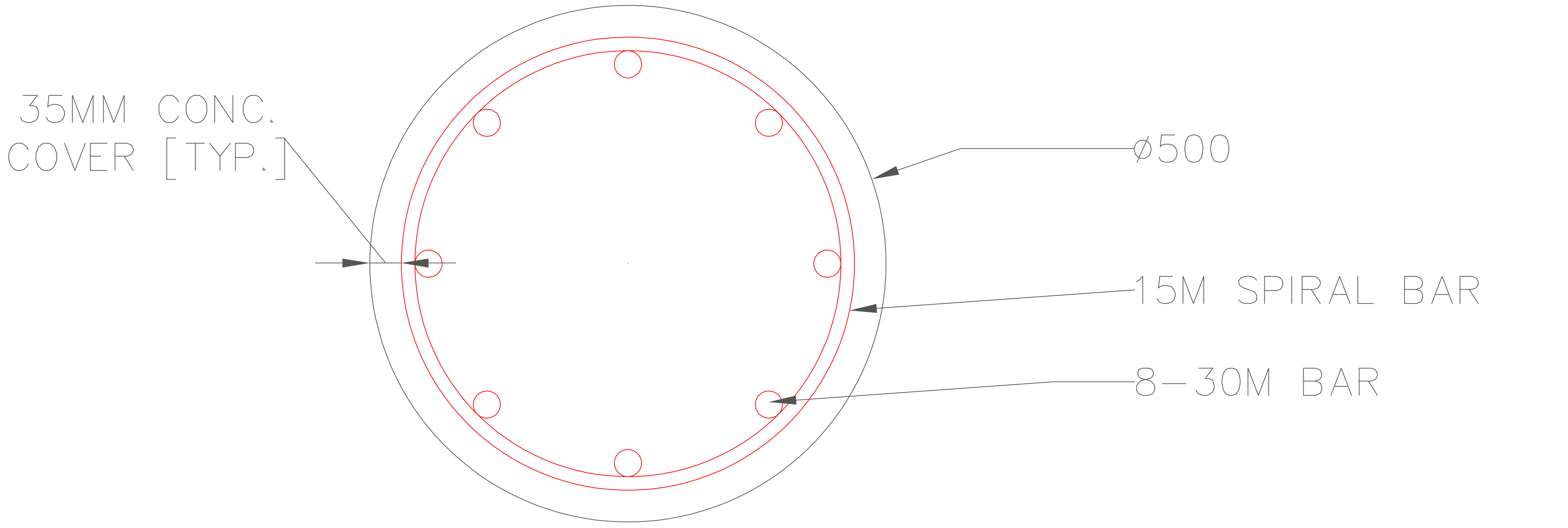
DRAWN BY: YZ

DESIGN BY: DL

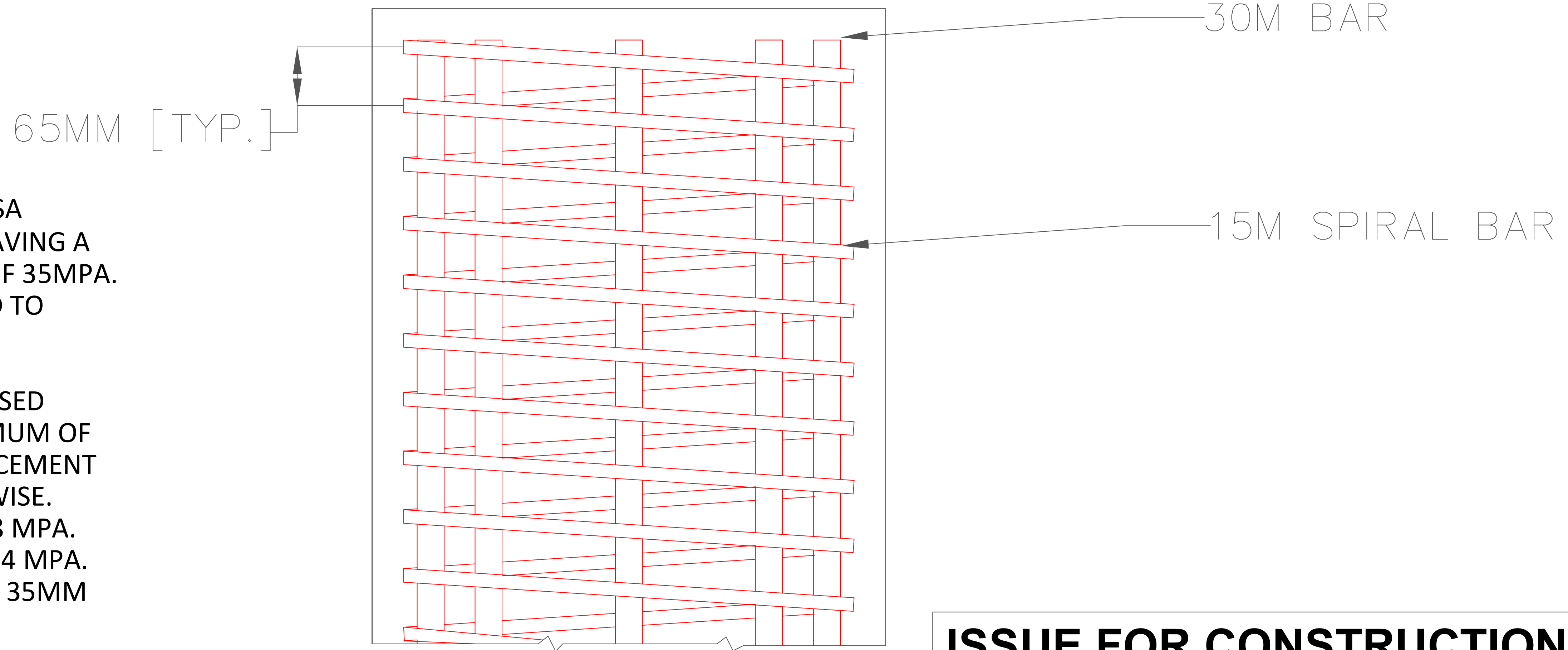
REVIEW BY: DL

DWG NO.: 11 of 20

REV.



PLAN VIEW



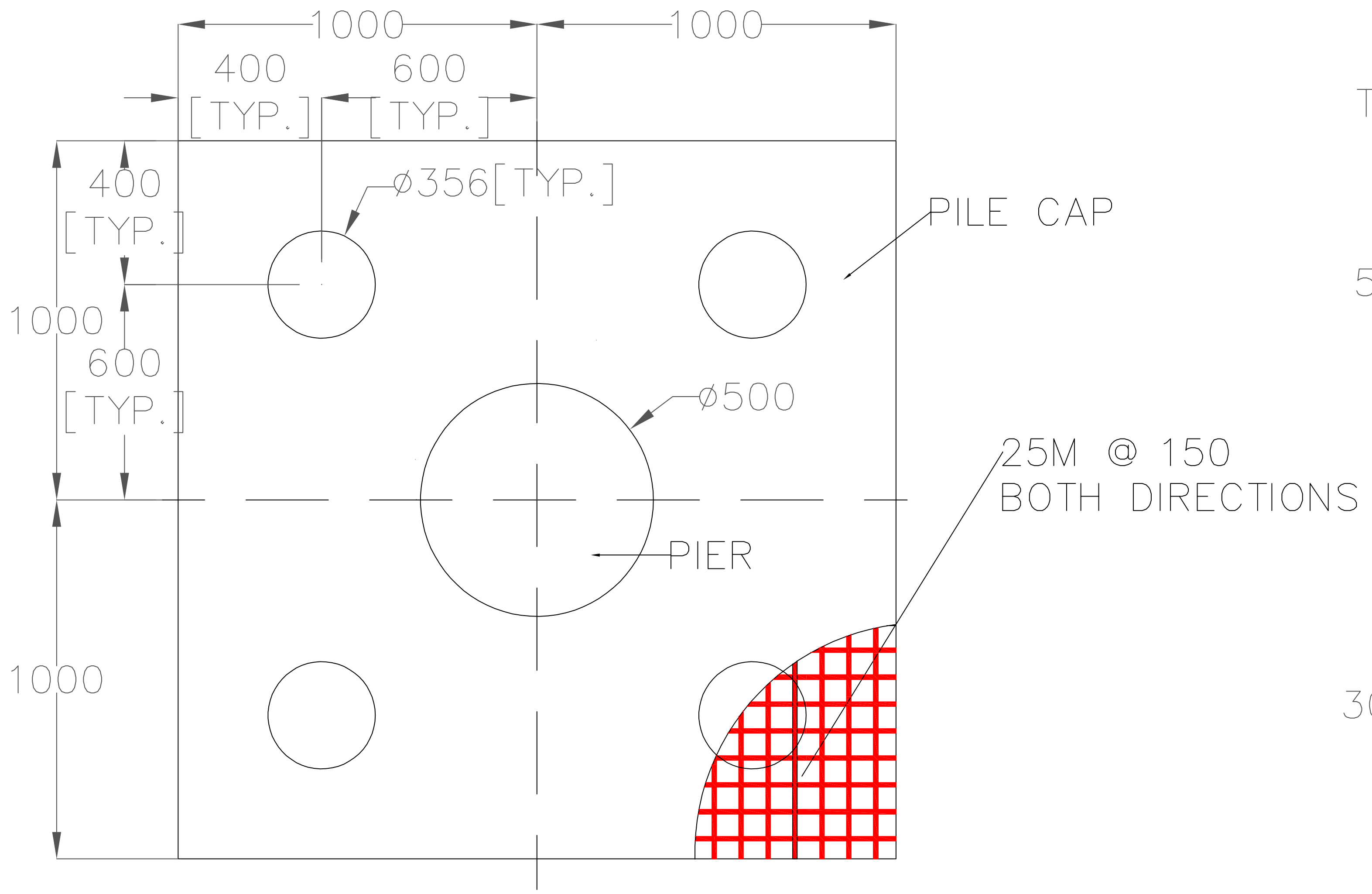
SECTION VIEW

GENERAL NOTES:

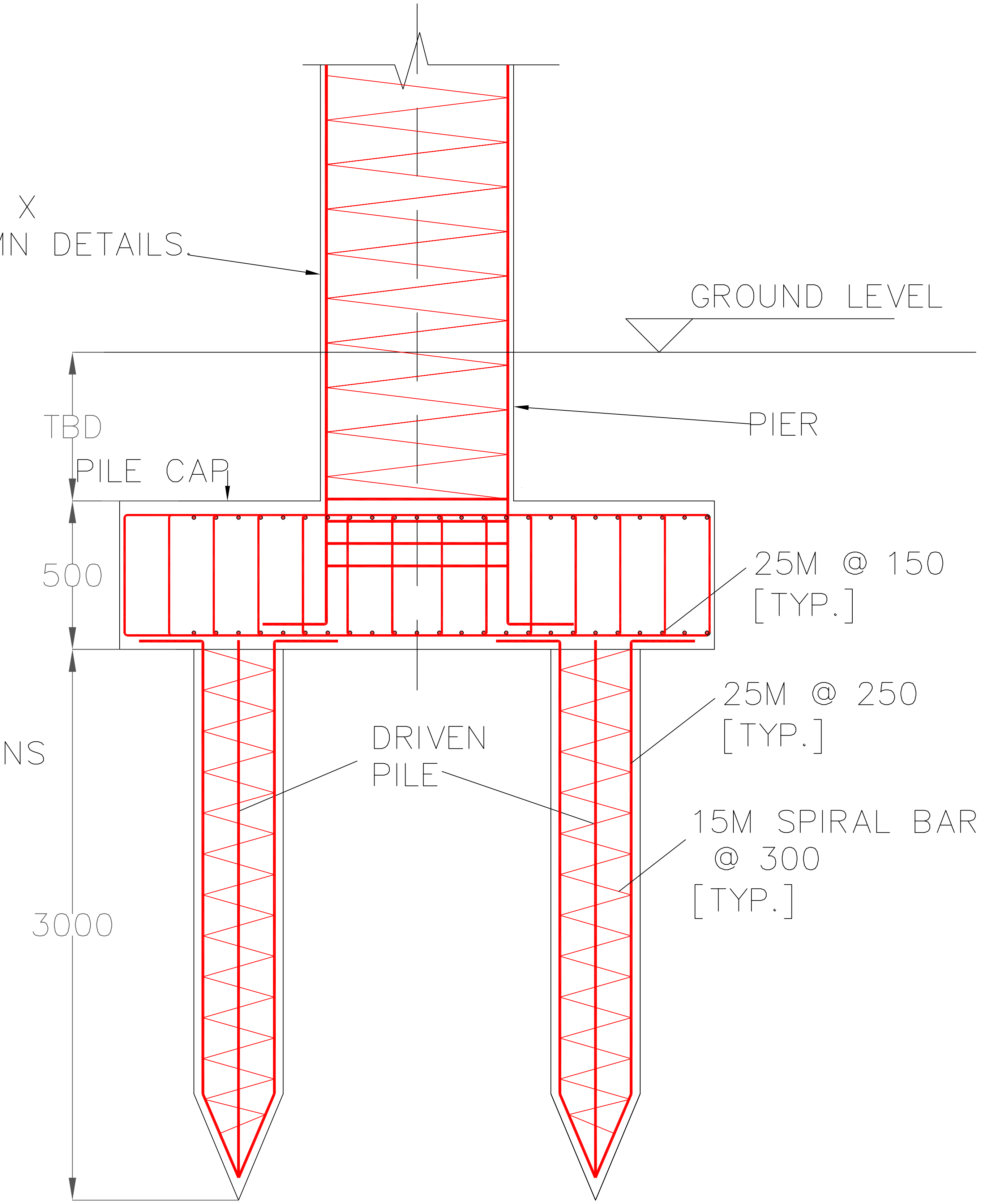
1. ALL CONCRETE SHALL CONFORM TO CSA STANDARD A23.1 (LATEST EDITION) HAVING A MINIMUM COMPRESSIVE STRENGTH OF 35MPA.
2. ALL CONCRETE THAT WILL BE EXPOSED TO WEATHER SHALL HAVE A 5 TO 7% AIR ENTRAINMENT AT TIME OF PLACING.
3. KEEP CONTINUOUSLY MOIST ALL EXPOSED NON-FORMED SURFACES FOR A MINIMUM OF SEVEN CONSECUTIVE DAYS AFTER PLACEMENT OF CONCRETE UNLESS NOTED OTHERWISE.
4. WWF MINIMUM YIELD STRENGTH: 448 MPA.
5. MINIMUM REBAR YIELD STRENGTH: 414 MPA.
6. ALL REINFORCING TO HAVE MINIMUM 35MM OF CONCRETE COVER.
7. ALL DIMENSIONS ARE IN MILLIMETERS.

ISSUE FOR CONSTRUCTION

CONSULTANT:	UBC Sustainability	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: REINFORCED CONCRETE COLUMN DETAILS	SCALE: 1:6	DATE: 2019.03.29
				DRAWN BY: YZ	DESIGN BY: DL
		PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: DL	DWG NO.: 12 of 20
				REV.	



PLAN VIEW



SECTION VIEW

ISSUE FOR CONSTRUCTION

CONSULTANT:

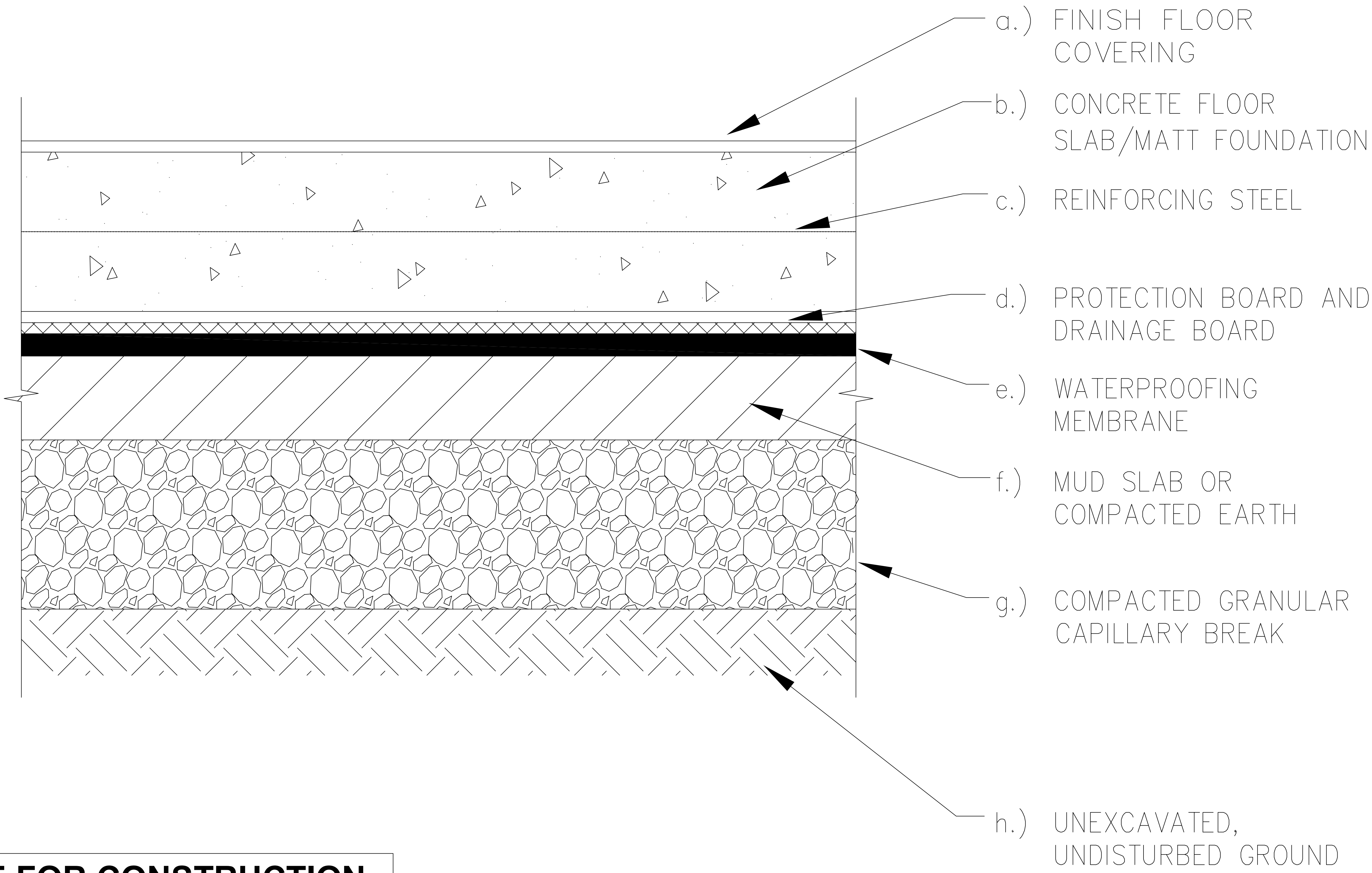
UBC Sustainability

CLIENT:
UBC SEEDS SUSTAINABILITY PROGRAM

PROJECT:
UBC STADIUM ROAD NEIGHBORHOOD
MUNICIPAL INFRASTRUCTURE IMPROVEMENT

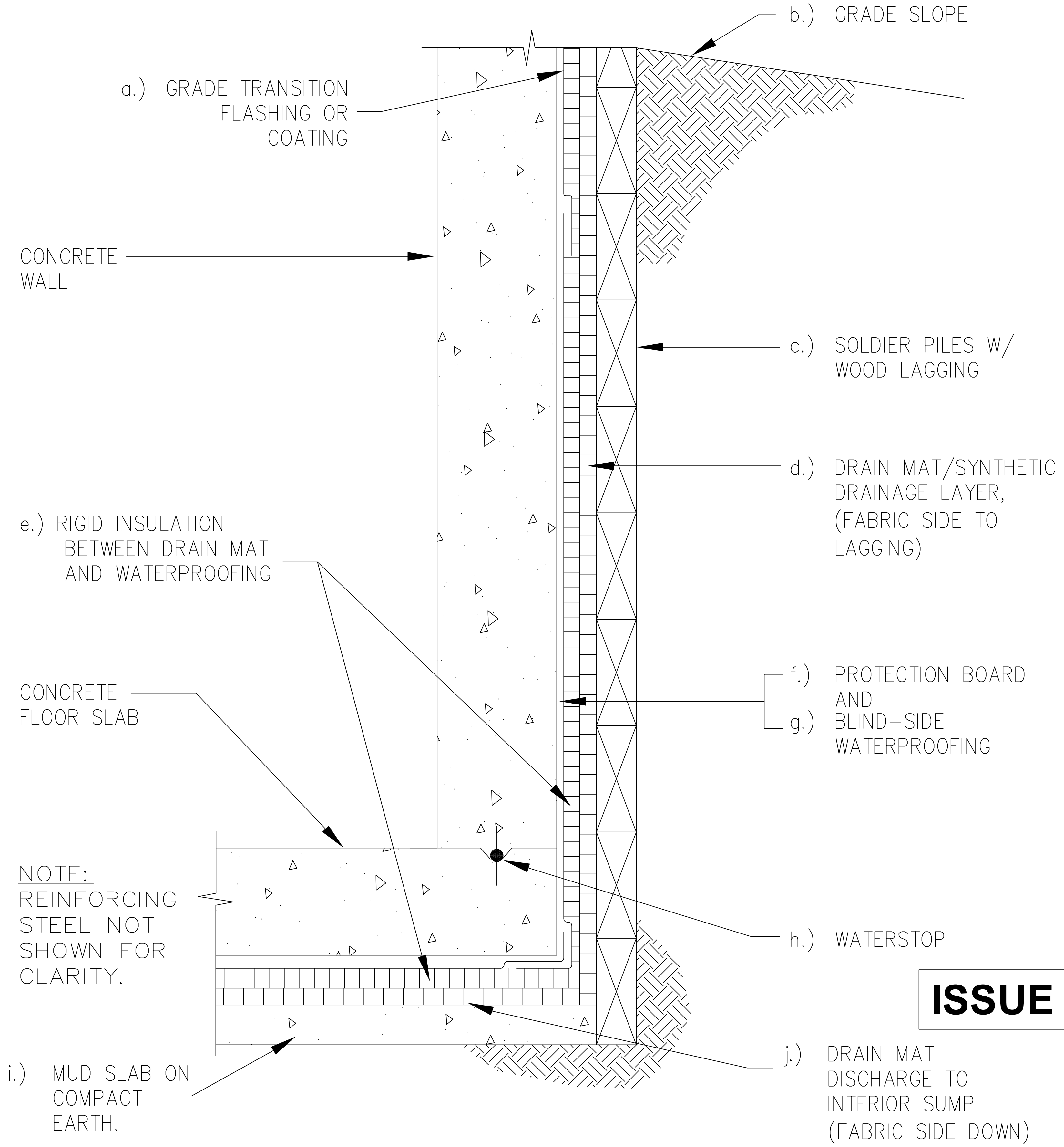
SHEET TITLE:
PILE FOUNDATION DETAILS

SCALE: 1:20
DATE: 2019.03.29
DRAWN BY: YZ
DESIGN BY: DL
REVIEW BY: DL
DWG NO.:
REV.
13 of 20



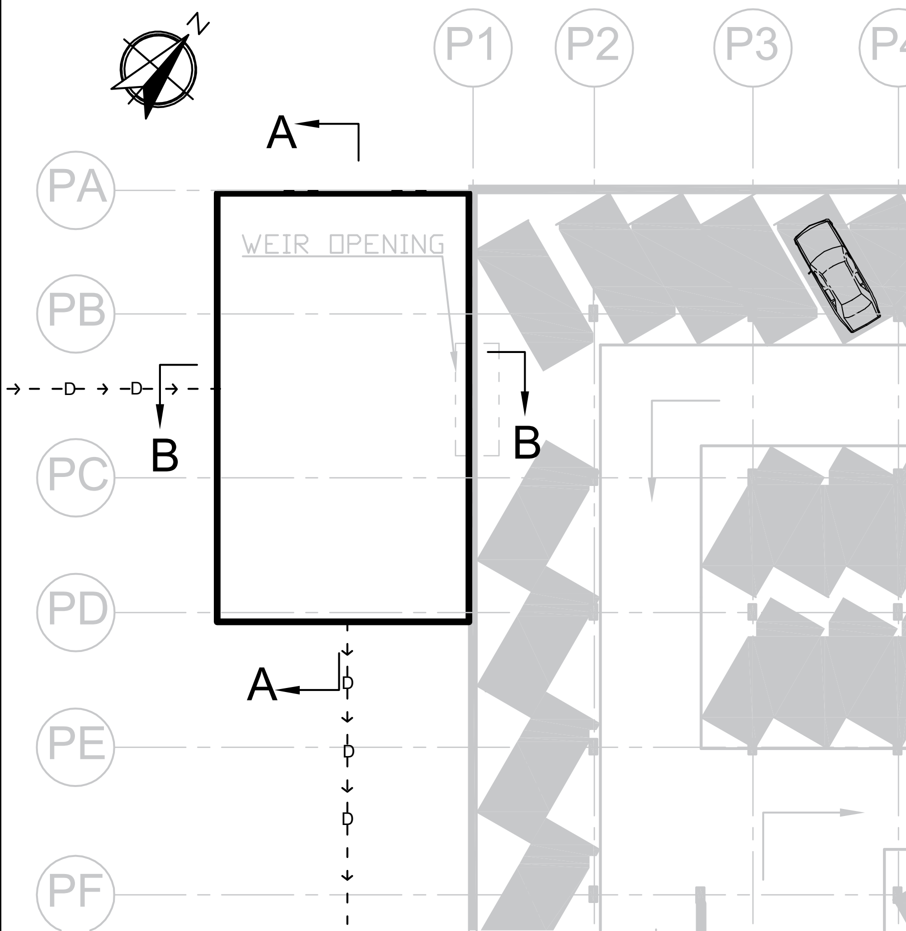
ISSUE FOR CONSTRUCTION

CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: PARKADE BELOW GRADE SLAB WATERPROOF SYSTEM	SCALE: 3:1	DATE: 2019.03.29
			DRAWN BY: YZ	DESIGN BY: DL
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: DL	DWG NO.: 14 of 20
			REV.	



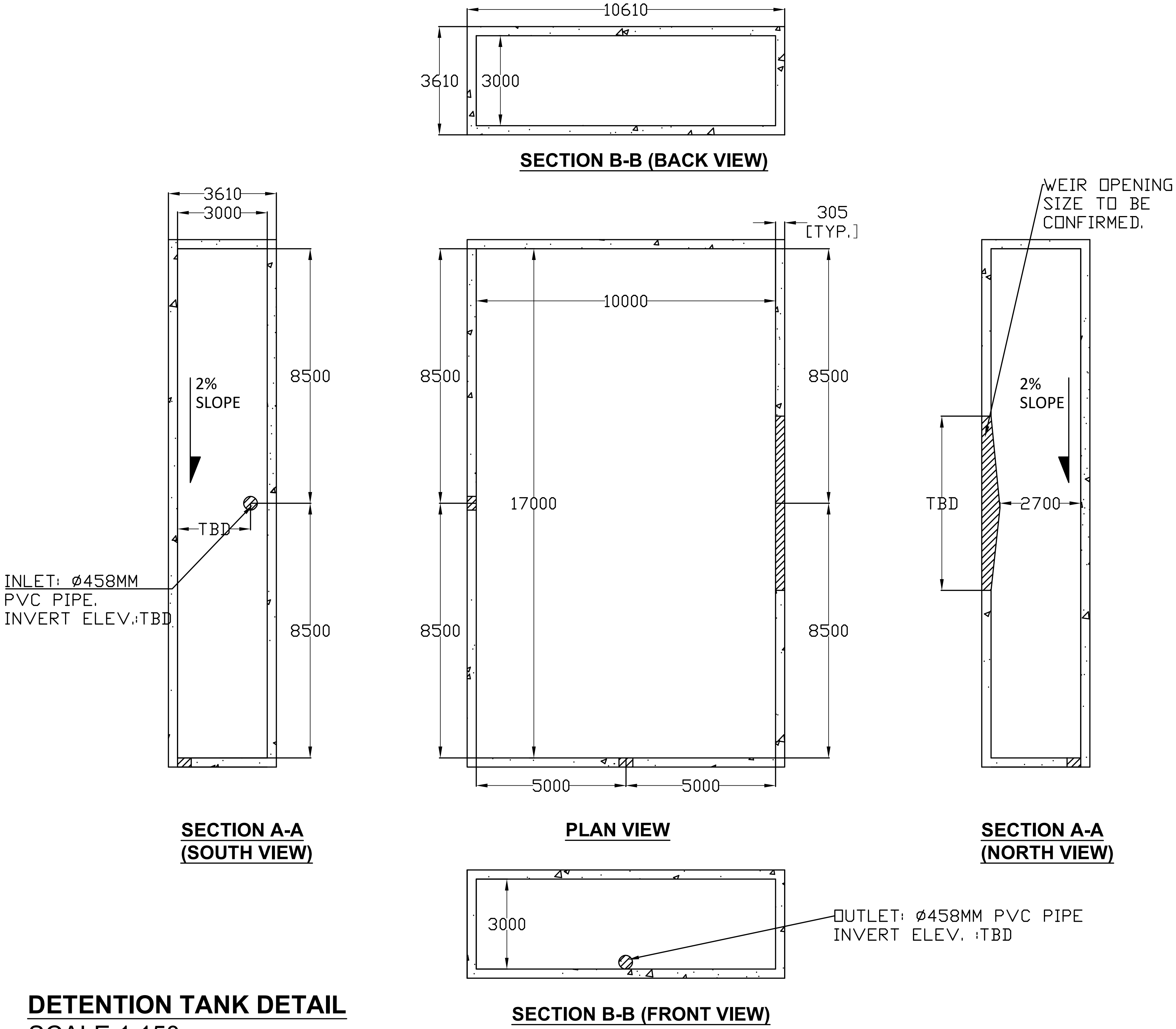
ISSUE FOR CONSTRUCTION

CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: PARKADE FOUNDATION WALL WATERPROOF SYSTEM	SCALE: 3:1	DATE: 2019.03.29
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		DRAWN BY: YZ	DESIGN BY: DL
			REVIEW BY: DL	DWG NO.: 15 of 20
			REV.	



DETENTION TANK LOCATION
SCALE 1:300

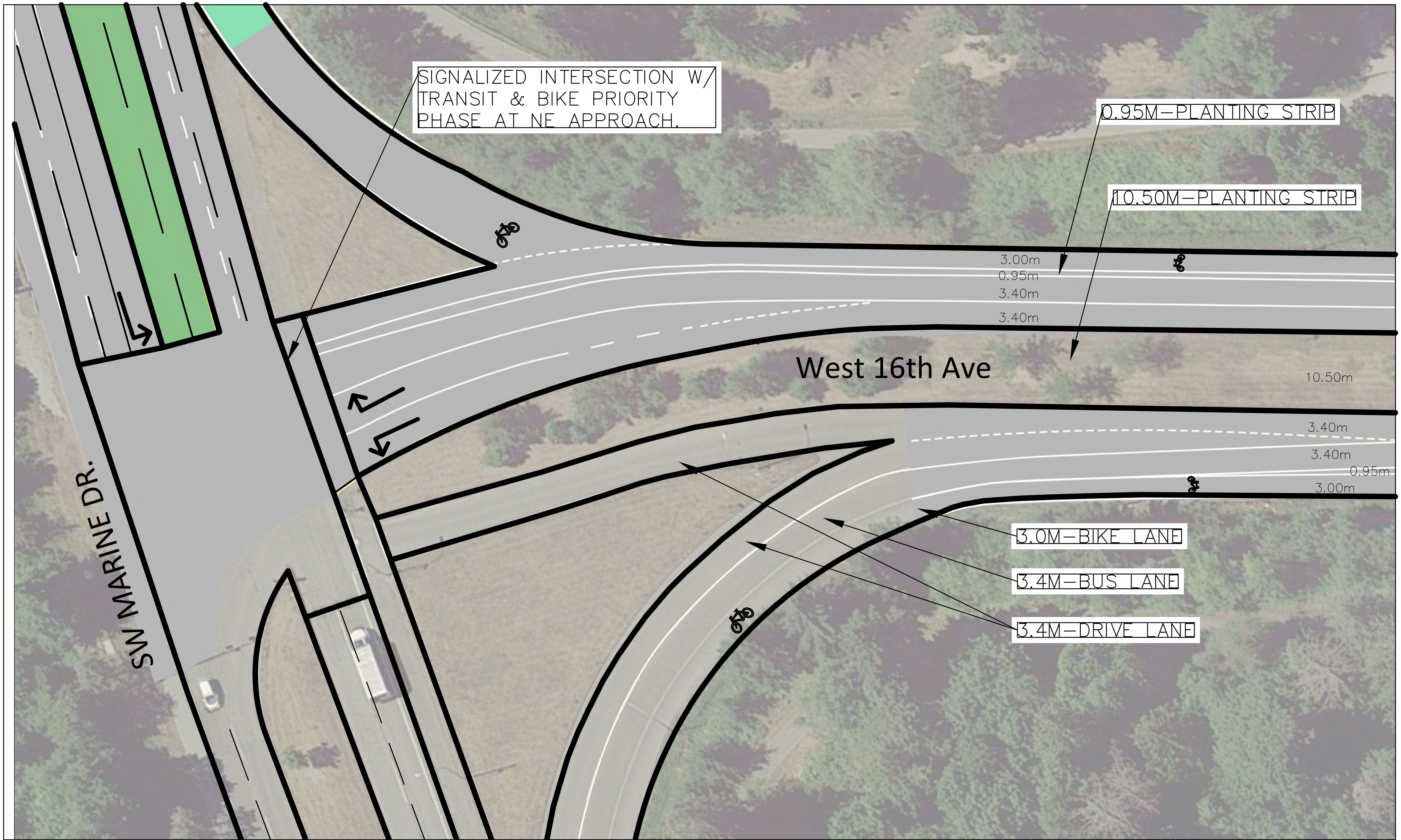
GENERAL NOTE:
1. CAST-IN-PLACE CONCRETE DETENTION TANK AS SHOWN.
2. TANK TO HAVE APPROXIMATE DETENTION VOLUME OF 460M^3.
3. SLAB THICKNESS TO BE 305MM (1').
4. BOTTOM OF THE TANK TO HAVE 2% SLOPE TOWARD THE OUTLET.
5. ALL DIMENSIONS ARE IN MILLIMETER.



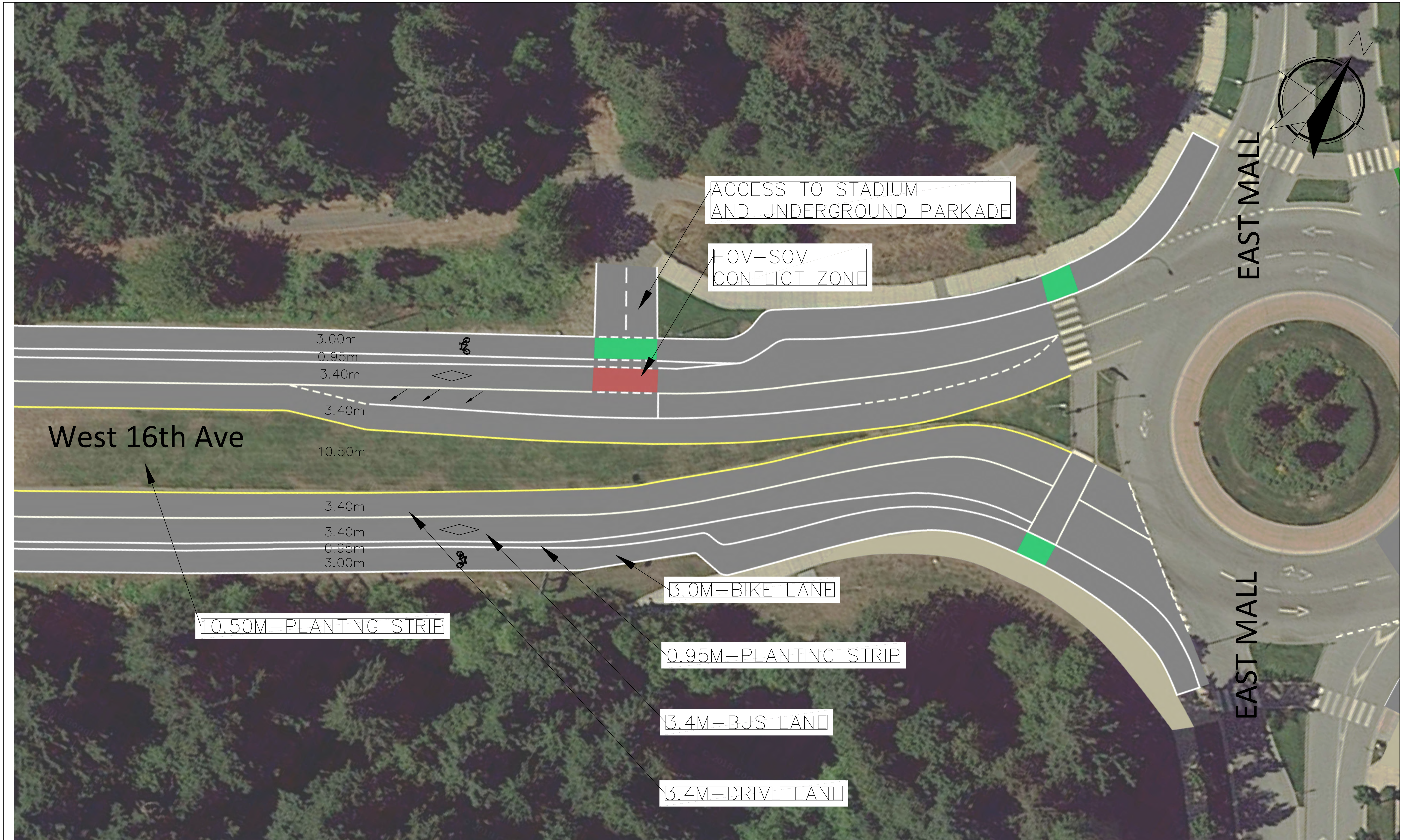
ISSUE FOR CONSTRUCTION

DETENTION TANK DETAIL
SCALE 1:150

CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: UNDERGROUND STORMWATER DETENTION TANK	SCALE: N/A	DATE: 2018.11.25
			DRAWN BY: YZ	DESIGN BY: PS/JF
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: PS/JF	DWG NO.: 16 of 20
			REV.	

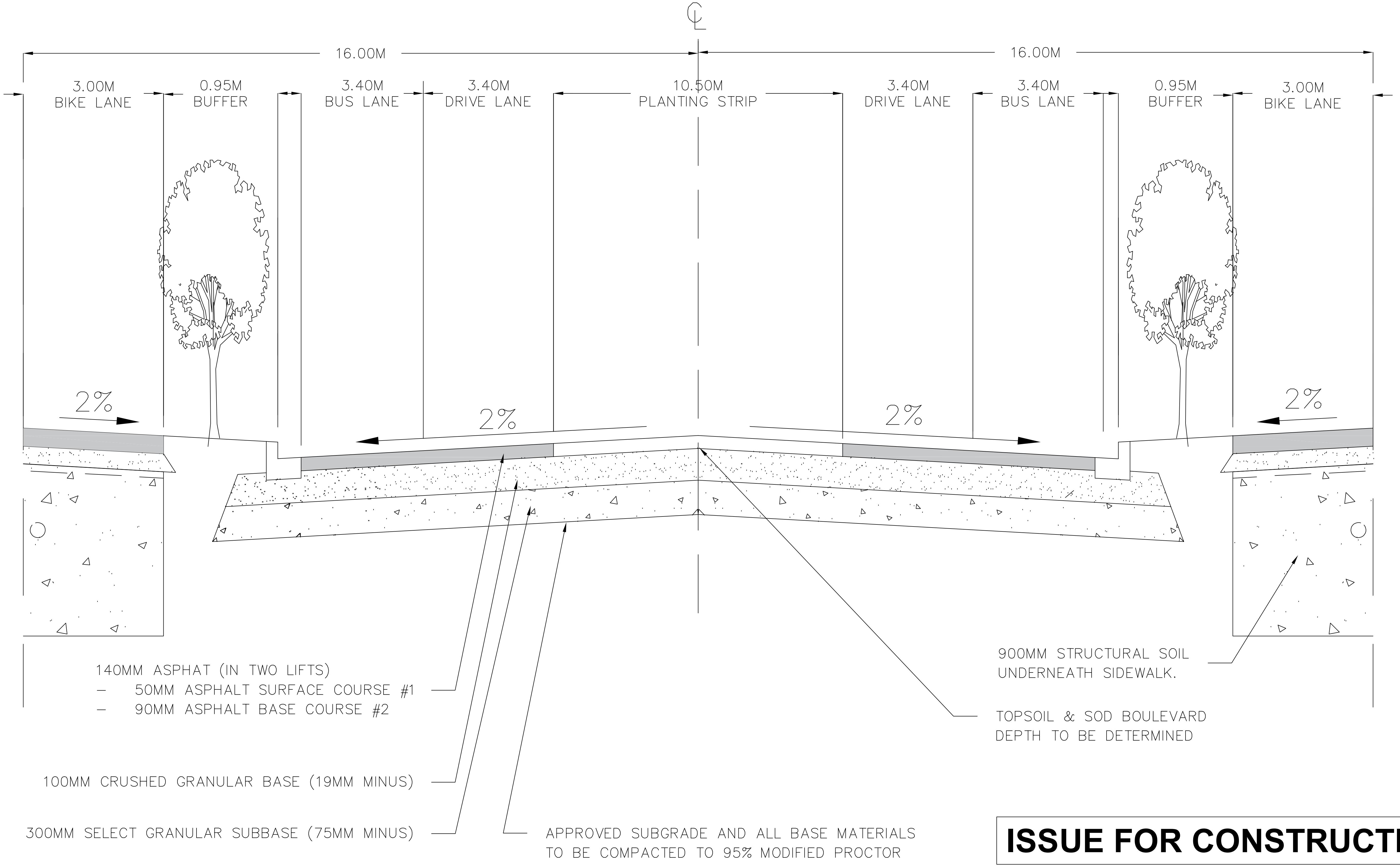


CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: West 16th Ave & SW MARINE DR ROAD GEOMETRIC	SCALE: N/A	DATE: 2019.03.29
			DRAWN BY: YZ	DESIGN BY: KW
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: GC	DWG NO.: 17 of 20
			REV.	



CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: West 16th Ave & EAST MALL ROAD GEOMETRIC	SCALE: 1:500	DATE: 2019.03.29
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		DRAWN BY: YZ	DESIGN BY: KW
			REVIEW BY: GC	DWG NO.: 18 of 20
			REV.	

CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: West 16th Ave & WESBROOK MALL ROAD GEOMETRIC	SCALE: 1:500	DATE: 2019.03.29
			DRAWN BY: YZ	DESIGN BY: KW
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: GC	DWG NO.: 19 of 20
			REV.	



ISSUE FOR CONSTRUCTION

CONSULTANT:	CLIENT: UBC SEEDS SUSTAINABILITY PROGRAM	SHEET TITLE: Typical Section West 16th Ave	SCALE: N/A	DATE: 2019.03.29
			DRAWN BY: YZ	DESIGN BY: KW
	PROJECT: UBC STADIUM ROAD NEIGHBORHOOD MUNICIPAL INFRASTRUCTURE IMPROVEMENT		REVIEW BY: GC	DWG NO.: 20 of 20
			REV.	

teamgantt
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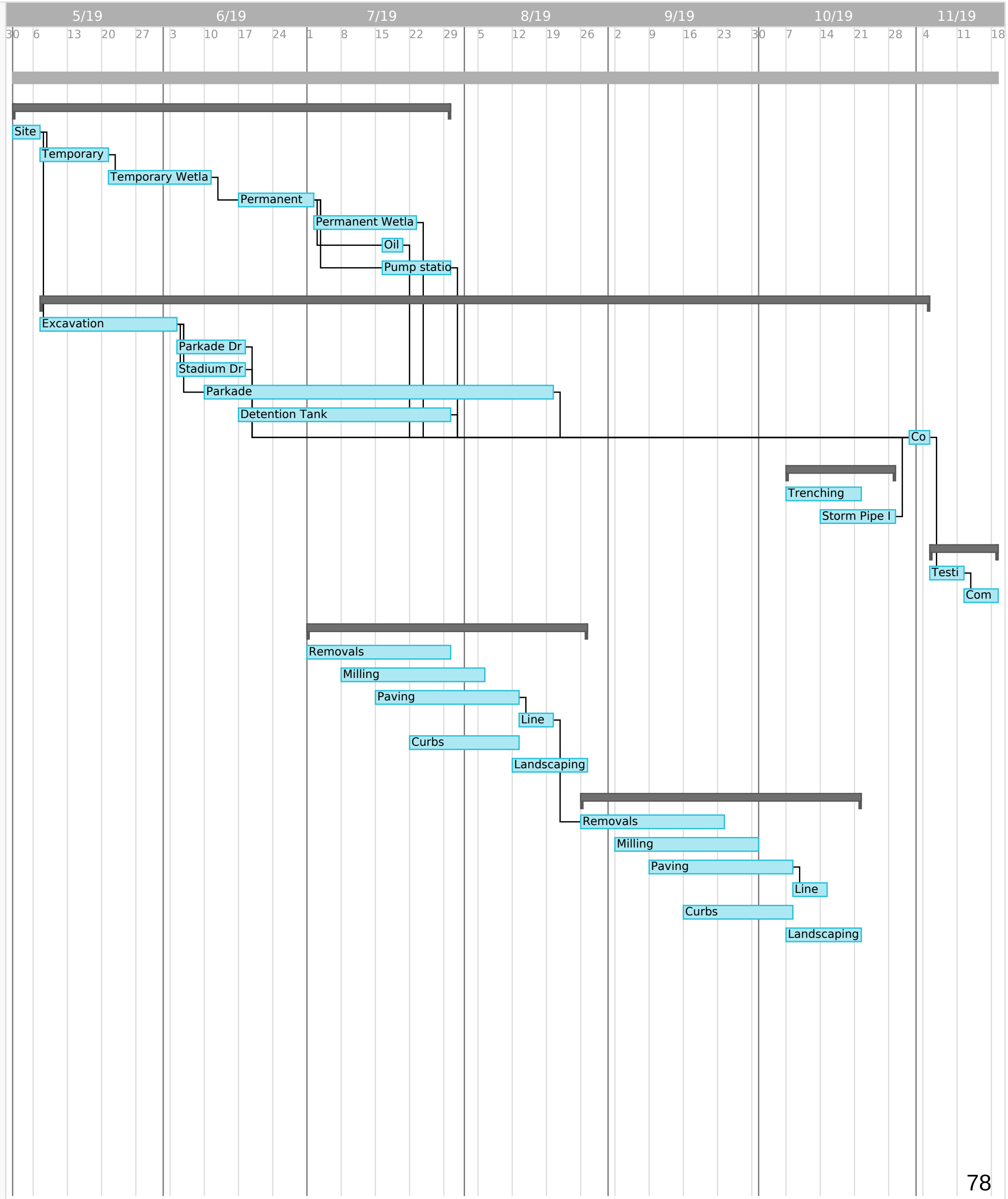
Appendix F Construction Schedule

Stadium Road Neighbourho...	start	end	0h	0%
South Area	**05/01/19**	**07/29/19**	**0h**	**0%**
Site Office	05/01	05/06	0	0%
Temporary Wetland Excavation	05/07	05/20	0	0%
Temporary Wetland	05/21	06/10	0	0%
Permanent Wetland Excavation	06/17	07/01	0	0%
Permanent Wetland	07/02	07/22	0	0%
Oil Grit Separators	07/16	07/18	0	0%
Pump station	07/16	07/29	0	0%
East Area	**05/07/19**	**11/04/19**	**0h**	**0%**
Excavation	05/07	06/03	0	0%
Parkade Drainage Network	06/04	06/17	0	0%
Stadium Drainage Network	06/04	06/17	0	0%
Parkade	06/10	08/19	0	0%
Detention Tank	06/17	07/29	0	0%
Connection with Municipal	10/31	11/04	0	0%
West Area	**10/07/19**	**10/28/19**	**0h**	**0%**
Trenching	10/07	10/21	0	0%
Storm Pipe Install	10/14	10/28	0	0%
Waterworks Closing	**11/05/19**	**11/18/19**	**0h**	**0%**
Testing	11/05	11/11	0	0%
Commissioning	11/12	11/18	0	0%
Roadworks - SW Marine to East Mall	**07/01/19**	**08/26/19**	**0h**	**0%**
Removals	07/01	07/29	0	0%
Milling	07/08	08/05	0	0%
Paving	07/15	08/12	0	0%
Line painting	08/13	08/19	0	0%
Curbs	07/22	08/12	0	0%
Landscaping	08/12	08/26	0	0%
Roadworks - East Mall to Wesbrook	**08/26/19**	**10/21/19**	**0h**	**0%**
Removals	08/26	09/23	0	0%
Milling	09/02	09/30	0	0%
Paving	09/09	10/07	0	0%
Line painting	10/08	10/14	0	0%
Curbs	09/16	10/07	0	0%
Landscaping	10/07	10/21	0	0%



Appendix G Construction Cost Estimate

ID Block						Quantity		Cost				
Item #	**Area**	**Category**	**Activity**	**Item**	**Level**	**Quantity**	**Units**	**Permanent Material**	**Temporary Material**	**Labour/ Equipment**	**SubContract**	**Total Cost**
100000				Directs	0							$ 9,201,559.22
	110000			Storm System	1							$ 2,916,021.35
		111000		Removals	2							
		112000		Roadworks	2							
		113000		Earthworks	2							
			113010	Cut	3	8850.9	m3			$ -	$ 100.00	$ 885,090.00
			113020	Fill	3	8065.763	m3			$ -	$ 100.00	$ 806,576.30
			113030	Drainage Rock	3	644.525	m3			$ -	$ 100.00	$ 64,452.50
			113040	Trenching	3		LM					
			113050	Trenching Backfill	3		LM					
		114000		Waterworks	2							
			114010	Storm Sewer	3							$ -
			114020	Ø1500mm Manhole	3	13	ea			$ 2,340.25	$ 4,255.00	$ 85,738.25
			114030	Storm Sewer, 600mm dia.	3	96	LM			$ 886.05	$ 1,611.00	$ 239,716.80
			114040	Storm Sewer, 500mm dia.	3	407	LM			$ 346.50	$ 630.00	$ 397,435.50
			114050	Storm Sewer, 400mm dia.	3	83	LM			$ 346.50	$ 630.00	$ 81,049.50
			114060	Storm Sewer, 350mm dia.	3	75	LM			$ 286.00	$ 520.00	$ 60,450.00
			114070	Storm Sewer, 300mm dia.	3	225	LM			$ 227.70	$ 414.00	$ 144,382.50
			114080	Diversion Structure c/w large Oil Grit Separator	3	1	EA			$ 24,840.00	$ 92,000.00	$ 116,840.00
			114090	Baseflow Diversion Structure c/w Oil Grit Separator	3	1	EA			$ 7,290.00	$ 27,000.00	$ 34,290.00
		115000		Temp. Works	2							
			115010	Shoring	3							$ -
	120000			Wetland	1							$ 380,566.86
		121000		Removals	2							
		122000		Roadworks	2							
		123000		Earthworks	2							
			123010	Cut	3	2290	M3			$ -	$ 100.00	$ 229,000.00
			123020	Fill	3	0.283	ACR				$ 46,526.00	$ 13,166.86
		124000		Waterworks	2							
			124010	Pump Station	3							$ -
		125000		Temp. Works	2							
			125010	Sediment control pond	3	1300	m3			$ -	$ 100.00	$ 130,000.00
			125020	Pump	3	2	ea	$ 3,000.00		$ 1,200.00		$ 8,400.00
			125030	Silt Fence	3		m					$ -
			125040	Construction Swale	3		m3					$ -
			125050	Catch Basin Sediment Trap	3		ea					$ -
			125060	Street Sweeping	3		ea					$ -
			125070	Rock Access Pad	3		m3					$ -
			125080	Shoring	3							$ -
			125090	Tie-in to existing storm pipe	3							$ -
	130000			Parkade + Detention Tank	1							$ 4,288,185.98
		131000		Removals	2							
		132000		Roadworks	2							

			132010	Line Painting - Parking Stall (Single Line)	3	62	ea				$ 8.79	$ 544.72
			132020	Line Painting - Parking Stall (Double Line with Cap)	3	0	ea				$ 14.15	$ -
			132030	Line Painting - Handicap Stall (Symbol with Blue Box)	3	5	ea				$ 58.57	$ 292.86
			132040	Line Painting - EV Stall (Symbol with Blue Box)	3	10	ea				$ 58.57	
			132050	Line Painting - Car Share Stall (Symbol with Blue Box)	3	5	ea				$ 58.57	
			132060	Line Painting - Arrow	3	6	ea				$ 29.29	$ 175.72
			132070	Line Painting - 4" Line	3	31.728	LM				$ 1.92	$ 60.97
			132080	Line Painting - Red/Yellow Curb Line	3	0	LM				$ 5.61	$ -
			132090	Line Painting - Stop Bar	3	1	ea				$ 48.81	$ 48.81
			132100	Line Painting - Stencliling per Letter (24" High)	3	13	ea				$ 5.86	$ 76.14
			132110	Line Painting - Numbers & Parking Stall Stenciling (12" High)	3	89	ea				$ 5.13	$ 456.13
			132120	Line Painting - Crosswalks	3	0	ea				$ 107.38	$ -
			132130	Asphalt Sealcoating	3	1762.4	SM				$ 4.10	$ 7,230.63
			132140	Asphalt Crack Seal	3	0	LM				$ 5.66	$ -
		133000		Earthworks	2							
			133010	Cut	3	10900				$ -	$ 100.00	$ 1,090,000.00
			133020	Fill	3	545				$ -	$ 100.00	$ 54,500.00
		134000		Storm water detention facility	2							
			134010	Rebar	3	4801	LM				$ 276,000.00	$ 276,000.00
			134020	Concrete	3	162	CM					
		135000		Temp. Works	2							
			135010	Shoring	3	1300	SM		$ 800.00	$ 216.00		$ 1,320,800.00
			135020	Formwork								
		136000		Parkade Structure	2							
			136010	Concrete	3	1266	CM				$ 1,538,000.00	$ 1,538,000.00
			136020	Rebar	3	35479	LM					
	140000			W 16th Ave	1							$ 1,384,009.03
		141000		Site Clearing Prep	2							
		142000		Roadworks	2							$ 644,004.52
			142010	Roads (x m wide, excl Asphalt)	3							$ -
			142020	Milling	3	15443					$ 4.00	$ 61,772.00
			142030	Overlay (x mm thick)	3	15443					$ 26.00	$ 401,518.00
			142040	Curb	3	3336					$ 50.00	$ 166,800.00
			142050	Sidewalk	3						$ 55.00	$ -
			142060	Barrier	3						$ 40.00	$ -
			142070	Line Painting - Parking Stall (Single Line)	3		ea				$ 8.79	$ -
			142080	Line Painting - Parking Stall (Double Line with Cap)	3		ea				$ 14.15	$ -
			142090	Line Painting - Handicap Stall (Symbol with Blue Box)	3		ea				$ 58.57	$ -
			142100	Line Painting - Arrow	3	20	ea				$ 29.29	$ 585.72
			142110	Line Painting - 4" Line	3	6123	LM				$ 1.92	$ 11,766.87
			142120	Line Painting - Red/Yellow Curb Line	3		LM				$ 5.61	$ -
			142130	Line Painting - Stop Bar	3	6	ea				$ 48.81	$ 292.86
			142140	Line Painting - Stencliling per Letter (24" High)	3	70	ea				$ 5.86	$ 410.00
			142150	Line Painting - Numbers & Parking Stall Stenciling (12" High)	3		ea				$ 5.13	$ -
			142160	Line Painting - Crosswalks	3	8	ea				$ 107.38	$ 859.06
			142170	Asphalt Sealcoating	3		SM				$ 4.10	$ -

			142180	Asphalt Crack Seal	3		LM				$ 5.66	$ -
		143000		Waterworks	2			$ -	$ -	$ -	$ 27,000.00	$ 27,000.00
			145030	Catch Basin c/w Leads	3		ea				$ 12,000.00	$ 12,000.00
			145040	Tie in to Existing Storm sewer	3		ea				$ 15,000.00	$ 15,000.00
		144000		Landscaping	2			$ -	$ -	$ -	$ 15,000.00	$ 15,000.00
			144010	Street Trees	3		ea				$ 15,000.00	$ 15,000.00
			144020	Street Sign c/w Pole	3		ea					$ -
			144030	Street Sign on streelight	3		ea					$ -
		145000		Removals	2			$ -	$ -	$ -		
			145010	Remove Existing Curb and Gutter	3						$ 12,000.00	$ 12,000.00
			145020	Remove Existing Basin	3		ea					$ -
	150000			Insurance, Bonds, Permits	1	1	LS	$ -	$ -	$ -	$ 232,776.00	$ 232,776.00
		151000		Insurance	2	1	LS				$ 66,388.00	$ 66,388.00
		152000		Bonds	2	1	LS				$ 66,388.00	$ 66,388.00
		153000		Permits	2	1	LS				$ 100,000.00	$ 100,000.00
200000				Indirects								$ 2,402,505.40
	210000			Escalation								$ 552,093.55
		211000		2019 Escalations							$ 276,046.78	$ 276,046.78
		212000		2020 Escalations							$ 276,046.78	$ 276,046.78
	220000			Accomodations								$ 7,000.00
		221000		Site Office							$ 6,000.00	$ 6,000.00
			221010	Office S&I, Demob							$ 1,000.00	$ 1,000.00
	230000			Safety								$ 600.00
		231000		First Aid and Site Safety Management							$ 600.00	$ 600.00
	240000			Staff Salary								
	250000			Communications and Tech Equip							$ 2,500.00	$ 2,500.00
	260000			Contingency							$ 1,840,311.84	$ 1,840,311.84
300000				**Grand Total**								**$ 11,604,064.62**

Stakeholder Register

Name	Role	Interests	Influence	Power
UBC SEEDS	Client	Carry out project requirements as given in guidelines (i.e. meet stormwater requirements)	High	High
UBC Endowment Lands	Property Owner	Efficient construction schedule and budget Project adheres to all relevant guidelines and plans (including ISMP and Transportation Plan)	High	High
UBC Recreation	Operator	Operation of the new Thunderbird Stadium; emergency plan during storm flooding event	Moderate	Low
Future Stadium Neighbourhood Residences	Renters/ Owners	Adequate stormwater management on site Low vehicular traffic on Stadium Rd	Moderate	Low
UBC Residents/ Students/ Faculty	Users	Minor construction delays Improved transportation infrastructure Usable underground parkade Safe parkade access off W 16th Ave	Moderate	Low
UBC Property Trust	Land Developer	Future residential development opportunities in Stadium Neighbourhood.	High	High
UBC Campus + Community Planning	Project Owner	Carry out project requirements as given in guidelines (i.e. meet stormwater requirements) Project aligns with Stadium Neighbourhood goals	High	High
UBC Botanical Gardens	Adjacent Property Owner	Possible stormwater management integration; seek to reduce amount of storm discharge to Minor construction disruptions/delays	Moderate	Moderate
TransLink	Transit Authority	Minor construction disruptions/delays to existing bus services. Transit access managed during construction. Improved transit access on W 16th Ave.	Moderate	High
BC Ministry of Transportation and Infrastructure	Property Owner (W 16th Avenue)	Consultation regarding construction and road design.	Moderate	High
General Public	Users	Minor construction traffic delays; Usable underground parkade.	Low	Low
St. John Hospice	Adjacent Property Owner	Minor construction disruptions/delays.	Moderate	Moderate
Wesbrook Village - Businesses	Adjacent Property Owner	Minor construction disruptions/delays; Increased sustainable mode share.	Moderate	Low

First Nations - Musqueam	Land Owners	Consultation and notification (assumed to be done mostly via UBC Campus + Community Planning).	High	Moderate
Thunderbird Park	Adjacent property	Minor construction disruptions/delays.	Low	Low
FP Innovations	Adjacent property	Minor construction disruptions/delays.	Low	Low
Rhodo Woods	Adjacent property	Minor construction disruptions/delays.	Low	Low
Hawthorn Place	Adjacent property	Minor construction disruptions/delays.	Low	Low

Full list of First Nations from Consultative Areas Database:

- Sto:lo Tribal Council
- Sto:lo Nation
- Soowahlie First Nation
- Seabird Island Band
- Shxw’ow’hamel First Nation
- Skawahlook First Nation
- Halalt First Nation
- Stz’uminus First Nation
- Cowichan Tribes
- Lake Cowichan First Nation
- Lyackson First Nation
- Penelakut Tribe
- Tsleil-Waututh Nation

Appendix I Risk Assessment

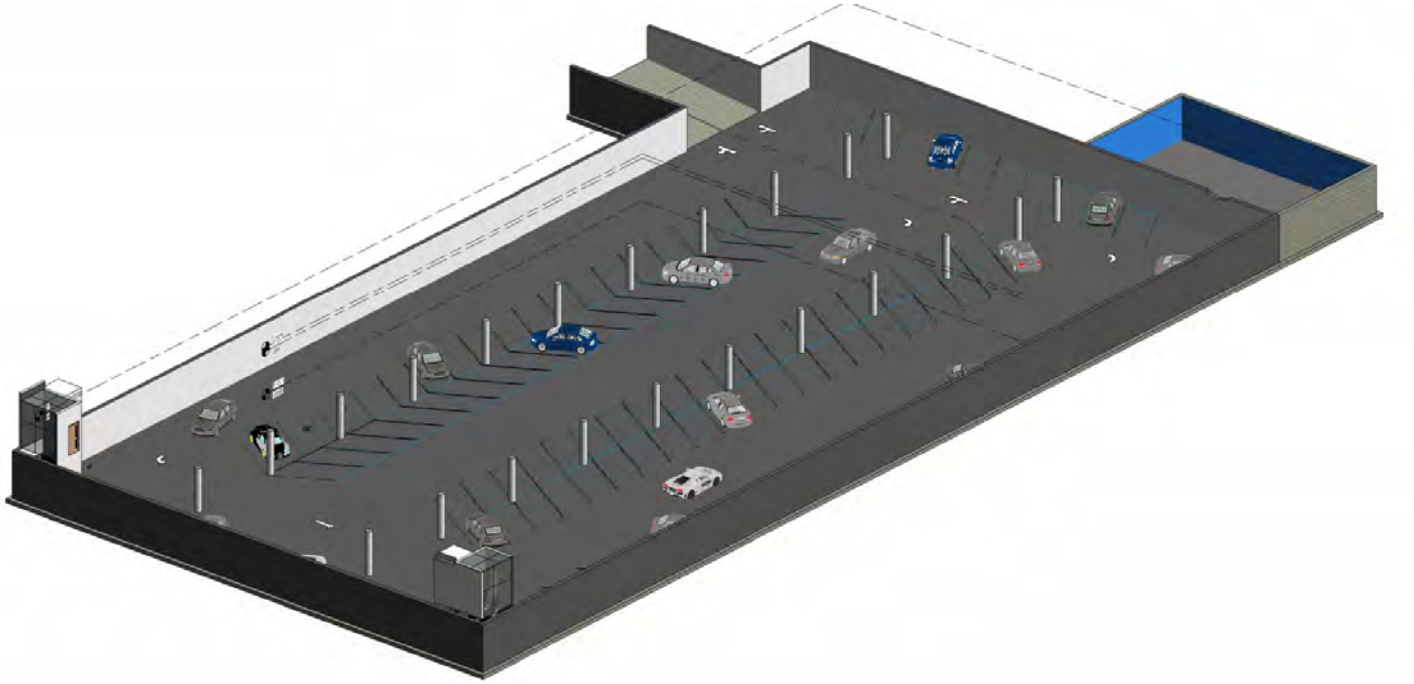
Preliminary Risk Analysis - Design Phase

Hazard	Potential impacts	Probability	Impact	Risk Level	Mitigation Strategy
Environmental					
Climate Change	Higher probability of large storm lead to under-designed detention system	UNLIKELY	HIGH	3	Reduction/Control
Unexpected Soil Contamination	Contaminated soil could lead to undesirable stormwater infiltration to underground aquifer.	MODERATE	HIGH	4	Reduction/Control
Unexpected High HGL	Piping system can be under-designed if the existing HGL is much higher than estimated.	MODERATE	HIGH	3	Acceptance
Resources					
Outdated Geotechnical Report from 2006	Inaccurate assumption of geotechnical conditions may affect design of underground structures	UNLIKELY	HIGH	2	Avoidance
Stadium Neighbourhood in Early Development Stage	Design was based off of architect’s recommendation at Open House and may not accommodate changes to the layout of the Neighbourhood.	LIKELY	EXTREME	4	Acceptance
Early Stage Architectural Plan	Current architecture plan only provides a high level site layout; any change to residential area or park area could alter runoff coefficient greatly.	LIKELY	EXTREME	4	Acceptance
No Site Topography	Design based on high level estimation of existing site condition, including site slope, elevation and existing utilities. Any change in assumption can greatly impact design.	ALMOST CERTAIN	EXTREME	4	Avoidance
Insufficient Information on Existing Stormwater System	Lack of information of existing storm information, including pipe location, sizing, slope, can greatly impact feasibility of proposed storm design and connections.	ALMOST CERTAIN	EXTREME	4	Avoidance

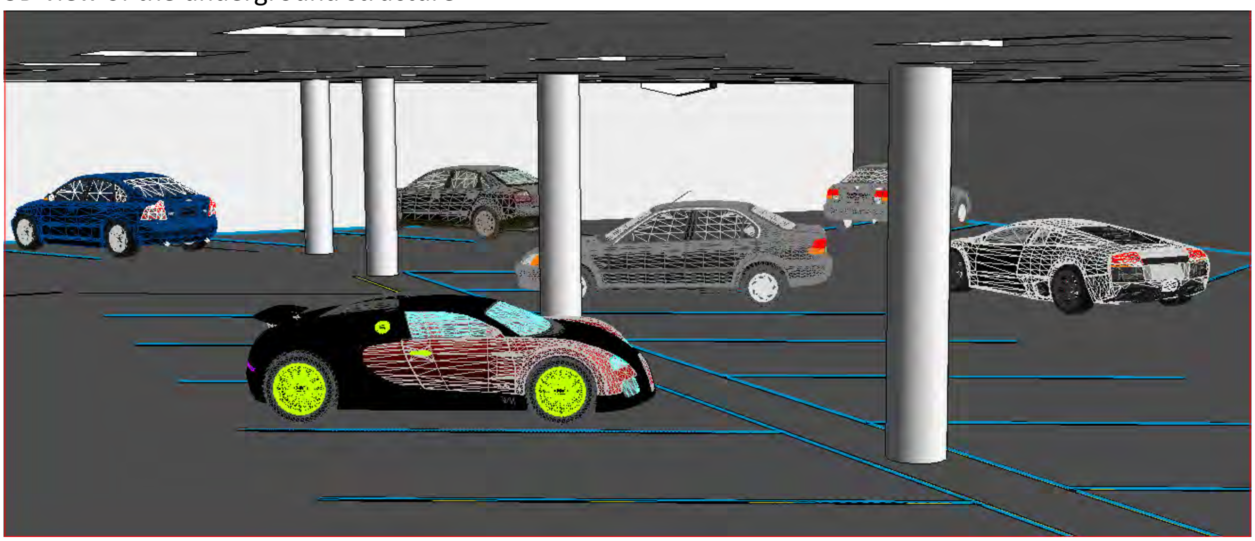
Financial					
Unavailable Funding	Funding to support the continuation of project design may become unavailable and lead to cancellation of project	RARE	EXTREME	3	Transference
Inaccurate Cost Estimate	Over/underestimated costs leading to inefficient project start-up and commencement. Affects UBC's capital budgeting decision and overestimation can lead to budget shortage for other projects -> opportunity cost	MODERATE	HIGH	3	Reduction/Control
Operational					
Inadequate Emergency Response Plan	Property damage and/or injuries if parkade is not evacuated in time during a storm event that will cause overflow.	UNLIKELY	MEDIUM	2	Reduction/Control
Severe Storm Events (>100-yr)	Current design is for 1/100 year storm, larger storm events will not be accommodated by the design. Resulted flooding will risk of property damage, wildlife damage, injuries etc.	UNLIKELY	EXTREME	4	Reduction/Control
Management					
Miscommunication with Client	Communication with client must be directed through third party. Miscommunication can lead to different levels of expectations on the deliverables, scope of work etc.	UNLIKELY	HIGH	3	Avoidance
Scope Creep	Increase of scope of work lead to insufficient time for completion. May cause project timeline delays, increase in project cost and compromised quality of work.	UNLIKELY	HIGH	3	Avoidance
Stakeholder					
Opposition from Stakeholders	Changes to scope of work and project timeline delays.	UNLIKELY	HIGH	3	Avoidance
Insufficient Consultation	Changes to scope of work and project timeline delays.	UNLIKELY	HIGH	3	Avoidance

Appendix J Standards and Software Packages

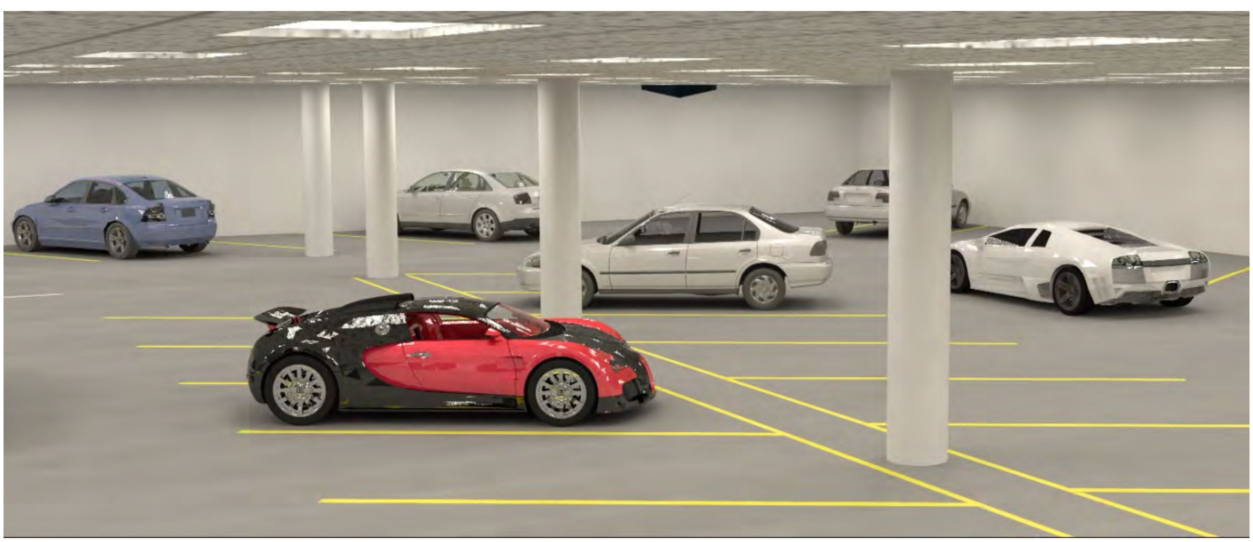
Codes/Guidelines	Software
BC Building Code 2018 BC Manual of Standard Traffic Signs & Pavement Markings BC Traffic Management Manual for Work on Roadways City of Vancouver Parking and Loading Design Supplement City of Surrey Design Criteria City of Surrey Standard Construction Documents CSA S413-14 Parking Structure A23.3-14 Design of Concrete Structure ITE Parking Generation Manual Master Municipal Construction Documents Metro Vancouver Stormwater Source Control Guidelines 2012 National Building Code of Canada 2015 NIBS Building Envelope Design Guide RS Means TAC Geometric Design Guide for Canadian Roads UBC Integrated Stormwater Management Plan UBC Technical Guidelines 2018 Edition UBC Vancouver Campus Plan Design Guidelines	AutoCAD 2019 Bluebeam REVIT 2019 SAP2000 EPASWMM 5.1 Microsoft Excel InkScape Adobe Illustrator Microsoft Word



1) 3D view of the underground structure



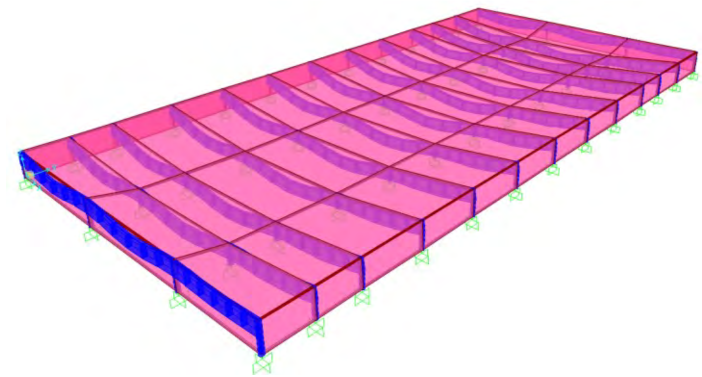
2) Detailed 3D view of the parkade before rendering



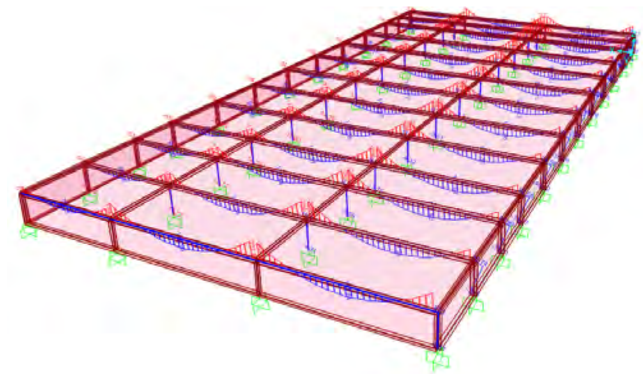
3) Detailed 3D view of the parkade after rendering

SAP2000 Analysis

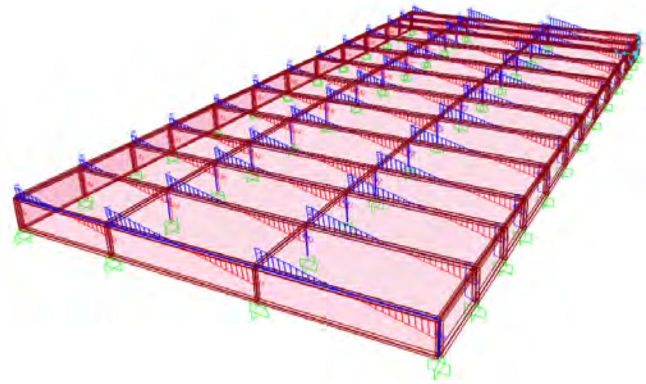
1) Plan view of the model



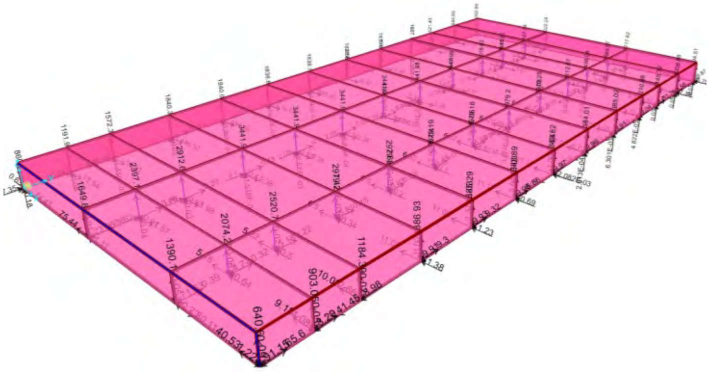
2) Deflection shape of the structure



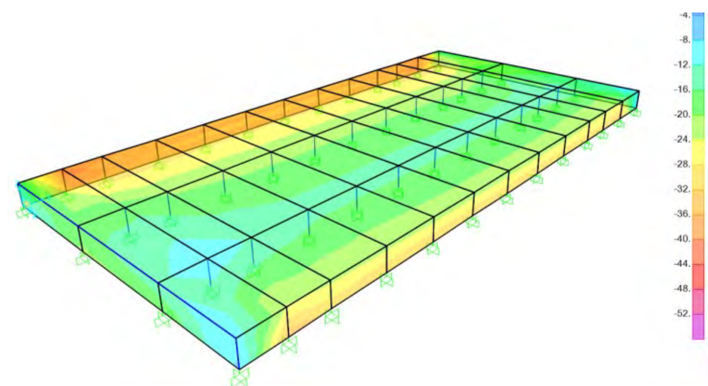
3) Bending Moment Diagram of beams



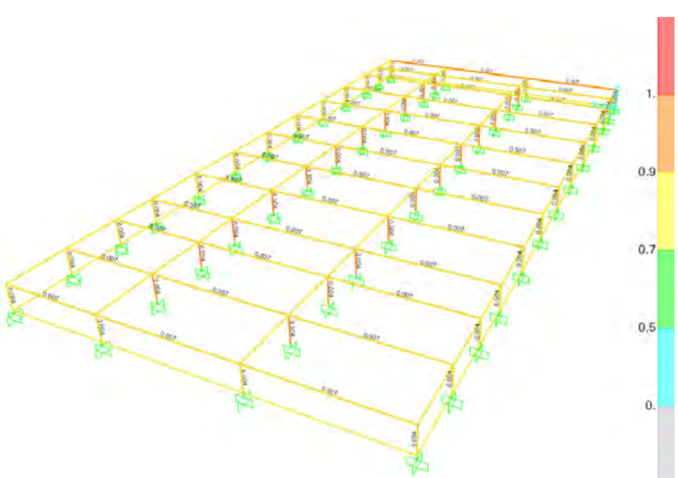
4) Shear Diagram of beams



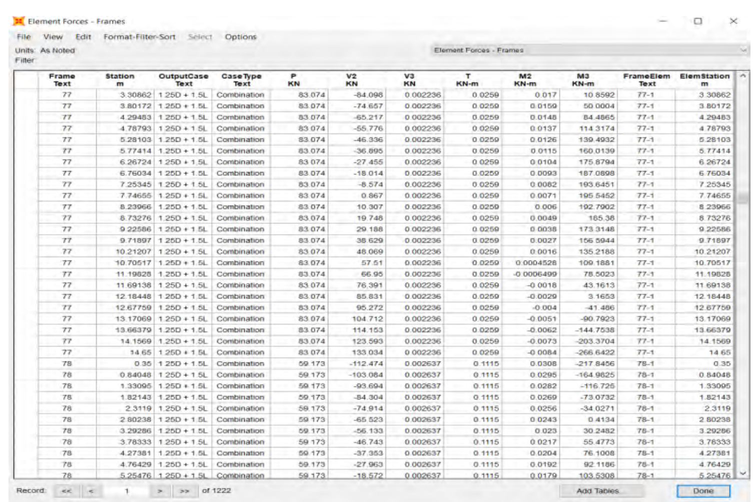
5) Forces at the joints



6) The stress contour of the slab



7) Built-in concrete design checks



Element Forces - Frames

File View Edit Format-Filter-Sort Select Options

Units: As Noted

Filter

Element Forces - Frames

Frame Text	Station m	OutputCase Text	CaseType Text	P KN	V2 KN	V3 KN	T KN-m	M2 KN-m	M3 KN-m	FrameElem Text	ElemStation m
77	3.30862	1.25D + 1.5L	Combination	83.074	-84.098	0.002236	0.0259	0.017	10.8592	77-1	3.30862
77	3.80172	1.25D + 1.5L	Combination	83.074	-74.657	0.002236	0.0259	0.0159	50.0004	77-1	3.80172
77	4.29483	1.25D + 1.5L	Combination	83.074	-65.217	0.002236	0.0259	0.0148	84.4865	77-1	4.29483
77	4.78793	1.25D + 1.5L	Combination	83.074	-55.776	0.002236	0.0259	0.0137	114.3174	77-1	4.78793
77	5.28103	1.25D + 1.5L	Combination	83.074	-46.336	0.002236	0.0259	0.0126	139.4932	77-1	5.28103
77	5.77414	1.25D + 1.5L	Combination	83.074	-36.895	0.002236	0.0259	0.0115	160.0139	77-1	5.77414
77	6.26724	1.25D + 1.5L	Combination	83.074	-27.455	0.002236	0.0259	0.0104	175.8794	77-1	6.26724
77	6.76034	1.25D + 1.5L	Combination	83.074	-18.014	0.002236	0.0259	0.0093	187.0898	77-1	6.76034
77	7.25345	1.25D + 1.5L	Combination	83.074	-8.574	0.002236	0.0259	0.0082	193.6451	77-1	7.25345
77	7.74655	1.25D + 1.5L	Combination	83.074	0.867	0.002236	0.0259	0.0071	195.5452	77-1	7.74655
77	8.23966	1.25D + 1.5L	Combination	83.074	10.307	0.002236	0.0259	0.006	192.7902	77-1	8.23966
77	8.73276	1.25D + 1.5L	Combination	83.074	19.748	0.002236	0.0259	0.0049	185.38	77-1	8.73276
77	9.22586	1.25D + 1.5L	Combination	83.074	29.188	0.002236	0.0259	0.0038	173.3148	77-1	9.22586
77	9.71897	1.25D + 1.5L	Combination	83.074	38.629	0.002236	0.0259	0.0027	156.5944	77-1	9.71897
77	10.21207	1.25D + 1.5L	Combination	83.074	48.069	0.002236	0.0259	0.0016	135.2188	77-1	10.21207
77	10.70517	1.25D + 1.5L	Combination	83.074	57.51	0.002236	0.0259	0.0004528	109.1881	77-1	10.70517
77	11.19828	1.25D + 1.5L	Combination	83.074	66.95	0.002236	0.0259	-0.0006499	78.5023	77-1	11.19828
77	11.69138	1.25D + 1.5L	Combination	83.074	76.391	0.002236	0.0259	-0.0018	43.1613	77-1	11.69138
77	12.18448	1.25D + 1.5L	Combination	83.074	85.831	0.002236	0.0259	-0.0029	3.1653	77-1	12.18448
77	12.67759	1.25D + 1.5L	Combination	83.074	95.272	0.002236	0.0259	-0.004	-41.486	77-1	12.67759
77	13.17069	1.25D + 1.5L	Combination	83.074	104.712	0.002236	0.0259	-0.0051	-90.7923	77-1	13.17069
77	13.66379	1.25D + 1.5L	Combination	83.074	114.153	0.002236	0.0259	-0.0062	-144.7538	77-1	13.66379
77	14.1569	1.25D + 1.5L	Combination	83.074	123.593	0.002236	0.0259	-0.0073	-203.3704	77-1	14.1569
77	14.65	1.25D + 1.5L	Combination	83.074	133.034	0.002236	0.0259	-0.0084	-266.6422	77-1	14.65
78	0.35	1.25D + 1.5L	Combination	59.173	-112.474	0.002637	0.1115	0.0308	-217.8456	78-1	0.35
78	0.84048	1.25D + 1.5L	Combination	59.173	-103.084	0.002637	0.1115	0.0295	-164.9825	78-1	0.84048
78	1.33095	1.25D + 1.5L	Combination	59.173	-93.694	0.002637	0.1115	0.0282	-116.725	78-1	1.33095
78	1.82143	1.25D + 1.5L	Combination	59.173	-84.304	0.002637	0.1115	0.0269	-73.0732	78-1	1.82143
78	2.3119	1.25D + 1.5L	Combination	59.173	-74.914	0.002637	0.1115	0.0256	-34.0271	78-1	2.3119
78	2.80238	1.25D + 1.5L	Combination	59.173	-65.523	0.002637	0.1115	0.0243	0.4134	78-1	2.80238
78	3.29286	1.25D + 1.5L	Combination	59.173	-56.133	0.002637	0.1115	0.023	30.2482	78-1	3.29286
78	3.78333	1.25D + 1.5L	Combination	59.173	-46.743	0.002637	0.1115	0.0217	55.4773	78-1	3.78333
78	4.27381	1.25D + 1.5L	Combination	59.173	-37.353	0.002637	0.1115	0.0204	76.1008	78-1	4.27381
78	4.76429	1.25D + 1.5L	Combination	59.173	-27.963	0.002637	0.1115	0.0192	92.1186	78-1	4.76429
78	5.25476	1.25D + 1.5L	Combination	59.173	-18.572	0.002637	0.1115	0.0179	103.5308	78-1	5.25476

Record: << < 1 > >> of 1222 Add Tables... Done

8) The tabulated results of the analysis

1. Environmental Protection
    a. Site Working Areas
        i. Confine operations to limits of the site working area shown on Drawings.
        ii. Provide access roads to the site working area and on the site in locations shown or otherwise acceptable to the Engineer.
        iii. Install fencing to clearly define the working limits to the site working area, haul routes, parking areas, access routes, and maintenance areas to ensure all activity is confined to these areas.
    b. Environmental Monitoring
        i. All recommendations of the Environmental Monitor must be implemented in a timely fashion.
        ii. The Environmental Monitor has the authority to halt work to remedy environmental risks and the Contractor must implement all recommendations made by the Environmental Monitor.
    c. Drainage
        i. Provide temporary drainage and pumping as necessary to keep excavations and site free from water.
        ii. Do not pump water containing suspended materials into waterways and drainage system.
2. Site Demolition and Removals
    a. Products
        i. Site Barrier Fence
            1. Silt fence to be manufactured from a woven, silt film geotextile material with a shiny to smooth surface texture designed to reduce velocity of runoff to a point that suspended particles settle out due to reduction of hydraulic energy.
            2. Minimum Requirements
                a. Grab Tensile 500 N
                b. Mullen Burst 1900 kPa
                c. Elongation at Break 25% Maximum
                d. Opening 600 µm maximum
                e. U.V. Rating at 500hrs 90% Retained
                f. Efficiency >75% minimum
                g. Construction Woven (tape)
                h. Texture Smooth, shiny
                i. Posts 4x4 cm, treated
                j. Post Spacing (centres) 2 metre maximum
                k. Permittivity 10 L/s/m2
3. Clearing and Grubbing
    a. Clearing: Clear as indicated or as directed by Engineer, by cutting at a height of not more than 300 mm above ground. In areas to be subsequently grubbed, height of stumps left from clearing operations to be not more than 1000 mm above ground surface.

b. Grubbing: Grub out stumps and roots to not less than 200 mm below ground surface. Grub out visible rock fragments and boulders, greater than 300 mm in greatest dimension, but less than 0.5 m3.

4. Granular Base
   a. Granular base: Type 1 fill in accordance with Section 02315 – Excavating, Trenching, and Backfilling.
   b. Compact to a density of not less than 100 percent maximum dry density in accordance with ASTM D698.
   c. Finished sub-base surface to be within 10 mm of elevation as indicated but not uniformly high or low.
5. Granular Sub-base
   a. Granular sub-base: Type 2 fill in accordance with Section 02315 – Excavating, Trenching, and Backfilling.
   b. Compact to a density of not less than 100 percent maximum dry density in accordance with ASTM D698.
   c. Finished sub-base surface to be within 10 mm of elevation as indicated but not uniformly high or low.
6. Site Grading
   a. Strip all organic material to specified limits and specified depth. Stockpile for re-use as shown in Contract Documents. Do not handle topsoil while in wet or frozen condition or in any manner in which soil structure is adversely affected. Remove all debris and unusable material as specified in the Contract Documents.
   b. Surface drainage: provide suitable temporary ditches or other approved means of handling drainage prior to excavation and during construction to protect construction area and adjacent and other affected properties. Provide siltation controls to protect natural watercourses or existing drainage facilities
7. Excavation, Trenching and Backfilling
   a. Type 1: select pit run gravel graded within the following limits:

	Sieve Size (Tyler)	Percent Passing
150	mm sq. opening	100
75	mm sq. opening	60 – 100
25	mm sq. opening	60 - 80
4.75	mm (No. 4 sieve)	25 – 45
0.85	mm (No. 20 sieve)	10 – 20
0.425	mm (No. 40 sieve)	5 – 18
0.075	mm (No. 200 sieve)	0 - 6

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b. Type 2: crushed gravel graded within following limits

	Sieve Size (Tyler)	Percent Passing
25	mm sq. opening	100
20	mm sq. opening	95 – 100
10	mm sq. opening	60 – 80
4.75	mm sq. (No. 4 sieve)	40 – 60
2.36	mm sq. (No. 8 sieve)	28 – 48
0.6	mm sq. (No. 30 sieve)	13 – 29
0.3	mm sq. (No. 50 sieve)	9 – 21
0.15	mm sq. (No. 100 sieve)	6 – 15
0.075	mm sq. (No. 200 sieve)	0 – 6

c. Type 3 fill: Selected material from excavation or other sources, approved by the Engineer for use intended, unfrozen and free from rocks larger than 75 mm, cinders, ashes, sods, refuse, or other deleterious materials.

d. Type 4 fill: (Bedding and Pipe Surround) screened or crushed aggregate conforming to the following gradation limits when tested to sizes to ASTM C136:

Sieve Designation	% Passing
19 mm	100
2.36 mm	60-100
4.75 mm	40-80
2.36 mm	30-60
1.18 mm	30-45
0.075 mm	2-9