UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Stadium Neighborhood Underground Parkade and Water Storage

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University of British Columbia

CIVL 446

Themes: Water, Climate, Land

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Executive Summary

We have prepared a detailed design report for the University of British Columbia (UBC), Campus and Community Planning department, as part of the Social, Ecological, Economic Development Studies program. Our team has been retained as the owner's engineer on the Stadium Road Neighbourhood Underground Parkades and Water Storage project. This report will provide a summary of work completed, including stormwater analysis, geotechnical considerations, hydraulic analysis, culvert design, parkade design, and construction plan, construction schedule, and financial costs.

The project has both primary and secondary objectives. The primary objective of the project is stormwater management of the site area, and the secondary objective is the design and integration of a parkade into the Stadium Neighbourhood. To meet client requirements, both daily precipitation and emergency storm water events will be included in the stormwater analysis. The parkade design will be inclusive of both current and future residential needs.

The majority of the stormwater storage capacity will be provided by a bioswale running between the travel lanes of West 16th Avenue. The bioswale will be 380m in length and range from 6.1m to 10.6m in width. The depth of the swale will be 2m from the top of wall to the top of bedding soil. The bedding soil will be 0.2m deep to allow it to act as an adequate growing median for the plants, including bullrush. The retaining walls of the swale will be 0.15m wide, and 4.3m deep and secure with anchor rods to prevent overturning. The bottom slab of the swale will be 0.45m deep, with 20M rebar at 300mm spacing to provide appropriate structural capabilities. Three pumps in series will recirculate water from the bottom of the swale to the top. In addition, a 2% slope will be maintained through the length of the swale; both of these measures will prevent water from remaining stagnant throughout the swale. A pedestrian crossing will be constructed midway along the length, with an 870mm corrugated steel pipe.

The underground parkade will measure 110m by 62m and be integrated into the stadium structure. The parkade will act as event parking, in addition to considering transportation projections and sustainable development. The parkade will require a 250mm thick, 13m deep concrete diaphragm wall with 9m anchor rods. The base slab will consist of 420mm concrete slab with 6-25M rebar, and a 450mm slab with 25M rebar at 80mm will form the roof. In each direction, ten Concrete beams sized 800mm x 400mm with 4-25M rebar will carry the loads to 970mm x 970 mm columns with 12-20M rebar. The parkade will replace the current number of stalls that are provided, coming to a total of 150 stalls. This will include 15 electric vehicle charging stations. Finally, the parkade will include 50 class A bike storage spaces.

The construction of the bioswale and parkade is expected to take 264 and 511 days respectively. The total project time is expected to be 796 days with 3 months of weathering allowance. The construction cost is estimated to be $3.16M for the swale, $4.97M for the parkade, $4.67M for fees and contingency, and a total cost of $12.8M. A service life maintenance plan yielded annual costs of $7k and $17k for the swale and parkade respectively. Converted to net present value over the 100-year design life yields a cost of $570K, bringing the total lifetime project cost to $13.4M.

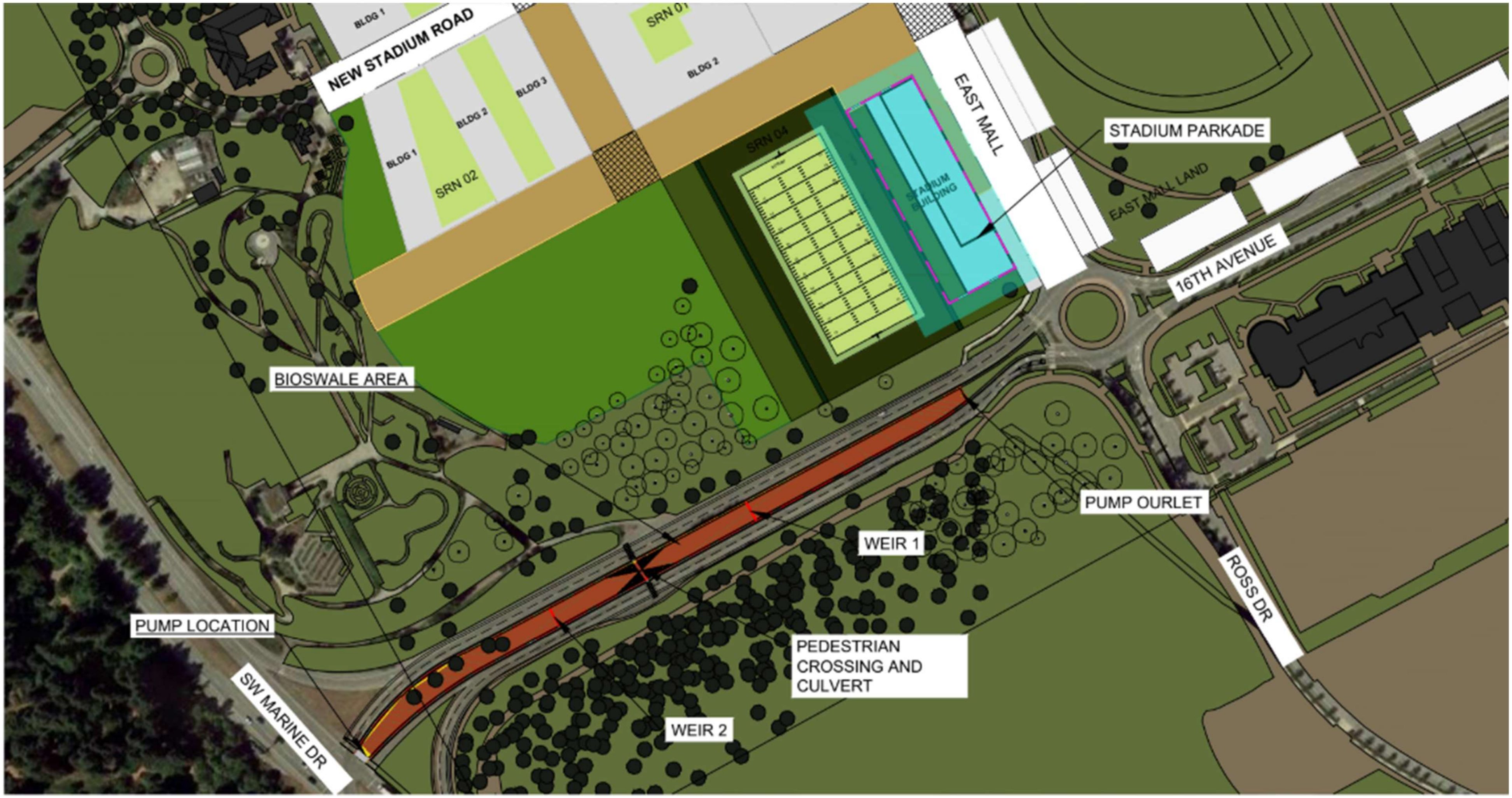


Figure 0: Stadium road neighbourhood - parking and water management mixed solution overview

TABLE OF CONTENTS

LIST OF ILUSTRATIONS

LIST OF FIGURES

LIST OF TABLES

1 Introduction

1.1 Overview and Objectives

Future land development of the Stadium Road Neighbourhood (SRN) is proposed by UBC. The SRN is bordered by the UBC Botanical Garden, East Mall, West 16th Avenue, and Stadium Road. Future land development of the area includes the relocation of the current Thunderbird Stadium and the development of a high-density residential area. Due to the increase of impermeable surfaces, design of a new mixed-use underground parkade and stormwater detention system has been requested. The designs in this report are based on the SRN community plan provided at the CIVL445 Plenary Session on September 10, 2018 and are subject to alteration upon changes made to the SRN development plan.

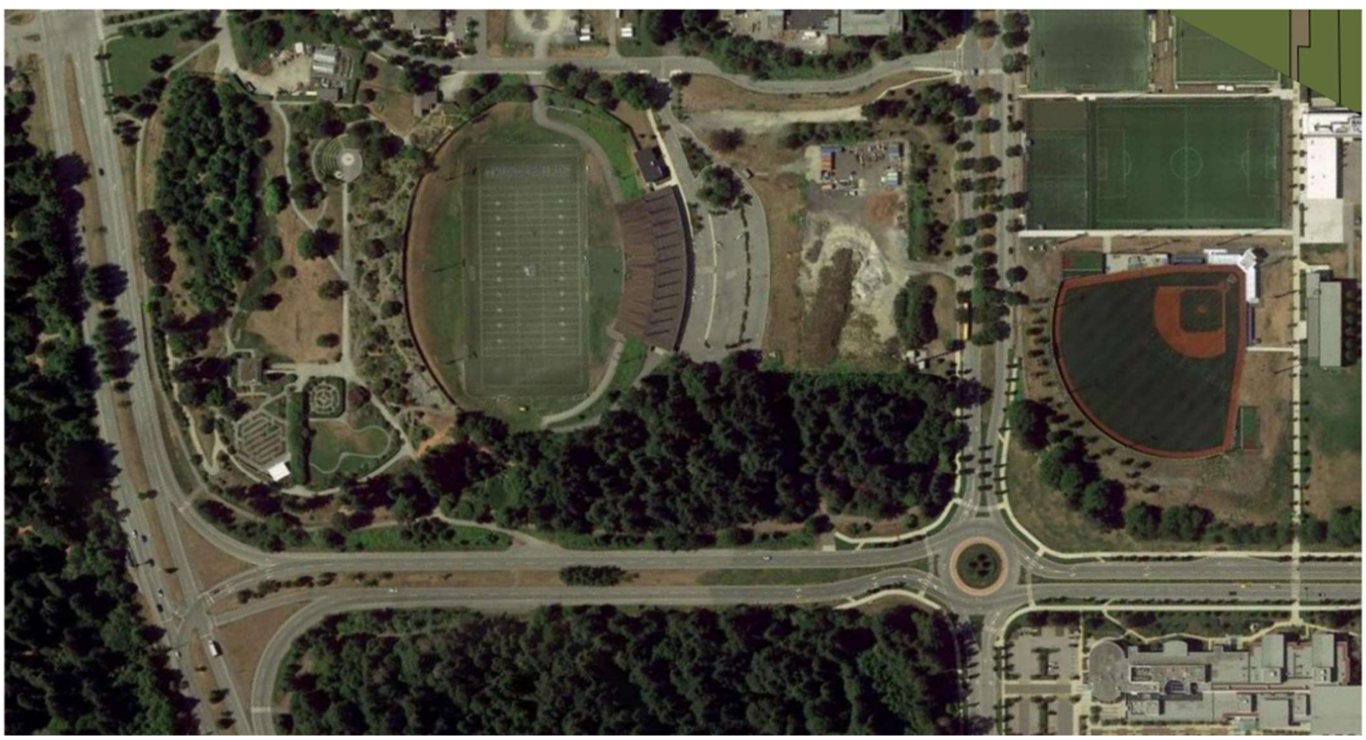


Figure 1: Site overview

1.2 Site Constraints

Site constraints for the stormwater retention system include limited space for storage. Additionally, the available space on site is a narrow and elongated shape, which poses design challenges. Further, the site resides on a slope that is highest in the North-East corner and lowest in the South-West corner. The grading of the site poses challenges for water storage, particularly in the underground parkade which is to be located along the Eastern edge of the site, where the elevation is among the highest in the catchment area.

A limit on water storage is a practical constraint for this project that arises from the limited land space on site. Average stormwater volumes can be practically stored, however the volume from a 1:100-year storm will necessitate a safe exit drainage to the ocean to prevent flooding.

Outflow constraints for this site are a significant design requirement. It is required in regular precipitation events, as well as in a 1:100-year storm event, that cliff erosion from water runoff is not permitted. Preventing stormwater flooding into the UBC Botanical Gardens is another design constraint. Runoff can be controlled and thus cliff erosion mitigated using detention and release systems explained in more detail in further sections of this report.

Taking the UBC Sustainability Initiative into account, we plan to meet or exceed these goals by minimizing the impact on the areas surrounding the SRN, by minimizing stormwater causing cliff erosion, and by utilizing an environmentally friendly and attractive swale design for water storage.

1.3 Geotechnical and Groundwater Investigation

A research investigation of soil and groundwater conditions has been conducted to gain an understanding of the impact of the proposed SRN developments. This section will detail the findings of the research investigation.

A geotechnical investigation was carried out by GeoPacific Consultants Ltd. in July of 2006 at the south-east corner of West 16th Avenue and Wesbrook Mall [1]. The investigation report has been provided to us by the client. GeoPacific Consultants performed and recorded three bore holes at the aforementioned location. The soil profile reported is summarized as shown in Table 1 below. If the stratigraphy at the SRN site is similar to soil profile in Figure 2, development can likely be carried out without requiring extensive ground improvement prior to construction.

Table 1: Approximate soil profile at 16th Avenue and Wesbrook Mall: [2]

Depth from (m)	Depth to (m)	Soil Description
0	0.3	Topsoil
0.3	9.2	Glacial Till

A geotechnical and groundwater investigation was carried out by Piteau Associates in September of 2002 at the North end of the UBC campus [2]. Their study area was centered around the Museum of Anthropology (MOA). The report of the investigation has been provided to us by the client. Piteau Associates drilled six bore holes, conducted a groundwater analysis, and performed a slope stability analysis at the aforementioned location.

Conclusions of relevance to this project from the Piteau report include:

1. In most areas, 16 to about 22 m-asl of dense, low permeability till overlays an upper aquifer quadra sand unit. Some of the water in the upper aquifer seeps down to the lower aquifer unit which is located just above sea level. Only a small portion of the water in the upper aquifer discharges high up on the cliff face where it could cause local slope instability.
2. The discharge from the Lower aquifer is typically through talus and beach deposits and does not exacerbate slope instability.
3. No significant change in water level from 1975 to 2002 was observed, which indicates that developments that occurred during that time period, including the construction of the MOA did not have an impact on aquifer water levels and did not increase discharge from the cliff face.

4. Provided that groundwater seepage control measure are implemented, new building development will not impact the upper quadra sand aquifer and so will not contribute to cliff slope instability.

From the relevant conclusions and recommendations in the Piteau report, recommendations for development of the SRN are as follows:

1. Perimeter drainage of new buildings should be directed to a piped storm drain system.
2. Water level monitoring using monitoring wells should be established at quarterly intervals for the next three years to produce a baseline trend prior to construction.

The installation of passive dewatering wells should be considered, similar to what has been installed near the cliffs by the MOA. A diagram of such a dewatering well is provided by Piteau Associates and is shown in the figure below. The purpose of the dewatering well is to drain water from the upper aquifer to the lower aquifer, where discharge does not exacerbate slope stability, thereby reducing the volume of water discharging from the upper aquifer higher on the cliff face.

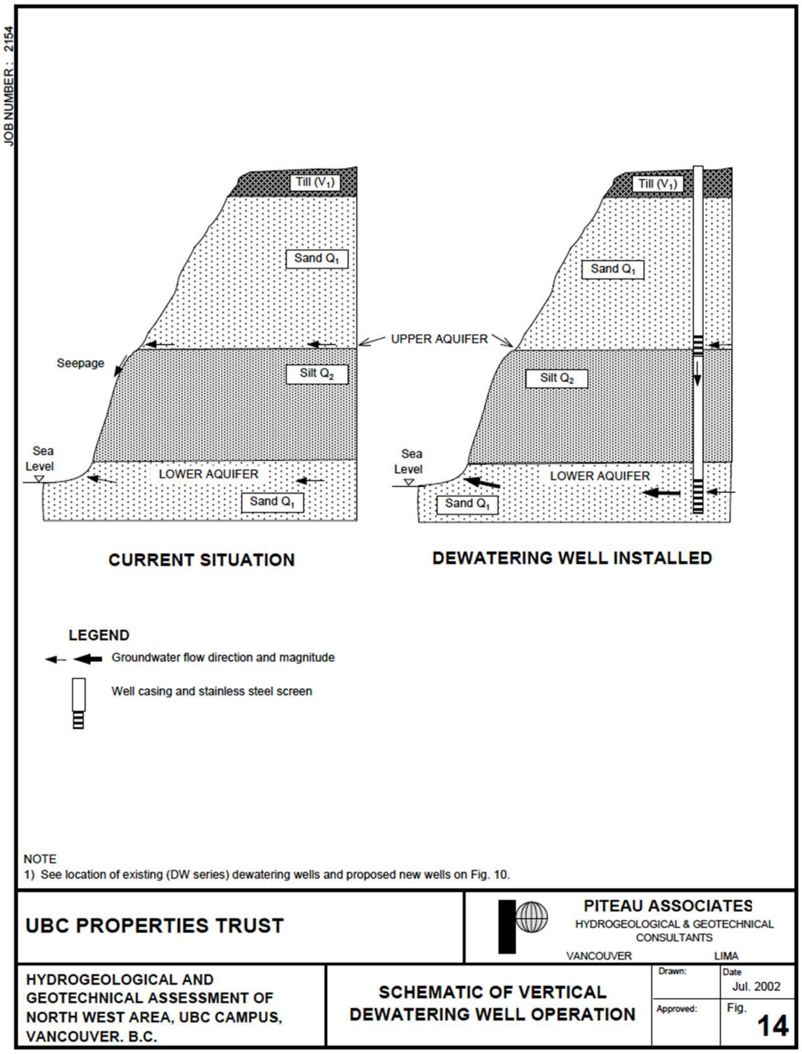


Figure 2: Dewatering well schematic [2]

It is important to note the research conducted in this section is based off of previous investigations which were both significant distance from the SRN site. Therefore, we are basing our soil layer and groundwater assumptions off of investigations that are spatially distant and hence must be followed with further investigation in the SRN site. In this report geotechnical design of the parkade foundation and retaining walls and swale retaining walls has been outlined. However, geotechnical investigation on site is required prior to construction.

1.4 Work Breakdown

Section	Primary	Reviewer
Letter of Transmittal	Erik Bonderud	Karin Huang
Executive Summary	Erik Bonderud	Karin Huang
Introduction	Erik Bonderud	Karin Huang
Report Creation	Erik Bonderud	Karin Huang
Geotechnical Investigation	Eric Rothfels	Alan Ehrenholz
Bioswale and Roadwork		
Overview	Erik Bonderud	Monica Liu
Stormwater Analysis	Trevor Jones	Alan Ehrenholz
Bioswale Sizing	Trevor Jones	Alan Ehrenholz
Retaining Wall	Eric Rothfels	Erik Bonderud
Slab Design	Trevor Jones	Eric Rothfels
Water Recirculation	Trevor Jones	Alan Ehrenholz
Steel Weir	Trevor Jones	Alan Ehrenholz
Pedestrian Culvert	Alan Ehrenholz	Trevor Jones
Parkade		
Overview	Monica Liu	Trevor Jones
Features	Monica Liu	Trevor Jones
Structural Analysis	Monica Liu	Trevor Jones
Geotechnical	Eric Rothfels	Erik Bonderud
Project Management		
Safety Plan	Monica Liu	Trevor Jones
Environmental Plan	Karin Huang	Trevor Jones
Stakeholder Plan	Karin Huang	Monica Liu
Schedule	Karin Huang	Erik Bonderud
Cost Estimate	Erik Bonderud	Karin Huang

Construction Plan	Erik Bonderud	Karin Huang
Construction Issues	Karin Huang	Erik Bonderud
Traffic Management Plan	Trevor Jones	Karin Huang
Service Life Maintenance Plan	Erik Bonderud	Karin Huang
Appendices:		
Drawings	Alan Ehrenholz	Trevor Jones
References	Erik Bonderud	Alan Ehrenholz

2 Bioswale and Roadwork

In order to minimize stormwater leaving the Stadium Road Neighbourhood, promote sustainable water use [3], and maintain the aesthetics and environmental integration that UBC promotes, a bioswale was designed along the length of W16th Avenue from East Mall to SW Marine Drive.

The bioswale is the primary rainfall storage facility for our project and is an 10.9 meter wide concrete structure that will be installed along the median of West 16th Avenue. The exact location of the bioswale is shown in Figure 3. The bioswale will be composed three 10.6 meter by 100 meter concrete slabs that each will have two retaining wall on either side of them. In addition, the bioswale will have a pump and pipe system to recirculate water throughout the bioswale and it will have three steel weirs at the downstream end of each slab. We have also designed a pedestrian crossing to connect the Southern bus stop to the crosswalk on the Northern side of West 16th Avenue.

Figure 3: Swale map

2.1 Stormwater Analysis

Based on the United States Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) file provided by the client, the peak stormwater precipitation rate and total daily precipitation in a 1:100-year storm event was determined to be 15 mm/h and 129 mm respectively. For the 34 hectare W 16th Avenue catchment area, the total precipitation in one such storm produces 43870 m3 of stormwater. This volume of stormwater far exceeds the proposed water retention system's capacity of 2700 m3 and hence would be discharged.

The Rational Method was used to determine the 1:100-year peak flow rate in the catchment of 3672 m3/h. The peak flow was calculated using a catchment area of 34 hectares and assumes a future ratio of 70 percent impermeable surfaces due to development of the SRN. Assuming an elevation difference of at least 2 m from the bottom of the swale to the bottom of the discharge pipe, an 18" (457 mm) diameter pipe would be sufficient to safely transport the peak flow to the outflow location. At the pipe outflow location, we propose installing a controlled runout to the ocean. The runout is to consist of a concrete base overlaying the slope, with rip rap placed on top of the concrete at the base of the slope to slow outflow. This system would not contribute to cliff erosion due to the water being not in contact with the soil. In terms of sustainability, the water will exit the runout with a reduced velocity due to the rip rap to ensure it does not disrupt the surrounding ecosystem.

For average precipitation, Canadian Climate Normals for Vancouver Oakridge station from 1981-2010 was utilised [4] for average precipitation volumes per month. These volumes were then used to calculate average volume of precipitation per day for the 34 hectare 16th Avenue catchment area. All of the rainwater will be retained for potential reuse to supply the Botanical Gardens, and the stadium field. For average winter months, we expect 2473 m3/day, as shown in the following table.

Table 2: Average daily precipitation volumes for 16th Avenue catchment by season

Season	Average Daily Precipitation (m3/d)
Winter	2473
Spring	1166
Fall	1184
Summer	581

2.2 Bioswale Sizing

The size of the swale was adjusted from the conceptual design based on a more detailed examination of the site, as well as preliminary stormwater demand calculations.

After more detailed calculations were conducted, it was determined that a typical winter storm event will deliver ~2400m3 of water over the course of the day. In order to account for that, the storage depth of the swale needs to be 1.2m; however, the swale was designed to 1.6m to allow space for the plant soil and a protective rip rap cover. The flow depth will remain at 1m as this is the height needed to reach the top of the outflow pipe with some buffer. This results in a total depth of 2.6m.

In order to withstand the expected flows of a 100-year storm event, the width was increased to be roughly 10m. Due to site constraints there will be some variation in swale width along the length, and at roughly the middle of the length the swale will contract and pass underneath a pedestrian path via a large culvert.

It was determined that the existing outflow pipes discharging at Old Marine Drive are sufficiently large to meet demand during the 100-year event. They will, however, be modified to connect the inflow to the West end of the swale and the outflow to the bottom of the cliff.

In order to prevent standing water, a pump system will transfer a low flow of water from the bottom of the swale to the top.

A pump and simple filtration system will be incorporated into the swale to allow the stored water to be used in the surrounding area. Some used for the water include watering the sports field and irrigating the botanical garden.

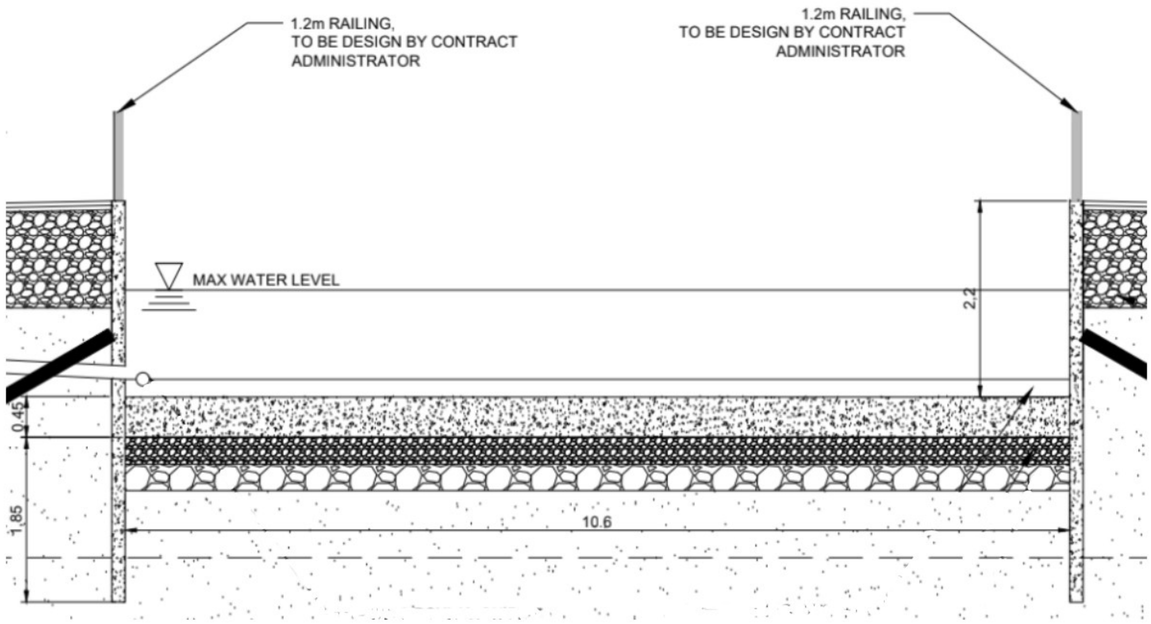


Figure 4: Typical swale cross section

2.3 Retaining Walls Design

The bioswale retaining walls were designed using WALLAP software with a factor of safety of 2. A 50kPa load adjacent to the walls was assumed to account for traffic loading from the West 16th Avenue roadway. Structural fill to a depth of 1.2m below surface level was assumed to overlay a layer of silty sand. Groundwater level was assumed to be static and at 4m below surface grade. WALLAP analysis results can be found in Appendix J.

Concrete diaphragm walls were designed with a depth of 4.3m and width of 150mm. The walls were designed with bar anchors having an unbonded length of 3m, a bonded length of 1m, a safety factor of 2, a load of 31kN per strut, and with specifications in the following table. A safety factor of 2.8 was found using WALLAP for the stability of the bioswale walls.

Table 3: Bioswale retaining wall anchor design

Type	Depth (m)	Horizontal Spacing (m)	Length (m)	Diameter (mm)	Inclination angle (deg)
Bar Anchor	1.5	3	4	150	30

Construction of the retaining walls and slab base will be carried out in the following sequence:

Table 4: Bioswale excavation sequence

Stage	Description
1	Excavate to elevation of 1.75m below existing grade
2	Install anchor at elevation 1.5m below surface grade
3	Excavate to elevation of 3.35m below existing grade
4	Compact natural soil
5	Place 300mm of granular subbase
6	Place 300mm of 2” minus crushed drain rock

Compaction of the natural soil, subbase, and crushed drain rock layer using vibratory or rolling compactors is required prior to pouring the concrete slab. The drain rock layer will mitigate differential settlement of the swale base in saturated conditions, given that some leakage is likely to occur. Note that on-site geotechnical investigation of soil and groundwater conditions is required prior to all excavation and construction

2.4 Bioswale Slab Design

The bioswale will have three 100 meter by 10.6 meter wide reinforced concrete slabs and will be designed according to CSA23.3 for Reinforced Concrete Structures. For the structural design of each bioswale slab, the bearing capacity of the soil beneath the slab needed to be determined. The bearing capacity was calculated to be 969kPa using the assumptions that phi is 33 degrees and that the saturated density of the soil is 19kN per meter cubed. The bearing capacity sample calculations are in Appendix J.

From there, the amount of steel needed for each slab can be determined. The design load for each slab is two meters of water and the water is considered a live load. Through the calculations in Appendix J, it was determined that no structural steel is needed for the slab and that only the minimum amount of steel is needed for shrinkage of the concrete.

The next step in the structural design of each bioswale slab is determining the thickness of the concrete slab. For these calculations, it was assumed that each slab is simply supported between the two retaining walls and that each slab is a one-way slab. The minimum slab thickness was determined to be 530mm. The actual thickness of the slab is 550mm for easier constructability.

The final step in the design of each bioswale slab is determining what type of rebar will be used and the spacing of the rebar. Through the calculations in Appendix J, it was determined that the minimum rebar area is 900mm2 for a one meter width of the slab. The maximum spacing of the rebar is 500mm. The rebar design for the concrete slab is 20M bars at 300mm spacing.

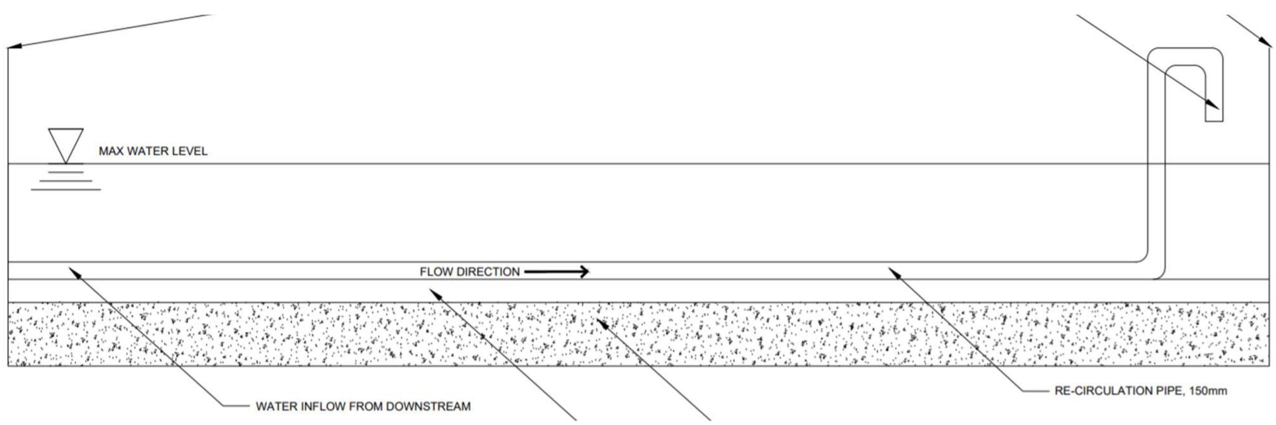


Figure 5: Water recirculation system

2.5 Water Recirculation System

For the recirculation of water throughout the bioswale, our team has designed a pump and pipe system that will transport water from the downstream end of the bioswale to the beginning of the bioswale. The pump system will have three pumps in series, each with a different range of operating flow rates. During the operation of the bioswale, only one pump will operate at a time and the pump system will be able to accommodate flows between 7L/s and 26L/s. The pump system needs that range of operational flow rates to accommodate the range of flow rates expected from the Stadium Neighborhood. The pump system is designed to have only one pump operate at a time to allow maintenance to be performed on the other pumps and to ensure each pump operates near maximum efficiency. The pump curve sheets are in Appendix G.

The pipe connecting the downstream pumps to the beginning of the bioswale is 150mm diameter steel pipe. The system demand curve and the different pump curves of the pumps operating at maximum rotational speed are shown in Figure 5. The system demand curve starts at 15 meters because there is a 15 meter elevation difference between the beginning and end of the pipe system. The system demand data sheet is in Appendix G.

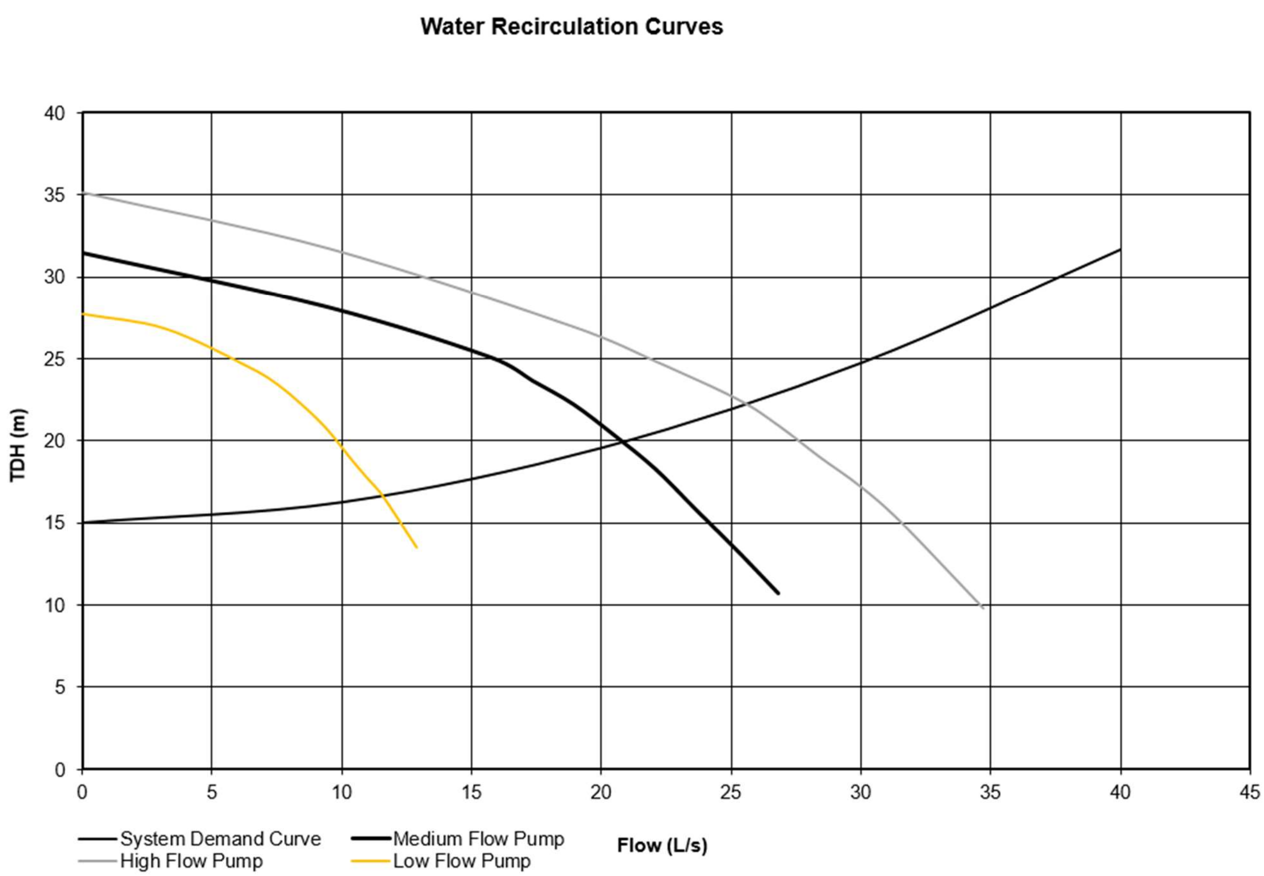
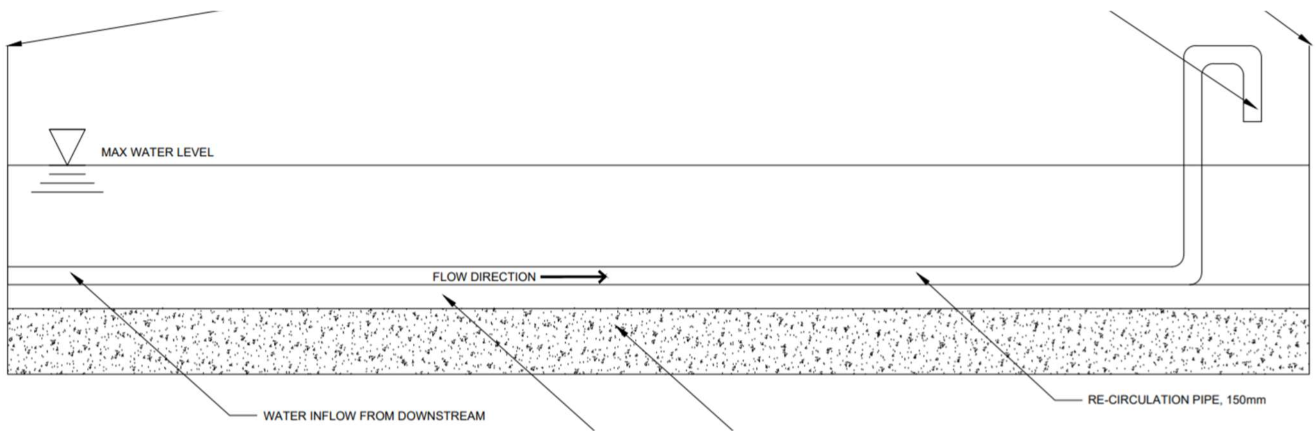


Figure 5: Pump and system demand curves

The pumps will be housed in a building on the downstream end of the bioswale as seen in Appendix J. The water will be siphoned at the bottom of the bioswale and will be transported to the pumps which will be one meter above the maximum water level. After the recirculated water has gone through each of the pumps it will then be transported to the upstream portion of the bioswale through a pipe at the bottom of the bioswale. The upstream portion of the water recirculation system is shown in

Figure 6. The structural design of the pump building will be contracted out to a structural



engineering consultant.

Figure 6: Recirculation pipe upstream

2.6 Steel Weir Design

At the downstream end of each bioswale slab, there will be a steel weir installed to control the flow of the stormwater throughout the bioswale. The steel weirs will have a rectangular opening shown in Figure 7 and in Appendix J. The dimensions of the rectangular opening are designed to handle the peak flow expected from the Stadium Neighborhood. The calculations for determining the size of the rectangular opening are shown in Appendix J. The calculations assumed that the water level in the bioswale is one meter deep because the rectangular opening is being sized for the situation where the bioswale is at its expected capacity. The assumed value of the discharge coefficient is the conservative coefficient value for rectangular weirs. The dimensions of the rectangular opening are 653mm wide and 1.9 meters high.

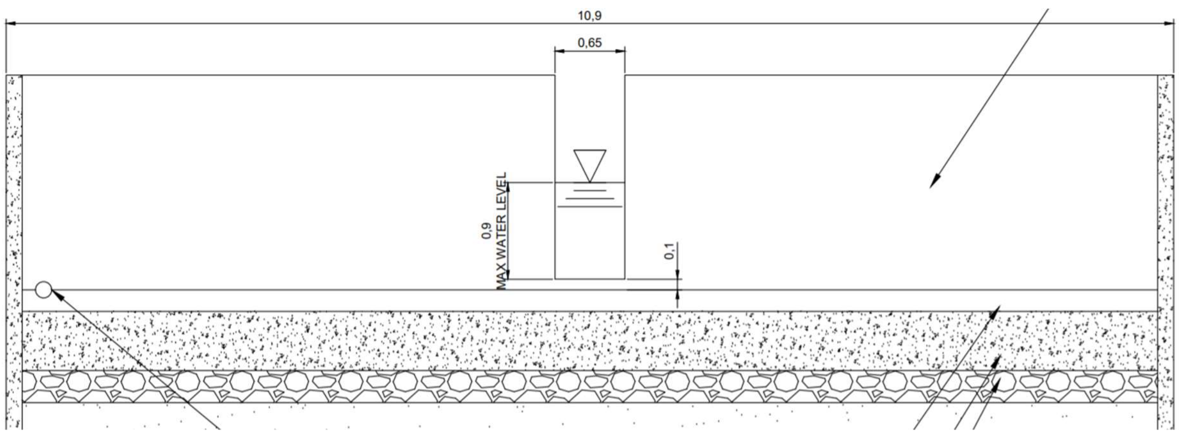


Figure 7: Steel weir cross-section

2.7 Pedestrian Culvert

We have designed a pedestrian crossing that connects the South bus stop to the North bus stop. The pedestrian crossing is an asphalt pathway, 50mm in depth, and is 2.4m in width. The culvert for the pedestrian crossing will be an 870mm diameter corrugated steel pipe. The calculations for the sizing of the culvert is in Appendix J . The calculations assumed that the flow through the culvert is the peak hour flow from the Stadium Neighborhood. The calculations show that the minimum size of culvert is 668mm diameter. The 870mm culvert was chosen to ensure the culvert would have the capacity to withstand unexpected large flows. The structural analysis of the culvert will be done by a sub consultant according to the Handbook of Steel Drainage and Highway Construction Products.

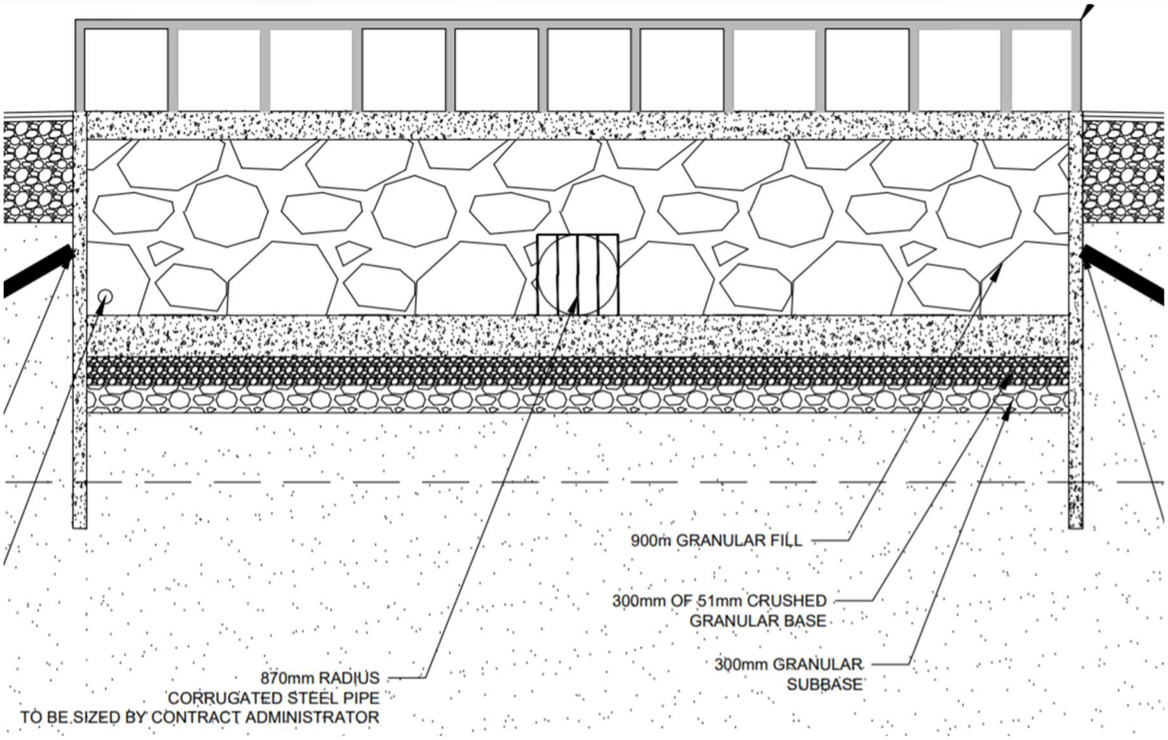


Figure 8: Pedestrian crossing culvert

3 Parkade

In addition to the bioswale, a parkade is also designed for the South Campus Stadium Neighbourhood to provide parking spaces for stadium events. A single-level underground parkade with a capacity of 162 cars is to be constructed directly underneath the stadium. It will situate directly beneath the stadium, with access from the South through East Mall. The parkade capacity is analyzed and proposed in the preliminary report based on the current Thunderbird Stadium parking capacity and the projection of population growth in the area. Functionality of the new stadium is also considered. The Vancouver Parking Bylaw dictates that at least 10% of the parking stalls should be equipped with EV charging stations.

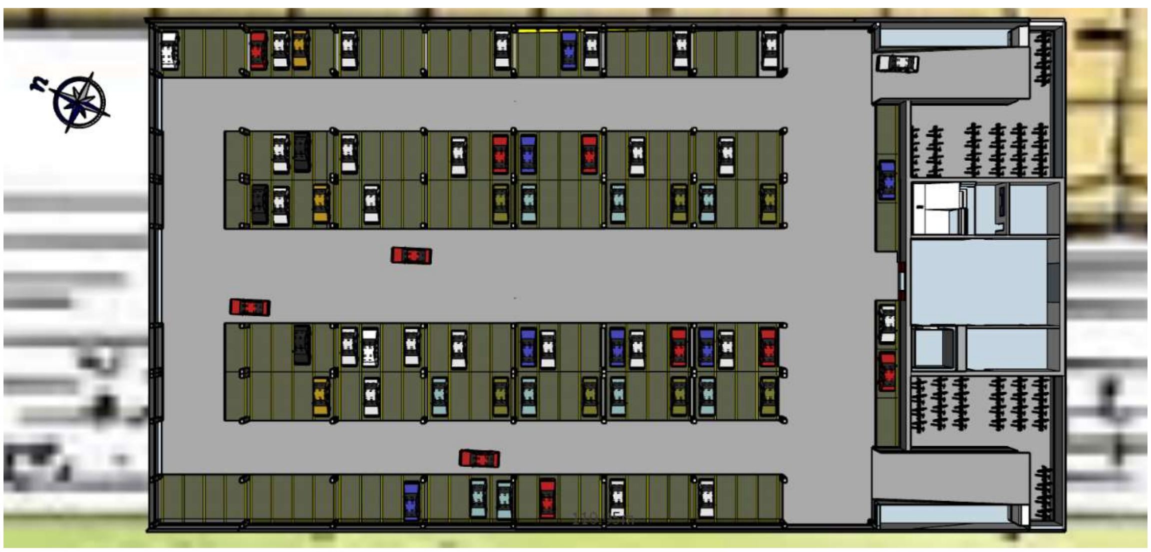


Figure 9: Plan view of the underground parkade

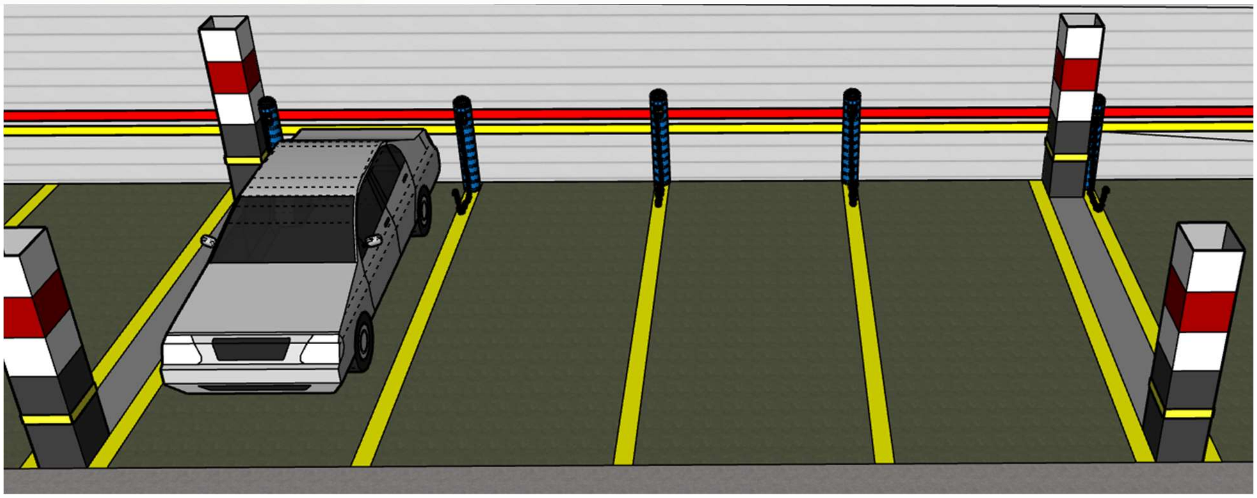


Figure 10: Electric car charging stations on the East side

3.1 Parkade Features

The parkade is designed with the goal to best move cars in and out of the space with ease. The entrance and exits will be single ramp designs and will be located on opposite sides of the parkade to minimize obstruction of view of the drivers and avoid potential collision. The parkade will include an elevator and concrete stair well that will take the guests to the ground floor as well as stadium levels. Design collaboration with the above stadium is required to provide the most efficient access to the space. The dimensions of the stalls and aisle space is designed in compliance with the City of Vancouver Parking Guidelines [5].

The parkade will feature temporary or permanent Class A storage place for 50 bicycles, as well as 15 electrical vehicle charging stations. The EV charging station will be located at the East side of the parkade, directly to the right coming down the ramp. The parkade will include illumination system with strip lighting fixtures running parallel with the aisles; fixtures will be installed above all stalls and at all corners of the facility. As a parking garage is rated as "Low Hazard Industrial Occupancies" as per the City of Vancouver Fire By-laws, fire protection system is needed and must be designed and reviewed by a sprinkler engineer. HVAC system is to design by a mechanical engineer to provide ventilation of the underground space.

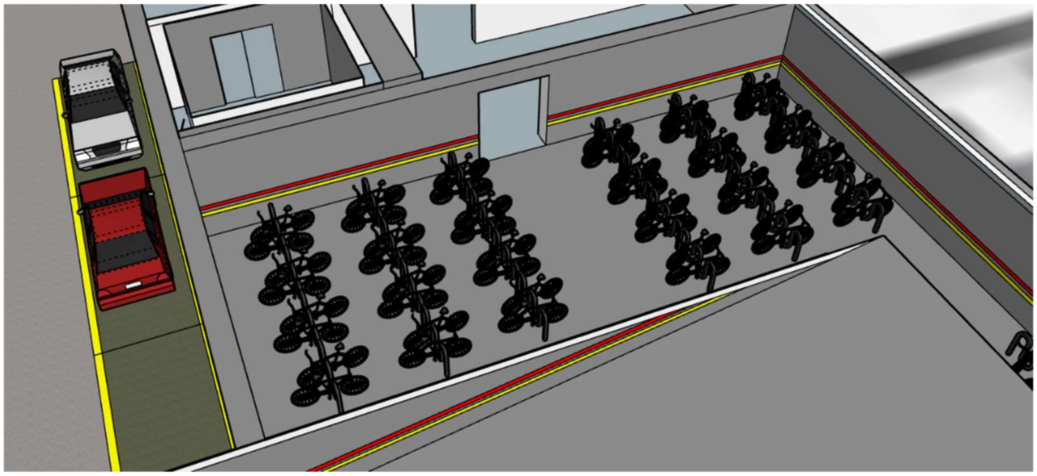


Figure 11: Bike storage

3.2 Structural Analysis and Design

The parkade is designed as a cast-in-place concrete beams and columns structure. In this section of the report, assumptions for design load, and dimensions of the columns, beams, and slab components are presented.

3.2.1 Design Loads

The parkade is situated directly above the stadium, so the gravity load demand calculation assumes of the weight of the distributed area load of the stadium. It should be noted that the design load will change once a more detailed design of the stadium structure is provided.

A summary of the calculated load is provided in Table 5 below. The wind load is calculated for the specific geological location obtaining relevant design values from the National Building Code (2010). The snow load is calculated using the ground snow load (Ss) of 1.9 kPa, and associated rain load (Sr) of 0.3 kPa. In addition, dead loads are calculated and analyzed based on the assumption that the stadium will be a steel frame structure with concrete slabs and decking. The MEP system, fixtures, and bleachers are also considered, which results in a total unfactored dead load of 52.1 kPa.

A live load of 4.8 kPa is prescribed for stadium bleachers as per the National Building Code (2010).

Table 5: Design loads

Wind Loads			
pi = Iw*q50*Ce*Cgi*Cp			
Iw	importance factor	1.15	
q50	basic roof snow load factor	0.45	kPa
Ce	wind exposure factor	1.55	
Cg	slope factor	2	
Cp	shape factor	-0.45 to 3	
Wind loads		1.77	kPa
Snow Loads			
S=Is [Ss*(Cb*Cw*Cs*Ca)+Sr]			
Ss	ground snow	1.9	kPa
Cb	basic roof snow load factor	0.8	
Cw	wind exposure factor	1	
Cs	slope factor	1	
Ca	shape factor	1	
Sr	associated rain load	0.3	kPa
Total snow load		1.82	kPa
Live Loads			
Live load for roof		1	kPa
Live load for bleachers		4.8	kPa
Total Live Load		5.8	kPa

Dead loads	Steel frame	15.80	kPa
	Concrete slabs	24.0	kPa
	membrane	1.0	kPa
	insulation	1.0	kPa
	sprinklers	1.0	kPa
	fixtures	1.0	kPa
	decking	10.0	kPa
	bleachers	0.3	kPa
Total Dead Load		54.10	kPa

Based on the above load components, the governing load is found to be 77.33 kPa applied evenly distributed through the top of the underground parkade. The combinations of loads analyzed are shown below:

Table 6: Design load combinations

Case		principal loads	Loads	
	1	1.4D	75.74	kPa
	2	(1.25D or 0.9D) +1.5L	76.33	kPa
	3	(1.25D or 0.9D) +1.5S	70.36	kPa
	4	(1.25D or 0.9D) +1.4W	75.52	kPa
	5	1.0D + 1.0 E	54.10	kPa
Governing Load			76.33	KPa

3.2.2 Structural Components

Using the distributed area load above, the parkade structure is modelled as a simple beams and columns structure with columns spaced out on average every 4 stalls in the parkade. The beams run parallel to the slab connecting all columns and providing slab support. An open web 3D structural analysis software SkyCiv is used to obtain the maximum bending moment, shear stress, and axial load of the structural components. A schematic drawing of the locations of the beams and columns is shown here:

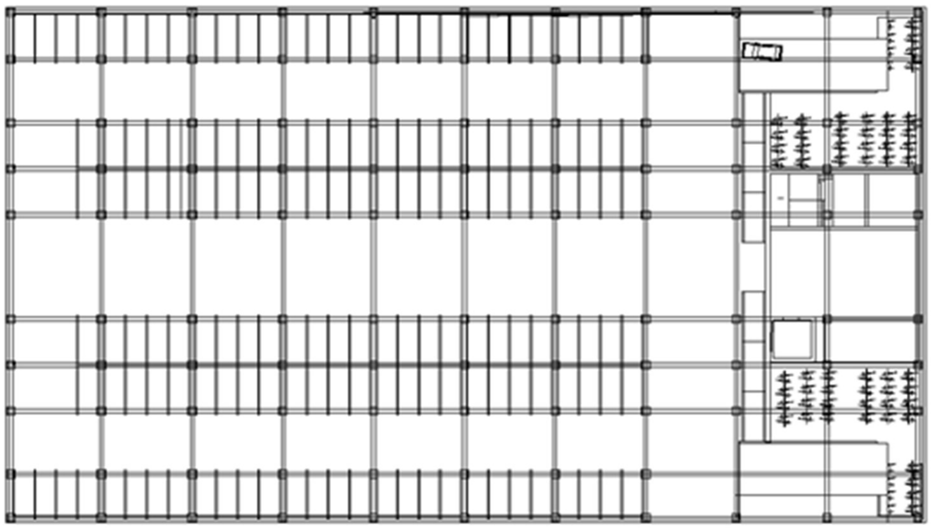


Figure 12: Beam and column locations

The underground parkade is designed to support the above stadium weight, and beams and columns are sized based on the maximum stress and moments using the <Reinforced Concrete Design: A Practical Approach> by Brzev and Pao. The beams are sized 800mm x 400mm and require 4-25M longitudinal rebars running throughout the length of the beam in the tension zone. Furthermore, columns are subject to combined axial load and flexure and are responsible for transmitting vertical loads to the foundation. The columns 970mm x 9700 mm and will have 12-25M longitudinal rebars that help increase the column's compression and flexural capacity. Section detailed design drawings of the columns and beams are attached in the Appendix J.

The suspended slab above the underground parkade will be 450 mm in depth with 12-25M steels rebars installed every 1000m width. The slab on grade will be 420 mm in depth and will have 6-25M rebars resisting the lateral earth pressure from below.

A sample of the structural calculation can be found in Appendix F. Specifications for cast-in-place concrete can also be found in Appendix I.

3.3 Geotechnical Design

This section of the report will outline the geotechnical design aspects of the parkade structure and includes design of the retaining walls as well as the column footings.

3.3.1 Retaining Walls

The retaining walls were designed using WALLAP analysis software. A factor of safety of 2 was used. A load of 50kPa was assumed from the adjacent roadways 1m in horizontal distance from the edge of the parkade wall. Structural fill to a depth of 1.2m below surface level was assumed to overlay a layer of natural silty sand. Groundwater level was assumed to be static and at 4m below surface grade. WALLAP analysis results can be found in Appendix J.

The retaining structure will consist of 250mm thick, 13m deep concrete diaphragm walls. Bar anchors with 150mm diameter and 9m length are to be installed at 2.5m below surface grade at 2m horizontal spacing. The anchors will have 3m of bonded length, 6m of unbonded length and were designed with a safety factor of 2 and a load of 273kN per anchor. The anchor specifications are shown below. A safety factor of 2.2 was found using WALLAP for the stability of the walls.

Table 7: Parkade retaining wall anchors

Type	Depth (m)	Horizontal Spacing (m)	Length (m)	Diameter (mm)	Inclination angle (deg)
Bar Anchor	2.5	2	9	150	30

3.3.2 Foundation

A square shallow foundation was designed using a factor of safety of 2 and assumed water level of 4m below existing grade. Soil unit weight was assumed to be 19 kPa, and the internal friction angle of the soil was assumed to be 33 degrees. The foundation design was checked for shear failure, punching shear, and contact bearing pressure. Footing design calculations can be found in Appendix J.

The footing was designed to be 3.3m by 3.3m wide, with a thickness of 0.9m. Rebar sized at 25mm in diameter will be placed with 150mm of cover from the bottom of the footing, 75mm of cover from the sides, and 215mm of horizontal spacing, for a total of 14 bars. The bottom of the footing is to be 3m below the bottom of the parkade slab. The footing's column is to be 2.1m in height, and 0.65m by 0.65m in width. A summary of the footing specifications is shown in the following table.

Table 8: Footing specifications summary

Item	Width (m)	Thickness (m)	Rebar, # of bars	Rebar Diameter (mm)	Rebar Cover from bottom (mm)	Rebar Cover from sides (mm)	Rebar Spacing (mm)
Square Footing	3.3	0.9	14	25	150	75	215

Schmertmann's method was used to estimate the amount of elastic settlement would occur assuming granular soil as described above. Water level was again assumed to be at a static 4m below existing grade, and a homogeneous soil modulus of elasticity of 37.5MPa was assumed. An elastic settlement of 47mm was calculated for the above specified foundation design. Additionally, a maximum differential settlement between adjacent footings of 16mm was calculated. Provided this settlement is determined to be above the allowable, preloading the parkade area with a suitable load prior to excavation is recommended.

Note that on-site geotechnical investigation of soil and groundwater conditions is required prior to all excavation and construction.

3.3.3 Excavation Construction Sequence

Construction of the retaining walls and slab base will be carried out in the following sequence:

Table 9: Parkade excavation sequence

Stage	Description
1	Excavate to elevation of 3m below surface grade
2	Install anchor no.1 at elevation of 2.5m below surface grade
3	Dewater excavation area to 5.5m below surface grade
4	Excavate to elevation of 5.3m below surface grade and compact
5	Place 300mm of 2” minus crushed drain rock and compact

Compaction of the natural soil and crushed drain rock layer using vibratory or rolling compactors is required prior to pouring the concrete slab. The drain rock layer will mitigate differential settlement of the slab base in saturated conditions.

4 Project Management

A detailed project management plan was created for this project. It consists of a risk management plan, environmental plan, safety plan, stakeholder plan, construction schedule, construction cost estimate, construction plan, traffic management plan, and service life maintenance plan.

4.1 Project Risk and Safety Management Plan

The project risk and safety management plan aims to identify and mitigate risks associated with the design and construction of the project. This section also includes a risk mitigation framework that would be followed and performed when a risk is identified.

Some project risks identified are listed below, but are not limited to:

- Difference in preliminary budget and actual project cost
- Request to change design drawings due to change in UBC South Campus Neighbourhood Development Plan
- Scope gap not identified in the designed phase of the project
- Unavailability and lead time of materials that can hinder construction schedule
- Potential delays in schedule due to unforeseen circumstances

All risks when identified should be report to the owner, project manager, or appropriate party in order to proceed with mitigation. Identified project risks should follow the below framework:

- Identify
  - Acknowledge the risk and accepts the existence of the risk
  - Report to project manager and authorizing party if appropriate
- Assess
  - Use qualitative or quantitative analysis to weigh the impact and likelihood of the risks

- Prioritize
  - Assign level of severity to all risks
  - Risks with high level of likelihood and consequences should be prioritized
- Track
  - Keep a record of the risk identification and mitigation process, continue to track the threat that the risks pose
- Implement
  - Create action plan to mitigate the risk

4.2 Environmental Plan

The cornerstone of campus environmental planning is the UBC Sustainability Campus Initiative, elements of which are stormwater management, water conservation, reduction of greenhouse gas emissions and reduction of construction and demolition waste. In that spirit, our team has incorporated that into this project's consideration and established the environmental plan accordingly.

Licenses required under the British Columbia Water Sustainability Act [5] will be obtained from the provincial government. In terms of stormwater management, this project will adhere to the objectives and implementation recommendations made in the UBC Vancouver Campus Integrated Stormwater Management Plan [6], and try to incorporate the bioswale into the existing stormwater management system UBC has in place.

This project contributes to the reduction of water consumption by conserving and reusing the stormwater collected from the bioswale for use in the stadium's toilets. There will also be a pump to circulate stormwater in the water network to prevent stagnant water, as it can be a breeding ground for bacterial and mosquitos.

To contribute to the Community Energy and Emissions Plan [7] put forward by UBC, and referencing the City of Vancouver parking bylaws [8], the parkade will incorporate at least 15 electrical charging stations in order to encourage the use of electric cars in an attempt to reduce carbon emissions.

In order to reduce construction and demolition waste in this project, our design aims to achieve net zero earth materials in regrading of the area. Contractors will also be obligated to submit a waste management plan prior to the start of the project and continue to monitor site wastes throughout the construction period.

4.3 Stakeholder Plan and Social Sustainability

The primary stakeholder for this project is the Musqueam community as the University of British Columbia's Point Grey campus is situated on the traditional, ancestral and unceded territory of the Musqueam people. A mutual agreement with the Musqueam community has been reached prior to the creation of the final design. Additional key stakeholders include students, staff, and faculty of the UBC Vancouver Campus; University Leadership (Board and Executive), and current and prospective residents of the neighbourhood. Design feedbacks and suggestions from key stakeholders are highly prioritized as this project will be undertaken within a residential community and will affect the stormwater management of the whole SRN. Regular in-person meetings were scheduled throughout the design process to incorporate design feedbacks from the key stakeholders.

We initially used the results of the SRN Phase 2 consultation as a reference for stakeholder views on current key directions of the SRN development planning. Additional stakeholder public open houses were held prior to the finalization of the detailed project design, and design feedback were collected via online surveys. All design feedback from the public open house was taken into consideration and many suggestions were integrated into the final detail design.

Additionally, to promote social sustainability as part of the UBC Sustainability Campus Initiative, current and future residents of the SRN will be invited to work with local Musqueam artists to contribute to the aesthetic design of the bioswale and promote Musqueam culture and values. We will ensure the bioswale will be successfully incorporated into the SRN as a whole aside from being a piece of green stormwater infrastructure.

4.4 Schedule

The UBC South Campus Neighbourhood Project schedule is divided into two main components; the road reconstruction and bioswale, and the parkade. The two components are geographically unrelated; as such, the start date of the two components are independent of each other and will be able to proceed simultaneously to shorten the overall construction duration of the project.

The parkade is expected to take 511 days and the road reconstruction and bioswale construction is expected to take 264 days. The shared component of this project consists mostly of tasks that take place prior to the construction phase, such as design, permitting, preconstruction, contractor mobilization, material procurement, submittal preparations, and project close out.

The entire project is expected to take 796 days to complete, with 3 months of weathering allowance included in the project close out task group. The progress of the project will be strictly monitored and iteratively optimized throughout the project to reflect any changes due to unforeseen circumstances. A summary of the main task groups of each component is presented below in Table 10 and the detailed project schedule is presented in Appendix B.

Table 10: Summary of main task groups

Component	Estimated Days
Design	93 days
Permitting	50 days
Preconstruction	41 days
Contractor Mobilization	20 days
Material Procurement	160 days
Submittal Preparation	15 days
Road Diet and Bioswale Construction	264 days
Underground Parkade Construction	511 days
Project Close-out	81 days
Total Project Duration	796 days

4.5 Cost Estimate

The construction portion of the project is expected to cost 7.70 million dollars. The road reconstruction and bioswale construction is expected to cost roughly 3.16 million dollars and the parkade construction cost is expected to cost 4.97 million dollars. A 30% contingency, 30% construction fee, and engineering fees calculated using the Saskatchewan Association of Engineering Companies formula [9] yields a fee total of 5.44 million dollars. This yields a total project cost of 12.8 million dollars. A summary of the main task groups of each component is presented below in Table 11.

Table 11: Construction cost estimate

Road Reconstruction and Swale		Parkade	
Component	**Cost**	**Component**	**Cost**
General	$167 K	*General*	$326 K
Road Work	$326 K	*Earthwork*	$1.97 M
Earthwork	$1.97 M	*Concrete Work*	$1.07 M
Concrete Work	$517 K	*Mechanical*	$592 K
Waterworks	$181 K	*Electrical*	$1.07 M
Subtotal	$3.16 M	*Subtotal*	$4.97 M
Subtotal	$7.70 M		
Contingency	$2.31 M		
Engineering Fees	$442 K		
Construction Fees	$2.31 M		
Total	**$12.8 M**		

4.6 Construction Plan and Methods

Construction vehicles will use East Mall to minimize traffic and noise pollution to the residential area North of the parkade project site. There will also be a full-time inspector for this project to ensure general construction quality and to ensure that construction is being carried out safely. In addition to the onsite inspector, the different design engineers will perform site inspections as needed to ensure construction meets the applicable standards. The contractor will arrange the testing of the concrete, soil conditions, and any other construction materials and the contractor will give the written test results to the site inspector. There will be a site office set up West of the parkade project site, and north of the swale and the site office will have a full-time first aid attendant. This will also be where workers sign in and out every day and where site visitors sign in for a site orientation

4.6.1 Swale and Road Diet

The general construction plan for the swale & road diet is as follows:

1. Site preparation
    - Cleanup, hoarding, staging
2. Traffic management plan implementation
    - Temporary signage
3. Regrading, Layout, and Construction of new alignment
    - Typical MoTI road sub-base and asphalt specifications
4. Inside lane removal
    - Asphalt sawcut and removal
5. Excavation
    - The bioswale will be constructed through excavating to a depth of 2 meters with a 4:3 slope
    - A trench will further be excavated on each side of the swale for the strip footings
6. Strip Footings, Walls, and Slab Cast
    - The footings, slab, and walls will be cast in place concrete constructed in 10m segments
7. Piping and Pump Work
    - Stormwater connections and recirculation pumps will be connected and installed
8. Weir Installation
    - Five steel weirs installed at fifty-meter increments
9. Backfill

- Fill in slope behind walls
- Add soil to bottom of swale

10. Regrading, Landscaping, and Railings
    - Prepare ground on either side of swale and place grass
    - Plant wetland plants in swale
    - Install safety railings

4.6.2 Parkade

The general construction plan for the parkade is as follows:

1. Site preparation
    - Cleanup, hoarding, staging
2. Excavation and Shoring
    - The parkade will be constructed through excavating to a depth of 5 meters with a 4:3 slope
3. Pad Footings, Fully Embedded Concrete Diaphragm, and Anchors
    - Pads at equidistant spacing, 13m diaphragm cast in 10m sections, and anchors 2.5m below grade a 2m spacing
4. Slab and Column Cast
    - The slab will be cast in place concrete constructed in 10mx10m segments.
5. Mechanical and Electrical Installation
    - Lighting, sprinkler, fire protection, HVAC, plumbing, elevator
6. Line Paint and Signage.
    - Standard MUTCD paint and signage

4.7 Traffic Management Plan

The traffic management plan has been developed in accordance with the MOTI 2015 Interim Traffic Management Manual for Work on Roadways. The traffic management plan consists of 2 stages, which were selected based on the road and traffic characteristics along the swale and road diet alignment as well as in accordance with its construction phases. Both directions of travel on West 16th Avenue will be directly impacted by the swale and road diet construction. The detailed traffic management plan can be found in Appendix E. The traffic management plan includes proposed work zone, traffic control type, and access management for each proposed construction phase.

All roadways, driveways, pedestrian sidewalks and access points that will be impacted will be provided with alternative or temporary accommodations to ensure access is maintained at all times. Minor modifications of the bus stop locations will be required to accommodate the proposed work zones, and the roadways remaining open shall be able to accommodate a B-12 design vehicle.

4.8 Anticipated Construction Issues

As both construction sites are located in close proximity to areas with high vehicle, bike, and pedestrian traffic, accidents occurring on the construction sites can result in injury or death of workers, students and campus staff. Some precautionary steps that will be implemented throughout the construction includes:

- Install fences around hazardous construction materials and construction operations
- Deliver and store construction materials with caution
- Install sufficient warning and signage at the construction sites and paths leading to the construction sites
- Limit construction machinery and temporary structures that can be climbed

The construction site for the swale and road diet will be taking place on a major commuter route to the UBC campus; therefore, full road closure is not advised as it would have a large impact on current commuter traffic. West 16th Avenue shall remain open at all times throughout the construction stages to accommodate vehicle traffic. Pedestrians will be provided with temporary sidewalks and be directed to the shortest detour possible by signage to cross the road. Cyclists will be sharing the road with pedestrians in the construction zone.

As both construction sites are located near high traffic areas, the lack of space on the construction sites will result in worker, construction material and equipment mobility difficulties. Onsite organization and space utilization will be especially crucial for the construction site for the swale and road diet as it takes place on a busy bus and truck route. Construction material arrival times will be strictly monitored by on-site construction managers to ensure cluttering does not happen on the construction site. In the same manner, construction equipment will be removed from the construction site when it is not being utilized. Construction worker schedules will be strictly monitored and updated frequently to minimize conflicts between work crews due to limited working space.

It is also worth noting that theft of construction materials and equipment can be a potential problem for both construction sites. Valuables are advised not to be left on site unattended and having a security guard at night and over weekends is recommended if costly construction equipment and machinery need to remain on site.

4.9 Service Life Maintenance Plan

In order to better understand the lifetime costs of this project and to assist with the operation following construction, a service life maintenance plan was developed. The plan was broken up into separate sections for the swale and the parkade. Annual maintenance costs are expected to be on the order of $7,000 and $17,400 for the swale and parkade respectively. The detailed plan is presented in Appendix D.

Applying the standard annuity equation to the $24,400 maintenance costs over a design life of 100 years, with an assumed annual inflation rate of 2% and an assumed annual interest rate of 5% yields a total lifetime cost of $567,300. This results in a total lifetime project cost of $13.4M.

A References

[1] GeoPacific Consultants Ltd., "Geotechnical Investigation Report for Proposed Mixed Commercial/Residential Development Lot 10 - UBC South Campus, Wesbrook Drive at 16th Avenue, Vancouver, BC," UBC Properties Trust, 2006.

[2] Piteau Associates Engineering Ltd., "Hydrogeological and Geotechnical Assessment of Northwest Area UBC Campus, Vancouver," UBC Properties Trust, 2002.

[3] UBC, "Climate Action Plan," UBC, 2010.

[4] Government of Canada, "Canadian Climate Normals," Government of Canada, 2018.

[5] Province of British Columbia, "Water Sustainability Act," Province of British Columbia, 2014.

[6] UBC Campus + Community Planning, "UBC Vancouver Campus Integrated Stormwater Management Plan," UBC, 2017.

[7] UBC, "UTown@UBC Community Energy and Emissions Plan," UBC, 2013.

[8] City of Vancouver, "City of Vancouver PARKING AND LOADING DESIGN SUPPLEMENT Appendix A: PARKING STALL GUIDELINES," City of Vancouver, 2002.

[9] Saskatchewan Association of Engineering Companies, "Schedule of Recommended Fees to be Charged for General Engineering and Geoscience Projects and Services," Saskatchewan Association of Engineering Companies, 2016.

[10] Kjpargeter, Artist, *Abstract blue background.* [Art]. www.freepik.com, 2016.

[11] Y. Nazhat, Artist, *Site Context.* [Art]. University of British Columbia, 2018.

[12] U. o. B. Columbia, Artist, *Planning-context-stadium-pt1.* [Art]. University of British Columbia, 2017.

[13] E. Bonderud, Artist, *Bioactive Swale Concept.* [Art]. 2018.

[14] G. Rotterdam, Artist, *Garage Museumplein, Rotterdam, The Netherlands.* [Art]. Urban green-blue grids for sustainable and resilient cities.

[15] V. Water Resources Research Center, Artist, *DRY SWALES.* [Art]. Virginia Water Resources Research Center.

[16] UBC, "20 Year Sustainability Plan," UBC, 2014.

[17] UBC, "Vancouver Campus Plan," UBC, 2010.

[18] UBC, "Waste Action Plan," UBC, 2014.

[19] S. Toope, "Place and Promise," UBC, 2012.

[20] S. Ono, "Shaping UBC’s Next Century," UBC, 2018.

[21] UBC, Artist, *Option 2 Bird's Eye View To North.* [Art]. UBC, 2018.

[22] City of Vancouver, "City of Vancovuer Parking Bylaw 6059," City of Vancouver, 2017.

[23] Fire and Rescue Services, City of Vancouver, "Storage in Underground Parking Facilities," City of Vancouver, 2015.

[24] H. L. N. K. Pierre Ouillet, "University Neighbourhoods Association for Noise Control and Enforcement and Disputes," UBC, 2012.

[25] UBC Campus + Community Planning, "UBC Vancouver Transportation Status Report Fall 2016," UBC, 2017.

[26] R. Raine, "Aquatic Plants That Purify Water," SFGATE, 2012.

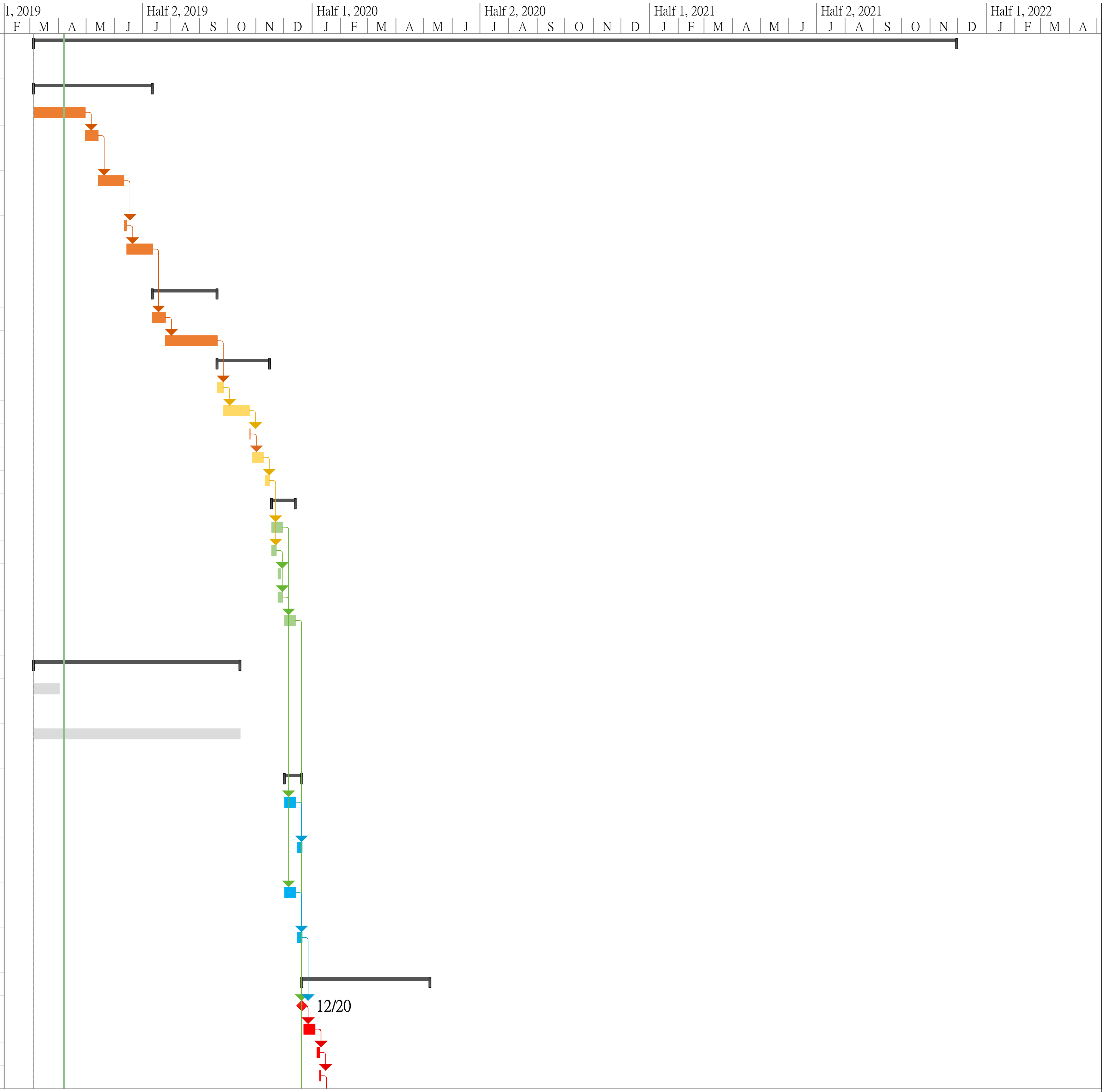
[27] Penn State College of Engineering, "Types of Shotcrete and Applications," Penn State College of Engineering, 1993.

[28] Government of Canada, "Canada's Fisheries Act," Government of Canada.

[29] UBC, "BOARD POLICY #92: LAND USE AND PERMITTING," UBC, 2004.

B Schedule

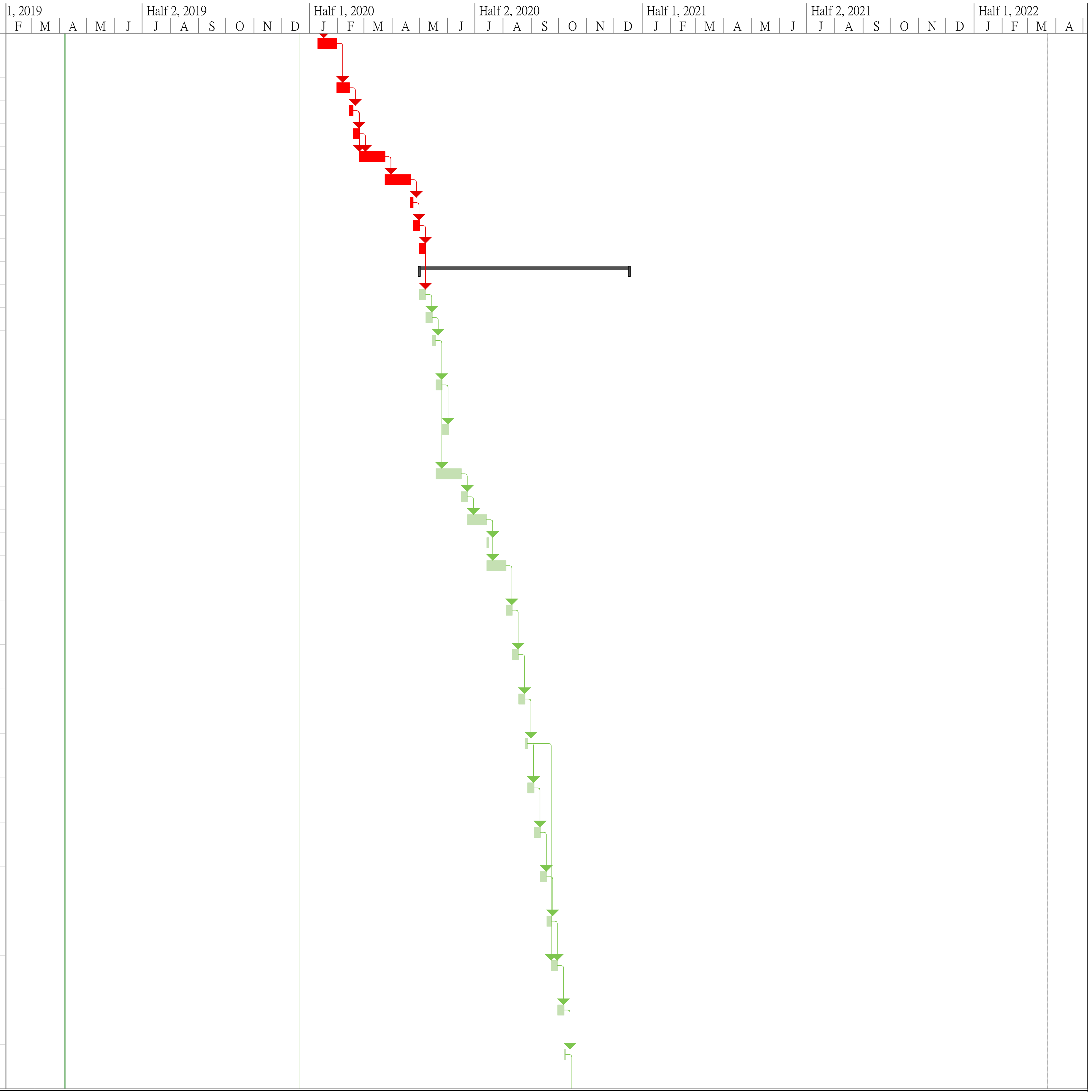
ID	Task Mode	Task Name	Duration	Start	Finish
1		**Parking and Stormwater Management Mixed**	**715 days**	**Tue 3/5/19**	**Mon 11/29/21**
2		**Design**	**93 days**	**Tue 3/5/19**	**Thu 7/11/19**
3		Detailed design drawing	8 wks	Tue 3/5/19	Mon 4/29/19
4		University approves deisng drawings	2 wks	Tue 4/30/19	Mon 5/13/19
5		Issue design development	4 wks	Tue 5/14/19	Mon 6/10/19
6		Public consultation	3 days	Tue 6/11/19	Thu 6/13/19
7		Complete design drawings (IFT)	4 wks	Fri 6/14/19	Thu 7/11/19
8		**Permitting**	**50 days**	**Fri 7/12/19**	**Thu 9/19/19**
9		Submit required permit	2 wks	Fri 7/12/19	Thu 7/25/19
10		Aquire required permits	8 wks	Fri 7/26/19	Thu 9/19/19
11		**Preconstruction**	**41 days**	**Fri 9/20/19**	**Fri 11/15/19**
12		Tender package develo	1 wk	Fri 9/20/19	Thu 9/26/19
13		Project tendering	4 wks	Fri 9/27/19	Thu 10/24/19
14		Bid close	1 day	Fri 10/25/19	Fri 10/25/19
15		Project awarding	2 wks	Mon 10/28/19	Fri 11/8/19
16		Contract signing	1 wk	Mon 11/11/19	Fri 11/15/19
17		**Contractor Mobolization**	**20 days**	**Mon 11/18/19**	**Fri 12/13/19**
18		Award subcontracts	2 wks	Mon 11/18/19	Fri 11/29/19
19		Land survey and layout	5 days	Mon 11/18/19	Fri 11/22/19
20		Set up site office and fe	3 days	Mon 11/25/19	Wed 11/27/19
21		Set up site storage area	5 days	Mon 11/25/19	Fri 11/29/19
22		Mobolize equipment and workers	2 wks	Mon 12/2/19	Fri 12/13/19
23		**Material Procurement**	**160 days**	**Tue 3/5/19**	**Mon 10/14/19**
24		Sheeting and shoring procurment	4 wks	Tue 3/5/19	Mon 4/1/19
25		Construction material procurment	32 wks	Tue 3/5/19	Mon 10/14/19
26		**Submittal Preparation**	**15 days**	**Mon 12/2/19**	**Fri 12/20/19**
27		Prepare and submit site drawings (IFC)	10 days	Mon 12/2/19	Fri 12/13/19
28		Review and prove site drawings (IFC)	5 days	Mon 12/16/19	Fri 12/20/19
29		Prepare and submit structural drawings	10 days	Mon 12/2/19	Fri 12/13/19
30		Review and prove structural drewings	5 days	Mon 12/16/19	Fri 12/20/19
31		**Road Diet**	**99 days**	**Fri 12/20/19**	**Thu 5/7/20**
32		Notice to proceed	0 days	Fri 12/20/19	Fri 12/20/19
33		Site survey and setout	2 wks	Mon 12/23/19	Fri 1/3/20
34		Temporary signage	3 days	Mon 1/6/20	Wed 1/8/20
35		Secure perimeter	1 day	Thu 1/9/20	Thu 1/9/20



Project: Project1
Date: Sun 4/7/19

Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone			

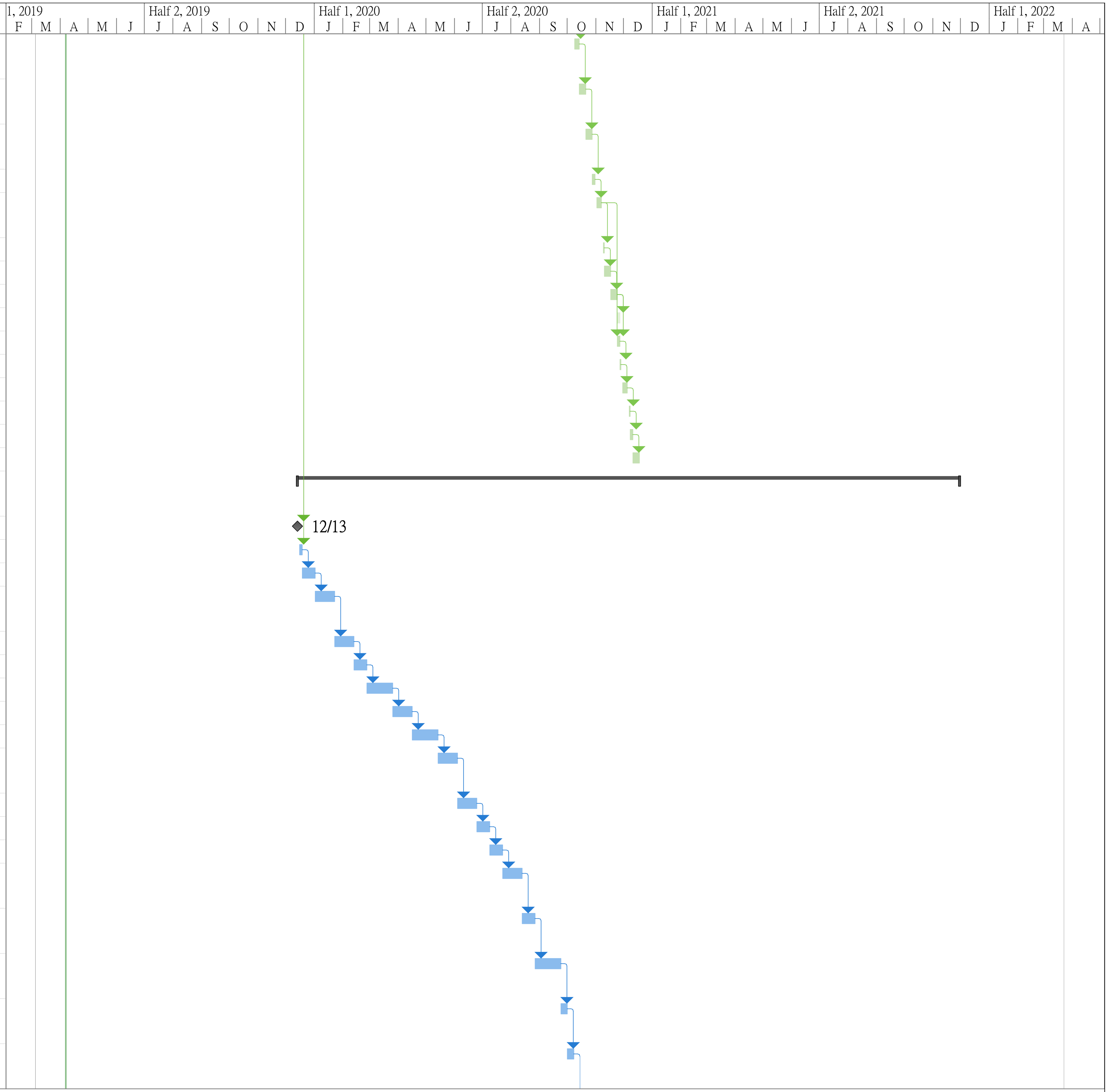
ID	Task Mode	Task Name	Duration	Start	Finish
36		Getechnical surveys and inspection	15 days	Fri 1/10/20	Thu 1/30/20
37		Utility relocation	2 wks	Fri 1/31/20	Thu 2/13/20
38		Site prep for excavation	2 days	Fri 2/14/20	Mon 2/17/20
39		Removal of trees and pl	1 wk	Tue 2/18/20	Mon 2/24/20
40		Demolion and excavatic	20 days	Tue 2/25/20	Mon 3/23/20
41		New pavement and cur	20 days	Tue 3/24/20	Mon 4/20/20
42		New paint	3 days	Tue 4/21/20	Thu 4/23/20
43		Lanscaping	5 days	Fri 4/24/20	Thu 4/30/20
44		Site cleanup and inspec	5 days	Fri 5/1/20	Thu 5/7/20
45		**Bioswale Construction**	**165 days**	**Fri 5/1/20**	**Thu 12/17/20**
46		Set layout and setup	1 wk	Fri 5/1/20	Thu 5/7/20
47		Site preperation	5 days	Fri 5/8/20	Thu 5/14/20
48		Implement traffic management plan	2 days	Fri 5/15/20	Mon 5/18/20
49		Instal erosion and sediment control	1 wk	Tue 5/19/20	Mon 5/25/20
50		Site examination and arrange required	1 wk	Tue 5/26/20	Mon 6/1/20
51		Regrading	20 days	Tue 5/19/20	Mon 6/15/20
52		Removal of inside lane	1 wk	Tue 6/16/20	Mon 6/22/20
53		Excavation	3 wks	Tue 6/23/20	Mon 7/13/20
54		Instal temporary access	2 days	Tue 7/14/20	Wed 7/15/20
55		Install lateral earth surpports if required	3 wks	Tue 7/14/20	Mon 8/3/20
56		Install concrete formwork - strip	1 wk	Tue 8/4/20	Mon 8/10/20
57		Rebar placement - strip footing cast	1 wk	Tue 8/11/20	Mon 8/17/20
58		Concrete pouring - strip footing cast	1 wk	Tue 8/18/20	Mon 8/24/20
59		Remove concrete formwork - strip	3 days	Tue 8/25/20	Thu 8/27/20
60		Install concrete formwork - concrete	1 wk	Fri 8/28/20	Thu 9/3/20
61		Rebar placement - concrete wall cast	1 wk	Fri 9/4/20	Thu 9/10/20
62		Concrete pouring - concrete wall cast	1 wk	Fri 9/11/20	Thu 9/17/20
63		Remove concrete formwork - concrete	3 days	Fri 9/18/20	Tue 9/22/20
64		Install concrete formwork - slab on	1 wk	Wed 9/23/20	Tue 9/29/20
65		Rebar placement - slab on grade	1 wk	Wed 9/30/20	Tue 10/6/20
66		Concrete pouring - slab on grade	2 days	Wed 10/7/20	Thu 10/8/20



Project: Project1
Date: Sun 4/7/19

Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone			

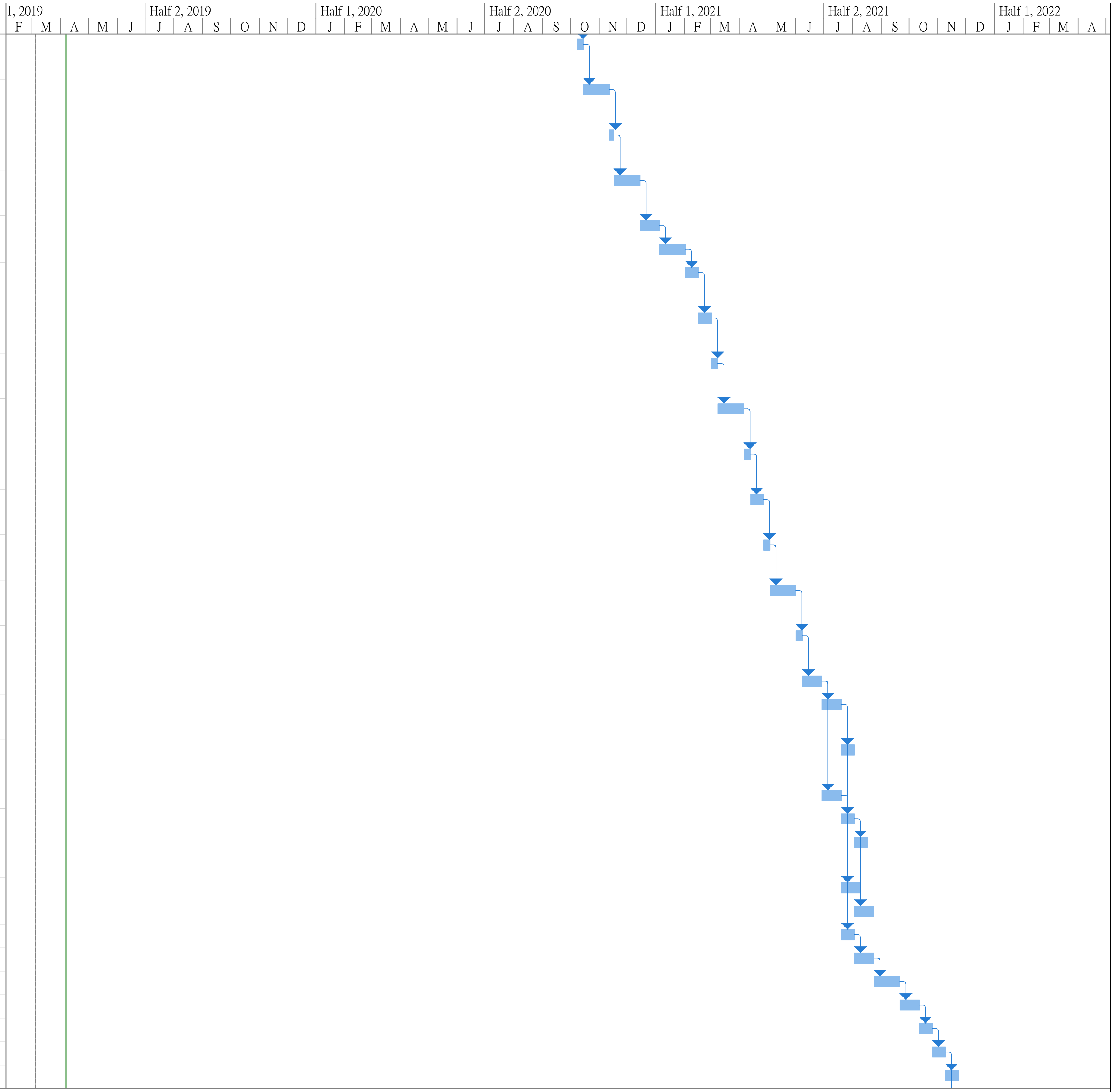
ID		Task Mode	Task Name	Duration	Start	Finish
67			Remove concrete formwork - slab on	3 days	Fri 10/9/20	Tue 10/13/20
68			Replace temporary access with permanent	1 wk	Wed 10/14/20	Tue 10/20/20
69			Install water purification system	1 wk	Wed 10/21/20	Tue 10/27/20
70			Install pipes and pumps	3 days	Wed 10/28/20	Fri 10/30/20
71			Tie in to existing stormwater network	5 days	Mon 11/2/20	Fri 11/6/20
72			Install weirs	1 day	Mon 11/9/20	Mon 11/9/20
73			Backfill	1 wk	Tue 11/10/20	Mon 11/16/20
74			Landscaping	1 wk	Tue 11/17/20	Mon 11/23/20
75			Confirm grading/ regarc	3 days	Tue 11/24/20	Thu 11/26/20
76			Planting	3 days	Tue 11/24/20	Thu 11/26/20
77			Install safety railings	1 day	Fri 11/27/20	Fri 11/27/20
78			System testing	1 wk	Mon 11/30/20	Fri 12/4/20
79			Removal of fences	1 day	Mon 12/7/20	Mon 12/7/20
80			Site clean up	3 days	Tue 12/8/20	Thu 12/10/20
81			Inspection	1 wk	Fri 12/11/20	Thu 12/17/20
82			**Underground Parkade Construction**	**511 days**	**Fri 12/13/19**	**Mon 11/29/21**
83			Notice to proceed	0 days	Fri 12/13/19	Fri 12/13/19
84			Mobolization	3 days	Mon 12/16/19	Wed 12/18/19
85			Site preperation	10 days	Thu 12/19/19	Wed 1/1/20
86			Getechnical surveys and inspection	15 days	Thu 1/2/20	Wed 1/22/20
87			Utility relocation	3 wks	Thu 1/23/20	Wed 2/12/20
88			Drill dewatering wells	2 wks	Thu 2/13/20	Wed 2/26/20
89			Excavation	1 mon	Thu 2/27/20	Wed 3/25/20
90			Shoring	3 wks	Thu 3/26/20	Wed 4/15/20
91			Regrading	20 days	Thu 4/16/20	Wed 5/13/20
92			Getechnical surveys and inspection	15 days	Thu 5/14/20	Wed 6/3/20
93			Pad footing installation:	3 wks	Thu 6/4/20	Wed 6/24/20
94			Install concretee diaphr	2 wks	Thu 6/25/20	Wed 7/8/20
95			Install anchors	2 wks	Thu 7/9/20	Wed 7/22/20
96			Install concrete formwork - foundation	3 wks	Thu 7/23/20	Wed 8/12/20
97			Rebar placement -foundation wall	2 wks	Thu 8/13/20	Wed 8/26/20
98			Concrete pouring - foundation wall	1 mon	Thu 8/27/20	Wed 9/23/20
99			Remove concrete formwork - foundation	1 wk	Thu 9/24/20	Wed 9/30/20
100			Install concrete formwork - slab on	1 wk	Thu 10/1/20	Wed 10/7/20



Project: Project1
Date: Sun 4/7/19

Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone			

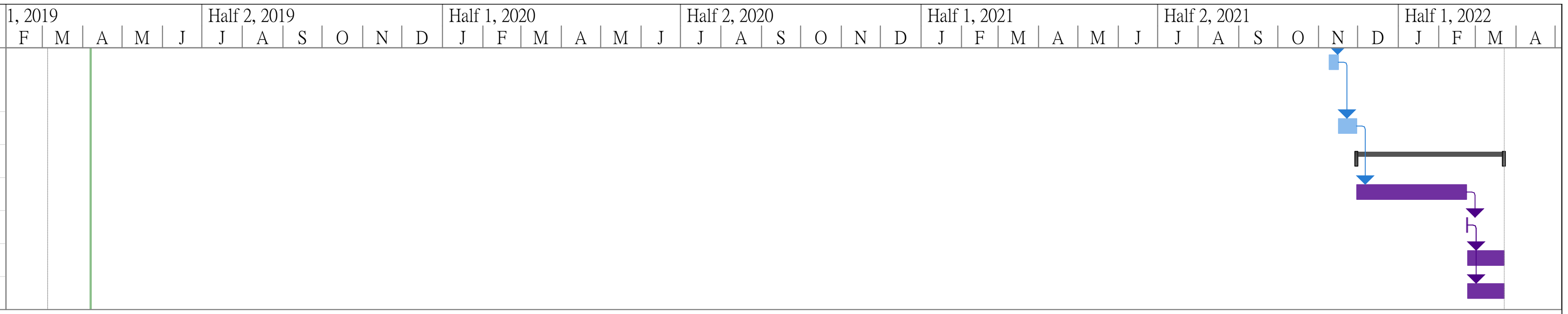
ID	Task Mode	Task Name	Duration	Start	Finish
101		Rebar placement - slab on grade	1 wk	Thu 10/8/20	Wed 10/14/20
102		Concrete pouring - slab on grade	1 mon	Thu 10/15/20	Wed 11/11/20
103		Remove concrete formwork - slab on	3 days	Thu 11/12/20	Mon 11/16/20
104		Install concrete formwork - columns	1 mon	Tue 11/17/20	Mon 12/14/20
105		Rebar placement - colu	3 wks	Tue 12/15/20	Mon 1/4/21
106		Concrete pouring - colu	1 mon	Tue 1/5/21	Mon 2/1/21
107		Remove concrete formwork - columns	2 wks	Tue 2/2/21	Mon 2/15/21
108		Install concrete formwork - suspended	2 wks	Tue 2/16/21	Mon 3/1/21
109		Rebar placement - suspended slabs	1 wk	Tue 3/2/21	Mon 3/8/21
110		Concrete pouring - suspended slabs	1 mon	Tue 3/9/21	Mon 4/5/21
111		Remove concrete formwork - suspended	1 wk	Tue 4/6/21	Mon 4/12/21
112		Install concrete formwork - roof slab	2 wks	Tue 4/13/21	Mon 4/26/21
113		Rebar placement - roof slab and stairs	1 wk	Tue 4/27/21	Mon 5/3/21
114		Concrete pouring - roof slab and stairs	1 mon	Tue 5/4/21	Mon 5/31/21
115		Remove concrete formwork - roof slab	1 wk	Tue 6/1/21	Mon 6/7/21
116		MEP layout and rough-i	3 wks	Tue 6/8/21	Mon 6/28/21
117		Mechanical, electrical and lighting install	3 wks	Tue 6/29/21	Mon 7/19/21
118		Painting, traffic coating, and markings	2 wks	Tue 7/20/21	Mon 8/2/21
119		Fire protection rough-in	3 wks	Tue 6/29/21	Mon 7/19/21
120		Erect CMU walls	2 wks	Tue 7/20/21	Mon 8/2/21
121		Install metal panels, louvers and canopy	2 wks	Tue 8/3/21	Mon 8/16/21
122		Parkade finishes	3 wks	Tue 7/20/21	Mon 8/9/21
123		Elevator installation	3 wks	Tue 8/3/21	Mon 8/23/21
124		MEP systems and testin	2 wks	Tue 7/20/21	Mon 8/2/21
125		Exterior hardscape	15 days	Tue 8/3/21	Mon 8/23/21
126		Backfill and lanscaping	20 days	Tue 8/24/21	Mon 9/20/21
127		Stripping and topsoil	15 days	Tue 9/21/21	Mon 10/11/21
128		Site restoration	10 days	Tue 10/12/21	Mon 10/25/21
129		System testing	2 wks	Tue 10/26/21	Mon 11/8/21
130		Commisioning and train	2 wks	Tue 11/9/21	Mon 11/22/21



Project: Project1
Date: Sun 4/7/19

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

ID		Task Mode	Task Name	Duration	Start	Finish
131			Site clean up and demobolization	1 wk	Tue 11/9/21	Mon 11/15/21
132			Final Inspection	2 wks	Tue 11/16/21	Mon 11/29/21
133			**Project Close-out**	**81 days**	**Tue 11/30/21**	**Tue 3/22/22**
134			Weather day allowance	3 mons	Tue 11/30/21	Mon 2/21/22
135			Client site walkthrough	1 day	Tue 2/22/22	Tue 2/22/22
136			Deficiencies	1 mon	Wed 2/23/22	Tue 3/22/22
137			Close out documents	1 mon	Wed 2/23/22	Tue 3/22/22



Project: Project1
Date: Sun 4/7/19

Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone			

C Cost Estimate

Note: all non bolded items are listed in USD. Bolded items have been converted to CAD using a conversion factor of 1.34.

C.I Road and Swale Construction

Task Name	Quantity	Unit	Cost
Road and Swale Construction			
Site survey and setout			$ 5,000.00
Temporary Signage			$ 2,000.00
Secure perimeter	540	m	$ 17,690.00
Demolion and excavation	780	m^2	$ 25,187.55
New curbs	540	m	$ 58,464.57
Excavation	5225.3125	m3	$ 1,263,795.87
Footing excavation	910	m3	$ 55,023.23
Footing Formwork	261	m2	$ 9,832.83
Footing Rebar	261	m2	$ 3,090.32
Footing pour	130	m3	$ 27,040.00
Wall Formwork	1890	m2	$ 71,203.27
Wall Rebar	1890	m2	$ 22,378.17
Wall Pour	283.5	m3	$ 58,968.00
Slab Rebar	2600	m2	$ 30,784.78
Slab Pour	780	m3	$ 162,240.00
Purchase pumps	3	each	$ 9,000.00
Install pipes	200	m	$ 2,000.00
Tie in to existing stormwater network			$ 3,000.00

Backfill	810	m3	$	-
Steel Weirs	4	each	$	21,376.00
Steel Culvert	1	each	$	340.00
Protective Rip Rap	80	m2	$	3,827.17
Landscaping	520	m2	$	5,597.23
Plant bullrushes	2600	m2	$	521.04
Outflow Excavation and Backfill	300	m3	$	145,116.21
Outflow Piping	400	m	$	99,487.56
Outflow Rip Rap	20	m2	$	956.79
Railing	560	m	$	73,490.81
Ladders	30	each	$	13,140.00
Repave	1872	m2	$	100,750.20
CMB Installation	260	each	$	58,760.00
System testing			$	2,000.00
Removal of fences			$	-
Site clean up			$	3,000.00
Inspection			$	2,000.00
Total			**$**	**3,158,462.56**

C.II Parkade Construction

Task Name	Quantity	Unit	Cost	
Underground Parkade				
Mobolization			$	2,000.00
Site preperation			$	4,000.00
Getechnical surveys and inspection			$	3,000.00
Sewer Relocation			$	10,000.00
Water Relocation			$	10,000.00
Drill dewatering wells			$	71,000.00
Excavation	3937.5	m3	$	952,325.10

Diaphragm Excavation	280	m3	$	67,720.90
Diaphragm Formwork	1300	m2	$	48,975.79
Diaphragm Rebar	1300	m2	$	15,392.39
Diaphragm Pour	455	m3	$	94,640.00
Install Anchors Rods	50	each	$	35,000.00
Pad Footings Excavation	15	m3	$	3,627.91
Pad Footing Formwork	12	m2	$	452.08
Pad Footing Rebar	12	m2	$	142.08
Pad Footing Pour	3	m3	$	624.00
Pad Footing Infill	12	m3	$	-
Invert Slab Formwork	600	m2	$	22,604.21
Invert Slab Rebar	600	m2	$	7,104.18
Invert Slab Pour	270	m3	$	56,160.00
Columns Formwork	1940	m2	$	73,086.95
Columns Rebar	1940	m2	$	22,970.18
Columns Pour	470.45	m3	$	97,853.60
Stair, Elevator Formwork	500	m2	$	18,836.84
Stair, Elevator Rebar	500	m2	$	5,920.15
Stair, Elevator Pour	500	m3	$	104,000.00
Roof Slab Formwork	600	m2	$	22,604.21
Roof Slab Rebar	600	m2	$	7,104.18
Roof Slab Pour	270	m3	$	56,160.00
Beams Formwork	672	m2	$	25,316.72
Beams Rebar	672	m2	$	7,956.68
BeamsPour	134.4	m3	$	27,955.20
Ramp Formwork	737.8	m2	$	27,795.65
Ramp Rebar	737.8	m2	$	8,735.77
Ramp Pour	212.415	m3	$	44,182.32
Mechanical Install			$	441,537.31
Electrical Install			$	801,173.51
Painting, traffic coating, and markings			$	15,000.00
Fire protection Roof	600	m2	$	6,522.93
Fire Protection Beams	672	m2	$	7,305.68
Elevator installation	1	each	$	100,000.00
MEP systems and testing			$	3,000.00
Backfill and lanscaping			$	50,000.00

Site restoration			$ 2,000.00
System testing			$ 2,000.00
Site clean up and demobolization			$ 5,000.00
Final Inspection			$ 2,000.00
Total			**$ 5,268,514.04**

C.III Summary

Summary			
Subtotal			**$ 8,426,976.60**
Contingancy			**$ 2,528,092.98**
Engineering Fees			**$ 480,129.76**
Construction Fees			**$ 2,528,092.98**
Total			***$ 13,963,292.32***

D Service Life Maintenance Plan

D.I Swale

Equipment Type	Description	Name Plate Validated
Pumps	Circulation Pumps pumps drawing water from one end of the swale to the other and pumps used to get water to stadium	Yes
Pipes	pipes allowing for the recirulation of water from base to top of swale and pipes to carry water to stadium	N/A
Access Ladders	Ladders for access to swale	Yes
Safety Railing	railings preventing falls into swale	N/A
Weirs	steel plates to control water flow in swale	N/A
Culvert	to convey water under pedestrian bridge	N/A
Rip Rap	rock armouring for slope on either side of culvert	N/A
Plant life	wetland plants in swale	N/A
Trash Racks	protective racks in front of culvert and outflow	

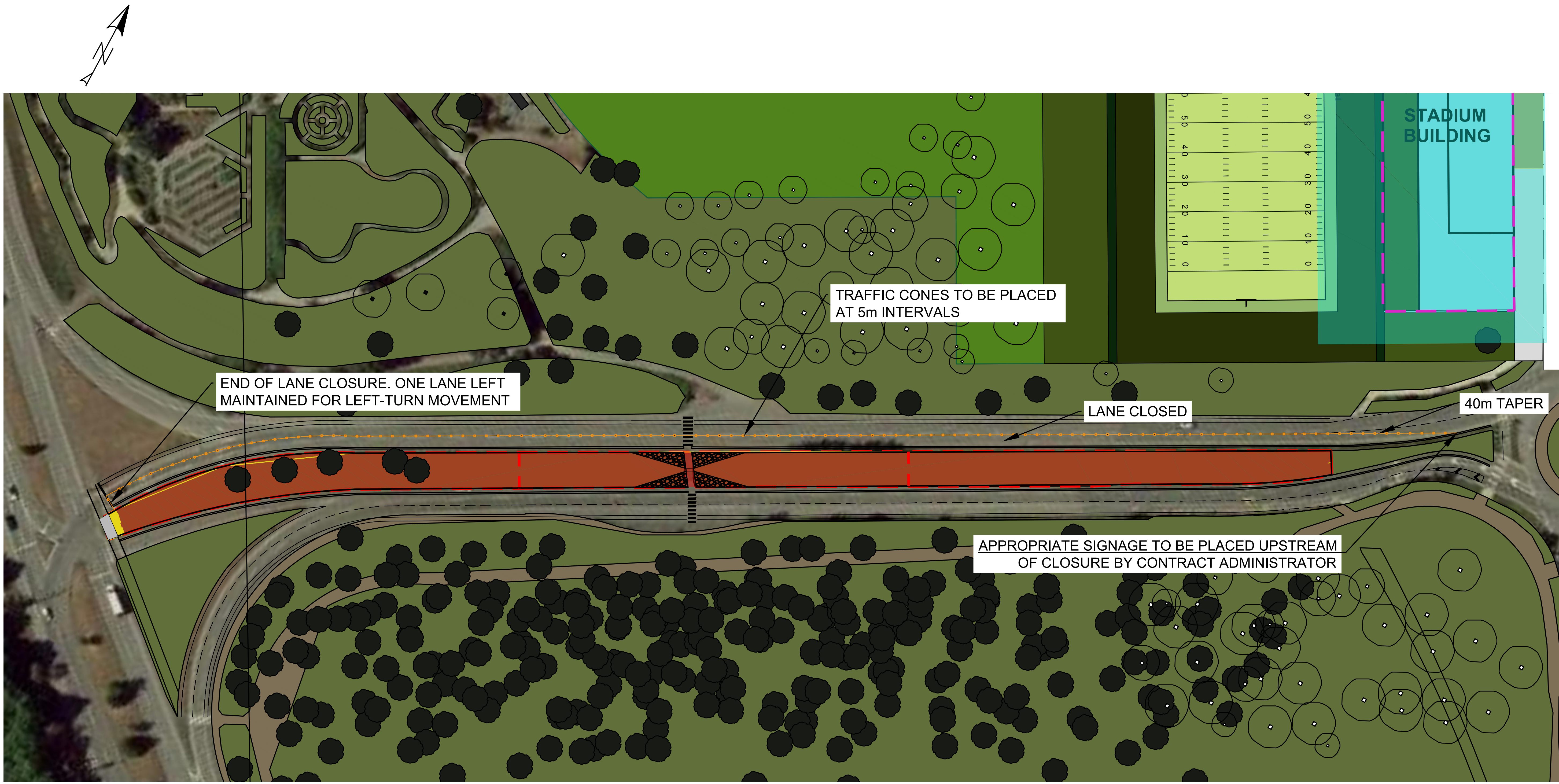
Item #	Equipment Type	Maintenance Task Description	Frequency [days]	Trade	Equipment Condition	Type	Procedure #	Est. Time [hours]	Special Tools/Materials	Annual Hours
1	Pumps	Inspect and replace seals, oil bearings	30	Operations	Shut off	Preventative	PM1	0.5	oil, wrench	6
2	Pumps	Detailed inspection: all parts, including motor calibration	365	Operations	Shut off	Preventative	PM2	3	toolkit	3
3	Trash Racks	Ensure the rack is at least 80% clear of debris and bars are undamaged	7	Operations	Not Raining	Preventative	PM3	0.1		5
4	Trash Racks	Repair trash rack	730	Metalshop/Operations	Not Raining	Predictive	PdM1	8		4
5	Plant life	Inspect vegetation coverage	7	Operations	Not Raining	Preventative	PM4	0.1		5
6	Plant life	regrade and replace growing medium and plants	365	Operations	Not Raining	Predictive	PdM2	32	small crane	32
7	Plant life	trash and debris accumulation in swale	30	Operations	Not Raining	Predictive	PdM3	2		24
8	Access Ladders	inspect ladder for structural issues	182.5	Operations	Not Raining	Preventative	PM5	2		4
9	Access Ladders	replace damaged ladder	1460	Operations	Not Raining	Predictive	PdM4	6		2
10	Safety Railing	inspect railing for structural issues	182.5	Operations	Not Raining	Preventative	PM6	8		16
11	Safety Railing	replace damaged railing	1460	Operations	Not Raining	Predictive	PdM5	12		3
12	Weirs	inspect connections	182.5	Operations	Not Raining	Preventative	PM7	2		4
13	Culvert	clear debris and sediment	365	Operations	Not Raining	Corrective	CM1	4		4
14	Rip rap	inspect for erosion	91.25	Operations	Not Raining	Preventative	PM8	1		4
										116
										@$30/hour
										x2 for material and equipment
										$6,980.71

D.II Parkade

Equipment Type	Description	Name Plate Validated
Paint	pipes, hazard indicators, and general paint	N/A
pavement	concrete pavement	N/A
drainage	floor drains and drain pipes	N/A
mechanical	hvac	N/A
electrical	lights and power	N/A

Item #	Equipment Type	Maintenance Task Description	Frequency [days]	Trade	Equipment Condition	Type	Procedure #	Est. Time [hours]	Special Tools/Materials	Annual Hours
1	Paint	Repaint walls, pipes, hazards, etc	4380	Operations	Lot Empty	Corrective	CM2	1800	painting equipment	150
2	Pavement	power was decks	91.25	Operations	Lot Empty	Preventative	PM9	16	pressure washer	64
3	drainage	flush and clean	365	Operations	Lot Empty	Preventative	PM10	32		32
4	mechanical	inspection and maintenance	365	Contractor	Lot Empty	Preventative	PM11	16		16
5	electrical	replace lightbulbs	30	Operations	None	Corrective	PdM6	1		12
6	electrical	inspection and maintenance	365	Contractor	Lot Empty	Preventative	PM12	16		16
										290
										@$30/hour
										x2 for material and equipment
										$17,4100.00

E Traffic Management Plan



NOTES:

1. A TRAFFIC CONTROL PERSON WILL BE PRESENT ON SITE DURING WORK AT ALL TIMES
2. TAPERS AND SIGNAGE WILL BE FIT ON SITE BY TRAFFIC CONTROL PERSON

0m 62.5m
1:1250

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA, CAMPUS AND COMMUNITY PLANNING

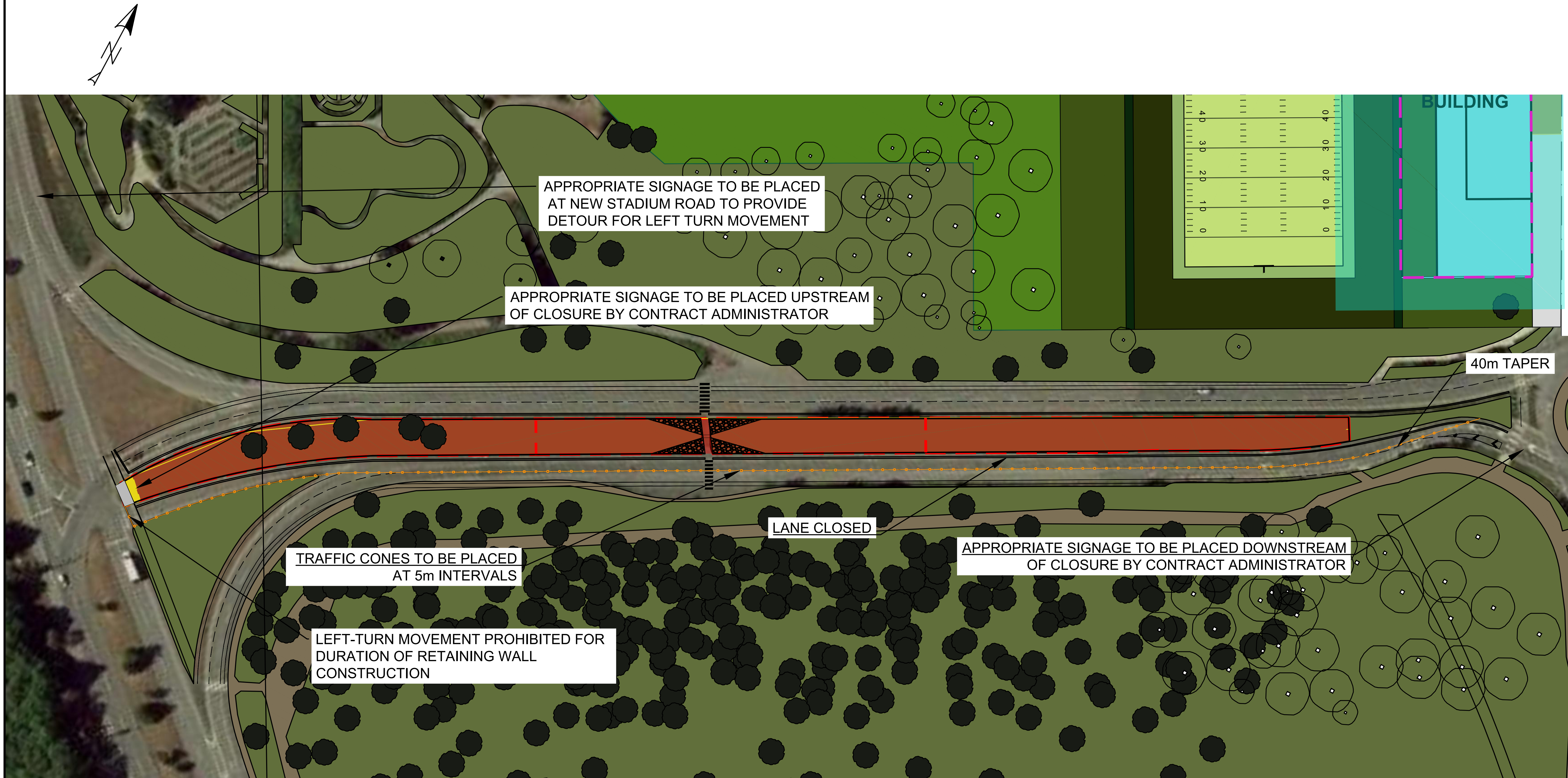
STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE
TRAFFIC MANAGEMENT PLAN
WESTBOUND 16TH AVENUE

REV	PURPOSE	DATE	DR.	CH.
1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	EB

KATmeet Konsulting

THE UNIVERSITY OF BRITISH COLUMBIA

UBC SEEDS Program



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0m 62.5m
1:1250

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
TRAFFIC MANAGEMENT PLAN
EASTBOUND 16TH AVENUE

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	EB
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

KATmeet Konsulting

THE UNIVERSITY OF BRITISH COLUMBIA

UBC SEEDS Program

F Structural Calculations (Beams and Columns)

Beams

Mf	289	kNm
Vf	29	kN
h	600	mm
d	530	mm
b	400	mm
f'c	35	MPa
fy	400	MPa
cover	30	mm
α1	0.7975	
β1	0.8825	
db (25M)	25	mm
dh (10M)	10	mm
ϕc	0.65	
ϕs	0.85	

Calculated reinforcement area required

$$As = \frac{\alpha 1 * Mf * f'c * b}{\varphi s * fy} * \left(d - \sqrt{d^2 - \frac{2 * Mf * 10^6}{\alpha 1 * \ \varphi c \ * f'c * b}} \right) = 1737.1 \text{ mm}^2$$

$$As = 4 * 500\text{mm}^2 = 2000 \text{ mm}^2$$

$$a = \frac{\varphi s * As * fy}{\alpha 1 * \ \varphi c \ * f'c * b} = 93.6 \text{ mm}$$

$$Mr = \varphi s * As * fy * \frac{\left(d - \frac{a}{2}\right)}{1000000} = 328.5 \text{ kNm} > Mf = 289 \text{ kNm}$$

Check spacing and reinforcement area

$$Smin = (1.4db, 1.4 \text{ max agg}, 30\text{mm}) = 28 \text{ mm}$$

$$S = \frac{b - 2 * cover - 2 * dh - 3 * db}{3} = 93 \text{ mm} > Smin \rightarrow ok$$

$$Asmin = 0.2 * \frac{\sqrt{f'c}}{fy * h * b} = 709 \text{ mm}^2 < As = 2000 \text{ mm}^2 \rightarrow ok$$

Shear Resistance

$$dv = \max(0.9d, 0.72h) = 477mm$$

$$Vc = \varphi c * \lambda * B * \sqrt{f'c} * bw * dv = 114.3\ kN > Vf \rightarrow ok$$

$$B = \frac{1000}{270 + dv} = 0.156$$

Check ρ

$$\rho\ min\ for\ 35MPa\ concrete = 0.03$$

$$\rho = \frac{As}{d*b} = 0.001 \rightarrow ok$$

Columns

Mf	2936	kNm
Vf	1149	kN
Pf	16658	kN
h	970	mm
d	900	mm
b	970	mm
f'c	35	MPa
fy	400	MPa
cover	30	mm
α1	0.7975	
β1	0.8825	
ϕc	0.65	
ϕs	0.85	

The required reinforcement is calculated using the P-M interactive diagram.

$$As = 8 * 500mm^2 = 4000\ mm^2$$

$$Ag = h * b = 940{,}900\ mm^2$$

point	1	2	3	4	5
c (mm)	150	400	563	700	800
Cr (kN)	2639.82469	7039.533	9908.142	12319.18	14079.07
e_s1	0.00233333	0.003063	0.003189	0.00325	0.003281
e_s2	-0.0179667	-0.00455	-0.00222	-0.0011	-0.00053
fs1	400	400	400	400	400
fs2	-400	-400	-400	-220	-105
Frs1 (kN)	680	680	680	680	680
Frs2 (kN)	-680	-680	-680	-374	-178.5

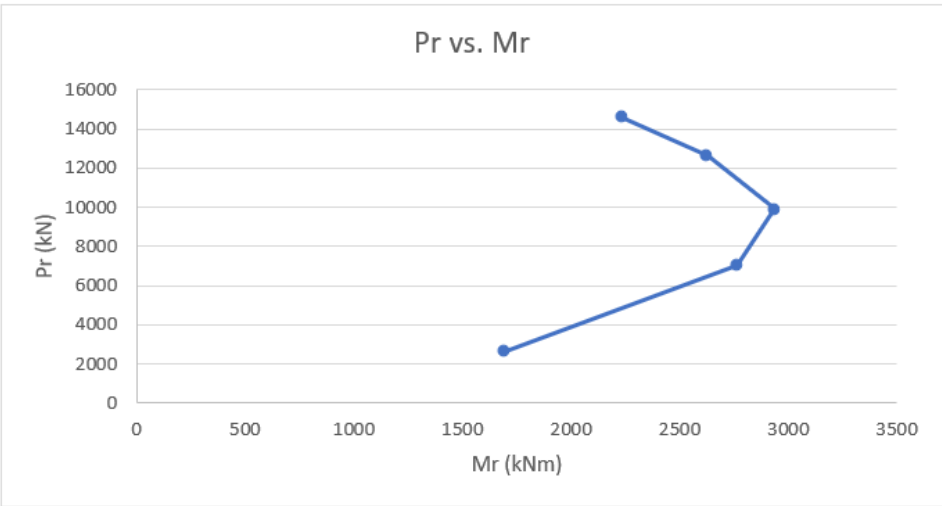
Pr (kN)	**2639.82469**	**7039.533**	**9908.142**	**12625.18**	**14580.57**
Mrc (kNm)	1105.59158	2171.696	2344.031	2169.716	1858.437
Mrs1 (kNm)	295.8	295.8	295.8	295.8	295.8
Mrs2 (kNm)	295.8	295.8	295.8	162.69	77.6475
Mr (kNm)	**1697.19158**	**2763.296**	**2935.631**	**2628.206**	**2231.884**

$$\mathrm{Mr} = 2935.6\ \mathrm{kNm} > \mathrm{Mf} \rightarrow \mathrm{ok}$$

$$\mathrm{Prso} = \mathrm{fy} * \varphi\mathrm{s} * \frac{\mathrm{Ast}}{1000} = 1360\ kN$$

$$\mathrm{Prco} = \alpha 1 * \varphi\mathrm{c} * \mathrm{f'}\mathrm{s} * \frac{\mathrm{Ag} - \mathrm{Ast}}{1000} = 16{,}998\ kN$$

$$\mathrm{Pro} = \mathrm{Prso} + \mathrm{Prco} = 18{,}358\ \mathrm{kN} > \mathrm{Pf} \rightarrow \mathrm{ok}$$



G Pump Data Sheets

UBC Civil 409
Example Spreadsheet
Pump Curve

Pump Model

3,467		**RPM**	**100%** **Speed**							
1	**Stages**									
1		**Pump Operating**					**2**	**Pumps Op.**	**3**	**Pumps Op.**
Flow (USgpm)	**TDH (ft/stage)**	**TDH (ft)**	**Eff (%)**	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
0	103.2	103.2	0.0%	0	31.5		0	31.5	0	31.5
150	92.3	92.3	57.8%	9	28.1	6.0	19	28.1	28	28.1
250	82.2	82.2	66.1%	16	25.1	7.8	32	25.1	47	25.1
275	77.6	77.6	67.8%	17	23.7	7.9	35	23.7	52	23.7
300	72.9	72.9	65.0%	19	22.2	8.5	38	22.2	57	22.2
325	66.7	66.7	64.2%	21	20.3	8.5	41	20.3	62	20.3
350	60	60.0	62.3%	22	18.3	8.5	44	18.3	66	18.3
375	51.8	51.8	58.2%	24	15.8	8.4	47	15.8	71	15.8
400	43.7	43.7	52.0%	25	13.3	8.5	50	13.3	76	13.3
425	35.2	35.2	41.4%	27	10.7	9.1	54	10.7	80	10.7

Reduced Speed

2427 RPM - 70%

2427	**RPM**	**70%**	**Speed**						
1	**Pump Operating**					**2**	**Pumps Op.**	**3**	**Pumps Op.**
		Eff (%)	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
		0.0%	0	15.4		0	15.4	0	15.4
		57.8%	7	13.8	2.1	13	13.8	20	13.8
		66.1%	11	12.3	2.7	22	12.3	33	12.3
		67.8%	12	11.6	2.7	24	11.6	36	11.6
		65.0%	13	10.9	2.9	26	10.9	40	10.9
		64.2%	14	10.0	2.9	29	10.0	43	10.0
		62.3%	15	9.0	2.9	31	9.0	46	9.0
		58.2%	17	7.7	2.9	33	7.7	50	7.7
		52.0%	18	6.5	2.9	35	6.5	53	6.5
		41.4%	19	5.3	3.1	38	5.3	56	5.3
		0.0%	0	0.0	#DIV/0!	0	0.0	0	0.0

Reduced Speed

2774 RPM - 80%

	2774	**RPM**	**80%**	**Speed**						
	1	**Pump Operating**					**2**	**Pumps Op.**	**3**	**Pumps Op.**
			Eff (%)	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
1			0.0%	0	20.1		0	20.1	0	20.1
2			57.8%	8	18.0	3.1	15	18.0	23	18.0
3			66.1%	13	16.0	4.0	25	16.0	38	16.0
4			67.8%	14	15.1	4.1	28	15.1	42	15.1
5			65.0%	15	14.2	4.3	30	14.2	45	14.2
6			64.2%	16	13.0	4.4	33	13.0	49	13.0
7			62.3%	18	11.7	4.4	35	11.7	53	11.7
8			58.2%	19	10.1	4.3	38	10.1	57	10.1
9			52.0%	20	8.5	4.3	40	8.5	61	8.5
10			41.4%	21	6.9	4.7	43	6.9	64	6.9
11			0.0%	0	0.0	#DIV/0!	0	0.0	0	0.0

Reduced Speed

3120 RPM - 90%

	3120	**RPM**	**90%**	**Speed**						
	1	**Pump Operating**					**2**	**Pumps Op.**	**3**	**Pumps Op.**
			Eff (%)	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
1			0.0%	0	25.5		0	25.5	0	25.5
2			57.8%	9	22.8	4.4	17	22.8	26	22.8
3			66.1%	14	20.3	5.7	28	20.3	43	20.3
4			67.8%	16	19.2	5.8	31	19.2	47	19.2
5			65.0%	17	18.0	6.2	34	18.0	51	18.0
6			64.2%	18	16.5	6.2	37	16.5	55	16.5
7			62.3%	20	14.8	6.2	40	14.8	60	14.8
8			58.2%	21	12.8	6.1	43	12.8	64	12.8
9			52.0%	23	10.8	6.2	45	10.8	68	10.8
10			41.4%	24	8.7	6.6	48	8.7	72	8.7
11			0.0%	0	0.0	#DIV/0!	0	0.0	0	0.0

UBC Civil 409
Example Spreadsheet
Pump Curve

Pump Model										
3,461		**RPM**	**100%** Speed							
1	**Stages**									
1		**Pump Operating**					**2**	**Pumps Op.**	**3**	**Pumps Op.**
Flow (USgpm)	**TDH (ft/stage)**	**TDH (ft)**	**Eff (%)**	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
0	91.0	91.0	0.0%	0	27.7		0	27.7	0	27.7
50	87.8	87.8	36.4%	3	26.8	3.0	6	26.8	9	26.8
100	80.1	80.1	54.2%	6	24.4	3.7	13	24.4	19	24.4
120	76.1	76.1	58.1%	8	23.2	4.0	15	23.2	23	23.2
140	70.2	70.2	59.8%	9	21.4	4.1	18	21.4	26	21.4
150	66.4	66.4	59.3%	9	20.2	4.2	19	20.2	28	20.2
160	62.3	62.3	57.4%	10	19.0	4.4	20	19.0	30	19.0
170	58.2	58.2	56.4%	11	17.7	4.4	21	17.7	32	17.7
180	54.3	54.3	55.7%	11	16.6	4.4	23	16.6	34	16.6
200	44.2	44.2	48.7%	13	13.5	4.6	25	13.5	38	13.5

Reduced Speed
2423 **RPM** **70%** **Speed** — 2423 RPM - 70%

1	**Pump Operating**				**2**	**Pumps Op.**	**3**	**Pumps Op.**
	Eff (%)	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
	0.0%	0	13.6		0	13.6	0	13.6
	36.4%	2	13.1	1.0	4	13.1	7	13.1
	54.2%	4	12.0	1.3	9	12.0	13	12.0
	58.1%	5	11.4	1.4	11	11.4	16	11.4
	59.8%	6	10.5	1.4	12	10.5	19	10.5
	59.3%	7	9.9	1.5	13	9.9	20	9.9
	57.4%	7	9.3	1.5	14	9.3	21	9.3
	56.4%	8	8.7	1.5	15	8.7	23	8.7
	55.7%	8	8.1	1.5	16	8.1	24	8.1
	48.7%	9	6.6	1.6	18	6.6	26	6.6
	0.0%	0	0.0	#DIV/0!	0	0.0	0	0.0

Reduced Speed
2769 **RPM** **80%** **Speed** — 2769 RPM - 80%

	1	**Pump Operating**				**2**	**Pumps Op.**	**3**	**Pumps Op.**
		Eff (%)	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
1		0.0%	0	17.8		0	17.8	0	17.8
2		36.4%	3	17.1	1.6	5	17.1	8	17.1
3		54.2%	5	15.6	1.9	10	15.6	15	15.6
4		58.1%	6	14.8	2.0	12	14.8	18	14.8
5		59.8%	7	13.7	2.1	14	13.7	21	13.7
6		59.3%	8	13.0	2.2	15	13.0	23	13.0
7		57.4%	8	12.2	2.2	16	12.2	24	12.2
8		56.4%	9	11.4	2.3	17	11.4	26	11.4
9		55.7%	9	10.6	2.3	18	10.6	27	10.6
10		48.7%	10	8.6	2.3	20	8.6	30	8.6
11		0.0%	0	0.0	#DIV/0!	0	0.0	0	0.0

Reduced Speed
3115 **RPM** **90%** **Speed** — 3115 RPM - 90%

	1	**Pump Operating**				**2**	**Pumps Op.**	**3**	**Pumps Op.**
		Eff (%)	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
1		0.0%	0	22.5		0	22.5	0	22.5
2		36.4%	3	21.7	2.2	6	21.7	9	21.7
3		54.2%	6	19.8	2.7	11	19.8	17	19.8
4		58.1%	7	18.8	2.9	14	18.8	20	18.8
5		59.8%	8	17.3	3.0	16	17.3	24	17.3
6		59.3%	9	16.4	3.1	17	16.4	26	16.4
7		57.4%	9	15.4	3.2	18	15.4	27	15.4
8		56.4%	10	14.4	3.2	19	14.4	29	14.4
9		55.7%	10	13.4	3.2	20	13.4	31	13.4
10		48.7%	11	10.9	3.3	23	10.9	34	10.9
11		0.0%	0	0.0	#DIV/0!	0	0.0	0	0.0

UBC Civil 409
Example Spreadsheet
Pump Curve

Pump Model										
3,400		**RPM**	**100%**	**Speed**						
1	**Stages**									
1		**Pump Operating**					**2**	**Pumps Op.**	**3**	**Pumps Op.**
Flow (USgpm)	**TDH (ft/stage)**	**TDH (ft)**	**Eff (%)**	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
0	226.5	226.5		0	69.0		0	69.0	0	69.0
300	197.8	197.8	65.0%	19	60.3	23.0	38	60.3	57	60.3
400	168.5	168.5	70.0%	25	51.4	24.3	50	51.4	76	51.4
450	148	148.0	75.0%	28	45.1	22.4	57	45.1	85	45.1
500	124.5	124.5	80.0%	32	37.9	19.6	63	37.9	95	37.9
525	112.8	112.8	85.0%	33	34.4	17.6	66	34.4	99	34.4
550	96.3	96.3	85.0%	35	29.4	15.7	69	29.4	104	29.4
575	82.8	82.8	82.0%	36	25.2	14.7	73	25.2	109	25.2
600	66.3	66.3	76.0%	38	20.2	13.2	76	20.2	114	20.2
625	52.2	52.2	70.0%	39	15.9	11.8	79	15.9	118	15.9

Reduced Speed									
2380	**RPM**	**70%**	**Speed**						2380 RPM - 70%
1	**Pump Operating**					**2**	**Pumps Op.**	**3**	**Pumps Op.**
		Eff (%)	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
		0.0%	0	33.8		0	33.8	0	33.8
		65.0%	13	29.5	7.9	26	29.5	40	29.5
		70.0%	18	25.2	8.3	35	25.2	53	25.2
		75.0%	20	22.1	7.7	40	22.1	60	22.1
		80.0%	22	18.6	6.7	44	18.6	66	18.6
		85.0%	23	16.8	6.0	46	16.8	70	16.8
		85.0%	24	14.4	5.4	49	14.4	73	14.4
		82.0%	25	12.4	5.0	51	12.4	76	12.4
		76.0%	26	9.9	4.5	53	9.9	79	9.9
		70.0%	28	7.8	4.0	55	7.8	83	7.8
		0.0%	0	0.0	#DIV/0!	0	0.0	0	0.0

	Reduced Speed									
	2720	**RPM**	**80%**	**Speed**						2720 RPM - 80%
	1	**Pump Operating**					**2**	**Pumps Op.**	**3**	**Pumps Op.**
			Eff (%)	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
1			0.0%	0	44.2		0	44.2	0	44.2
2			65.0%	15	38.6	11.8	30	38.6	45	38.6
3			70.0%	20	32.9	12.4	40	32.9	61	32.9
4			75.0%	23	28.9	11.5	45	28.9	68	28.9
5			80.0%	25	24.3	10.1	50	24.3	76	24.3
6			85.0%	26	22.0	9.0	53	22.0	79	22.0
7			85.0%	28	18.8	8.1	56	18.8	83	18.8
8			82.0%	29	16.2	7.5	58	16.2	87	16.2
9			76.0%	30	12.9	6.8	61	12.9	91	12.9
10			70.0%	32	10.2	6.0	63	10.2	95	10.2
11			0.0%	0	0.0	#DIV/0!	0	0.0	0	0.0

	Reduced Speed									
	3060	**RPM**	**90%**	**Speed**						3060 RPM - 90%
	1	**Pump Operating**					**2**	**Pumps Op.**	**3**	**Pumps Op.**
			Eff (%)	**Flow (L/s)**	**TDH (m)**	**Power (HP)**	**Flow (L/s)**	**TDH (m)**	**Flow (L/s)**	**TDH (m)**
1			0.0%	0	55.9		0	55.9	0	55.9
2			65.0%	17	48.8	16.8	34	48.8	51	48.8
3			70.0%	23	41.6	17.7	45	41.6	68	41.6
4			75.0%	26	36.5	16.3	51	36.5	77	36.5
5			80.0%	28	30.7	14.3	57	30.7	85	30.7
6			85.0%	30	27.8	12.8	60	27.8	89	27.8
7			85.0%	31	23.8	11.5	62	23.8	94	23.8
8			82.0%	33	20.4	10.7	65	20.4	98	20.4
9			76.0%	34	16.4	9.6	68	16.4	102	16.4
10			70.0%	35	12.9	8.6	71	12.9	106	12.9
11			0.0%	0	0.0	#DIV/0!	0	0.0	0	0.0

UBC Civil 409
Example Spreadsheet
Pump Selection

Head Head

Pumps Operating	1
Flow	28.0 L/s
Discharge HGL=	85.00 m
Suction HGL=	70.00 m
Hazen-Williams C Value	110.00

Flow in L/s, head in m

No. of Pumps

Flow (L/s)	23.72	1	2	3	4
	0	15	15	15	15
	10	16	16	16	16
	20	20	19	19	19
	30	25	24	24	24
	40	32	31	31	31
	50	41	39	39	39
	60	51	49	48	48
	70	63	60	59	59
	80	77	72	72	71
	90	92	86	85	85
	90	92	86	85	85
	90	92	86	85	85
	90	92	86	85	85
	90	92	86	85	85
	90	92	86	85	85
	90	92	86	85	85
	90	92	86	85	85

Element	Dia (nom) in	I.D. mm	Total Flow L/s	Flow in Element L/s	Length m	"C"	"K"	"CV"	Velocity m/s	Delta H m
Discharge elbow		150	28	28.00			0.05			
90 degree bend		150	28	28.00			0.60		1.58	0.08
Sch. 40 Steel Pipe		150	28	28.00	0.5	110			1.58	0.01
Swing check valve		150	28	28.00				4600	1.58	0.01
Gate valve x 3		150	28	28.00			0.90		1.58	0.12
90 degree bend		150	28	28.00			0.60		1.58	0.08
Sch. 40 Steel Pipe		150	28	28.00	3	110			1.58	0.07
90 degree bend		150	28	28.00			0.60		1.58	0.08
Sch. 40 Steel Pipe		150	28	28.00	3	110			1.58	0.07
90 degree bend		150	28	28.00			0.60		1.58	0.08
Sch. 40 Steel Pipe		150	28	28.00	6	110			1.58	0.15
90 degree bend		150	28	28.00			0.60		1.58	0.08
Sch. 40 Steel Pipe		150	28	28.00	300	110			1.58	7.27
90 degree bend		150	28	28.00			0.60		1.58	0.08
Sch. 40 Steel Pipe		150	28	28.00	6	110			1.58	0.15
90 degree bend		150	28	28.00			0.60		1.58	0.08
Sch. 40 Steel Pipe		150	28	28.00	3	110			1.58	0.07
90 degree bend		150	28	28.00			0.60		1.58	0.08
Sch. 40 Steel Pipe		150	28	28.00	3	110			1.58	0.07
Exit		150	28	28.00			1.00		1.58	0.13

Total Head Losses (m)	**8.72**
Static Head	15.00
Total Dynamic Head (m)	24

March 2, 2019

H Reinforced Cast-In-Place Concrete Specifications

H.I General

H.I.I Requirements

- Supplying of materials and mixing and planning of reinforced cast-in-place concrete in accordance with the drawings and specifications.
- Supplying, fabrications, constructing, storing, maintaining, removing of materials and temporary work where necessary.
- Development of mix design that meets the performance requirement set out in this report.

H.I.II References

- CSA-A23.1/A23.2, Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete
- CSA A283, Qualification Code for Concrete Testing Laboratories
- CSA-A3001, Cementitious Materials for Use in Concrete
- CAN/CSA-A3000, Cementitious Materials Compendium

H.I.III Submittals

- At least 4 weeks prior to commencing work, inform Owner's Representative of the proposed source of aggregate and provide sampling of aggregate if necessary. Submit the following manufacturers' data:
    - Portland Cement
    - Supplementary cementing materials
    - Admixtures
    - Aggregates
    - Water
    - Joint Filler
- Provide certification that plant, equipment and materials to be used conform to CSA A23.1/A23.2
- Provide certification of concrete testing that meets the required properties of concrete. All testing shall conform to CSA A23.1. The submission of mix design shall include the performance criteria of the following:
    - Compressive Strength
    - Density
    - Proposed Slump
    - Set time

H.II Products

H.II.I Fine Aggregate

Grading shall meet the requirements set out in CAN/CSA-A23.2-2A-14. Fine aggregate shall have a fineness modulus between 2.3 (minimum) and 3.1 (maximum), and meet the sieve designation of the following:

MTO Sieve Designation	Percentage Passing
9.5 mm	100
4.75 mm	95-100
2.36 mm	80-100
1.18 mm	50-85
600 um	25-60
300 um	10-30
150 um	0-10

H.II.II Coase Aggregate

- All coarse aggregates shall have the maximum nominal size of 20mm and meet the grading requirements in CAN/CSA-A23.2-2A-14. Coase aggregates shall be uniformly graded.

H.II.III Cement

- All cementitious materials shall conform with CAN/CSA-A3000 Cementitious Materials Compendium, and shall exhibit homogeneity and free of any lumps and clutters. Normal Portland Cement shall be used unless otherwise specified by the engineer.

H.II.IV Formwork and Falsework

- The contractor shall be responsible for the design of all proposed falsework and formwork and submit design calculations and drawings to the structural engineer at least 2 weeks before the commencement of the work.
- Formwork shall not have any split, cracks, or defect that will compromise the performance of the material or create concerns for workers safety. The face of the formwork shall be free of any protruding nails, and debris.
- Formwork ties and components shall be fixed that they shall not touch reinforcements or built-in components.

H.III Construction

H.III.I Mixing

- All concrete shall should be thoroughly mixed until the material appears to be homogenous and all aggregates are evenly distributed throughout the batch.
- Concrete shall have the below properties unless otherwise specified:
  - Minimum cement content: 300 kg/m^3
  - Class of exposure: N

- Nominal maximum size of coarse aggregate: 20mm
- Slump: 75-100mm
- Air content: 5-8%

H.III.II Pumping

- Provide hot or cold weather protection when required as specified in CAN3-A23.1.
- Contractor to choose pumping equipment and method. Concrete shall be pumped with continuous flow without air pockets entrapment.

H.III.III Finishing

- Concrete finishing compliance with CSA-A23.1/A23.2.
- Wet cure concrete using polyethylene sheets placed over concrete to prevent damage.

H.III.IV Field Quality Control

- Sampling of concrete shall be done in the field as concrete is pumped and placed, the same batch of concrete shall be used for sampling.
- Create concrete test cylinders in accordance with CSA-A23.1/A23.2. At least 4 cylinders should be made for each day's pour, and for each type of grade of aggregate.
- Conduct at least one slump test and air entrainment test in the field with every batch of concrete.

I Geotechnical Results and Calculations

I.I Swale WALLAP Analysis Results

```
STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method
 Factor of safety on gross pressure (excluding water pressure)

                                  FoS for toe        Toe elev. for
                                 elev. =   -4.30      FoS = 2.000
                                 ----------------    --------------
 Stage   --- G.L. ---   Strut    Factor  Moment       Toe    Wall    Direction
  No.    Act.   Pass.   Elev.     of     equilib.    elev.  Penetr      of
                                 Safety  at elev.           -ation    failure
   1     0.00    0.00    ---     Conditions not suitable for FoS calc.
   2     0.00    0.00    ---     Conditions not suitable for FoS calc.
   3     0.00   -1.75   Cant.    1.210    -4.07       ***     ***      L to R
   4     0.00   -1.75            No analysis at this stage
   5     0.00   -2.00   -1.50    2.792     n/a       -3.39    1.39     L to R
```

```
Maximum and minimum bending moment and shear force at each stage
Stage  ------------ Bending moment -----------   ------------- Shear force -------------
 no.   ------- Calculated ------    Factored     ------- Calculated ------    Factored
       max.  elev.    min.  elev.  max.   min.   max.  elev.   min.  elev.   max.   min.
      kN.m/m        kN.m/m           kN.m/m      kN/m          kN/m          kN/m   kN/m
  1       0  -1.50     -0  -3.12     0     -0       1  -1.20     -0  -2.20     1     -1
  2       0  -1.50     -0  -3.12     0     -0       1  -1.20     -0  -2.20     1     -1
  3      23  -2.88     -0  -4.30    46     -0      17  -2.00    -27  -3.80    33    -53
  4    No calculation at this stage
  5      17  -3.12     -0  -4.30    34     -0      11  -2.40    -22  -3.80    23    -44
================================================================================
Run ID. Swale Walls_SLS                                        | Sheet No.
Swale Walls                                                    | Date:14-03-2019
Please modify / add                                            | Checked :
--------------------------------------------------------------------------------
Summary of results   (continued)

Maximum and minimum displacement at each stage
Stage -------- Displacement ---------   Stage description
 no.   maximum  elev.   minimum  elev.   -----------------
          m               m
  1    0.003   -4.30    0.000    0.00   Apply surcharge no.1 at elev. 0.00
  2    0.003   -4.30    0.000    0.00   Apply water pressure profile no.1
  3    0.055    0.00   -0.002   -4.30   Excav. to elev. -1.75 on RIGHT side
  4    No calculation at this stage     Install strut no.1 at elev. -1.50
  5    0.053    0.00   -0.000   -4.30   Excav. to elev. -2.00 on RIGHT side

Strut forces at each stage  (horizontal components)
Stage    ----- Strut no. 1 -----
 no.         at elev.-1.50
        --Calculated-- Factored
        kN per  kN per   kN per
         m run   strut    strut
  5        10      31       63
```

I.II Parkade WALLAP Analysis Results

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method
Factor of safety on gross pressure (excluding water pressure)

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = -13.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 2.000: Toe elev.	Wall Penetr -ation	Direction of failure
1	0.00	0.00	Cant.	6.937	-11.78	***	***	L to R
2	0.00	0.00	Cant.	6.937	-11.78	***	***	L to R
3	0.00	-3.00	Cant.	2.100	-12.01	-12.44	9.44	L to R
4	0.00	-3.00		No analysis at this stage				
5	0.00	-3.00	-2.50	4.280	n/a	***	***	L to R
6	0.00	-5.00	-2.50	2.241	n/a	-12.11	7.11	L to R

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment – Calculated max. kN.m/m	elev.	min. kN.m/m	elev.	Factored max. kN.m/m	Factored min. kN.m/m	Shear force – Calculated max. kN/m	elev.	min. kN/m	elev.	Factored max. kN/m	Factored min. kN/m
1	0	-1.20	-4	-5.00	1	-7	1	-1.20	-2	-2.50	3	-4
2	0	-1.20	-4	-5.00	1	-7	1	-1.20	-2	-2.50	3	-4
3	133	-5.50	-0	0.00	266	-0	52	-3.50	-34	-7.20	104	-69
4	No calculation at this stage											
5	114	-5.50	-0	0.00	228	-0	43	-3.50	-30	-7.20	86	-60
6	57	-2.50	-39	-5.00	113	-78	62	-2.50	-75	-2.50	123	-150

Run ID. Parkade Walls	Sheet No.
1.25 GW Level	Date: 2-03-2019
Please modify / add	Checked :

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.007	-2.50	0.000	0.00	Apply surcharge no.1 at elev. 0.00
2	0.007	-2.50	0.000	0.00	Apply water pressure profile no.1
3	0.090	0.00	0.000	0.00	Excav. to elev. -3.00 on RIGHT side
4	No calculation at this stage				Install strut no.1 at elev. -2.50
5	0.086	0.00	0.000	0.00	Apply water pressure profile no.2
6	0.067	0.00	0.000	0.00	Excav. to elev. -5.00 on RIGHT side

Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. -2.50 – Calculated kN per m run	Calculated kN per strut	Factored kN per strut
5	14	27	55
6	137	273	547

I.III Parkade Calculations

Effective Stress Analysis

$$q_{ult} = \sigma'_D N_q + 0.5\gamma' B N_\gamma - \text{for strip footings}$$

$$q_{ult} = \sigma'_D N_q + 0.4\gamma' B N_\gamma - \text{for square footings}$$

$$q_{ult} = \sigma'_D N_q + 0.3\gamma' B N_\gamma - \text{for circular footings}$$

Where:

q_{ult} - Ultimate gross bearing capacity
σ'_D - Vertical effective stress foundation base level
γ' - Effective unit weight of soil (below footing underside level)
D - Depth of footing below ground surface
B - Width of footing
N_q, N_γ - Bearing capacity factors (Note: dependent on ϕ' as per Table below)

Footing Sizing	
Item	Value
thickness (m)	0.8
Width (m)	3.3
Depth (m)	3
soil weight (kN)	455.20
concrete weight (kN)	253.85
effective stress (kPa)	27.57
P (kN)	6132.91
qult (kPa)	1291.71
Qallow (kPa)	430.56
q applied	604.97
FOS	**2.07**

Shear Failure Check		
Item	Value	Unit
Df	3	m
concrete density	2400	kg/m3
Load Combination	6132.91	kN

q footing (kPa)	563.17	kPa
thickness (t)	0.9	m
B	3.3	m
Qult	1291	kPa
qt (kPa)	15000	kPa
Reduction Factor	0.44	
Factor of Safety	**2.29**	

Contact Bearing Pressure		
Item	Value	Unit
P0 = 0.85*fc'*A1	8978125	N
A1	422500	mm^2
A2	13322500	mm^2
phi	0.7	
Pnb (footing) 1	35290.94	kN
Pnb (footing) 2	12569.38	kN
Pnb (footing) actual	12569.38	kN
Pnb (column)	6284.688	kN
Footing Check	**no failure**	
Column Check	**no failure**	

Punching Shear		
Item	Value	Unit
Thickness t	900	mm
B=	3300	mm
Load Combo=	6132.905	kN
d=	750	mm
Column width c	650	mm
Rebar Coverage	150	mm
qu=	563.1685	kPa
Vu=	5029.095	kN
bo=	5600	mm
as	20	
Beta(c)	1	

fc'	25	
Vc1	10710	kN
Vc2	13132.5	kN
Vc3	7000	kN
0.85*Vc	5950	>Vu
Failure:	**No**	

Rebar Sizing		
Item	Value	Unit
b =	1000	mm
fy =	400	MPa
a0 =	0.019	1/mm
phi =	0.9	
Lm =	1325	mm
Mu =	4.94E+08	N*mm
As =	2150.55	mm2/m
As	7096.82	mm2
Diam bar	25	mm
As per bar	490.8739	mm2
# bars	14	
spacing	215	mm

Elastic Settlement (Schmertmann's Method)						
Iz	Iz*z/E (m3/kN)	Depth Top (m)	Depth Bottom (m)	E (MPa)	Item	Value
0	0	0	0.5	37.5	Df (m)	3
0	0	0.5	1	37.5	q (kPa)	57
0	0	1	1.5	37.5	qbar (kPa)	563.1685
0	0	1.5	2	37.5	q'z (kPa)	81.9735
0	0	2	2.5	37.5	z1 (m)	1.65
0	0	2.5	3	37.5	z2 (m)	6.6
0.213408	2.85E-06	3	3.5	37.5	Izmax	0.748491
0.440223	5.87E-06	3.5	4	37.5	L=B (m)	3.3

0.667039	8.89E-06	4	4.5	37.5	Load (kN)	6132.91
0.73337	9.78E-06	4.5	5	37.5	sum (m3/kN)	7E-05
0.657765	8.77E-06	5	5.5	37.5	C1	0.943695
0.58216	7.76E-06	5.5	6	37.5	C2	1.4
0.506555	6.75E-06	6	6.5	37.5	S (mm)	46.8
0.430949	5.75E-06	6.5	7	37.5	span (m)	7.7
0.355344	4.74E-06	7	7.5	37.5	max diff. S (mm)	15.4
0.279739	3.73E-06	7.5	8	37.5		
0.204134	2.72E-06	8	8.5	37.5		
0.128529	1.71E-06	8.5	9	37.5		
0.052924	7.06E-07	9	9.5	37.5		

J Swale Calculations

Sample Calculation: Bioswale Slab – Bearing capacity of the soil

$$N_q = tan^2\left(45 + \frac{\emptyset}{2}\right) * e^{\pi * \tan(\emptyset)}$$
$$\emptyset = 33°$$
$$N_q = 26.09$$

$$N_y = 2 * \left(N_q + 1\right) * \tan(\emptyset)$$
$$N_y = 35.19$$

$$q_{ult} = 0.5 * B * y' * N_y$$
$$B = 8.7m$$
$$y' = 19\frac{kN}{m^3}$$
$$q_{ult} = 2908.45\frac{kN}{m^2}$$

$$Factor\ of\ Safety = 3$$
$$q_{ult,design} = 969.45\frac{kN}{m^2}$$

Sample Calculation: Bioswale Slab – Design Loads

$$Live\ Load = LL = d * y_w$$
$$Depth\ of\ water = d = 2m$$
$$Weight\ of\ water = y_w = 9.8\frac{kN}{m^3}$$
$$LL = 19.6\frac{kN}{m^2}$$

$$q_{design\ load} = 1.5 * LL = 29.4\frac{kN}{m^2}$$

$$q_{ult,design} > q_{design\ load}$$

Because the bearing capacity of the soil beneath the slab is greater than the design loads, the slab will only need the minimum steel area.

Sample Calculation: Bioswale Slab – Thickness of slab

$$Minimum\ depth\ of\ slab = d_s = \frac{l_n}{20}$$

Assumptions:

- Simply supported between retaining walls
- One-way slab

$$l_n = 8.7m$$

$$Min.depth = 530mm$$

$$Actual\ depth\ of\ slab = 550mm$$

Made slab 450mm thick for easier constructability.

Sample Calculation: Bioswale Slab – Minimum steel area

$$A_{s,min.} = 0.002 * A_g$$

Find the minimum steel for a unit width of one meter.

$$A_g = L * d_s = 1m * 0.45m = 0.45mm^2$$

$$A_{s,min.} = 900mm^2$$

Sample Calculation: Bioswale Slab – Maximum Spacing

$$Spacing\ of\ rebar = s$$

$$s_{max.} = min.(5 * d_s, 500mm)$$

$$5 * d_s = 2250mm$$

Therefore,

$$s_{max.} = 500mm$$

Sample Calculation: Bioswale Slab – Rebar Arrangement

The arrangement of steel for the bioswale is 20M bars is 300mm.

For a unit width of one meter of the bioswale, the following calculations are to ensure that the steel arrangement meet the minimum steel area requirement.

$$A_s = 300mm^2 * \frac{1000mm}{300mm} = 1000mm^2$$

Therefore, the steel arrangement meets the minimum required steel area.

Sample Calculation: Steel Culvert

The following formula is a rearrangement of the Manning Formula:

$$D_{min} = \left(\frac{Q * n * 10.097}{S^{0.5} * 3.14159}\right)^{\frac{3}{8}}$$

Q = Peak Stormwater Flow = 1.02m^3/s
n = Manning Roughness Coefficient = 0.024
S = Slope of the culvert = 16m/300m = 5.3%
Dmin = Minimum diameter of the culvert

Sample Calculation: Steel Weir

$$B = \frac{Q * 1.5}{C_D * (2 * g)^{0.5} * H\text{^}1.5}$$

Q = Peak Stormwater Flow = 1.02m^3/s
Cd = Discharge Coefficient = 0.62 for rectangular weirs
g = Acceleration due to gravity = 9.81m/s^2
H = Head above the weir = 1 meter
B = Width of the rectangular opening

K Detailed Design Drawings

UBC CAMPUS AND COMMUNITY PLANNING
STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE

ISSUED FOR CONSTRUCTION
APRIL 8TH, 2019

0m 125m
1:2500

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE
COVER PAGE

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	EB
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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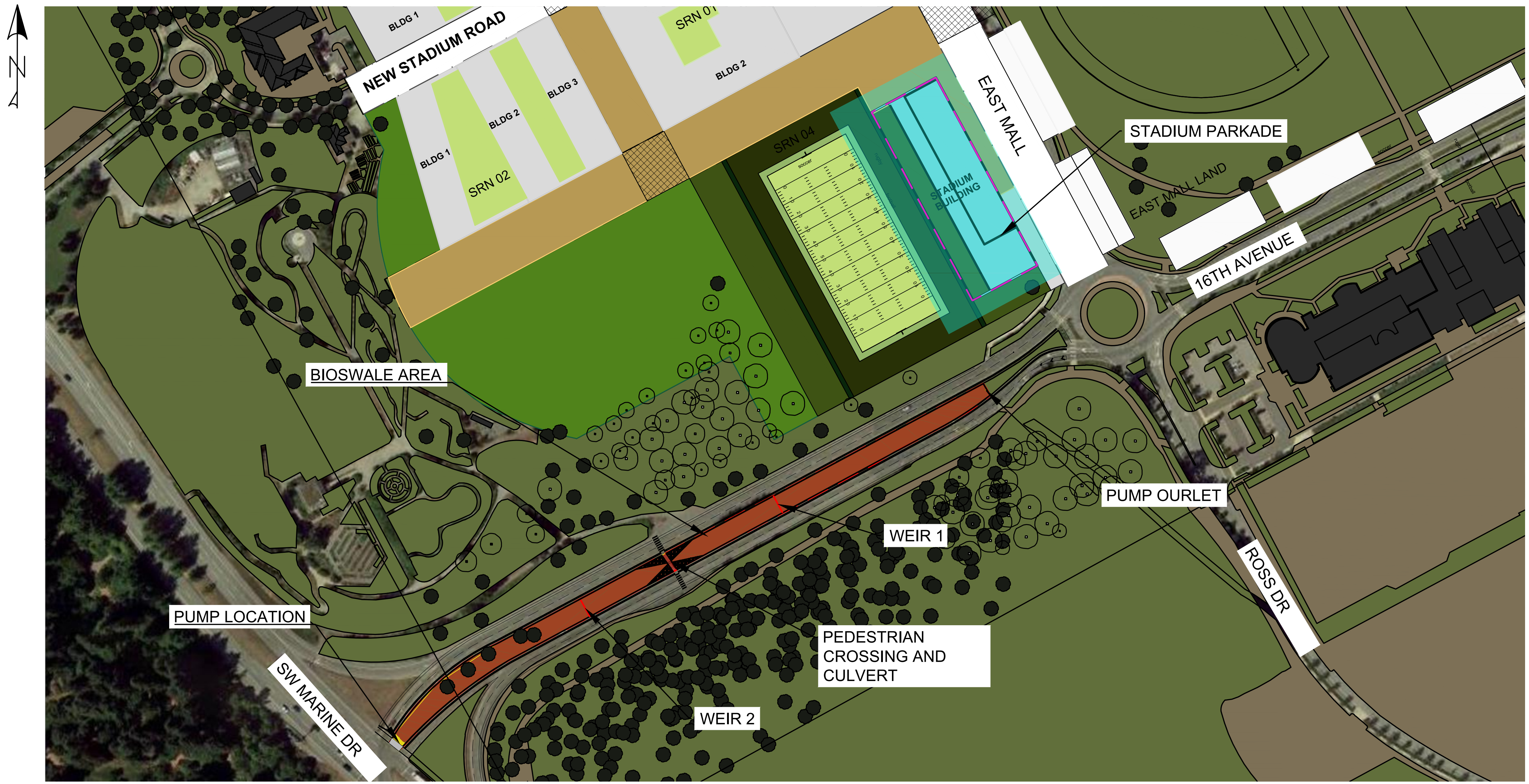
STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE



ISSUED FOR CONSTRUCTION
APRIL 8TH, 2019

0m 125m
1:2500

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE
SITE OVERVIEW

REV	PURPOSE	DATE	DR.	CH.
1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	EB

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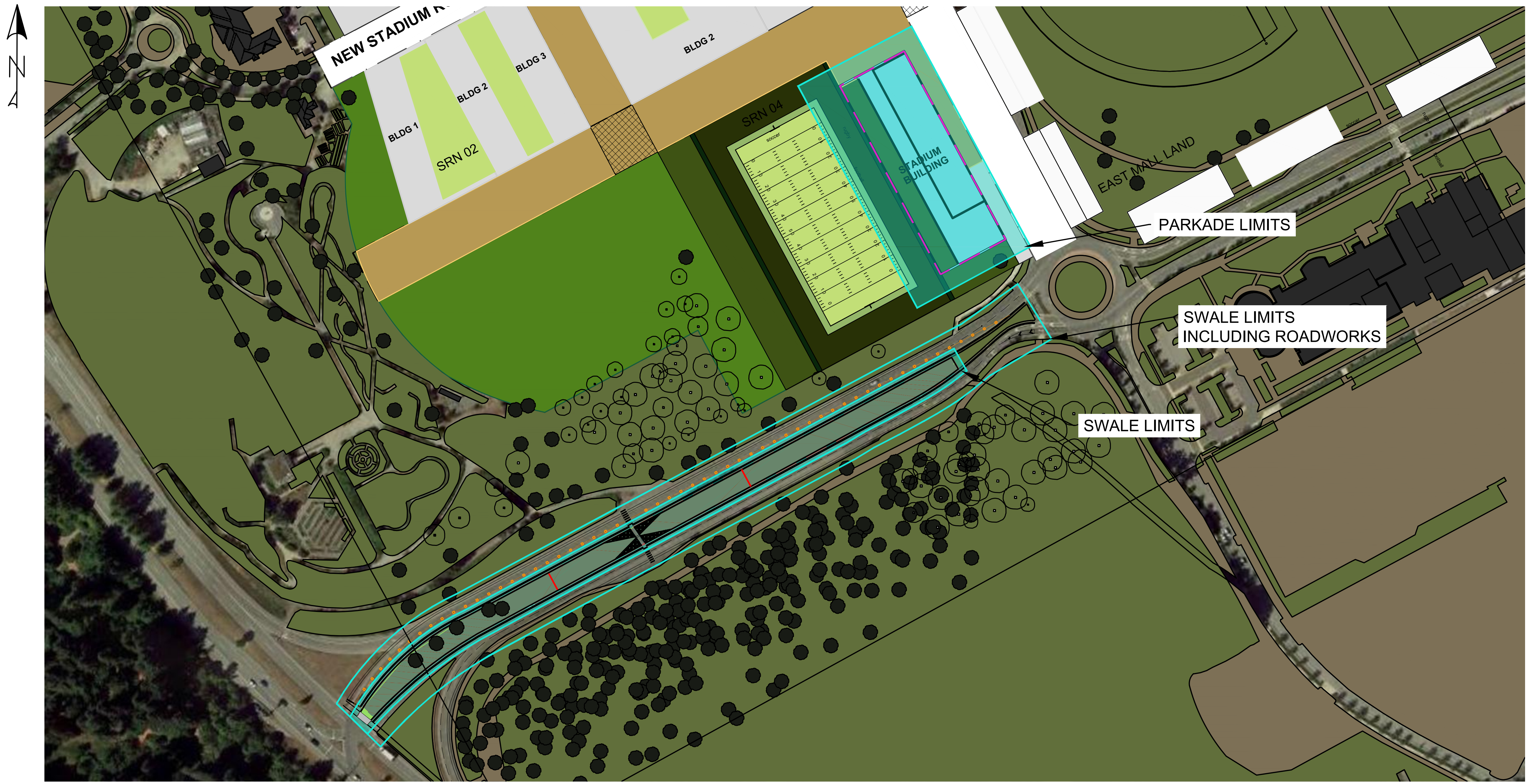
STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE



NOTES:
1. ALL LIMITS INCLUDE EXCAVATION AND REMOVALS AREA

ISSUED FOR CONSTRUCTION
APRIL 8TH, 2019

0m 125m
1:2500

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
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CLIENT:
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STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE CONSTRUCTION LIMITS

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	EB
REV	PURPOSE	DATE	DR.	CH.

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GENERAL STRUCTURAL NOTES

1. STRUCTURAL DRAWINGS SHALL BE USED IN CONJUNCTION WITH THE SPECIFICATIONS AND OTHER RELATED DRAWINGS AND DOCUMENTS BY OTHER DISCIPLINES. ALL WORK SHALL CONFORM TO NATIONAL, PROVINCIAL, AND MUNICIPAL BUILDING BY-LAWS.
2. THESE DRAWINGS DO NOT INDICATE METHOD OF CONSTRUCTION. CONTRACTORS SHALL VERIFY ALL DIMENSIONS AND ELEVATION RELATIONS TO EXISTING CONDITIONS BY MAKING FIELD SURVEYS AND MEASUREMENTS PRIOR TO CONSTRUCTION AND MANUFACTURING OF PARTS.
3. THE GENERAL CONTRACTOR SHALL OBTAIN COPIES OF THE LATEST CONTRACT DOCUMENTS AND COPIES OF ALL RELATED COMMUNICATION AND ADDENDA. GENERAL CONTRACTOR SHOULD PROVIDE RELEVANT DOCUMENTS TO SUB-CONTRACTORS AND SUPPLIERS WHERE DEEMED NECESSARY FOR THE COMPLETION OF THE PROJECT.
4. ALL SUBMITTALS AND SHOP-DRAWINGS SHALL BE REVIEWED AND STAMPED BY THE GENERAL CONTRACTOR PRIOR TO SUBMITTAL TO THE ENGINEERS AND ARCHITECTS. DRAWING REVIEWS WITHOUT CONTRACTOR REVIEW MAY RESULT IN DELAYS.
5. THE GENERAL CONTRACTOR SHALL COORDINATE DRAWINGS OF ALL REPORTS AND SUBMITTALS. THE GENERAL CONTRACTOR SHALL SUBMIT THE SHOP-DRAWINGS FOR REVIEW TO THE STRUCTURAL ENGINEER:
   a. CONCRETE MIX DESIGNS
   b. STEEL REINFORCEMENTS
6. WHERE THERE IS A CONFLICT BETWEEN THE DRAWINGS AND THE SPECIFICATIONS, THE STRICTER REQUIREMENT SHALL GOVERN. CONSULT WITH THE PROJECT ENGINEER AND ARCHITECTURE AND OBTAIN APPROVAL PRIOR TO COMMENCEMENT OF THE WORK.
7. NO STRUCTURAL MEMBER SHALL BE CUT, REDUCED IN DIMENSIONS AND STRENGTH UNLESS OTHERWISE NOTED BY THE STRUCTURAL ENGINEER.

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
STRUCTURAL NOTES

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	EB
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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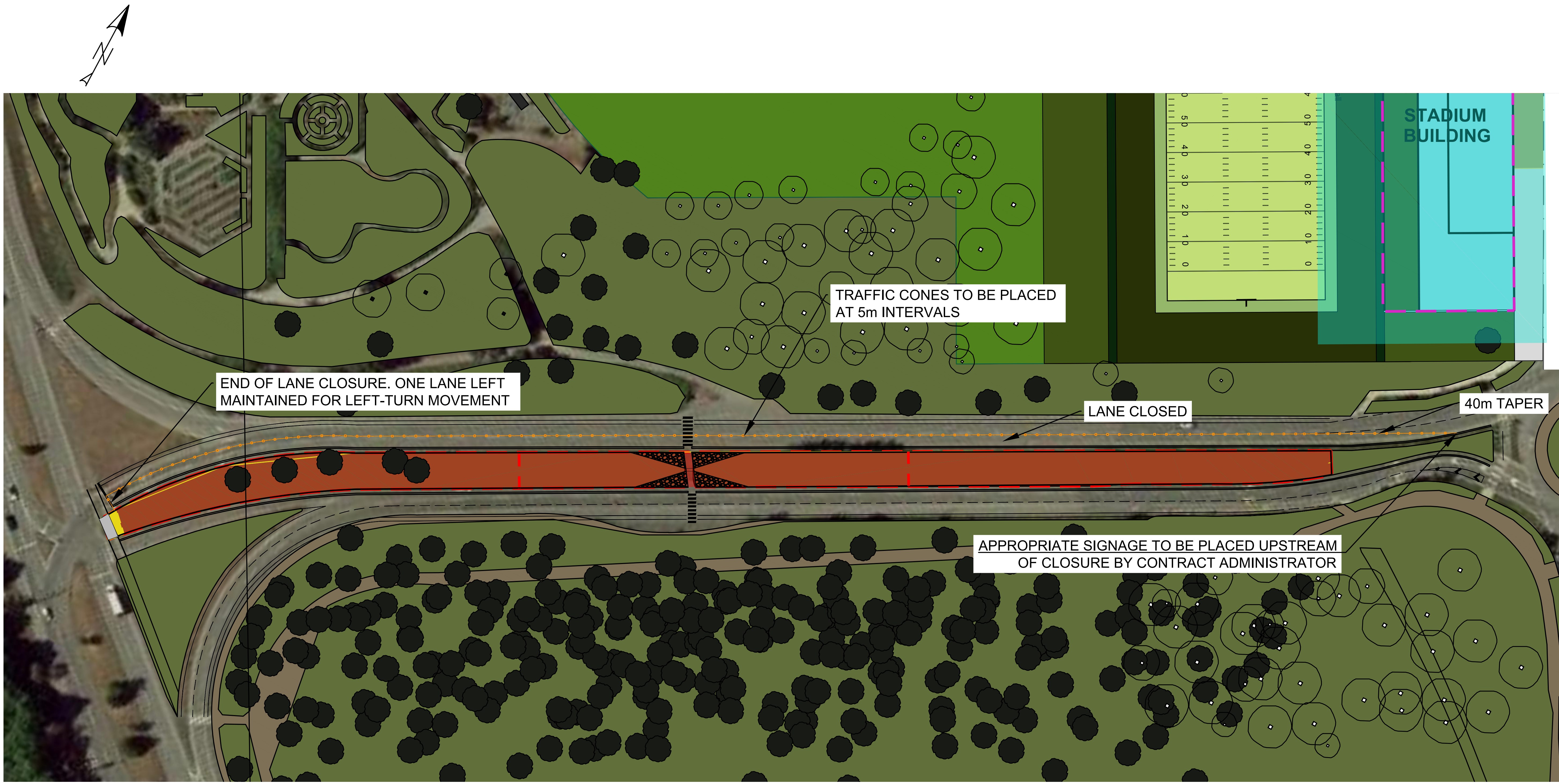

NOTES:

1. A TRAFFIC CONTROL PERSON WILL BE PRESENT ON SITE DURING WORK AT ALL TIMES
2. TAPERS AND SIGNAGE WILL BE FIT ON SITE BY TRAFFIC CONTROL PERSON

0m 62.5m
1:1250

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE
TRAFFIC MANAGEMENT PLAN
WESTBOUND 16TH AVENUE

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	EB
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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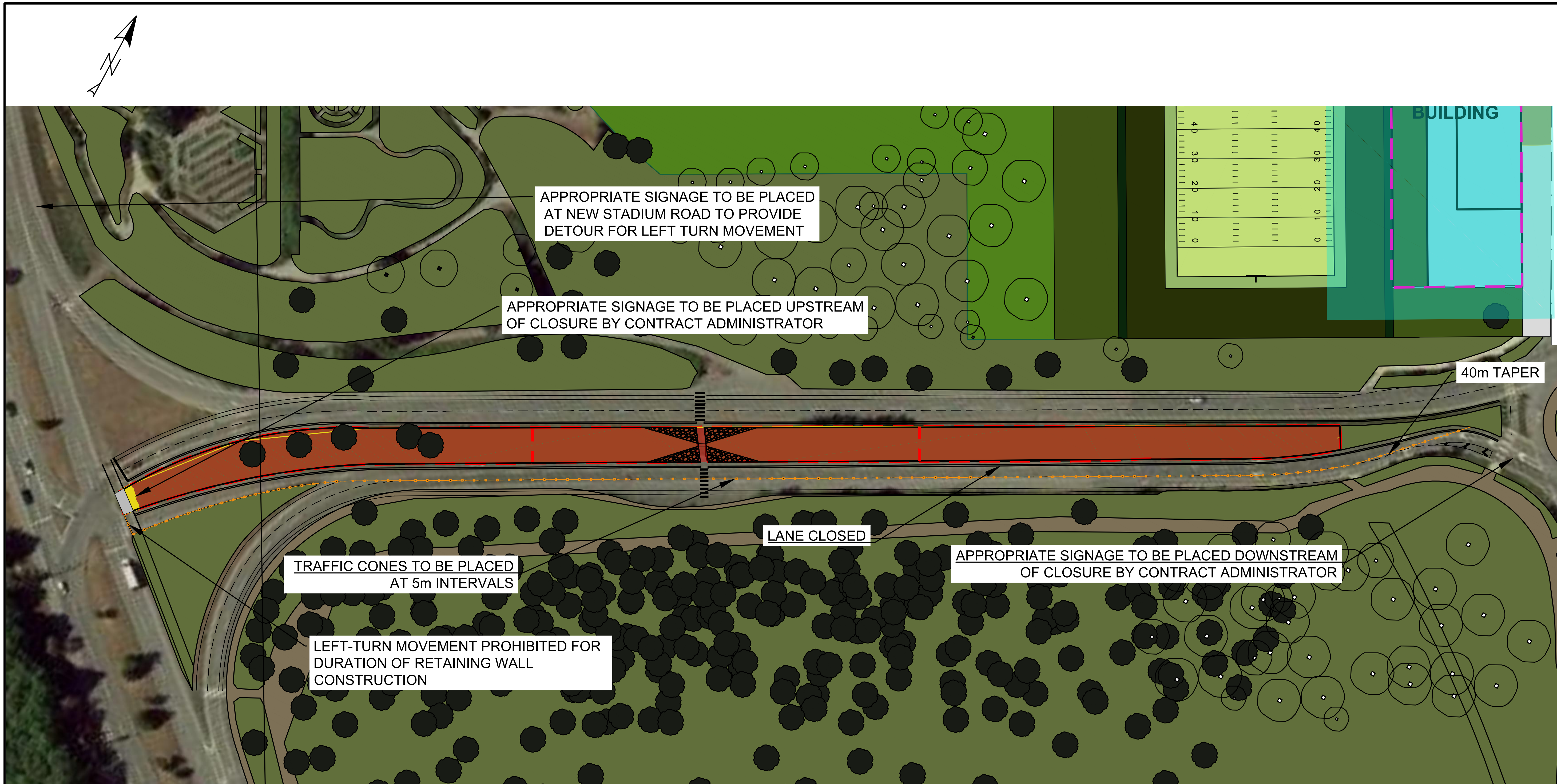

NOTES:

1. A TRAFFIC CONTROL PERSON WILL BE PRESENT ON SITE DURING WORK AT ALL TIMES
2. TAPERS AND SIGNAGE WILL BE FIT ON SITE BY TRAFFIC CONTROL PERSON

0m 62.5m

1:1250

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE
TRAFFIC MANAGEMENT PLAN
EASTBOUND 16TH AVENUE

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	EB
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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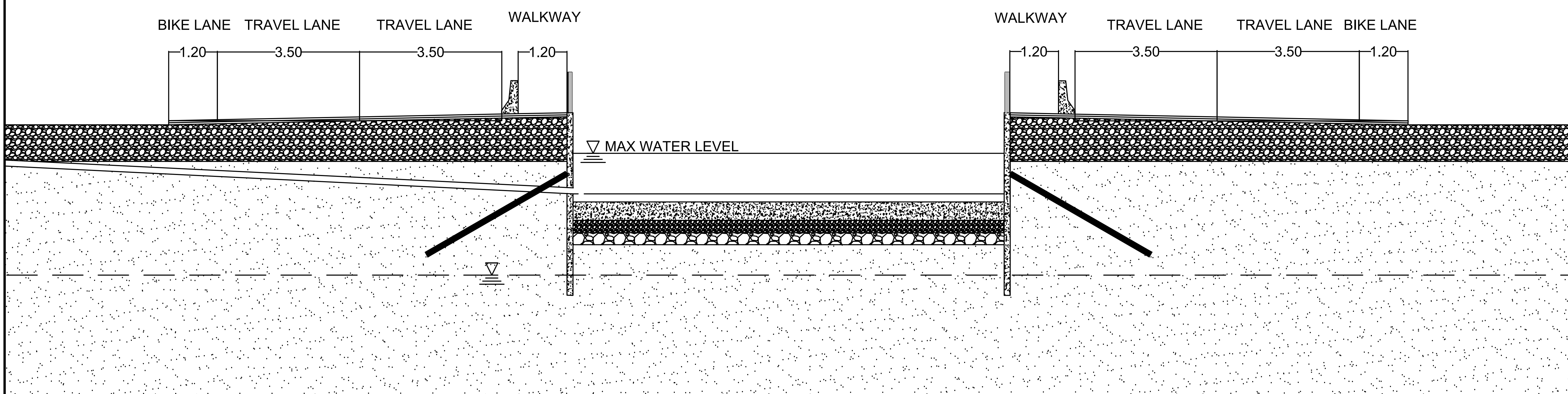

NOTES:

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED

0m 5m
1:100

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
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STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
ROAD CROSS SECTION

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	TJ
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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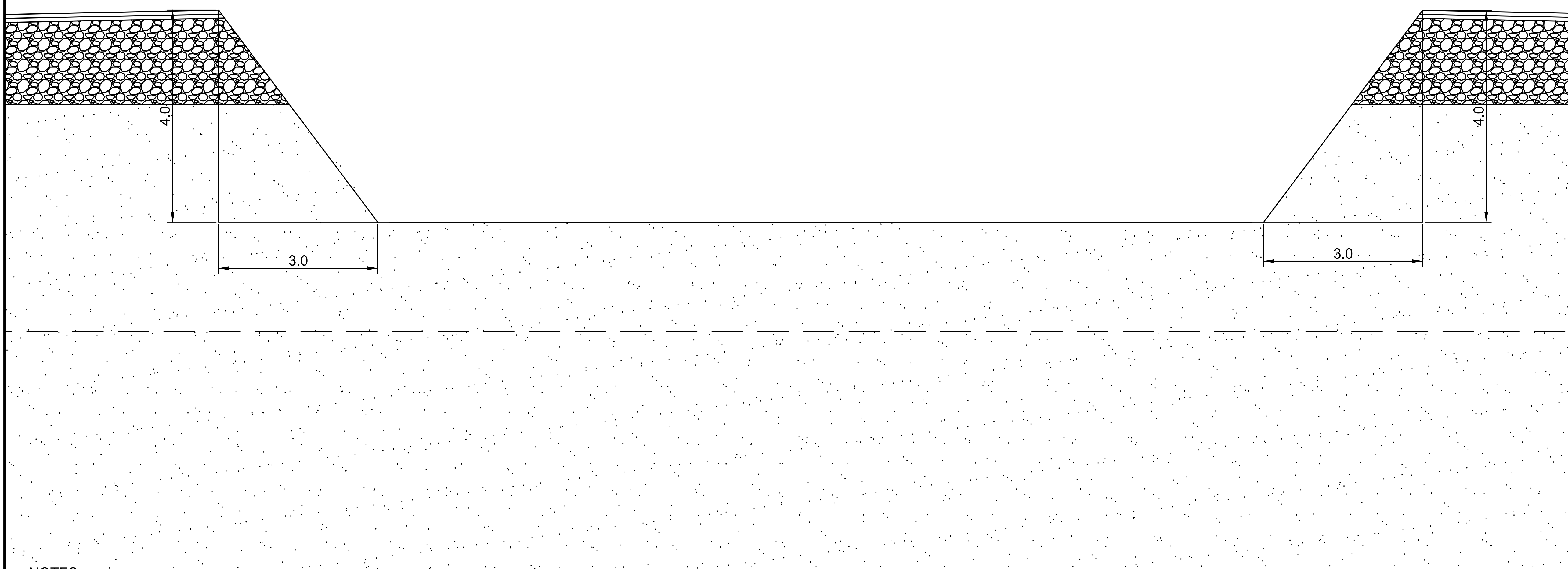

NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
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CLIENT:
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STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE EXCAVATION DETAIL

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	TJ
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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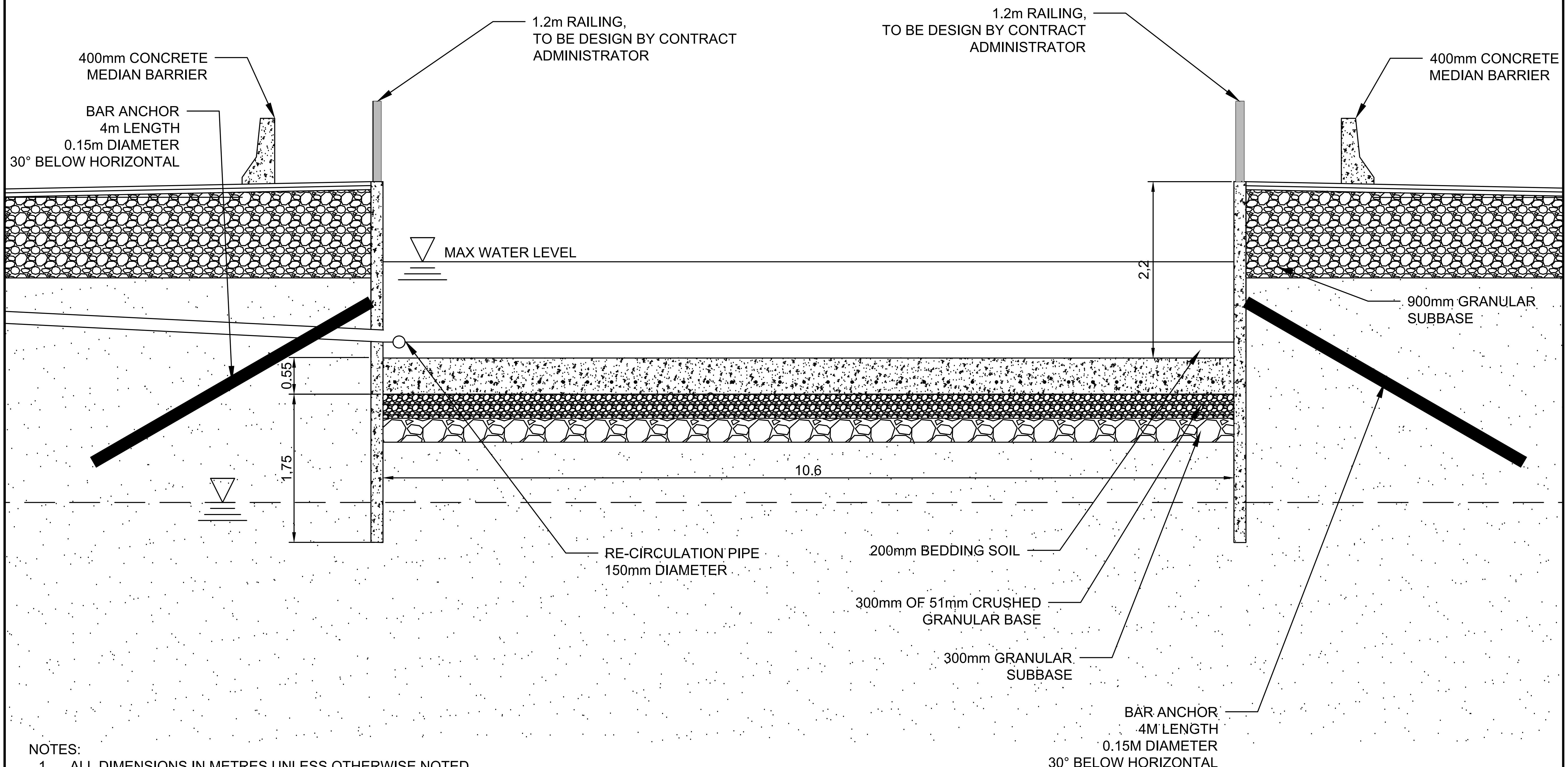

NOTES:

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. MAX WATER LEVEL 1m
3. REBAR SPECIFICATION PROVIDED SEPARATELY

0m 2.5m
1:50

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
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CLIENT:
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STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
SWALE CROSS SECTION

REV	PURPOSE	DATE	DR.	CH.
1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	TJ

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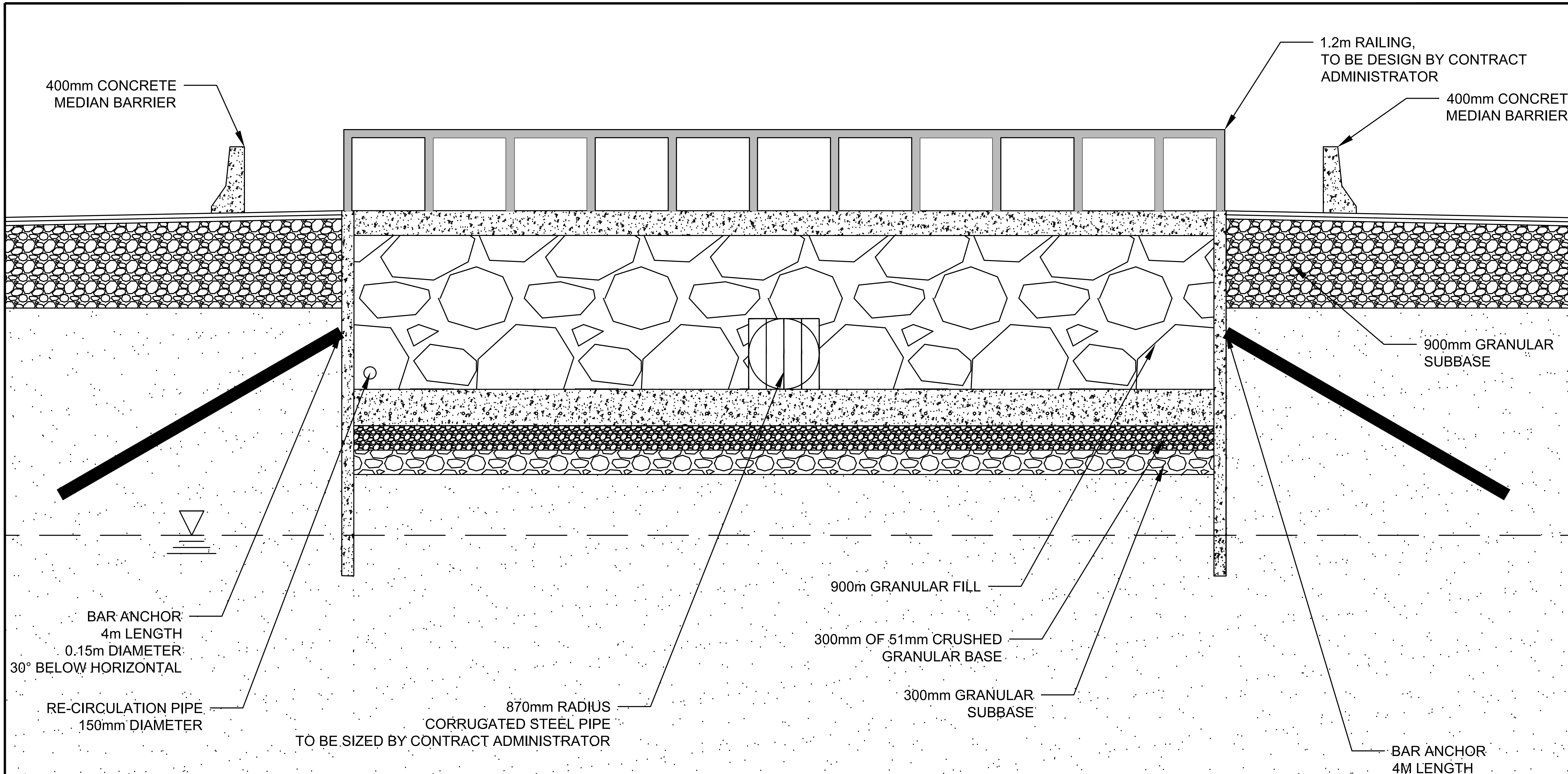

NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED

0m 2.5m
1:50

STADIUM NEIGHBORHOOD UNDERGROUND
PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
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COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
PEDESTRIAN WALKWAY
CROSS SECTION

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	TJ
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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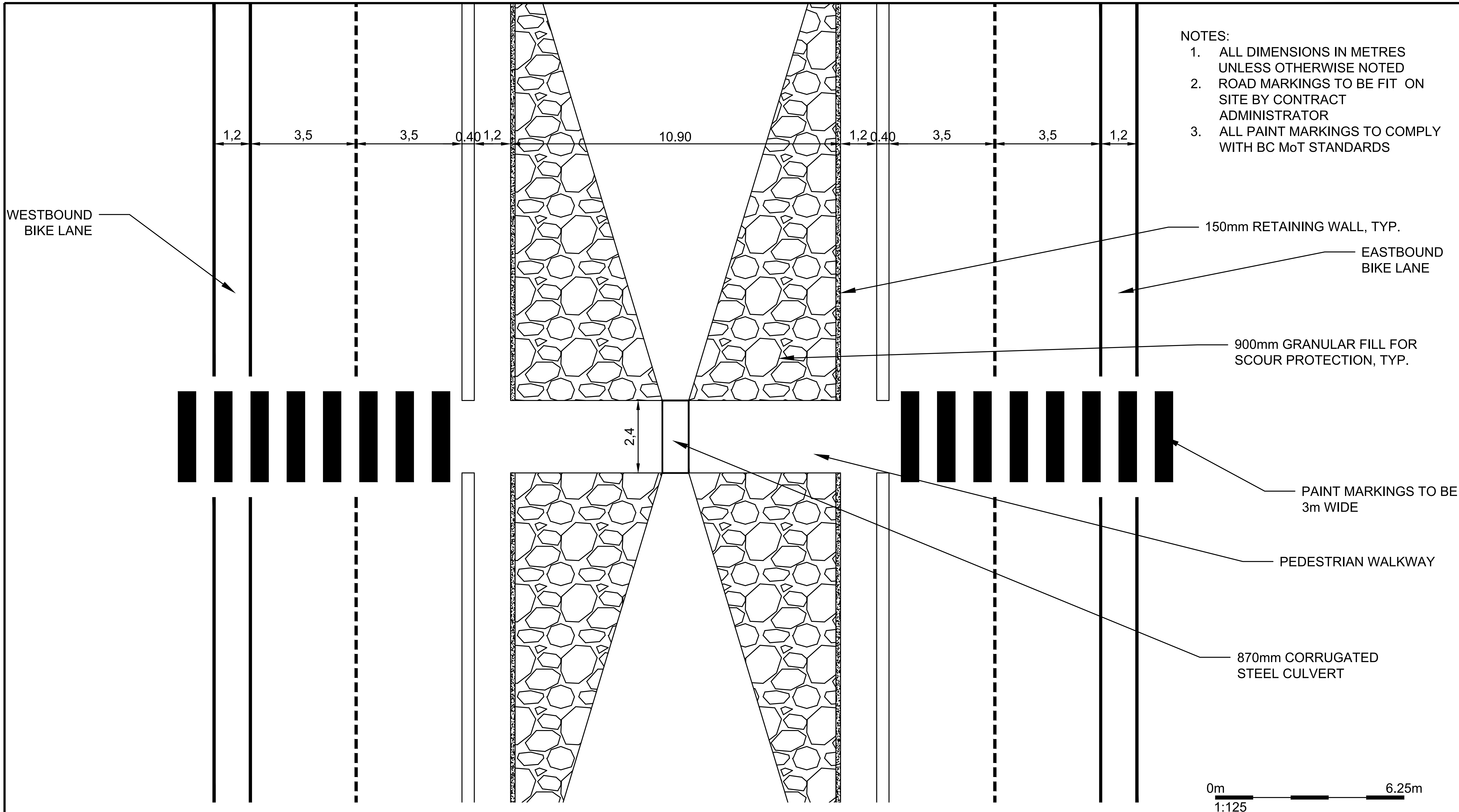

NOTES:

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. ROAD MARKINGS TO BE FIT ON SITE BY CONTRACT ADMINISTRATOR
3. ALL PAINT MARKINGS TO COMPLY WITH BC MoT STANDARDS

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
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STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
PEDESTRIAN WALKWAY

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	TJ
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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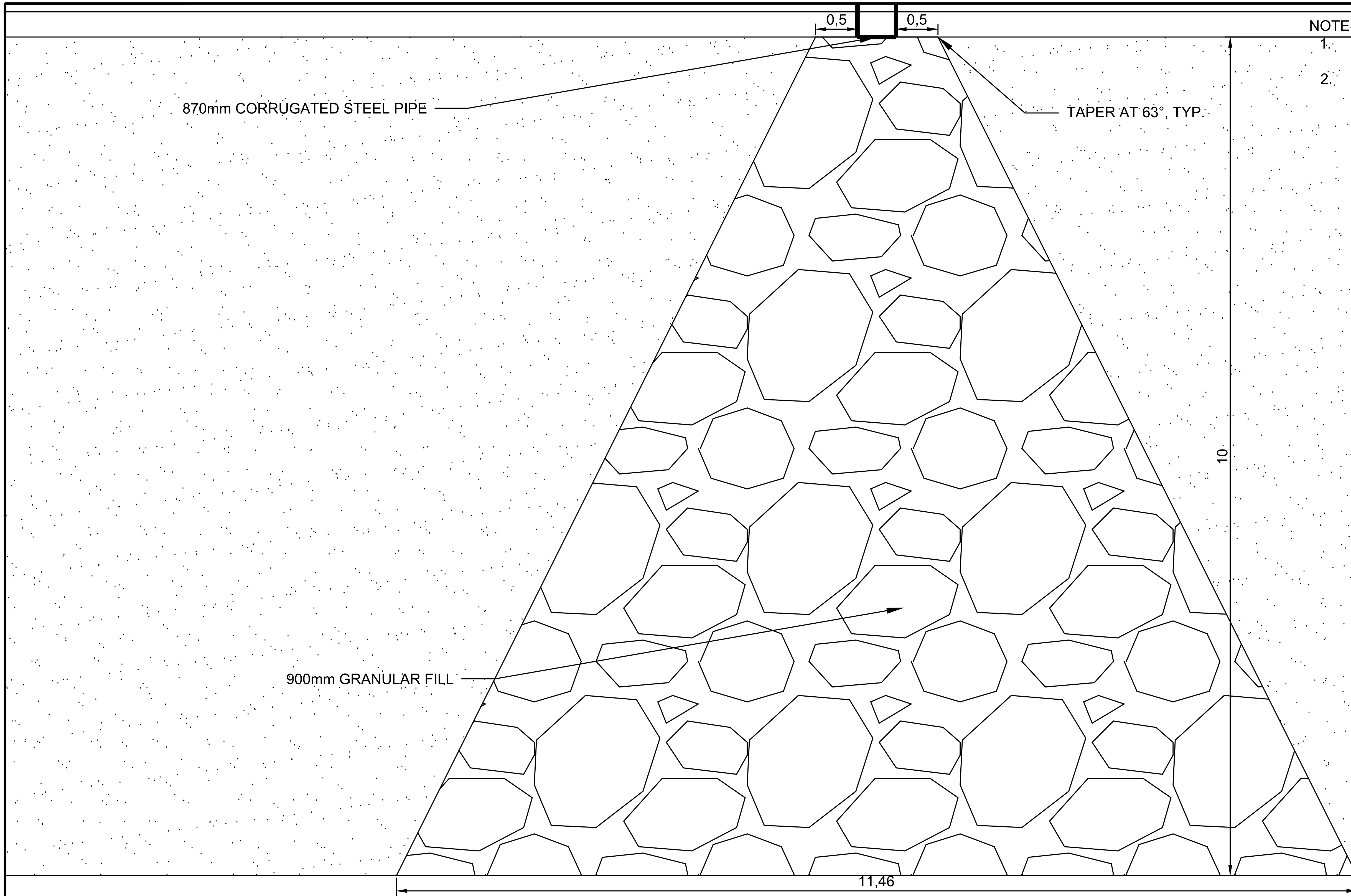
UBC SEEDS Program



NOTES:

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. VERTICAL PROFILE TO BE FIT ON SITE BY CONTRACT ADMINISTRATOR

0m 2.5m
1:50

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
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CLIENT:
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STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE
SWALE OUTFLOW DETAIL

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ER
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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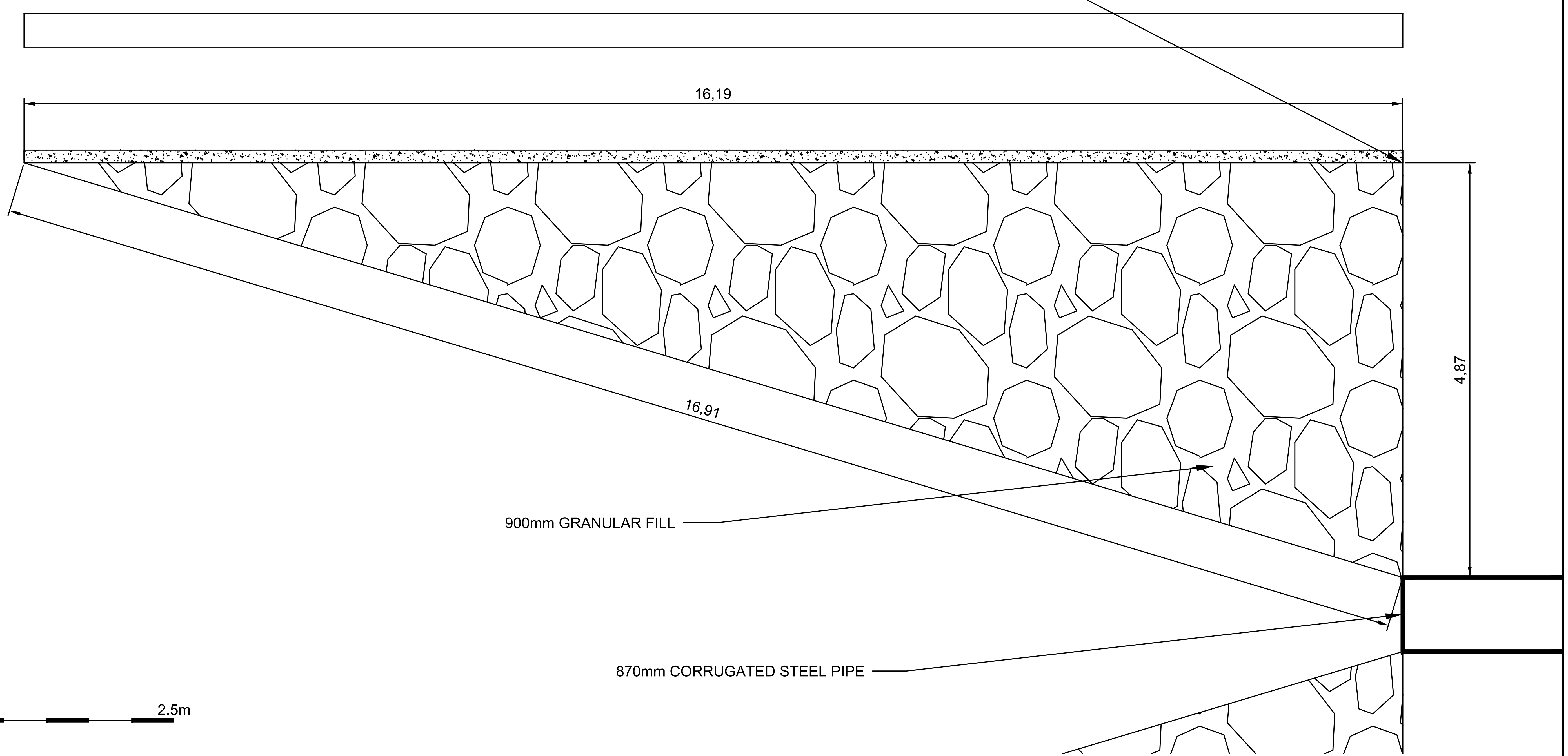
[redacted]

NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. VERTICAL PROFILE TO BE FIT ON SITE BY CONTRACT ADMINISTRATOR



0m 2.5m
1:50

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
SCOUR PROTECTION DETAIL

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ER
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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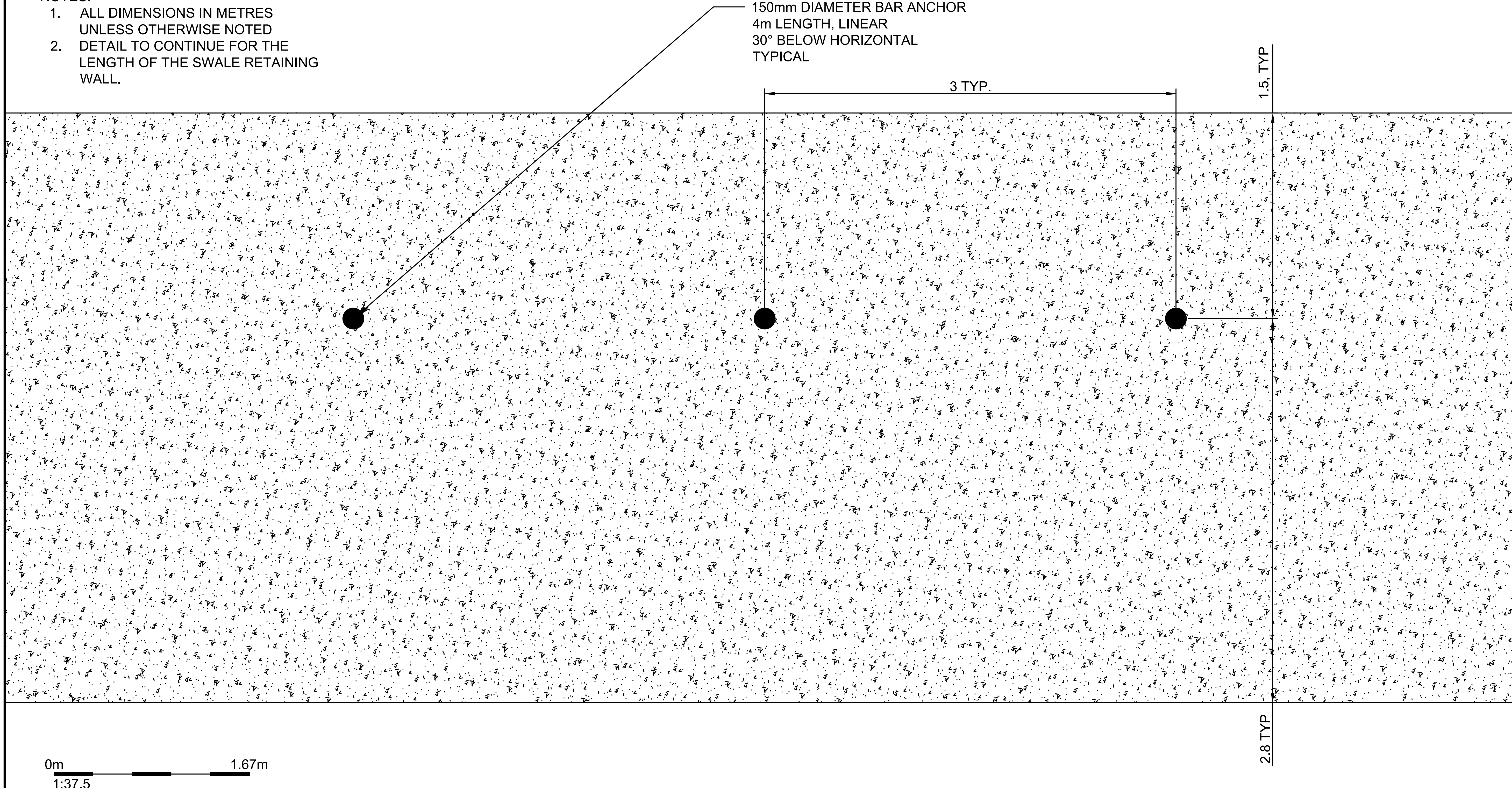
NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. DETAIL TO CONTINUE FOR THE LENGTH OF THE SWALE RETAINING WALL.



STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE
BAR ANCHOR DETAIL

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ER
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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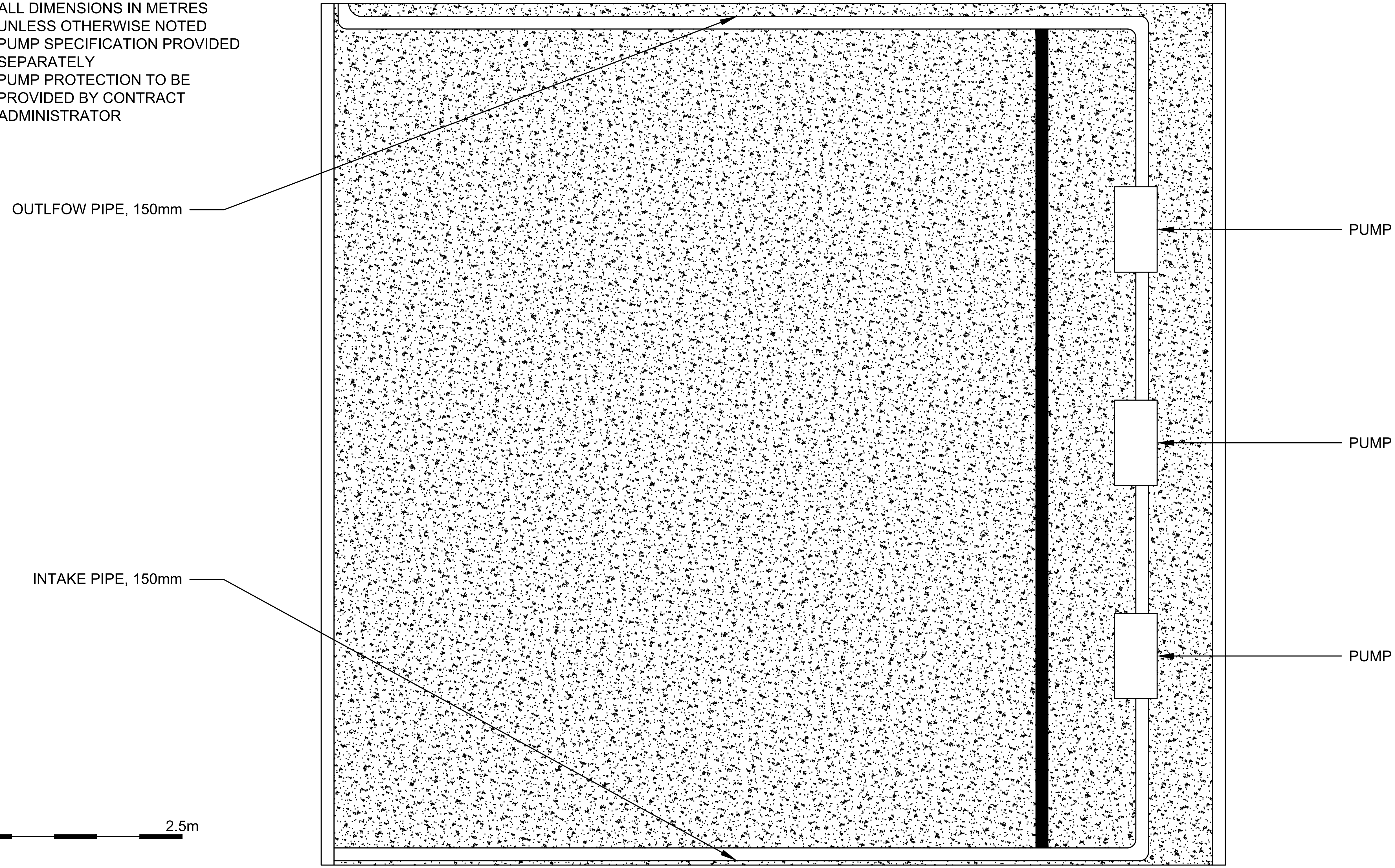
NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. PUMP SPECIFICATION PROVIDED SEPARATELY
3. PUMP PROTECTION TO BE PROVIDED BY CONTRACT ADMINISTRATOR



0m 2.5m
1:50

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
PUMP HOUSE DETAIL

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ER
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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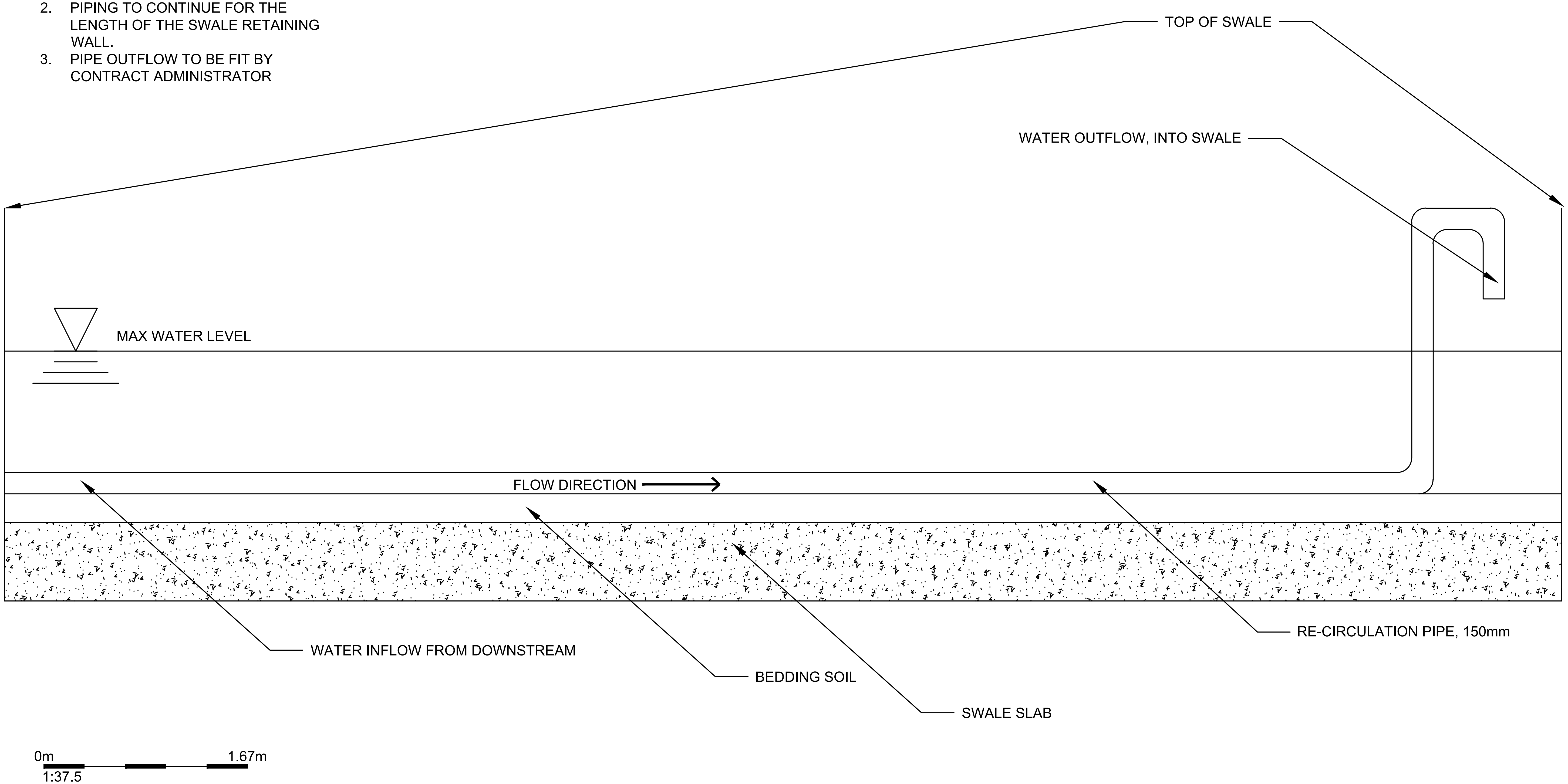
UBC SEEDS Program

NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. PIPING TO CONTINUE FOR THE LENGTH OF THE SWALE RETAINING WALL.
3. PIPE OUTFLOW TO BE FIT BY CONTRACT ADMINISTRATOR



STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE
RE-CIRCULATION PIPE DETAIL

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ER
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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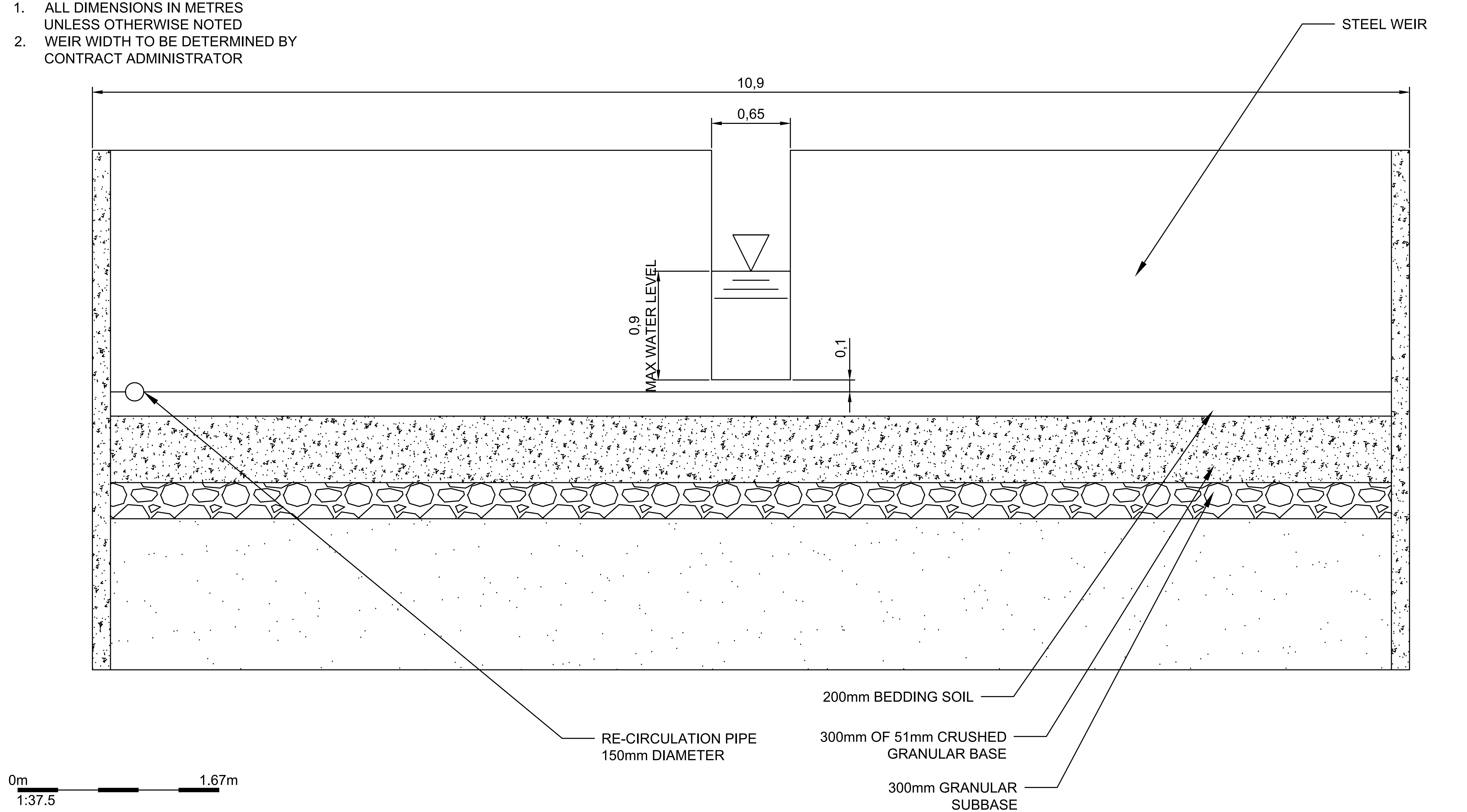
NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. WEIR WIDTH TO BE DETERMINED BY CONTRACT ADMINISTRATOR



STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
STEEL WEIR DETAIL

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ER
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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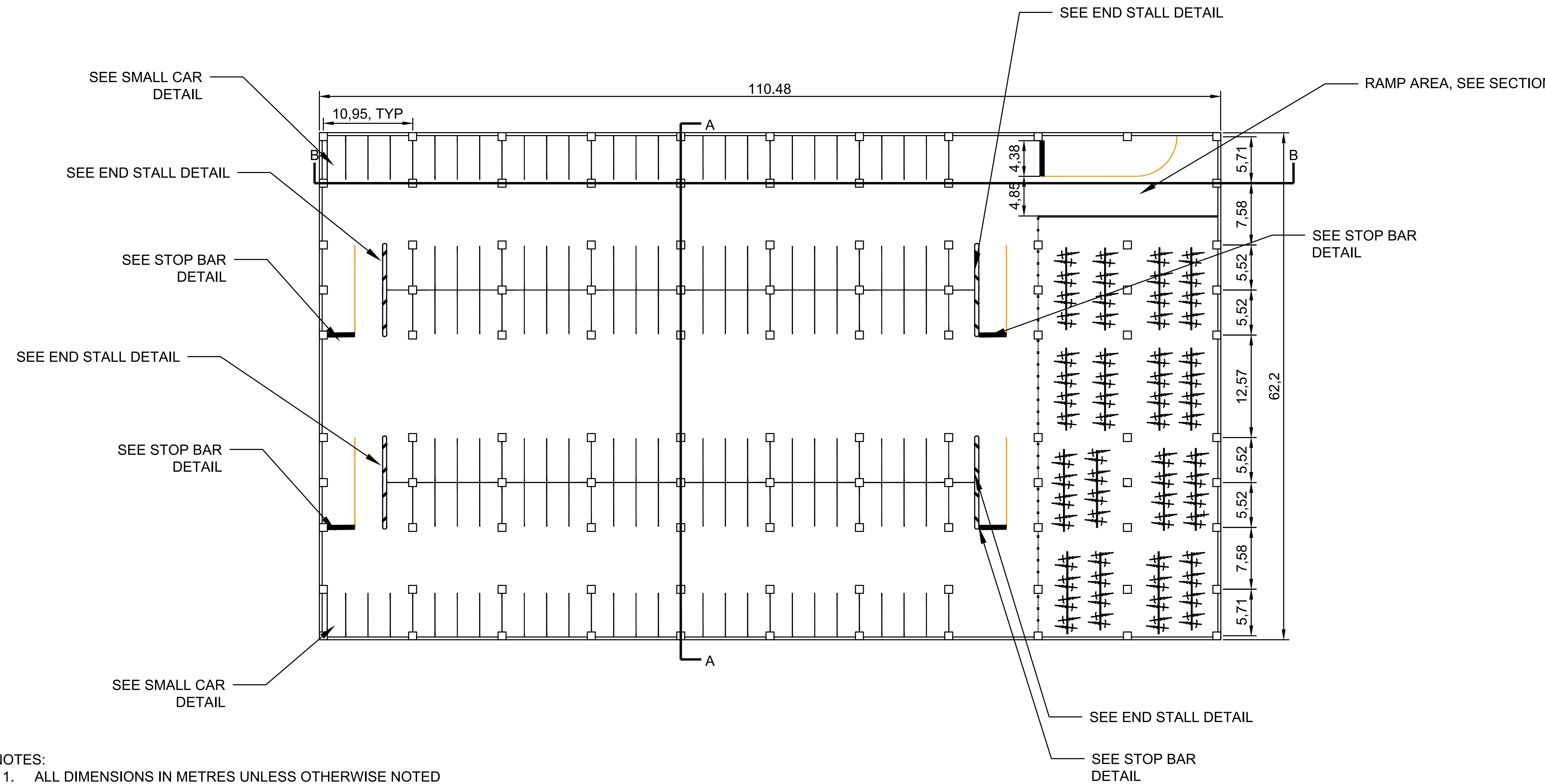

NOTES:

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. COLUMN, BEAM, AND CONNECTION DETAILS PROVIDED ON SEPARATE SHEET

0m 25m

1:500

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE
PARKADE PLAN

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ML
REV	PURPOSE	DATE	DR.	CH.

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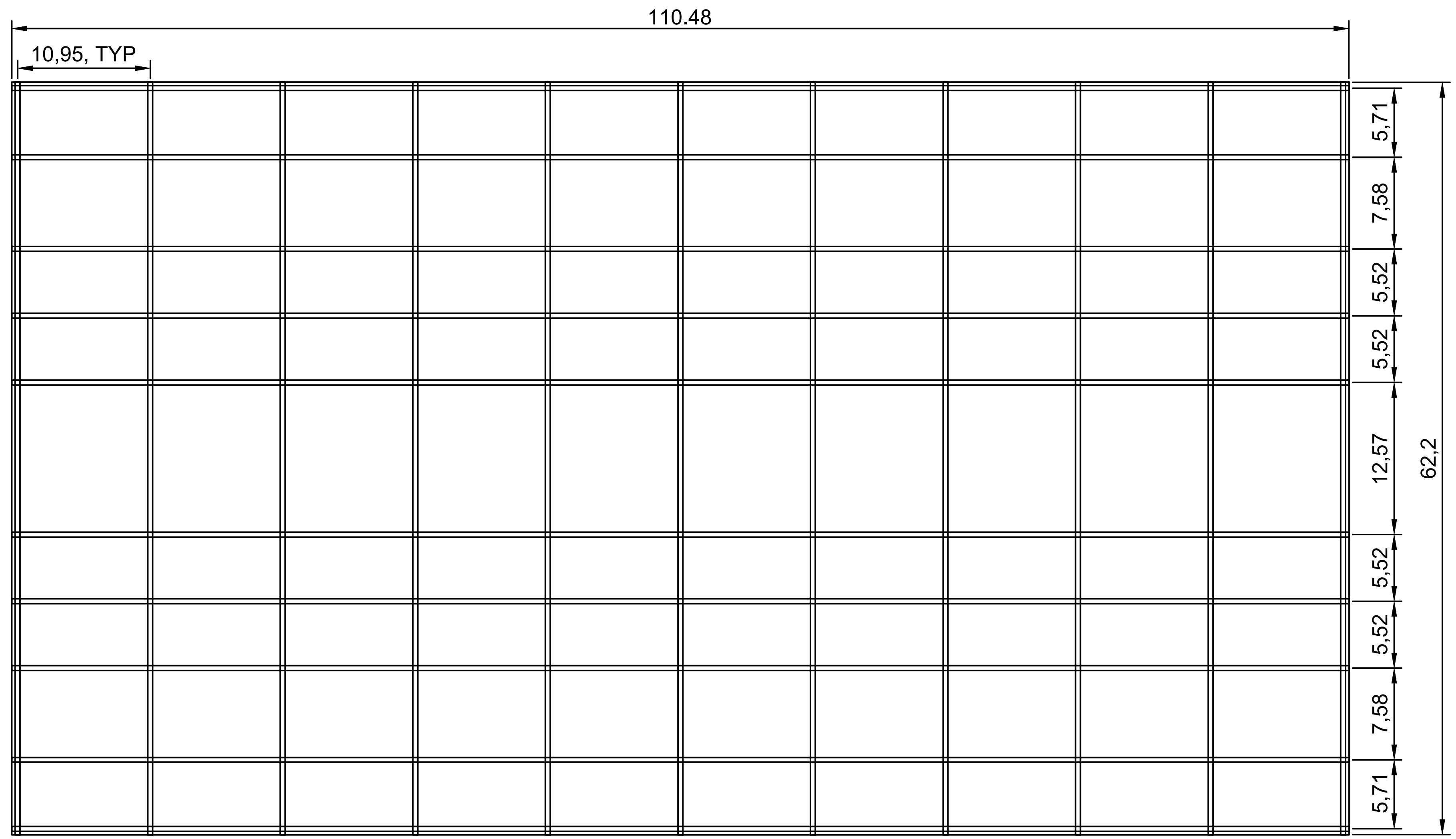

NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. COLUMN, BEAM, AND CONNECTION DETAILS PROVIDED ON SEPARATE SHEET

0m 25m
1:500

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
BEAM LAYOUT

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	TJ
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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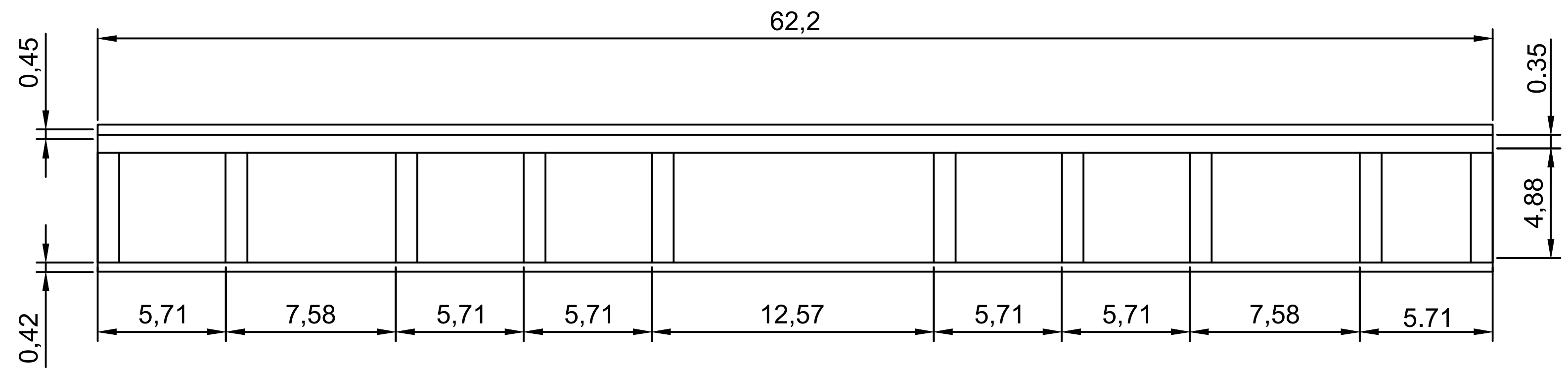
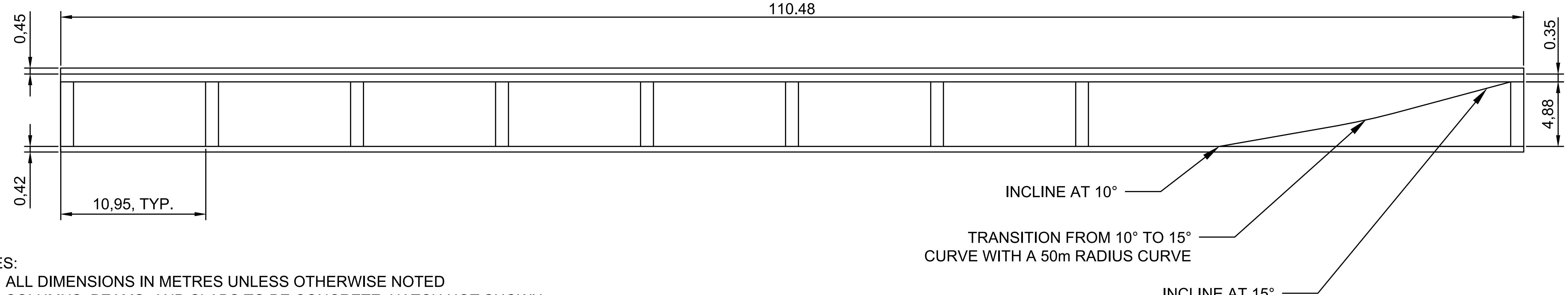
UBC SEEDS Program

SECTION A-A



SECTION B-B



NOTES:

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. COLUMNS, BEAMS, AND SLABS TO BE CONCRETE. HATCH NOT SHOWN
3. SPRINKLER SYSTEM AND LIGHTING TO BE DESIGN BY CONTRACT ADMINISTRATOR

0m 16.5m
1:333

STADIUM NEIGHBORHOOD UNDERGROUND
PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND
COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
SECTION DETAILS

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ML
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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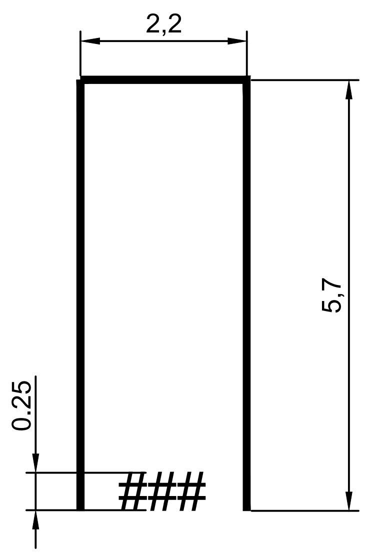
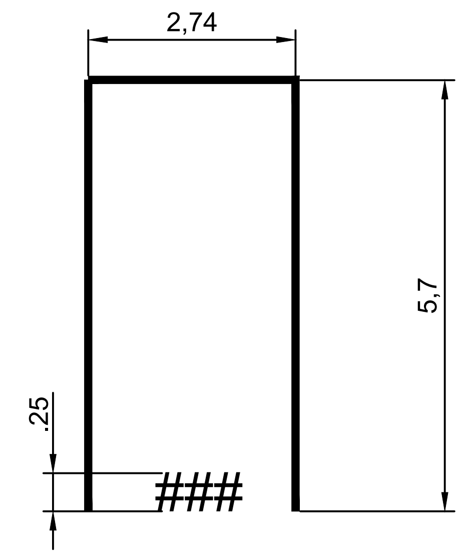
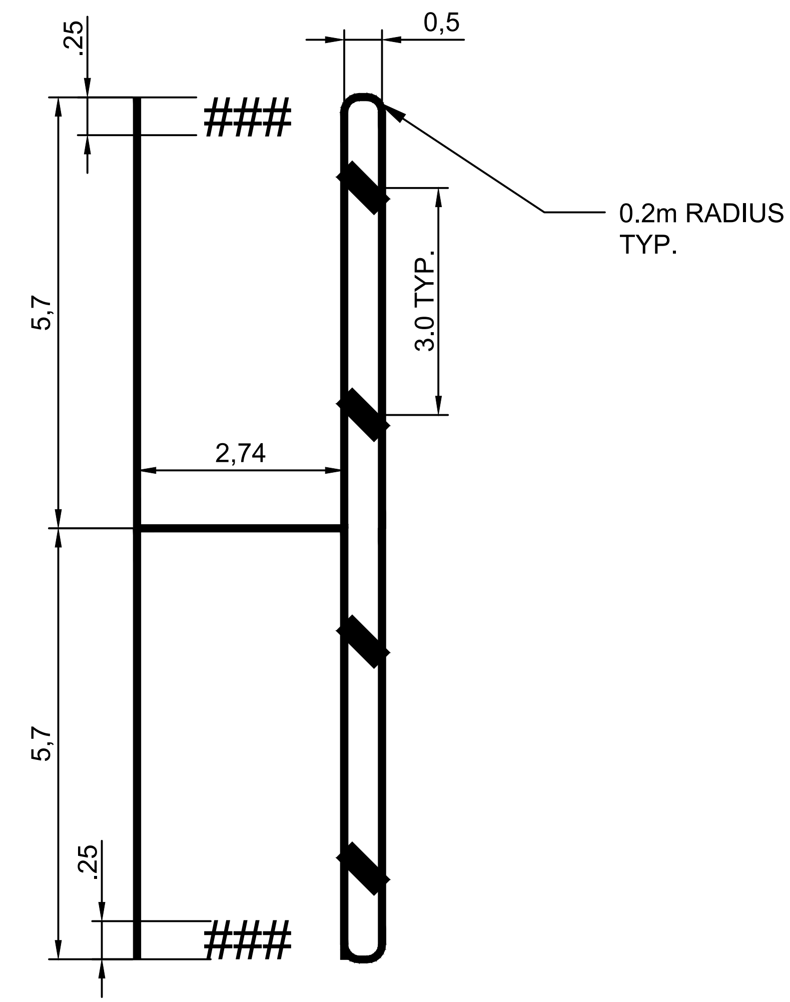
SMALL CAR STALL DETAIL



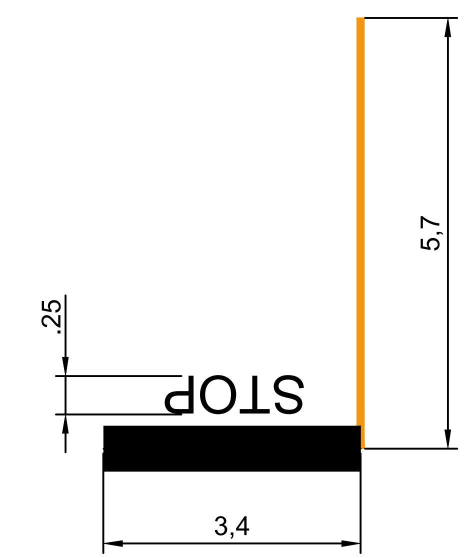
CAR STALL DETAIL



END STALL DETAIL



STOP BAR DETAIL



NOTES:

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. STALL NUMBERING TO BE CENTERED IN THE STALL, IN LINE WITH THE END OF THE PAVEMENT MARKINGS
3. STALL NUMBERING TO BE DETERMINED ON SITE BY CONTRACT ADMINISTRATOR

0m 5m
1:100

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
PARKADE DETAILS

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ML
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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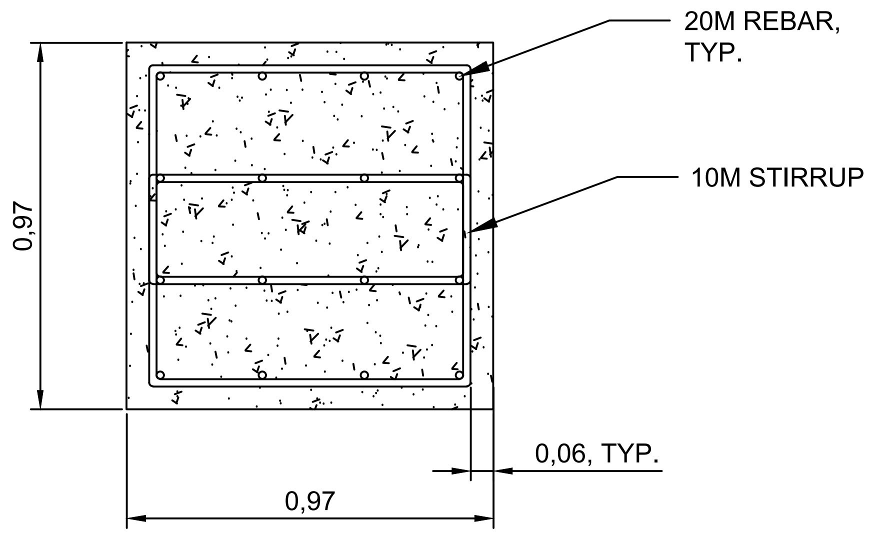
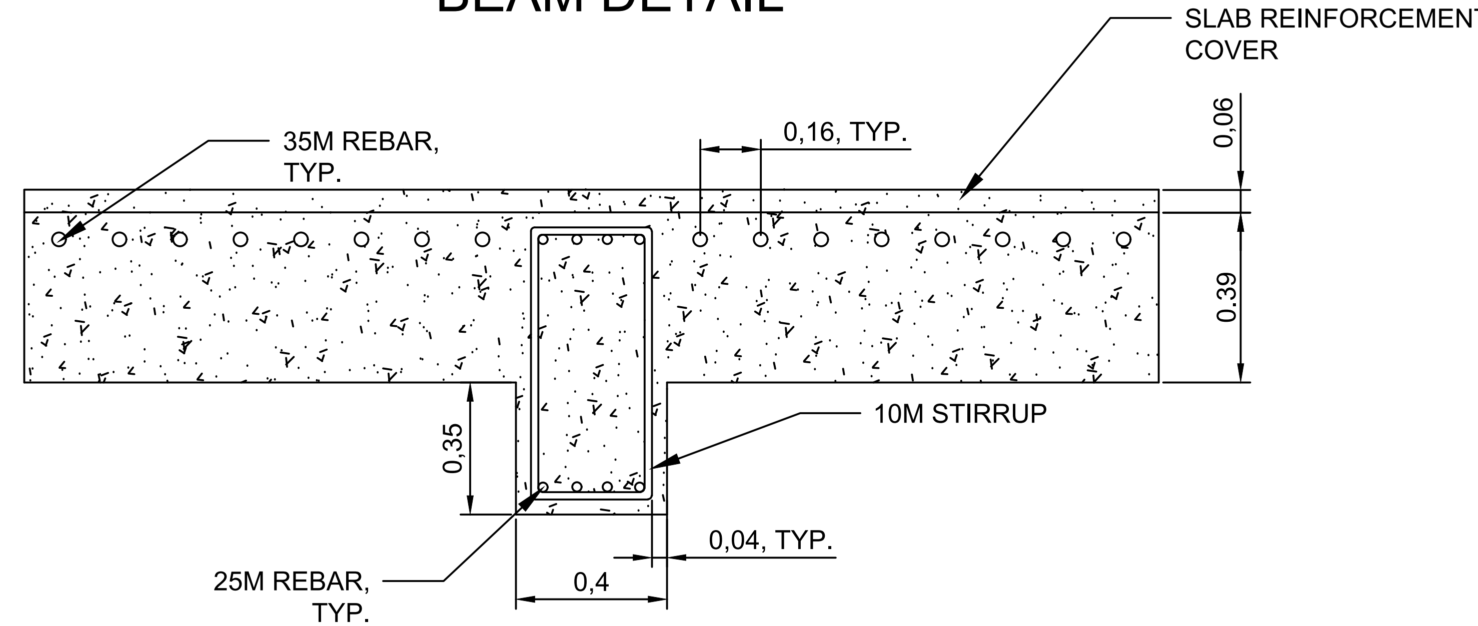
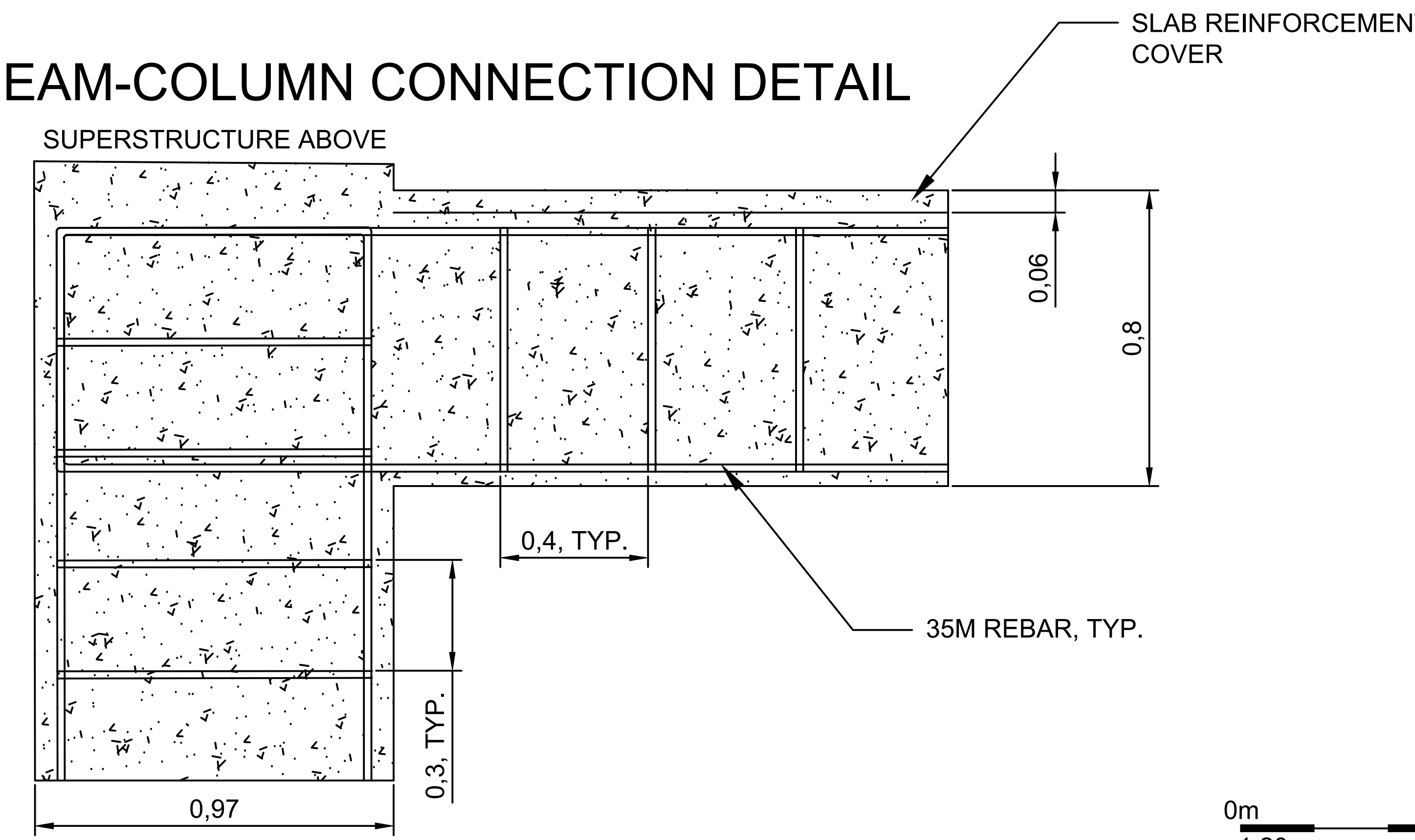
COLUMN DETAIL



BEAM DETAIL



BEAM-COLUMN CONNECTION DETAIL



NOTES:

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. RADIUS OF ALL REBAR ANGLE BENDS IS TO BE NO LESS THAN R=105mm

0m 1m

1:20

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
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STADIUM NEIGHBOURHOOD UNDERGROUND PARKADE AND WATER STORAGE STRUCTURAL DETAILS

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ML
REV	PURPOSE	DATE	DR.	CH.

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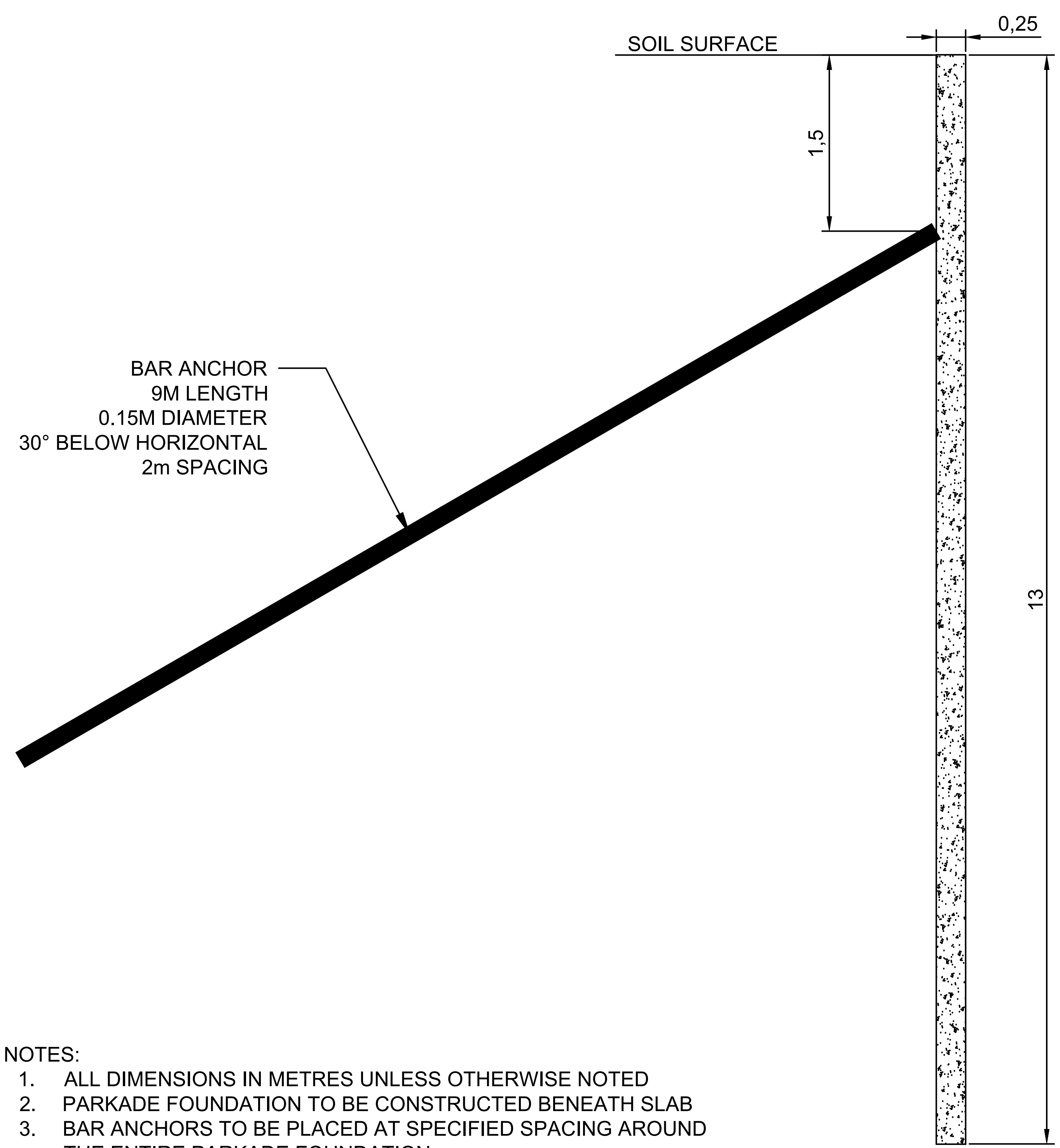

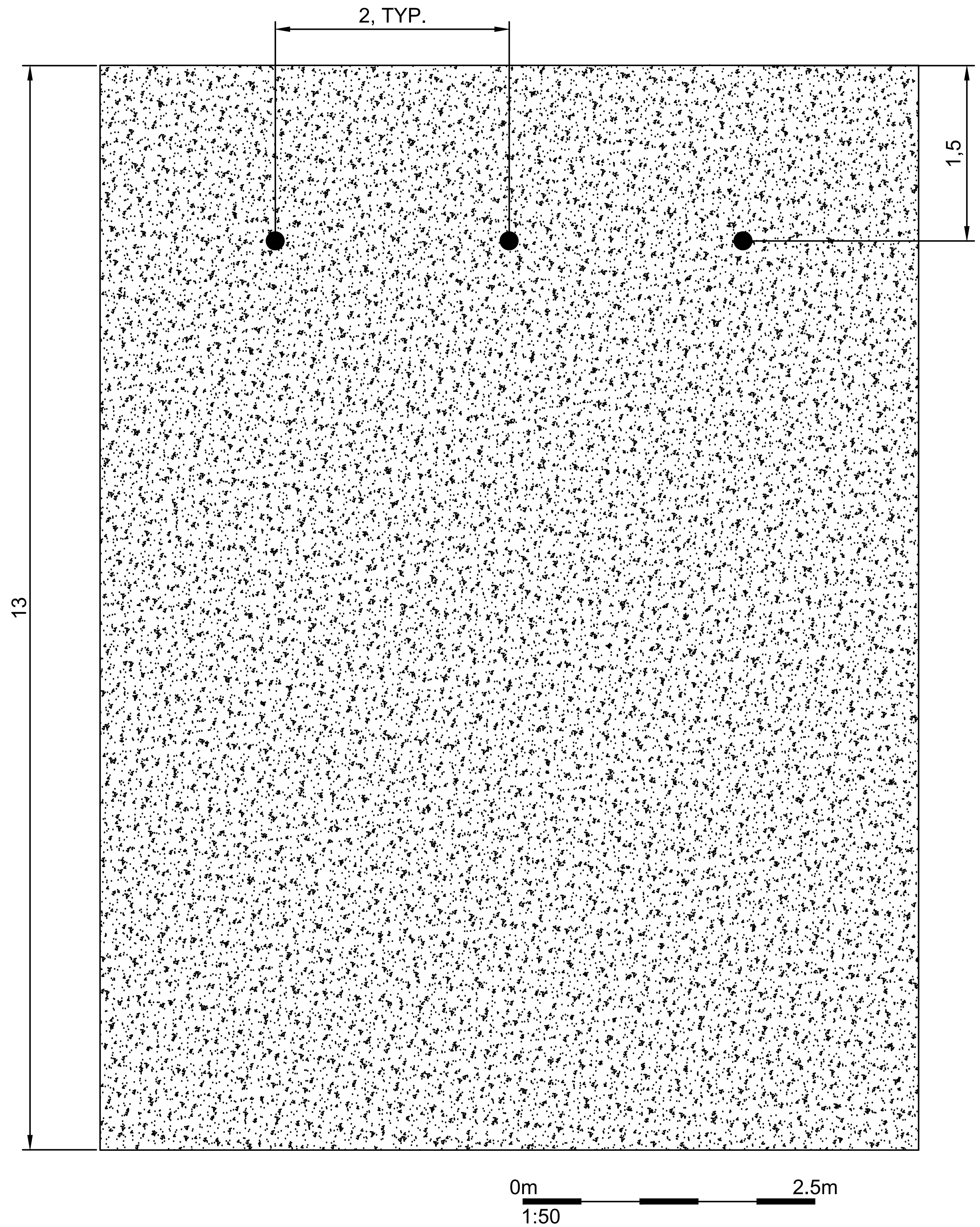

NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. PARKADE FOUNDATION TO BE CONSTRUCTED BENEATH SLAB
3. BAR ANCHORS TO BE PLACED AT SPECIFIED SPACING AROUND THE ENTIRE PARKADE FOUNDATION

STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
PARKADE FOUNDATION

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ML
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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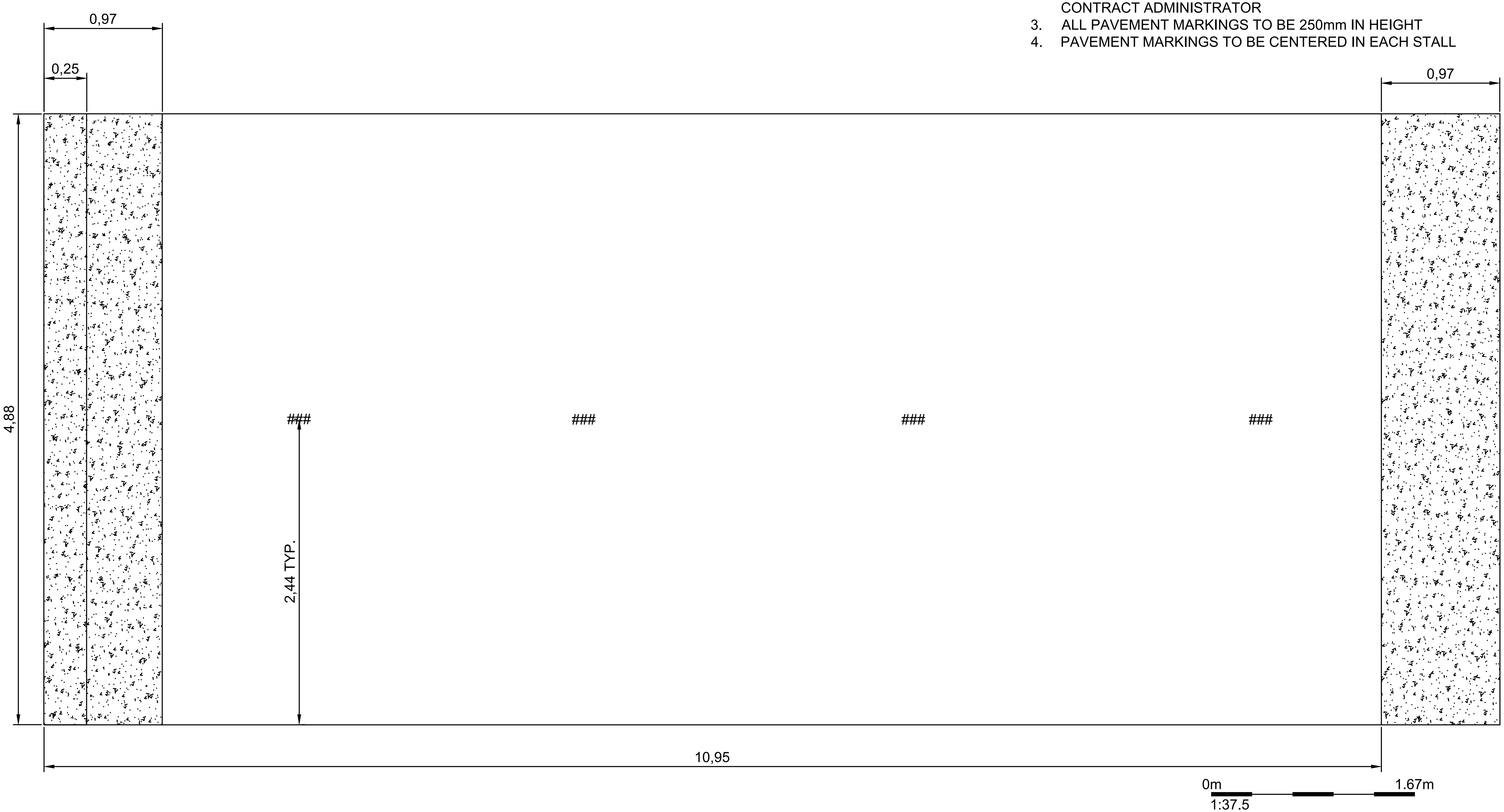
NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED
2. ALL PAVEMENT NUMBERS TO BE DETERMINED ON SITE BY CONTRACT ADMINISTRATOR
3. ALL PAVEMENT MARKINGS TO BE 250mm IN HEIGHT
4. PAVEMENT MARKINGS TO BE CENTERED IN EACH STALL



STADIUM NEIGHBORHOOD UNDERGROUND PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA, CAMPUS AND COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
PARKADE WALL MARKINGS

1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ML
REV	**PURPOSE**	**DATE**	**DR.**	**CH.**

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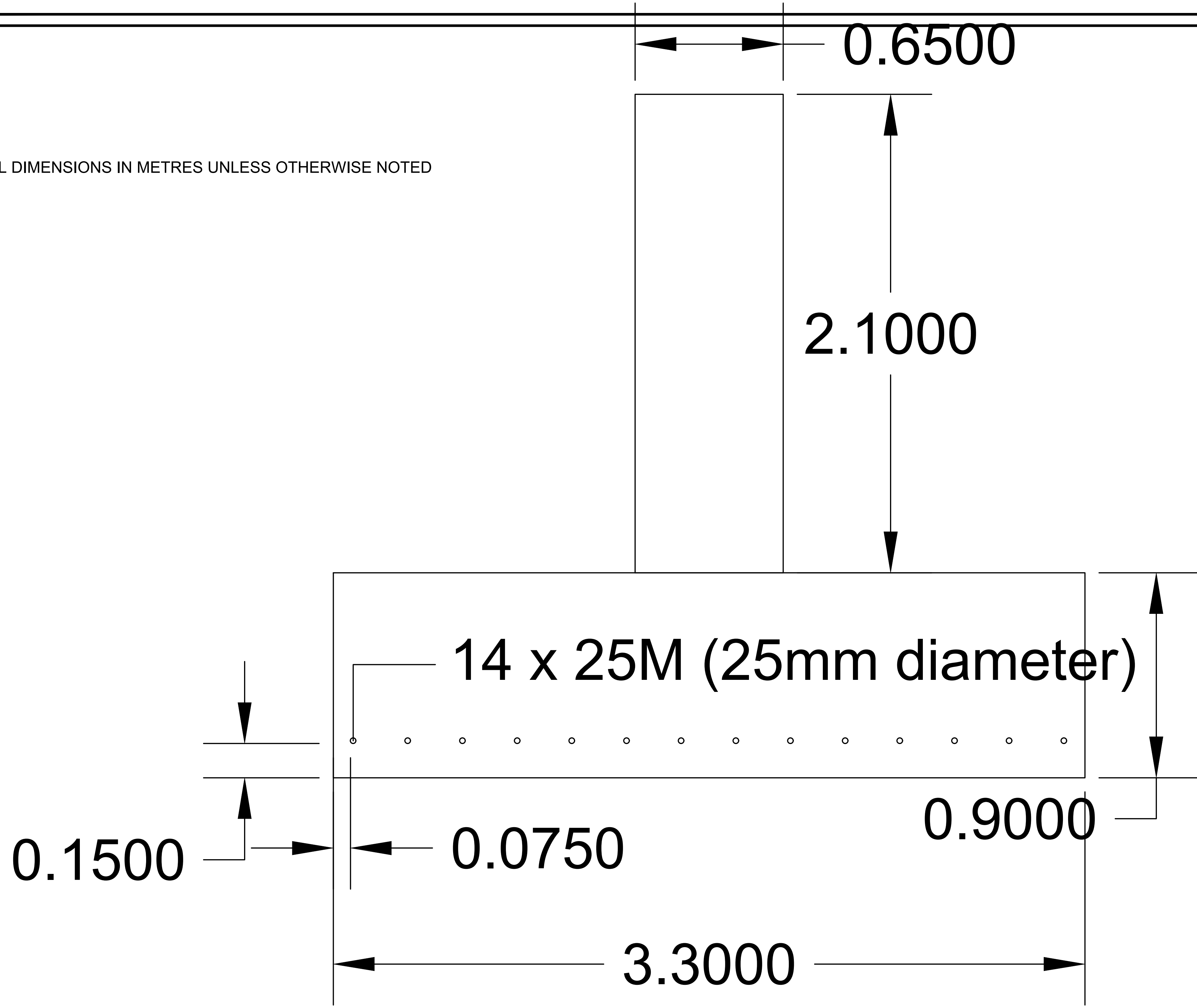
NOTES:
1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED



0m 1m
1:20

STADIUM NEIGHBORHOOD UNDERGROUND
PARKADE AND WATER STORAGE

CONSULTANT:
KATMEET KONSULTING

CLIENT:
UNIVERSITY OF BRITISH COLUMBA, CAMPUS AND
COMMUNITY PLANNING

STADIUM NEIGHBOURHOOD UNDERGROUND
PARKADE AND WATER STORAGE
PARKADE FOOTING

REV	PURPOSE	DATE	DR.	CH.
1	ISSUED FOR CONSTRUCTION	4/8/2019	AE	ML

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