UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

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Antonio Mendoza, Kyle Mitchell, Ali Wagih, Robert Gumuchian, Haley Oosterman,

Anthony van Engelen

University of British Columbia

CIVL ппрк446

Themes: Water, Climate, Land

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Executive Summary

Recent studies by the UBC SEEDS Sustainability Program show that a 1 in 100-year storm event would cause overland flooding in the southern parts of UBC campus, with flows capable of severely damaging the delicate sandy cliffs above Wreck Beach. This report covers the design of a multipurpose stormwater management facility in south campus which will mitigate damaging storm event runoff while providing a useful and respectable space for students, faculty, and visitors to enjoy. The final design is a miniature golf and stormwater detainment facility, appealing to all ages as a space for fun outdoor activity while efficiently storing, cleaning, and carefully releasing all storm runoff in UBC's south water catchment area.

To align with UBC SEEDS sustainability goals, a facility has been designed to meet or exceed expectations in areas of multifunctionality, low-impact development, and cost. The facility includes three at-grade pools which serve as scenery during the summer and large collectors of potential flood water during seasons of high precipitation. Vegetation such as moss and reeds will aid in filtering all water that enters the system in this way. Supplementing the storage capacity of the pools is a large underground tank structure, with an oil and grits chamber to further clean the water and outlets designed to control the rate of flow back into the existing stormwater system.

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1.0 Introduction

1.1 Project Description

Due to a severe flood risk at the intersection of SW Marine Drive and Wesbrook Mall, it is necessary to develop a stormwater detention system capable of mitigating the potential damage of a large storm. This system must not only be capable of withstanding the inflow generated by a 1 in 100-year storm event, but also controlling the subsequent outflow while separating debris.

The existing stormwater network is not only too small to handle the 100-year event, it also does not make any effort to control outflow volumes onto the cliffs to the south of the site. This uncontrolled outflow causes severe erosion to the natural landscape of the surrounding beaches and to property outside the ownership of the client. The new system must limit outflow volumes to 1.2 cubic meters per second to prevent further cliff erosion due to storms.

In addition to its physical requirements, the project must incorporate progressive practices of sustainable development in accordance with the University of British Columbia's (UBC) Sustainability Guidelines. This includes active stakeholder engagement, multipurpose functionality, and incorporating low-impact development into design.

1.2 Site Description

Located northwest of the intersection of SW Marine Drive and Wesbrook Mall, the project site is densely forested as seen in Figure 1. A pullout-lane connected to the northwest-bound direction of SW Marine Drive provides access to a walking trail directly adjacent to the site. This location is a natural confluence point for stormwater flow from Wesbrook and SW Marine Drive.

Figure 1: Street view of project site.

The project site area is approximately 6000 square meters (96 m by 62.8 m), with an additional 600 square meters (42.5 m by 14 m) of parking space to be developed.

2.0 Design Criteria

2.1 Design Life

The storage facility is designed to manage stormwater from a 1 in 100-year storm event, which includes ensuring adequate storage to prevent flooding at the project intersection, minimizing runoff discharge to prevent erosion over the south facing cliffs, and improving stormwater runoff quality. The UBC Technical Guidelines only specify the storm service system to be designed to convey the peak 1 in 10-year storm flows (The University of British Columbia, 2018). However, given the persistent flooding at the Wesbrook Mall and SW Marine Drive intersection and increasing storm flows due to climate change, the UBC Integrated Stormwater Management Plan (ISMP) outlines a 1 in 100-year return period design requirement of approximately 3200 cubic meters.

With a capacity this large, careful consideration must be given to account for maintenance or damage caused by a natural disaster such as an earthquake. As such, the facility must be designed with these parameters in mind. The structure of the system must be analyzed under both full and empty conditions for any assumed loads, as water volumes may aid or detract from the integrity of the structure for any given situation.

The cleanliness of the system during service-life impacts the intended design functions such as outflow and water quality maintenance. The grit and oil chamber have been designed for easy cleaning access to avoid clogging. The construction materials were selected to require little maintenance, such as pre-fabricated metal piping which do not require welds.

With all this considered, the design life of the system can be maintained for approximately 100 years.

2.2 Software Packages

The software packages used for engineering design and analysis are summarized in Table 1.

Table 1: Summary of software packages used in this project.

Software Package	Purpose and Use in This Project
Autodesk AutoCAD	Technical 2D drafting
US EPA SWMM	Stormwater flow modelling
GeoStudio SLOPE/W	Slope stability analysis
Trimble SketchUp	Conceptual 3D modelling

2.3 Bylaws & Regulations

The technical requirements for the preliminary storage tank design are governed by federal and provincial laws and regulations, in addition to UBC's own technical policies. UBC has developed a set of technical guidelines for the design, construction, or renovation of any University-owned property and buildings. These guidelines are in accordance with the following federal and provincial legislation:

- 2014 Vancouver Building Bylaw (VBBL)
- CSA A23.3-14: Design of Concrete Structures
- Wood Design Manual, 2015
- *Fisheries Act, 2018* (Federal)
- *Canadian Environmental Protection Act, 1999* (Federal)
- *Water Sustainability Act, 2016* (Provincial)
- *Environmental Management Act, 2018* (Provincial)
- City of Vancouver Parking Design By-Laws

The UBC Board of Governors has also developed relevant standards that must apply to the UBC Technical Guidelines. These standards include:

- B.C. Master Municipal Construction Documents
- GVRD Sewer Use Bylaw No. 299

- UBC Environmental Protection Policy #6
- UBC Sustainability Development Policy #5
- The UBC Integrated Storm-Water Management Plan (ISMP), 2017
- Noise Control Bylaw 6555

The technical requirements for the proposed storage facility at UBC Centre for Comparative Medicine (CCM) are predominantly outlined by the UBC Technical Guidelines. These requirements are discussed in further detail in the following sections.

2.4 Hydrotechnical Design Load

The current storm main network of the South Catchment is presented in **Error! Reference source not found.** below:

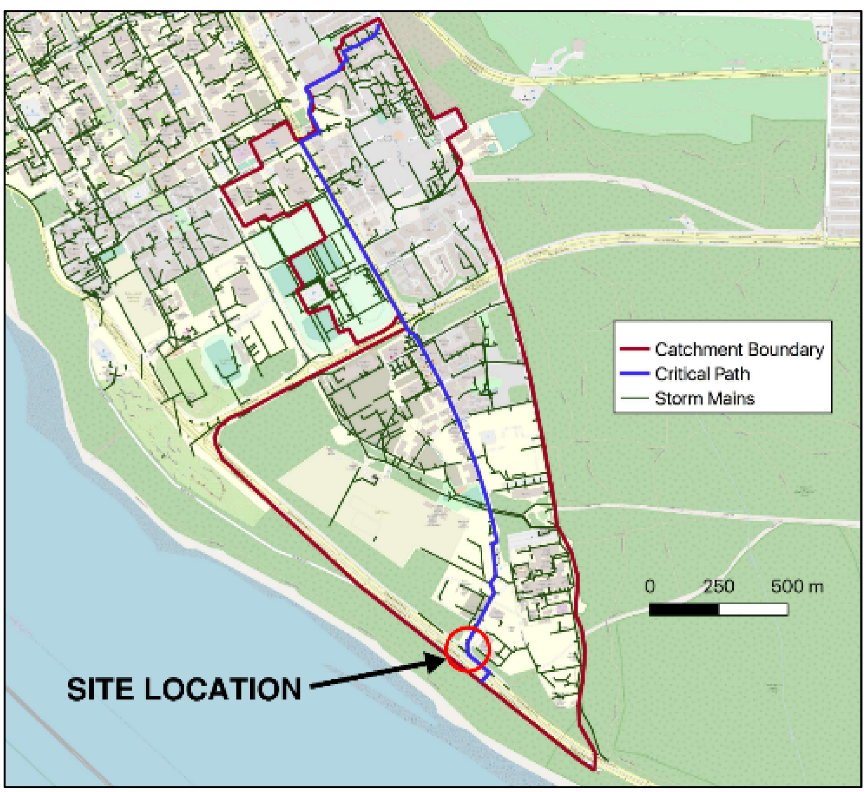


Figure 2: South catchment storm main network.

Smaller branching storm mains in the South Catchment varying from 150 mm to 650 mm in diameter connect into an arterial storm main that runs along Wesbrook Mall. The storm main along Wesbrook Mall is composed of 1050 mm concrete pipe segments which expands to 1200 mm concrete pipe at the location of the project site before joining a 1950 mm concrete storm main along Southwest Marine Drive. The Wesbrook Mall and SW Marine Drive intersection currently experiences significant flooding during large rainfall events, as stormwater flowing through the sewer system at this point has accumulated over the entire catchment. Thus, the required hydraulic capacity for the detention system is modelled based on a critical storm duration equivalent to the time it takes for the most distant part of the south catchment to contribute to the catchment outflow. The critical path that the most distant water parcel will take during a storm event is highlighted in **Error! Reference source not found.**.

Hydrotechnical design parameters from the UBC ISMP and UBC Technical Guidelines (Section 33 49 00) specify for stormwater sewers: minimum velocities of 0.6 m/s, maximum velocities of 3.0 m/s, and maximum discharge rate of 1.2 m^3/s for any storm water detention facility.

Based on these criteria, the storage design load volume was determined by analyzing the 24-hour hydrograph at the project site against the allowable discharge rate, presented in Figure 3 below:

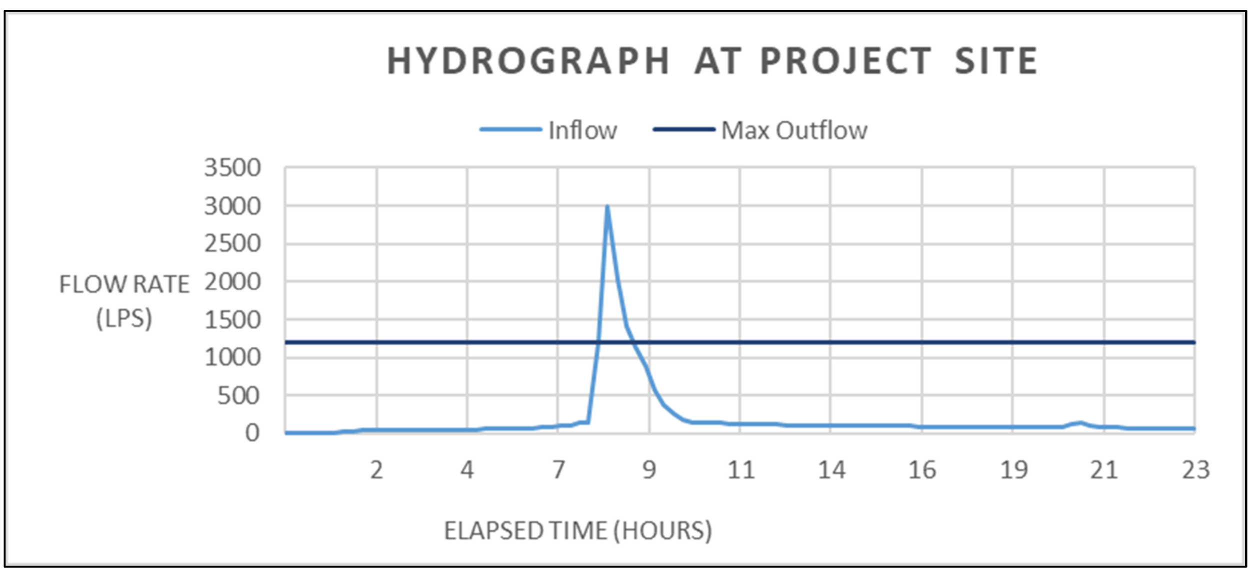


Figure 3: Hydrograph at project site during 1 in 100-year storm event.

From approximately 8:15:00 am to 9:15:00 am, inflow rates significantly exceed the designated maximum outflow rate. The area between the inflow and outflow hydrographs represents the excess volume of stormwater that accumulates during a 24 hour 100-year return period storm event, and was calculated by the following mass-balance equation:

$$V_{excess} = \sum_{i=1}^{n}\left(Q_n - Q_{discharge}\right) * \Delta t \quad \textbf{(Eqn. 2-1)}$$

where $Q_{discharge}$ represents the maximum discharge rate for the stormwater tank and Q_n represents the incoming flowrate at each "n^{th}" timestep. Sample calculations can be found in Appendix A. The required storage volume was calculated to be **3200 m^3**.

2.5 Geotechnical Requirements

In lieu of complete geotechnical data for the project site, a soil stratigraphy model was created using an interpolation from nearby borehole soil data. The stratigraphy model is shown in Figure 4 below. Several estimates and assumptions were made regarding the relevant material properties of each soil type. All assumptions are informed by regional precedent or analysis of soils with similar geological origins. An adequate field investigation and lab testing regime must be completed to confirm material properties before any action is made based on these assumptions.

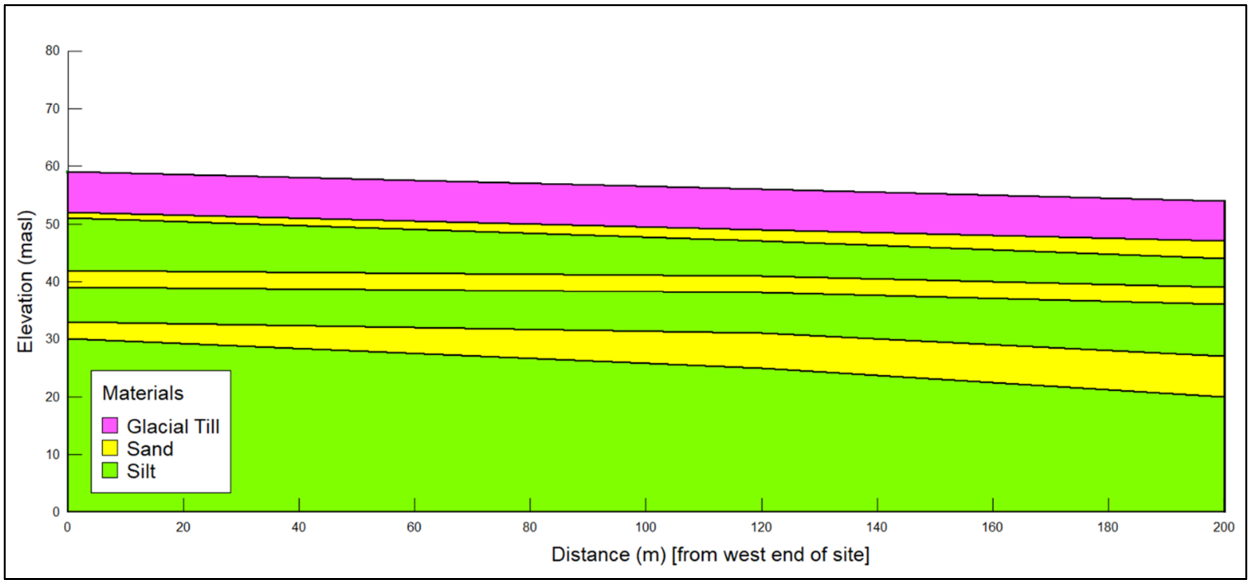


Figure 4: Assumed soil stratigraphy at project site.

All earthworks will take place within the top 7 m of soil, which is expected to be a glacial lodgement till. Glacial tills generally have high density and strength in-situ and have been deemed suitable for load-bearing across the site. However, tills are prone to liquefaction when saturated, and segregation when transported by construction processes. Measures will be taken to prevent new pathways for water infiltration into the till and gravel will be placed as reinforcement around sensitive project elements such as concrete slabs, as shown in Figure 5 below.

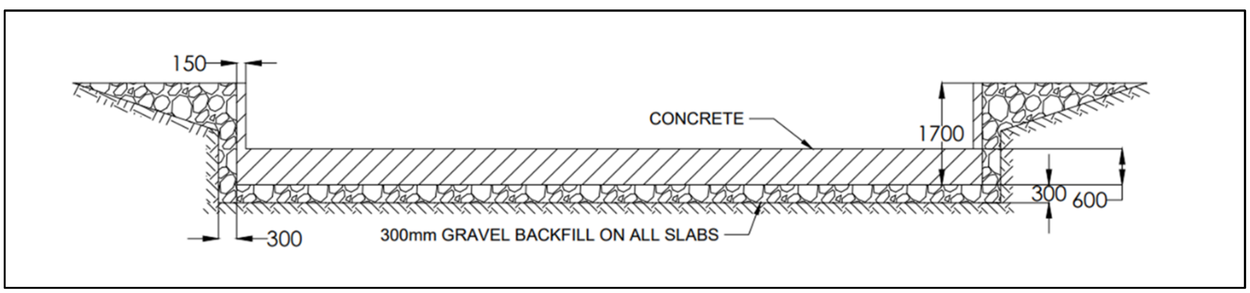


Figure 5: Exemplary profile view of gravel reinforcement around a concrete slab.

Underlying the till is a stratum of sand ranging from 1 m to 3 m in thickness, followed by a stratum of silt ranging from 4 m to 9 m in thickness. The sand is expected to have high hydraulic conductivity, allowing any water infiltrating this layer to be quickly conducted away from its source. The silt will act as an aquitard, eliminating the practical influence of deeper soil strata. The water table is expected to be about 22.4 m below the sand layer, so liquefaction during an earthquake is unlikely to be a concern.

2.6 Structural Requirements & Inputs

All structural components of this project have been designed in accordance with the 2014 Vancouver Building Bylaw, the 2015 Wood Design Manual, and the 2014 CSA Standard for the Design of Concrete Structures (CSA A23.3-14).

Prior to the design process, loading conditions needed to be established. When calculating factored loads, a dead load factor of 1.25 and a live load factor of 1.5 were used. Dead loads were calculated using unit weights of the various construction materials, while live loads were obtained from the 2014 Vancouver Building Bylaw. For outdoor assembly areas, an unfactored live load of 5 kPa was used.

2.7 Environmental Requirements

In accordance with Section 33 49 00 of the UBC Technical Guidelines, stormwater management designs are encouraged to incorporate biofiltration methods to improve water quality treatment (The University of British Columbia). Additionally, UBC has developed the UBC Storm Water Pollution Prevention Guidelines which state that “depositing or permitting the deposit of any substance which is likely to be rendered deleterious to aquatic habitat (e.g. fish, organisms, plants, etc.) is prohibited.” Although there are regulations under the Fisheries Act and the BC Hazardous Waste Regulation that place limits on pollutants being discharged into storm sewer systems, it is optimal to place additional filtration methods in the detention tank to add a factor of safety to stormwater discharge. This additional filtration falls in line with the UBC ISMP that promotes the inclusion of oil and grit separators to minimize the amount of particulate matter, which could have adverse effects on the surrounding vegetation and habitat being discharged into the ocean.

There are numerous measures in place to mitigate environmental impact that must be applied during and after the construction phase. The relevant construction phase activities that will impact existing environment are summarized in the following list:

- Site clearing and shrub removal
- Construction and modification of access roads
- Delivery of heavy equipment
- Construction of permanent and temporary structures
- Construction of parking lot

As a result, considerable emphasis is placed on reducing any negative impacts of the proposed design through adopting an avoidance-first strategy and using low-impact development (LID) strategies during the design process. Most importantly, to avoid impacts to any mature vegetation, efforts will be made to adjust the future layout of the mini golf holes around old growth trees within the site. Moreover, the design will incorporate the use of nest boxes around the facility to ease the effects of avian habitat loss due to any tree removals.

Regarding the mitigation measures taken during the construction activities, certain measures such as the installation of sediment control systems during construction and the provision of a third-party environmental monitor will be used to minimize any construction impacts.

3.0 Design Components

3.1 System Overview

The final design includes an 18-hole miniature golf course along with a stormwater management facility designed to withstand stormwater volumes in a 1 in 100-year rainfall event. The system consists of a bypass line, surface detention ponds, an underground stormwater detention tank system, an outlet connection, a mini-golf facility, and a parking lot. Each component of the system will be described in the following sections.

3.2 Bypass Line

To maintain a gravity-fed system while accounting for the design depth of the detention facility, a 135 m long, 1050 mm Class IV reinforced concrete bypass line will be installed at an invert elevation of 54.89 m in the existing stormwater main. The bypass main will run at the minimum 0.1% grade specified in Section 33 of the UBC Technical Guidelines until it connects to the first cascading pond at an invert elevation of 54.73 m. The bypass line will connect into the existing storm sewer 5.5 m from the southeast corner of the Centre for Comparative Medicine at a new junction labelled S6D-S26B. These details are outlined in Figure 6 below.

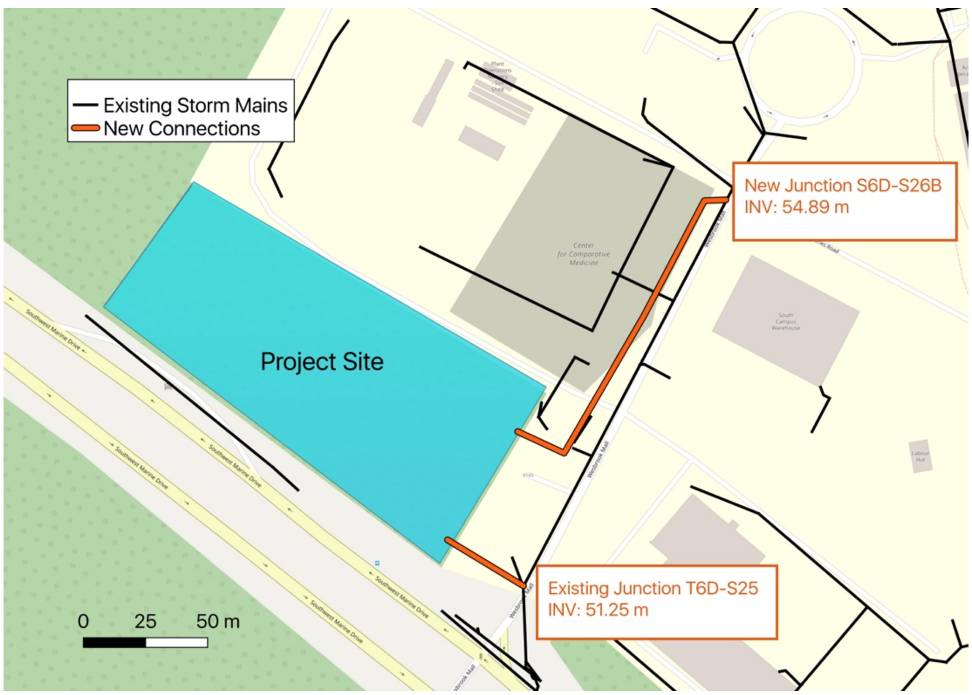


Figure 6: Plan view of storm sewer connections to existing main.

The new line will tie into the existing 1050 mm storm sewer through a reinforced concrete manhole with an inner diameter of 2400 mm. The manhole will be pre-benched, with the invert elevation of the bypass outlet located 0.15 m below the existing outlet invert to ensure stormflows are directed to the detention tank system. The manhole will be 4.1 m deep and installed with an extended base to prevent against floatation in the event of complete soil saturation. Ten meters past the manhole connection, the 1050 mm bypass line will be bent 90 degrees using a reinforced concrete double-mitre bend. The bypass line will then run straight for 120 m before being bent into the first cascading pond.

All concrete pipe and the new manhole structure will be installed as per MMCD standards, which can be found in Appendix C. Manufacturer's drawings of the 1050 mm class IV concrete pipe, 2400 mm concrete manhole pieces, and 1050 mm double mitre-bend can be found in Appendix C. A completed manhole take-off sheet for S6D-S26B detailing invert elevations, outlet angles, and connecting pipe is presented in Appendix C. Manhole and concrete sewer specifications are detailed in Section 4.1. Drawing 11-009-A in Appendix C shows the plan view and location of manholes for the new connections to the storm sewer.

3.3 Cascading Pond Conveyance System

Through a system of cascading ponds and channels, stormwater is collected and conveyed to the underground detention tanks. The cascading ponds and channels serve to collect runoff and hold stormwater through a bypass connection to the existing storm drain network. This system of cascading ponds and channels plays a significant role in improving the water quality as the stormwater percolates through biologically filtering plants while maintaining a controlled flow rate into the tank. Furthermore, this design provides an aesthetically pleasing center piece for the mini golf facility, enhancing the multipurpose aspect of the design. The network of cascading ponds and channels consists of three large ponds connected by two channels, following the layout shown in Figure 7 below.

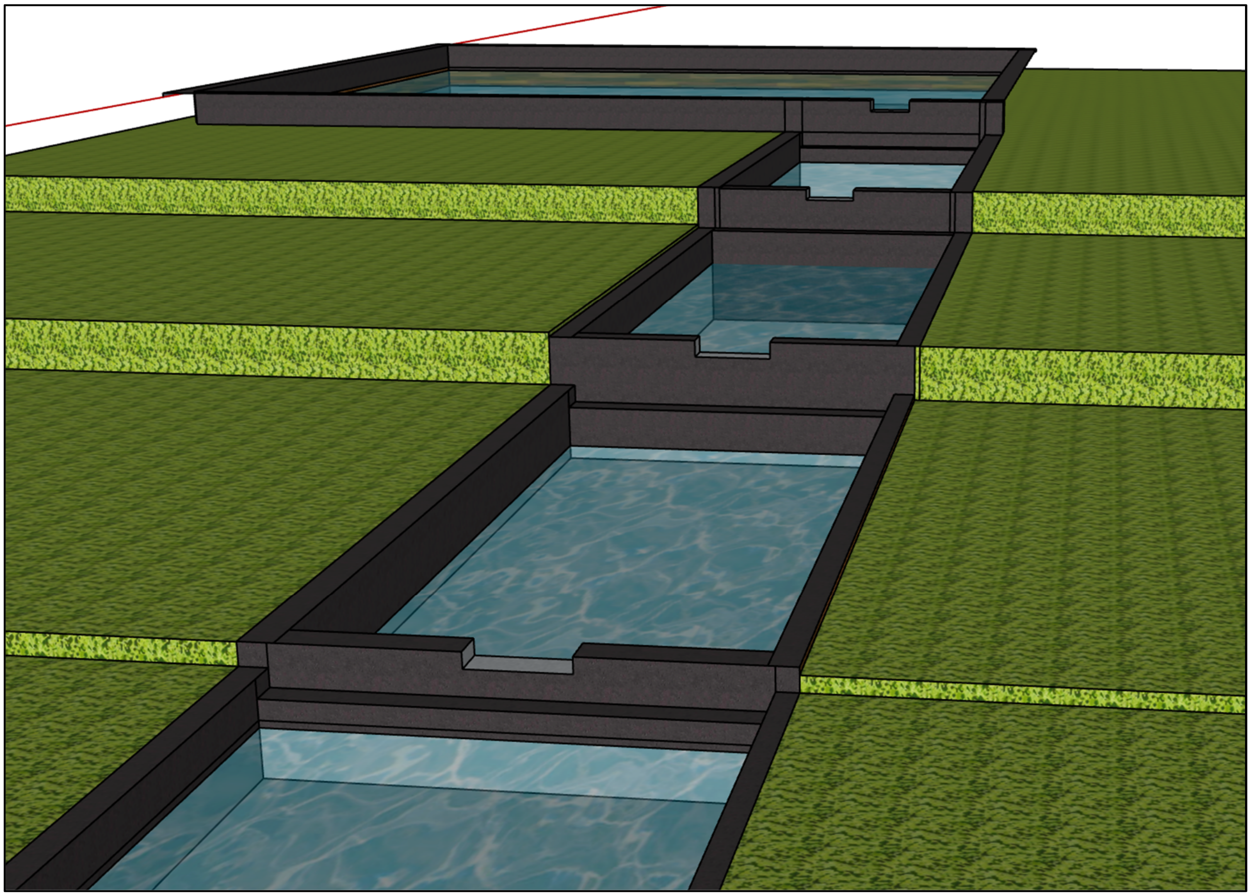


Figure 7: Layout of cascading ponds and channels.

In order to store the required amount of water, each pond is designed to hold 187 m^3 of water with outer dimensions of 12.3 m x 12.3 m and a depth of 1.7 m. The two channels each consist of five smaller ponds with outer dimensions of 6.3 m x 3.3 m and a depth of 1.4 m, designed to hold 180 m^3 of water. In total, the system provides a storage capacity of 922 m^3. Please refer to Appendix C for a detailed drawing of the pools and channels.

The system utilizes a multilayer filtering and growing system for the aquatic plants. At the base of the ponds and channels, a growing medium will be placed over an HDPE geomembrane and a drainage layer. Stone ballast is used to dissipate the flow momentum and aquatic plants are used for erosion control. The plants utilized in the design are Water Sedge (Carex Aquatilis) and Hardstem Bullrush (Scirpus Acutus). These native plants to western North America are known for their erosion control qualities due to their prolific root systems and are often used for soil stabilization (United States Department of Agriculture).

Additionally, Corten steel weirs will be placed at the end of each pond to deliver the water to the lower pond and to create the desired cascading effect by utilizing a drop of 15 cm between each pond. This design is inspired by the stormwater terraces on University Boulevard, which utilizes similar ponds on a smaller scale to convey stormwater to an underground cistern (Phillips Farevaag Smallenberg).

The structural and geotechnical aspects of the cascading ponds and channels are summarized in the following list:

- An impermeable HDPE geotextile is placed on top of the till layer to avoid saturation.
- A 300 mm thick compacted layer of 25 mm gravel will be placed over the geotextile.
- The shoring slope utilized will be 2H:1V.
- The side backfill will consist of permeable gravel stretching half a meter around all the structures.
- The load combinations specified by the Vancouver Building Bylaw were used to estimate the design of the structural elements.
- The maximum total bearing pressure on the soil will occur at the large ponds and it is estimated to be approximately 30 kPa.
- Krystol Internal Membrane admixture will be applied to the surface of the ponds and channels for waterproofing and to protect the reinforcing steel from corrosion.
- The details of the structural design of the ponds and channel including rebar placement can be found in Appendix C.

3.4 Stormwater Detention System

After stormwater has been collected and conveyed down the cascading ponds, it enters the underground stormwater detention system. Refer to Appendix C for plan and section views of the system. The system is comprised of three parts: the oil and grit chambers, the diversion channel, and the five stormwater detention tanks.

The roof slab of the stormwater detention system will be located 1.3 meters below ground. The reinforced concrete roof slab is 40 cm deep and utilizes 30M longitudinal reinforcement, 15M stirrups, and 10M temperature and shrinkage reinforcement. The roof is supported by a combination of reinforced concrete strip footings and columns. Further description of columns supporting the roof slab can be found in Section 3.4.2. The strip footings are connected to the roof slab via a cold joint, and they also serve as the walls of the diversion channel and the oil and grit chambers. All concrete specified is normal density, has a maximum aggregate size of 20 mm, and a 28-day compressive strength (f'_C) of 25 MPa. All steel specified has a tensile strength of 400 MPa. Figure 8 below shows an isometric view of the entire stormwater detention system.

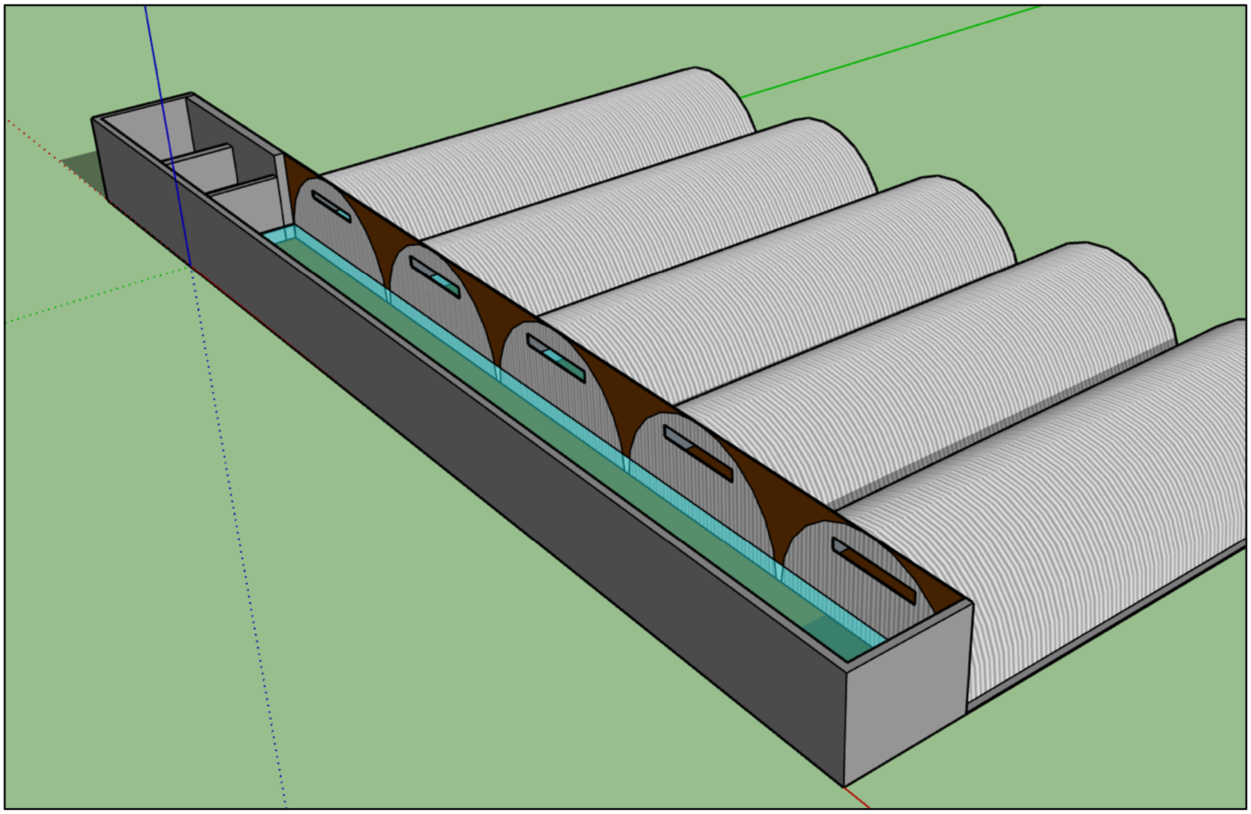


Figure 8: Isometric view of stormwater detention system.

3.4.1 Oil and Grit Chamber

The first component of the stormwater detention system is the oil and grit chamber. This component consists of two 48 cubic meter holding cells that separate oils and grits from the stormwater. Each holding cell has a plan area of 4 m x 4 m, and is 4 m deep. The walls of these cells are strip footings, and the floor is a 400 mm deep concrete slab reinforced with 25M longitudinal reinforcement and 10M temperature and shrinkage reinforcement. Reinforced concrete was chosen as a floor surface in order to prevent contamination of the surrounding environment.

An outlet valve connected to the main storage area is located 0.5 m above the bottom of the chamber, leaving 3.5 m above. As the chamber fills, oil sits on top of the fluid until it has reached the top. At this point, the pressure of fluid above the outlet intake will push the bottom fluid (water) up and into the main storage tank, leaving only oil in the chamber. The grit chamber is designed to allow particulates to settle at the bottom of the cell. Every 6 months, this oil and grit chamber can be easily cleared of sediment and oil by using a vacuum truck through an access point located directly above. A cross-sectional view of the oil and grit chamber is presented in Figure 9 below.

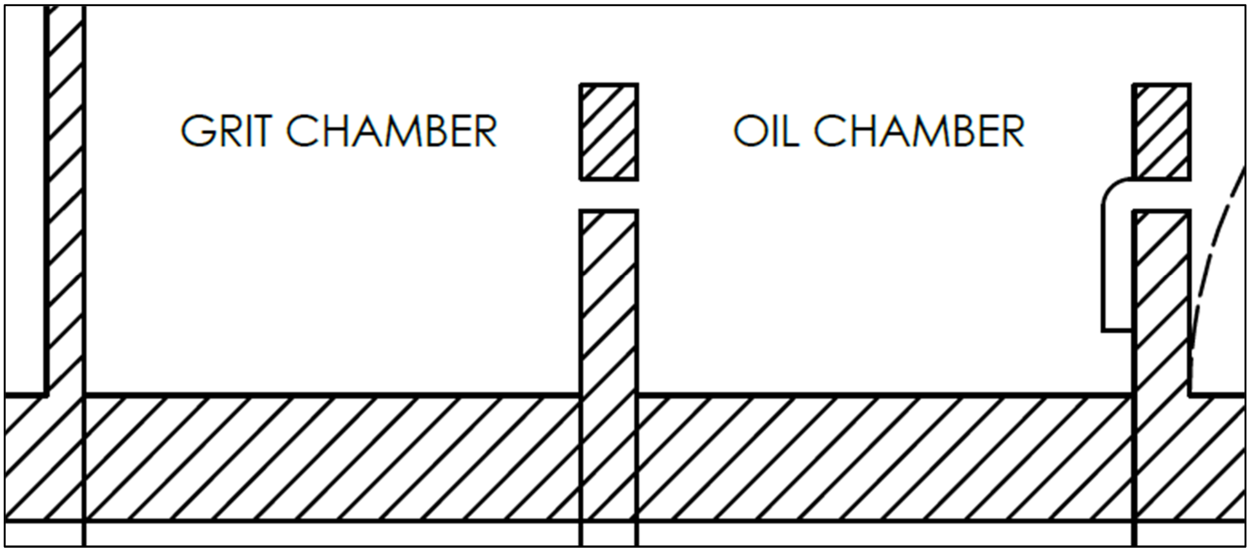


Figure 9: Cross section of oil and grit chamber.

3.4.2 Diversion Channel

After stormwater has passed through the oil and grit chambers, it enters the diversion channel. Its purpose is to divert stormwater into the five stormwater detention tanks. The diversion channel is 41.6 m long, 4 m wide, and 4 m tall. At 8 m intervals along the length of the channel, there are 300 mm square reinforced concrete columns which provide partial support for the roof slab. These columns are reinforced with 4-20M longitudinal rebar and 10M ties which are spaced at 350 mm. Sample calculations for the design of these columns can be found in Appendix A. The floor of the diversion channel will be constructed using permeable earth-fill, a less costly alternative to reinforced concrete. Designing the system with a permeable floor allows for stormwater to recharge the groundwater of the surrounding environment. Allowing seepage through the floor of the detention system also reduces the amount of stormwater being released as effluent which contributes to one of the projects overarching goals of limiting outflow from the UBC campus to less than 1.2 m^3/s.

3.4.3 Stormwater Detention Tanks

The final component of the stormwater detention system is the group of five stormwater detention tanks. Each tank is a 20 m long, 8 m diameter corrugated steel half pipe. These tanks bear the geotechnical loads directly above them by being in direct contact with earth fill. The apex of each tank is 1.3 m below the ground surface. Each tank is supported at its legs by a 500 mm x 500 mm concrete strip footing that extends along the full 20 m length. The floor of these tanks is identical to that of the diversion channel, encouraging permeation of stormwater into the surrounding environment. A 3D rendering of the steel detention tanks can be seen in Figure 10 below.

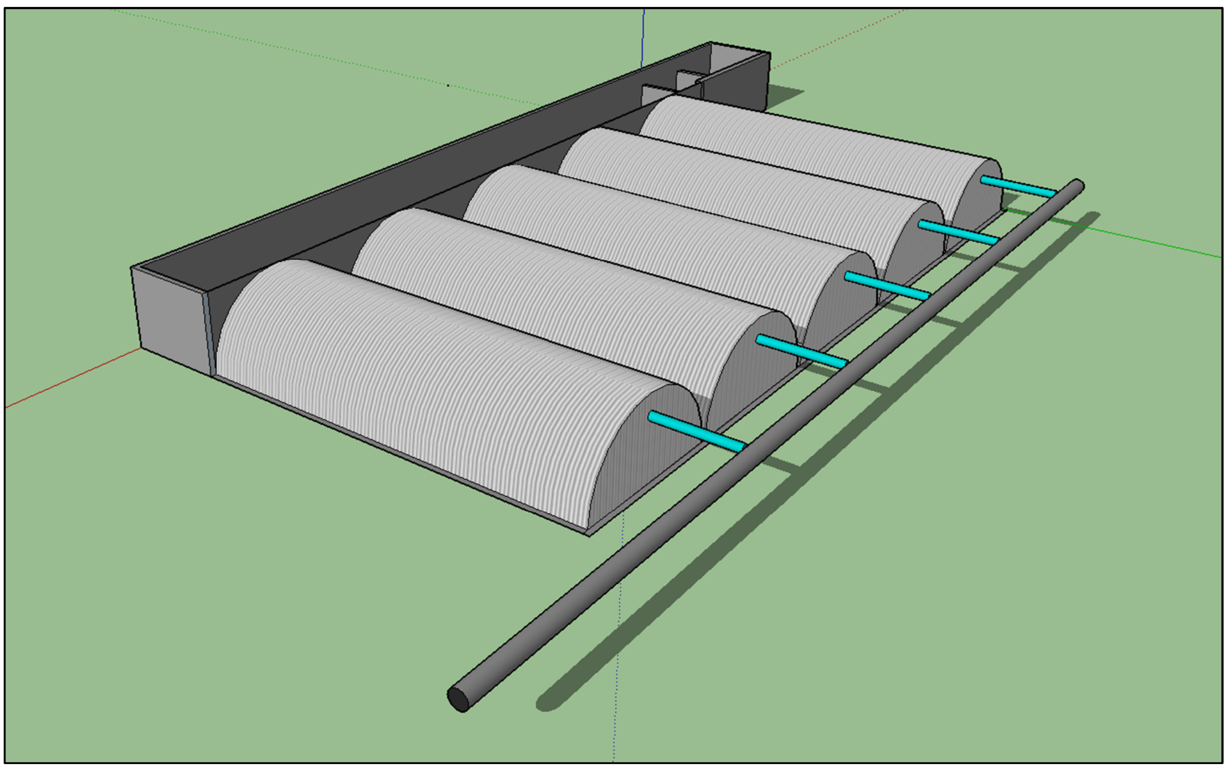


Figure 10: Steel detention tanks, PVC outlet pipes connecting into reinforced concrete pipe.

At the end of each detention tank, stormwater is discharged from the system through a 200 mm inner diameter PVC pipe that acts as an orifice located 0.5m below each tank's full height. Drawings 11-001 and 11-008 in Appendix C detail this configuration. The PVC outlets were sized based on the maximum discharge requirement of 1.2 m^3/s outlined in the UBC Technical Guidelines. The final design exit flow is

0.2 m^3/s for each tank, totaling 1.05 m^3/s for the facility. All exit flow rates were calculated using a simplified result of Bernoulli's equation below. Sample calculation can be found in Appendix A:

$$\dot{V} = C_c C_v A\sqrt{2gh} \quad \textbf{(Eq. 3-2)}$$

$$C_v = Velocity\ Coefficient$$
$$C_c = Contraction\ Coefficient$$

The 200mm PVC outlet pipes will exit the tanks at an invert elevation of 51.85 m and will then connect into a 750 mm Class IV reinforced concrete pipe at a grade of 1%. Each connection will be 500 mm in length and connect into the concrete pipe at the pipe mid-section – 375 mm above the pipe invert. Each PVC connection will be installed and bedded in accordance with the specifications outlined in Section 4.1. Drawing 11-008 in Appendix C outlines the connection details.

3.5 Downstream Connection

The 750 mm inner diameter concrete pipe will run from the final chamber of the stormwater detention tank at an invert elevation of 51.46 m, where it will then run for 54 m at a grade of 0.5% before connecting to the existing junction T6D-S25 at an invert elevation of 51.25 m, as shown in Figure 11 below.

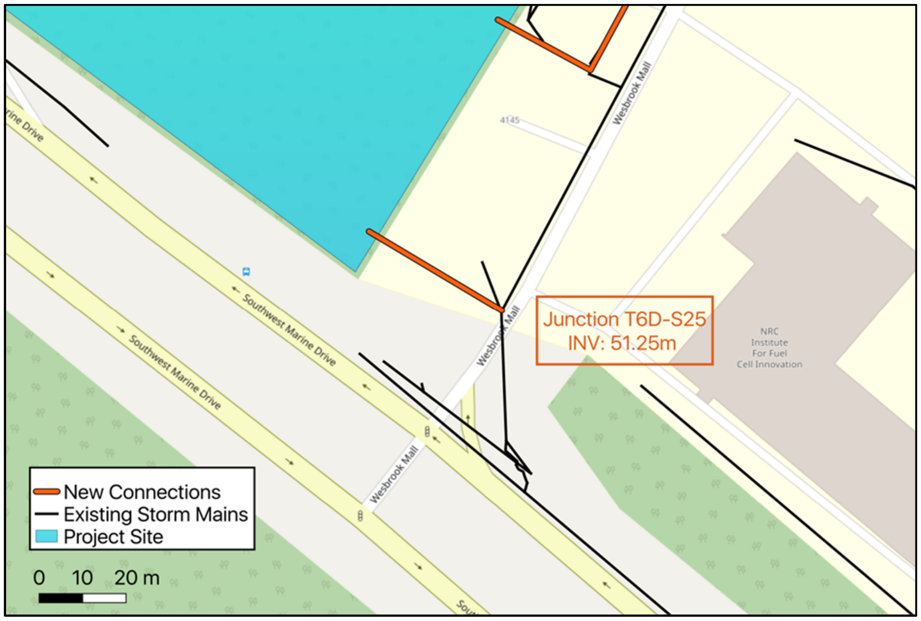


Figure 11: Plan view of downstream connection to existing system.

The outlet pipe will connect into the existing storm sewer main through a 2400 mm inner diameter reinforced concrete manhole that 2.23 m deep. Drawings 11-008-A and 11-009-A in Appendix C provide a layout of the new connection system.

3.5 Operations Hut

A 64 m^2 timber operations hut will be used to support daily operations at the miniature golf course. The hut has a square plan area of 8 m x 8 m, and a height that slopes from 6 m to 4 m. The hut will serve as storage for golf clubs and other equipment, and it will be occupied by one or two workers who are collecting green fees.

The hut was designed to withstand dead, wind, and snow loads. The hut will be framed using 2x4'' cedar lumber, spaced 16'' on center. The hut will be supported using 8 square concrete pads which bear on a geotechnical foundation of gravel on top of native topsoil. The roof will be constructed using a 2-ply membrane system. The two plies consist of a cap sheet and a base sheet, and are made of Styrene Butadiene Styrene (SBS) modified bitumen. Metal flashing on the roof edges will utilize standing seam joints due to their reliability.

3.6 Mobility Improvements

In order to manage the induced traffic demand of the mini-putt facility, a new parking lot, pedestrian walkway, and a site access ramp will be constructed. All mobility structures have been designed as per the City of Vancouver Parking and Loading Design Supplement (2002). Figure 12 shows where the new infrastructure will be located relative to site.

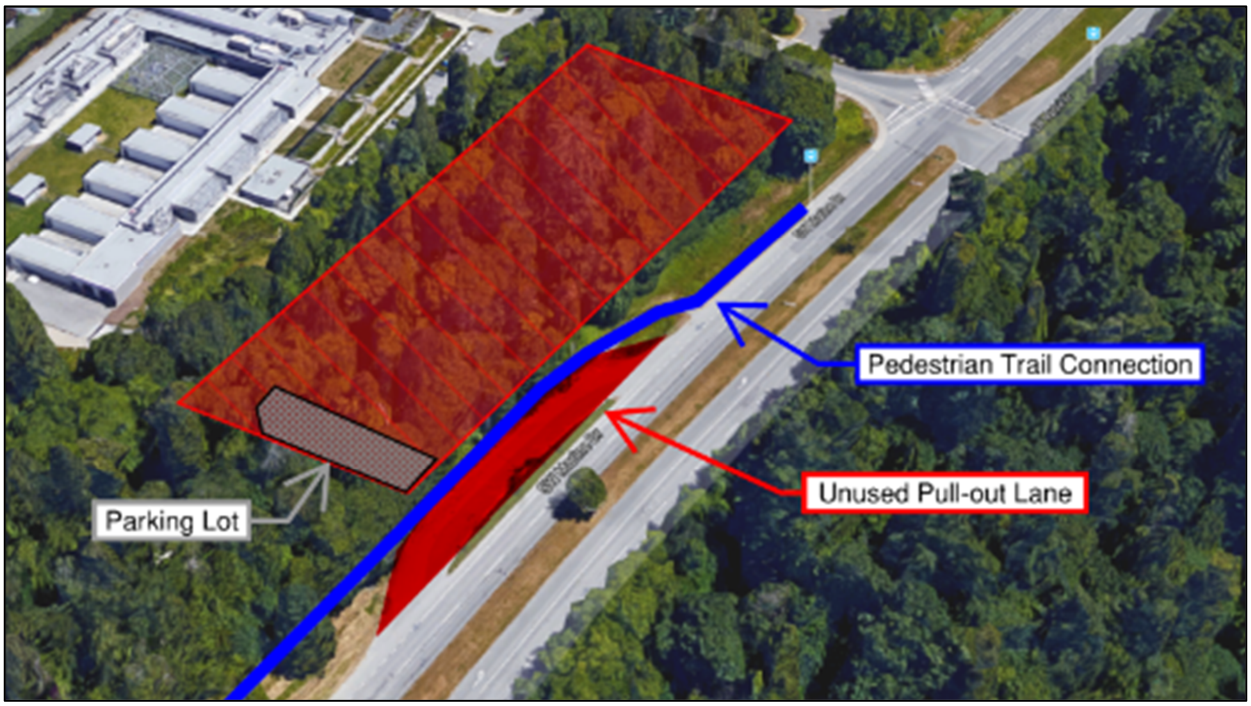


Figure 12: Overview of parking lot location on project site.

3.6.1 Parking Lot

The number of stalls in the parking lot design was determined using guidelines outlined in the City of Vancouver's "Transportation Demand Management for Developments in Vancouver" bulletin (2018). This development plan targeted to have walking, cycling, and public transit make up at least 50% of trips within the city by the year 2020. A limited amount of vehicle parking will be supplied to encourage transit and other modes of transportation. The parking lot will contain seven regular parking stalls and three handicap accessible stalls, as required by City of Vancouver Parking Accessibility By-laws. A plan view of the parking lot can be seen in Figure 13 below. The parking lot road and non-handicap stalls will be gravel-top to minimize the introduction of impermeable surfaces to the site.

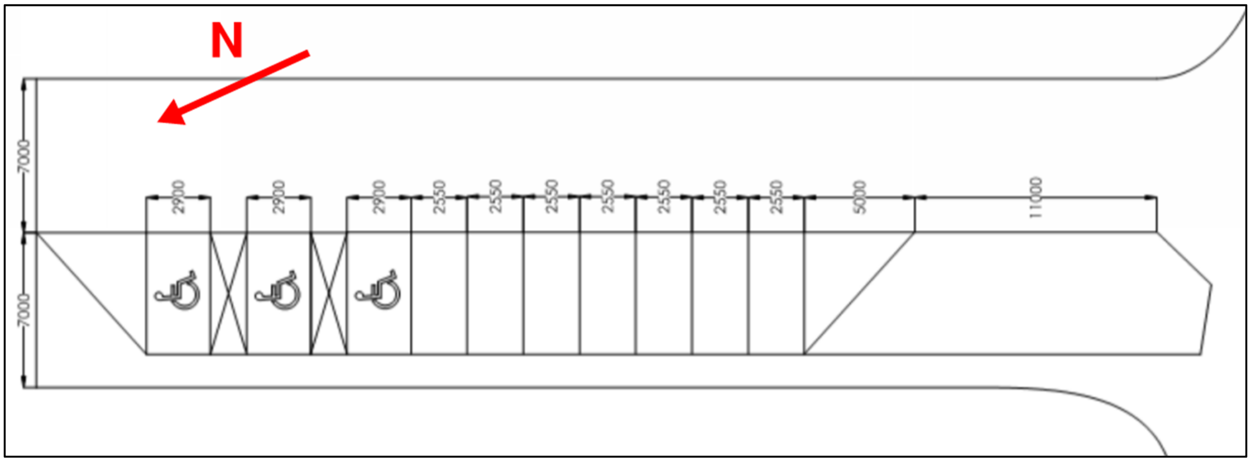


Figure 13: Plan view of parking lot.

3.6.2 Vehicle and Pedestrian Accessibility

In order to use the existing pull-out lane as an access road, improvements must be made to ensure vehicles and pedestrians can safely travel through the access ramp. For instance, the speed limit at the adjacent section of the SW Marine Drive is 80 km/hr and speed must be reduced to 30 km/hr within the 100 m approach. Speed calming structures will be constructed on the pull-out lane to ensure drivers will slow down in the access road. A sidewalk will be developed to allow pedestrians to cross the access road without the risk of vehicle encroaching on their walking area.

The addition of the parking lot accessed by the pull-out lane introduced a pedestrian-vehicle crossing. The access ramp crossing will include pedestrian-cross road signs and speed calming structures 5 m and 10 m before the access ramp to ensure vehicle speeds are regulated. Figure 14 below outlines the plan layout of the access road and speed-calming structures.

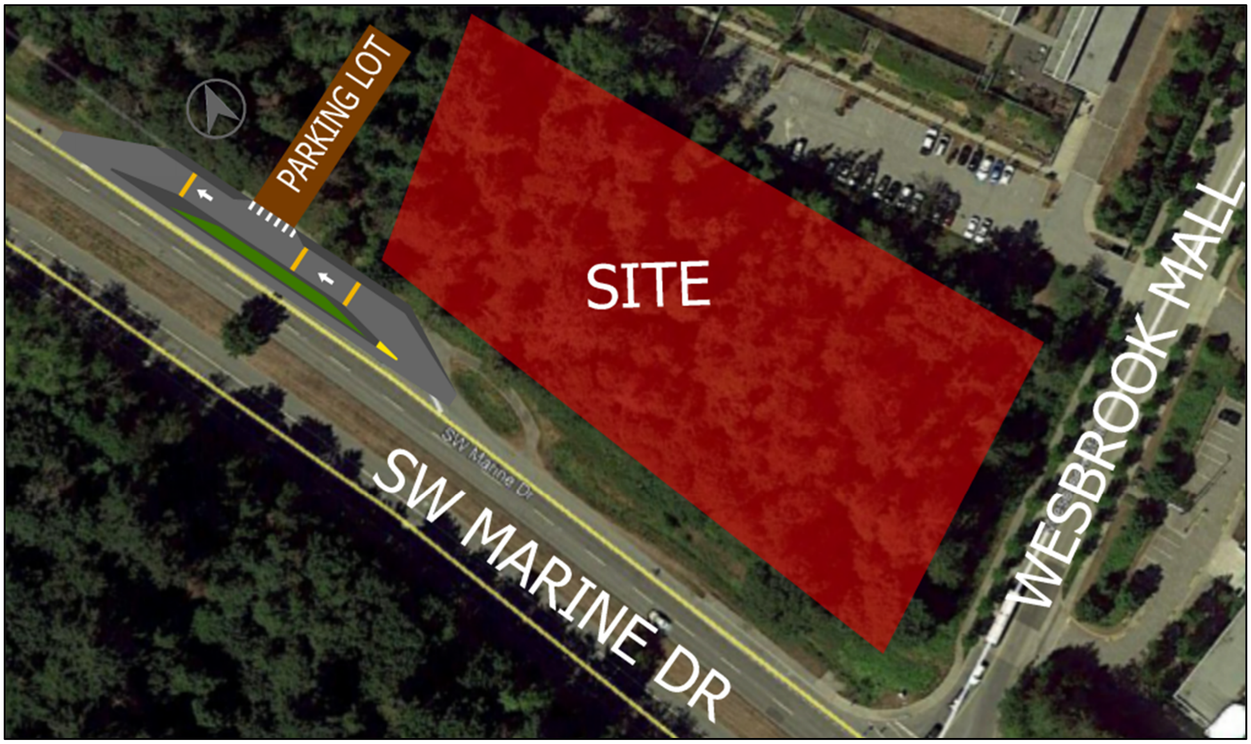


Figure 14: Overview of permanent access road.

4.0 Construction Plan

4.1 Specifications & Standards

4.1.1 Corrugated Steel Detention Tanks

For each of the 5 stormwater detention tanks, CP-A-42 constructed by Canada Culvert will be used. These pipes are manufactured with a diameter of 8 m, and as semi-circles. Each pipe should be coated with a Thermoplastic Copolymer to ensure durability when in direct contact with soil and water. More information on this product, including specific dimensions and material strengths can be found in Appendix B.

4.1.2 Manholes and Connections

All manholes and connections shall be designed in accordance with MMCD S1 and S2. Manholes will have a minimum 2400 mm inside diameter to account for 90-degree outlets and two or more connections consisting of 1050 mm concrete pipe. Manhole bases will be 200mm thick with a square extension to account for floatation in the event of full soil saturation. Additionally, manhole bases will be benched to the crown of the highest pipe. 3 x 8T lift pins will be placed equidistant on the manhole base and slab tops to ensure structural integrity during installation. Galvanized ladder rungs shall be placed every 305mm along the manhole depth and will be cast into the manhole riser pieces. 2400 mm manholes will have a minimum lid thickness of 254 mm.

Connections to manholes will be a maximum of 500 mm in length. Concrete pipe connections shall utilize Tylox SuperSeal gaskets made of isoprene that meet ASTM C361, C425, and C443 standards. PVC connections shall utilize a rubber sleeve and stainless-steel band to tie PVC into concrete. Contractor shall contact the concrete pipe manufacturer to confirm PVC-concrete connection.

4.1.3 Concrete Sewer Pipe

All concrete pipe shall be Class IV reinforced concrete, Type GU cement, and be manufactured in 2.5 m length pieces in accordance with ASTM C76 standard. All 750 mm and 1050 mm will have extended bells, to be installed bell-to-spigot downstream. Each concrete pipe piece will have 2 x 4T lift pins for installation purposes.

All concrete pipe connections shall utilize Tylox SuperSeal gaskets made of isoprene that meet ASTM C361, C425, and C443 and create a watertight seal between adjacent pipe pieces.

4.2 Project Phasing

In order to expedite the permit approval process for the stormwater detention facility, the construction work for this project will be split up into three phases:

1. Stormwater detention centre construction

2. Mini-golf facility installation and mobility improvements

3. Stormwater system connection construction

The construction work was divided into these phases because each phase involves an increasing amount of reconstruction of existing infrastructure.

4.3 Excavation Plan

The entire project site will be graded prior to excavation to control the excavation depths and minimize concerns regarding sloping ground levels. This project will include large bulk excavations up to 7 m in depth and 50 m in length. Several excavation stability support methods were researched but sloping alone was determined to be the most appropriate for the project's scale and budget. Sloping parameters for the bulk excavations are based on the WorkSafeBC Occupational Health & Safety Handbook. Several slopes were analyzed for stability using GeoStudio SLOPE/W. One result from stability analysis of the bulk excavation slope is shown in Figure 15.

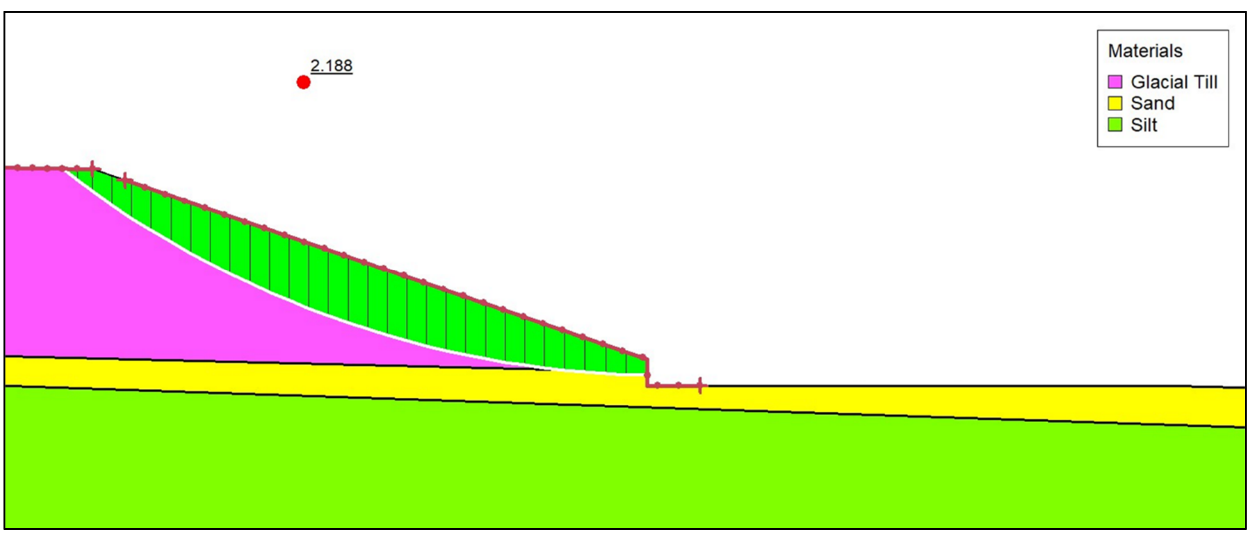


Figure 15: SLOPE/W stability analysis result for bulk excavation slope.

Further excavation will be required for the pipes facilitating external connection to the existing storm sewer system. Proper support of the pipe trench is also based on the WorkSafeBC Occupational Health & Safety Handbook. A vertical section of the pipe trench will be supported by a steel trench box, allowing for a 4:3 slope from the top of the vertical section to the ground surface. The stability of this slope was also analyzed in SLOPE/W, and the result is shown in Figure 16.

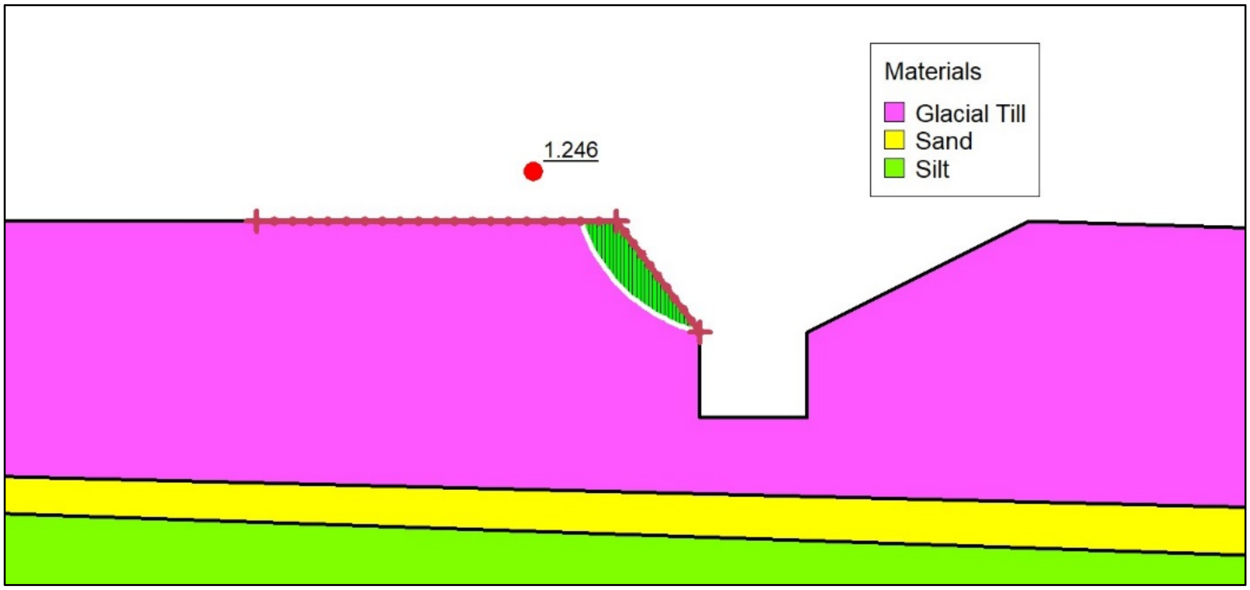


Figure 16: SLOPE/W stability analysis result for pipe trench excavation.

Backfill of the pipe trenches is specially designed to support the pipe over its entire length, based on the installation handbook from the American Concrete Pipe Association. Clean bedding sand will be placed with thickness of 300 mm below, above, and on the sides of the pipe. Above this, native material will be placed as backfill.

4.4 Traffic Management Plan

Traffic disruption from construction processes will be minimal during Phase 1 construction. During Phases 2 and 3, there will be no access to traffic moving South along Wesbrook Mall. Access to SW Marine Drive from UBC is possible through 16th Ave. The only public bus that will have to be rerouted will be the 041 Joyce Stn. The bus will follow the same route as all the other buses that travel along SW Marine Drive. Traffic flows during different phases of construction are shown in the following figures.

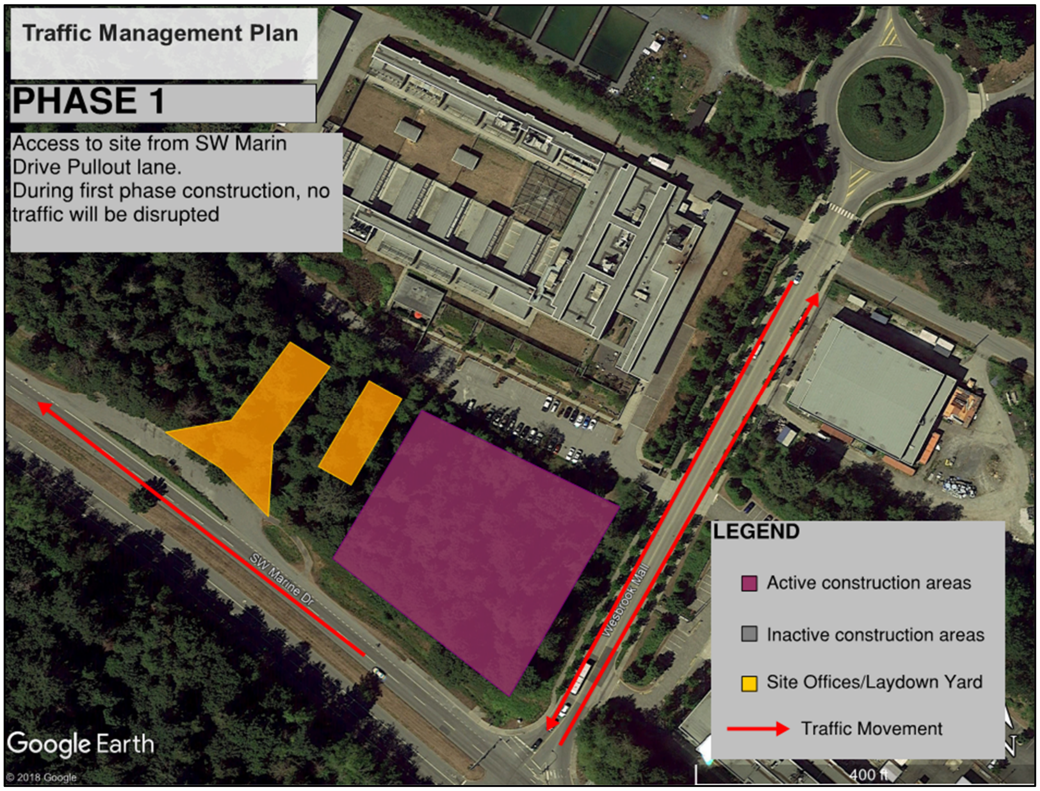


Figure 17: Traffic flow during construction phase 1.

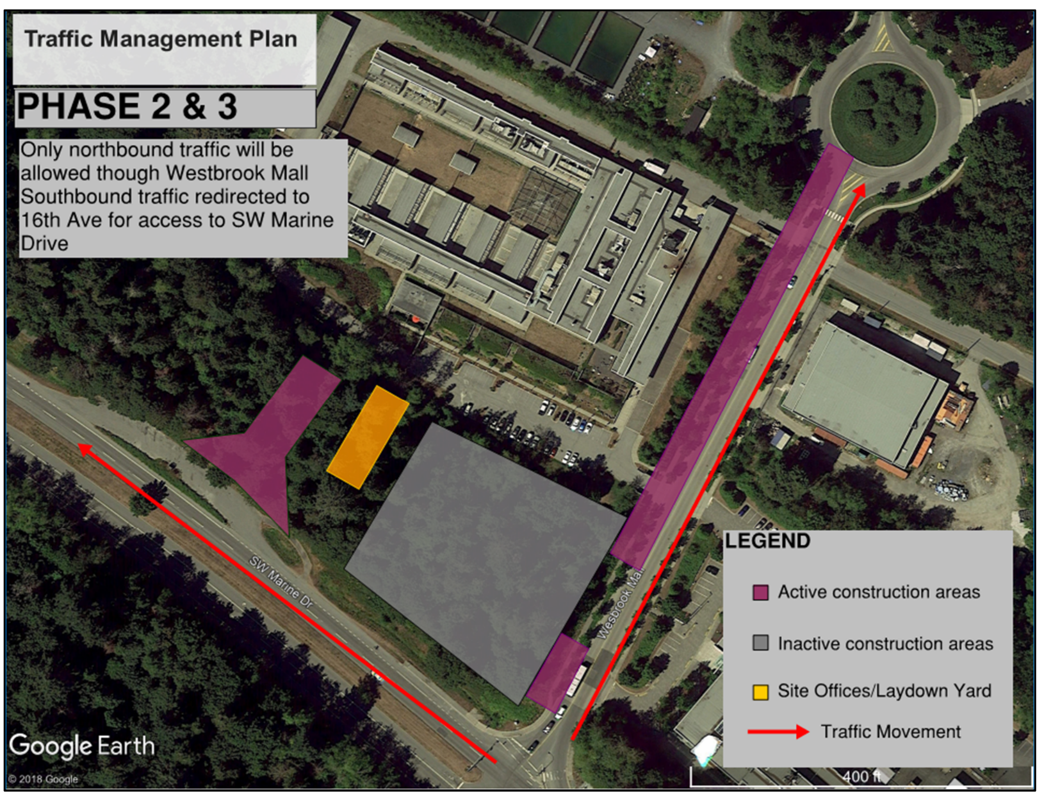


Figure 18: Traffic flow during construction phases 2 and 3.

5.0 Cost Breakdown

Construction costs were determined using the average unit rates report from the Alberta Infrastructure & Transportation Department. Table 2: Summary of estimated costs. Table 2 provides a high-level summary of the cost of implementation of the project as well as projected maintenance and operations costs. This cost breakdown includes site permitting, project management cost (based on a 5% lump sum contract), and construction cost (materials and labour inclusive).

Table 2: Summary of estimated costs.

COST ESTIMATE SUMMARY		
DESCRIPTION		TOTAL
Permitting[1]		$12,385.00
Project Management[2]		$103,400.40
Construction Costs[3]		$1,552,318.90
	UP-FRONT COST	$1,668,103.30
Maintenance and Operations Cost		$5,940.00
	ANNUAL COST	$8,940.00

[1]*Derived from City of Vancouver Building Permit Costs*

[2]*Professional Engineering Costs Derived from the ACEC BC Fee guidelines*

[3]*Construction labour and material costs calculated using Unite Price Averages Report from the Alberta Infrastructure & Transportation.*

[3]*Unit rates and materials costs cross checked with separate source as indicated in report*

For a more detailed cost breakdown of construction costs with unit rates, please refer to Appendix D.

6.0 Schedule

Due to the complexity of the project, coordinated construction phasing will be undertaken to guarantee the smooth operation of all the work activities. The schedule assumes a start date of May 1st, 2019. However, construction cannot begin without the distribution of public notices and holding project open-houses. Moreover, the project must undergo permitting, tendering, and final design approvals before construction can commence in May. Therefore, the chart in Figure 19 below outlines the critical path schedule for the work activities and their respective durations with a start date of March 1st, 2019.

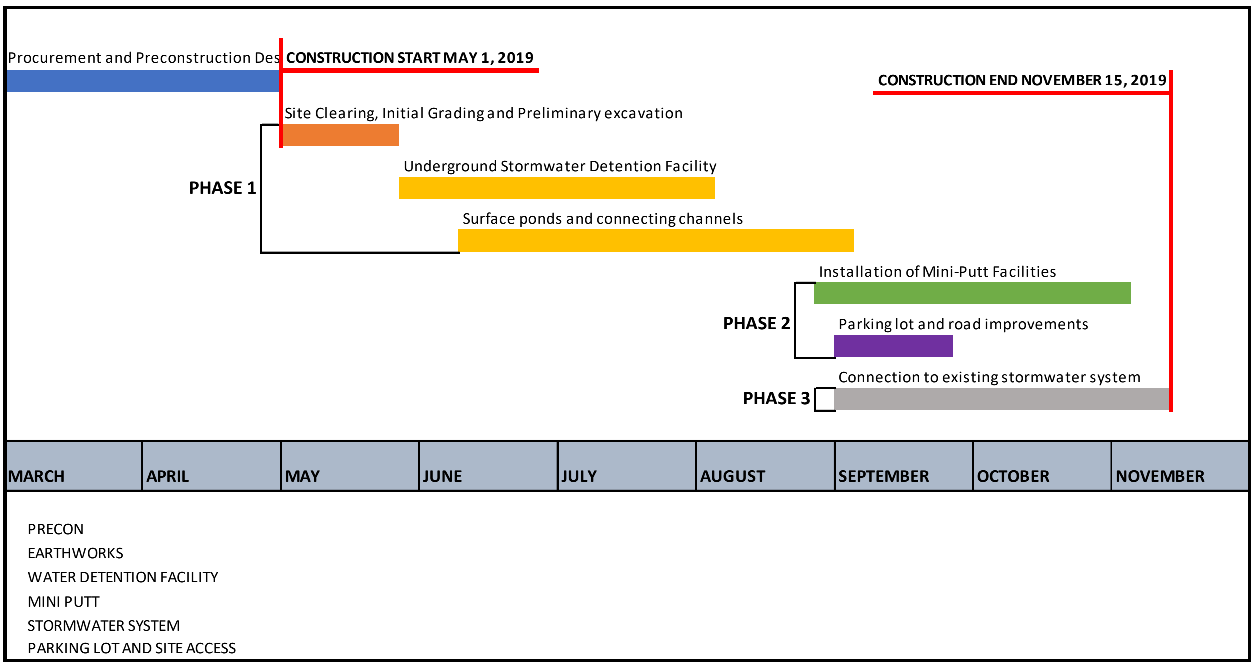


Figure 19: Gantt chart for critical path of construction schedule.

Based on this plan, one specialized crew will be working concurrently on the detention tank, ponds and channels, given the similarities in their construction methods and the large excavation area required. Upon completion of the last pond, the crews will proceed to work on the miniature golf facility, as well as the parking lot. Lastly, the system connections will be made to the existing infrastructure and any deficiencies will be addressed prior to commissioning. A detailed construction schedule can be found in Appendix E which outlines the durations of specific work activities on a Gantt chart.

6.1 Service-Life Maintenance Plan

The maintenance plan for the stormwater detention facility is shown in Table 3 below.

Table 3: Summary of maintenance plan for the facility.

LANDSCAPING AND MINI-PUTT FACILITIES
Bi-weekly landscaping work and mini-golf greens maintenance
Natural pest control methods will be used to repel unwanted plants and animals
In seasons of low precipitation, surface ponds will act as dry ponds to reduce need for maintenance
STORMWATER DETENTION FACILITIES
Bi-annual cleaning of oil/grit chamber using vacuum truck
Annual inspection of oil/grit chamber by certified professionals

7.0 Conclusion

The final design presented in this report is the design team's response to the stormwater problems occurring on UBC's south campus. The design diverts stormwater from UBC's existing storm sewer network into the designed stormwater management system, then filters and discharges it at a controlled rate. The diversion and collection of stormwater is designed to prevent flooding at the intersection of Southwest Marine Drive and Wesbrook Mall, and its controlled discharge is expected to reduce erosion on the environmentally sensitive cliffs of Wreck Beach. The engineering benefits of this project are also complimented by the societal and cultural benefits of an 18-hole miniature golf course that can serve the UBC Vancouver campus for decades. The design team believes that the developed solution meets the project's overarching objectives in an efficient, aesthetically pleasing, and multifunctional way.

Should the client have any questions regarding the contents of this report or next steps such as the tendering process, please contact Haley Oosterman at haley.oosterman@gmail.com

Appendix A: Sample Calculations

1. Excess volume at project node

$From\ SWMM\ output, peak\ flows\ were\ experienced\ during\ timesteps\ from\ 8{:}15\ a.m\ to\ 9{:}15\ a.m.$

$An\ example\ calculation\ for\ excess\ volume\ from\ one\ time\ step:$

$$Volume\ into\ node = Qin * \Delta t = 3\frac{m^3}{s} * (15 * 60)s = 2701.51\ m^3$$

$$Volume\ out\ of\ node = Qout * \Delta t = 1.05\frac{m^3}{s} * (15 * 60)s = 945\ m^3$$

$$Excess\ Volume = Vin - Vout = 2701.51\ m^3 - \ 945\ m^3 = 1756.51\ m^3$$

$The\ summary\ of\ excess\ volume\ generated\ between\ 8{:}15a.m\ to\ 9{:}15a.m:$

Time Step (a.m)	Q_{in}	$V_{in}\ (m^3)$	$V_{out}\ (m^3)$
8:15:00	1192.63	1073.37	945
8:30:00	3001.68	2701.51	945
8:45:00	2039.62	1835.66	945
9:00:00	1418.50	1276.65	945
9:15:00	1131.30	1018.17	945
	$\sum V$	7905.36	4725
	$Excess\ Volume\ (m^3)$	3180.36	

2. Roof slab of oil and grit chambers (Designed using CSA A23.3-14)

- Slab is 47.4m long by 4m wide. These dimensions provide a length to width ratio which is greater than 2, so the slab can be designed using one-way slab principles.
- Supports are positioned such that maximum clear span is 8m
- Soil unit weight = γ_s = 20kN/m^3
- Concrete unit weight =γ_c=23kN/m^3
- Slab is located 2m below ground surface ∴ depth of soil bearing on structure = d= 2m.
- Live Load from area above slab is 4.8kPa
- Minimum clear cover of 75mm for slabs cast against and permanently exposed to earth.
- Maximum aggregate size=a_g= 20mm

$$Minimum\ thickness\ of\ the\ slab\ = h = \frac{l_n}{20} = \frac{8000mm}{20} = 400\ mm$$

Where: l_n= Slab clear span

<u>Factored Loads</u>

$$Dead\ Load\ from\ soil = \ \gamma_s * d * b = 20kN/m^3 * 1m * 1m = 20kN/m$$

Where: b = Width of slab section considered

$$Dead\ Load\ from\ slab\ self\ weight = \ \gamma_s * b * h = \frac{23kN}{m^3} * 1m * .4m = 9.2\ kN/m$$

$$\therefore Dead\ Load = DL = 20kN/m + 9.2kN/m = 29.2kN/m$$

$$Live\ Load\ per\ meter\ length\ of\ slab = LL = 4.8kPa * 1m = 4.8kN/m$$

$$Total\ factored\ load\ on\ slab = 1.25DL + 1.5LL = (1.5 * 29.2) + (1.25 * 4.8)$$

$$\approx 49.8\ kN/m = q$$

$$Maximum\ Factored\ Moment = M_f = \frac{qL^2}{8}\ (for\ simply\ supported)$$

$$L = length\ of\ one\ way\ slab = 8m$$

$$\therefore M_f = \frac{(49.8)(8^2)}{8} \approx\ 398.4\ kN \cdot m$$

$$Maximum\ Factored\ Shear = V_f = \frac{qL}{2} = \frac{49.8 * 8}{2} \approx 199.2kN$$

Flexural Rebar Arrangement

$$Use\ 400mm\ deep\ slab\ with\ 1\ layer\ of\ 30M\ steel\ reinforcement\ and\ 15M\ stirrups\ so,$$

$$effective\ depth = d = 295mm$$

$$Calculate\ steel\ reinforcement\ area\ using\ direct\ approach:$$

$$Area\ of\ Steel\ Required = \ A_s = \frac{\alpha_1 \phi_c f_c' b}{\phi_s f_y}\left(d - \sqrt{d^2 - \frac{2M_r}{\alpha_1 \phi_c f_c' b}}\right)$$

$$= \frac{.8 * .65 * 25 * 1000}{.85 * 400}\left(295 - \sqrt{295^2 - \frac{2 * 398.94 * 10^6}{.8 * .65 * 25 * 1000}}\right) = 5155.83mm^2$$

$$Spacing\ (centre\ to\ centre) = A_b * \frac{1000}{A_s} = 130mm\ < s_{max}\quad OK$$

$$Also\ Passes\ Minimum\ Reinforcement, Strength, and\ Cracking\ Control\ requirements$$

Temperature and Shrinkage Reinforcement

Use 10M reinforcement for temperature and shrinkage

$$A_{smin} = .002A_g = .002 * 1000mm * 400mm = 800mm^2$$

$$Spacing\ (centre\ to\ centre) = \ A_b * \frac{1000}{A_s} \approx 125mm < s_{max}\ \ OK$$

Shear Reinforcement

Check if shear reinforcement is required

$$V_c = \phi_c \lambda \beta \sqrt{f_c'} b_w d_v$$

Where: $d_v = \max(.9d, .72h) = \max(265.5, 288) = 288mm$

$$\beta = \frac{230}{1000 + d_v} = \frac{230}{1288} = .1786$$

$$\lambda = 1\ for\ normal\ density\ concrete$$

$V_c = .65 * 1 * .1786 * \sqrt{25} * 1000 * 288 = 167.14kN < V_r = 199.2kN$ so shear reinforcement is required

$$Assume\ minimum\ shear\ reinforcement, \beta = 0.18, new\ V_c = 168.5kN$$

$$V_s = V_r - V_c = 199.2 - 168.5kN = 30.7kN$$

$$s = \frac{\phi_s A_v f_y d_v cot\theta}{V_s}$$

$$Use\ 15m\ stirrups, A_v = 2 * 200mm^2 = 400mm^2$$

$$s = \frac{.85 * 400mm^2 * 400MPa * 288mm * \cot(35)}{30{,}700N} = 1822mm$$

$$s_{max} = \max(600, .7d_v) = \max\left(600, .7(288)\right) = 600mm$$

$$s > s_{max}, \therefore 15M\ stirrups\ at\ s = 600mm$$

3. Stormwater detention tank reinforced concrete columns (Designed using CSA A23.3-14)

- Assume columns and walls of grit chamber act as simple supports
- Assume columns support three quarters of end reaction (conservative)
- No load eccentricity on columns due to symmetry, e=0
- Unsupported column length of 4m, with both ends pin supported
- Clear span of roof slab between column supports is L=8m
- 20M longitudinal reinforcement with 10M ties
- Square column, 300mmx300mm
- 40mm clear cover on ties

$$Total\ factored\ load\ on\ slab\ (from\ sample\ calculation\ 2) = q = 49.8kN/m$$

$$End\ reactions = V_f = \frac{qL}{2} = \left(\frac{49.8kN}{m}\right) * \frac{8m}{2} = 199.2kN$$

$$Factored\ axial\ load\ on\ each\ column = P_f = \frac{3V_f}{4} = 3 * \frac{199.2kN}{4} = 149.4kN$$

$$Check\ slenderness\ of\ column{:}\ \frac{kl_u}{r} \leq \frac{25-10\left(\frac{M_1}{M_2}\right)}{\sqrt{\frac{P_f}{f_c' A_g}}}$$

Where: $k = 1\ for\ pin - pin\ support$

$$l_u = 4000mm$$

$$r = 0.3h = 0.3 * 350mm = 90mm$$

$$M_1 = M_2 = 0\ (within\ acceptable\ code\ limits)$$

$$A_g = (300mm)^2 = 90000mm^2$$

$$f_c' = 25MPa$$

$$\frac{kl_u}{r} = 1 * \frac{4000mm}{90mm} = 44.44$$

$$\frac{25-10\left(\frac{M_1}{M_2}\right)}{\sqrt{\frac{P_f}{f_c' A_g}}} = \frac{25-0}{\sqrt{\frac{149{,}400N}{25MPa * 90000mm^2}}} = 97.02$$

$$44.44 < 97.02\ so\ column\ can\ be\ designed\ as\ a\ short\ column$$

$$Using\ \frac{P_f}{A_g} = \frac{P_r}{A_g} = \frac{149{,}400N}{90000mm^2} = 1.66\ and\ M_r = 0$$

$$\rho_t = 0.01\ from\ column\ interaction\ diagram$$

$$A_s = \rho_t A_g = 0.01 * 90000mm^2 = 900mm^2 = 3 - 20M\ (use\ 4 - 20M\ for\ symmetry)$$

$$Tie\ spacing{:}\ s \leq \min(16d_b, 48d_s, 300mm) = \min(16 * 20, 48 * 10, 300) = 300mm$$

$$Required\ development\ length\ into\ column\ footing\ (compression) = l_{db}$$

$$l_{db} = .24 * \frac{f_y}{\sqrt{f_c'}} * d_b \leq .044 f_y d_b$$

$$l_{db} = .24 * \frac{400MPa}{\sqrt{25MPa}} * 20mm = 384mm$$

$$.044 f_y d_b = .044 * 400MPa * 20mm = 352mm$$

$$384mm > 352mm\ so\ use\ 352m\ (round\ to\ 350mm)$$

4. Sample calculation for the bottom concrete slab of the ponds in the channels:

$$Ratio\ of\ Length\ to\ Width = \frac{6m}{3m} = 2\ \therefore\ slab\ can\ be\ designed\ as\ one\ way$$

Factored Loads

$$Minimum\ thickness\ of\ the\ slab\ = \frac{l_n}{20} = \frac{6000\ mm}{20} = 300\ mm$$

$Dead\ Load\ per\ meter\ length\ of\ slab\ (DL) = \gamma_c wt$

$\gamma_c = concrete\ unit\ weight = 25.0\ kN/m^3$

$b = width\ of\ slab\ section\ considered = 1m\ (one\ way\ slab)$
$t = thickness\ of\ slab = 0.3\ m$

$\therefore DL = (25.0 * 1 * 0.3) = 7.5\ kN/m$

$Live\ Load\ per\ meter\ length\ of\ slab\ (LL) = \gamma_w db$

$\gamma_w = water\ unit\ weight = 9.81\ kN/m^3$

$d =\ depth\ of\ water\ above\ slab =\ 1m$
$b = width\ of\ slab\ section\ considered = 1m\ (one\ way\ slab)$
$\therefore LL = (9.81 * 1 * 1) = 9.81\ kN/m$

$Total\ factored\ load\ on\ slab = 1.5DL + 1.25LL = (1.5 * 7.5) + (1.25 * 9.81)$

$= 23.51\ kN/m$

$$Total\ Factored\ Moment = M_f = \frac{qL^2}{8}\ (assume\ simply\ supported)$$

Where: $q = total\ factored\ load\ on\ slab = 23.51\ kN/m$
$L = length\ of\ one\ way\ slab = 6m$

$$\therefore M_f = \frac{(23.51)(6^2)}{8} =\ 105\ kN \cdot m$$

Slab Geometry

$Concrete\ Cover\ =\ 75\ mm\ for\ a\ structure\ permanently\ exposed\ to\ earth$

$$Effective\ depth =\ d\ =\ t\ -\ cover\ -\ \frac{d_b}{2}$$

$d_b =\ diameter\ of\ longitudinal\ rebar\ = 15mm\ (15M)$

$$d = 300mm\ -\ 75mm\ -\ \frac{15mm}{2} =\ 217.5\ mm\ \approx\ 215\ mm$$

$$Area\ of\ Steel\ Required = A_s = \frac{\alpha_1 \phi_c f_c' b}{\phi_s f_y}\left(\mathrm{d} - \sqrt{d^2 - \frac{2M_r}{\alpha_1 \phi_c f_c' b}}\right)$$

$$A_s = 1.53 * 10^{-3} * 25MPa * 1000mm(215mm - \sqrt{(215mm)^2 - \frac{3.85 * 105x10^6 Nmm}{25MPa * 1000mm}}) = 1592\ mm^2$$

$$A_s \rightarrow 2000\ mm^2 \rightarrow 10 - 15M$$

$$s = 85\ mm$$

Structural Checks

$$A_{s_{min}} = 0.002 * b * h = 0.002 * 1000mm * 300mm = 600mm^2$$

$$s_{max} = \frac{1000mm * A_b}{A_s} = \frac{1000mm * 200mm^2}{2000mm^2} = 100mm$$

$$b_{min} = (\#\ of\ bars) * d_b + (\#\ of\ bars - 1) * s$$

$$b_{min} = (10 * 15mm) + (9 * 85mm) = 915mm$$

$$depth\ of\ compression\ zone = a = \frac{\phi_s f_y A_s}{\alpha_1 \phi_c f_c' b}$$

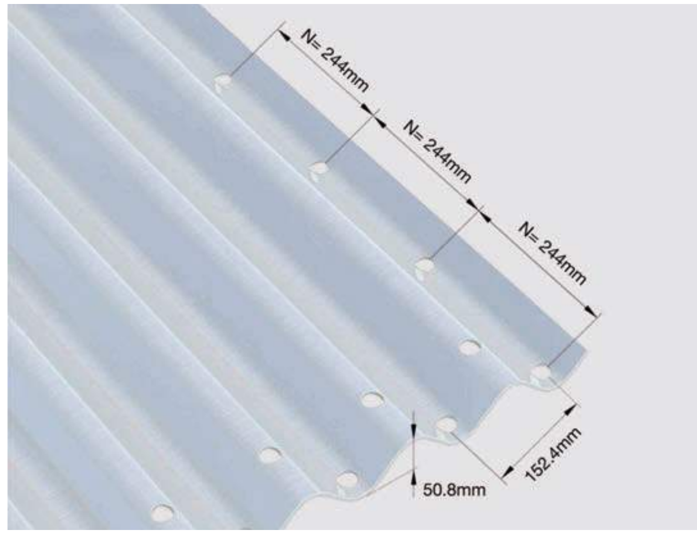
$$a = \frac{0.85 * 400 * 2000}{0.8 * 0.65 * 25 * 1000} = 52.3\ mm$$

$$M_r = \phi_s f_y A_s (d - \frac{a}{2}) = 0.85 * 400 * 2000(215 - \frac{52.3}{2}) = 128.4\ kN * m$$

Appendix B: Design Specifications

Engineering Parameters

Design Codes



CorPlate structures are engineered using industry recognized design codes for soil-metal buried structures. The analysis and design is completed in accordance with the specific requirements of Section Seven of the CAN/CSA S6 Canadian Highway Bridge Design Code pertaining to soil-metal structures.

For jurisdictions outside of Canada, or as requested by an owner, other industry accepted design codes are available:

- AISI (American Iron and Steel Institute)
- AASHTO (American Association of State Highway Transportation Officials)
- ASTM (American Society for Testing and Materials)

Section properties for Corrugated Structural Plate

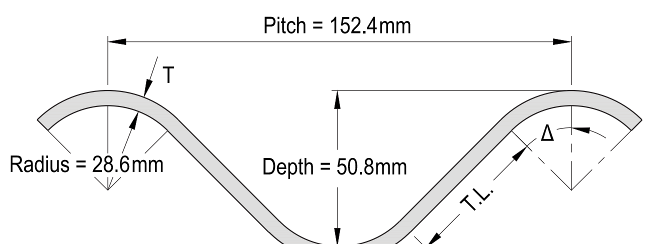
Wall Thickness		Area	Tangent Length	Tangent Angle	Moment of Inertia	Section Modulus	Radius of Gyration
Specified	Design						
T	T	A	TL	Δ	I	S	r
mm	mm	mm^2/mm	mm	Degrees	mm^4/mm	mm^3/mm	mm
3.0	2.84	3.522	47.876	44.531	1057.25	39.42	17.326
4.0	3.89	4.828	46.748	44.899	1457.56	53.30	17.375
5.0	4.95	6.149	45.582	45.286	1867.12	66.98	17.425
6.0	6.00	7.461	44.396	45.686	2278.31	80.22	17.475
7.0	7.00	8.712	43.237	46.083	2675.11	92.56	17.523

Dimensions are subject to manufacturing tolerances

Material and Manufacturing Specifications

The material and fabrication of Canada Culvert's CorPlate structures follows the requirements for structural plate in accordance with the most current version of the CSA Standard G401 – Corrugated Steel Pipe Products.

For specific components, the following specifications are used in accordance with the CSA G401 as previously described:



Corrugation Profile: 152 x 51mm

Reference Specifications	
Plates	ASTM A761/A761M
Bolts	ASTM A449
Nuts	ASTM A563
Hook Bolts	ASTM F1554
Galvanizing	CAN/CSA-G164-M92
Polymer Coating	CAN/CSA G401

Coatings

Coatings that stand up to any environment

Canada Culvert offers four finishes that provide a range of performance levels from temporary applications to severe environmental conditions. Black steel can be used for temporary or short-term applications; Z915 is the industry standard galvanized coating; Z1220 is a heavier galvanized coating, or a thermoplastic copolymer.

Black Steel

Black steel structures are ideal for temporary work or short-term projects where CorPlate structures will be removed. Since the structures are not coated in zinc, significant savings can be gained in both dollars and, delivery time.

Galvanized Z915

Z915 galvanized (915 g/m^2) is a hot-dip zinc coating that forms a superior barrier over steel. Calcium attracted from naturally hard water can aid in providing additional protection as it develops mineral scale on the pipe surface. As the zinc coating corrodes slowly over time, it galvanically protects the base steel as long as any zinc remains.

Galvanized Z1220

The Z1220 coating consists of 1220 g/m^2 zinc total on both sides. This heavier galvanized coating offers increased abrasion and corrosion resistance by forming an impervious barrier between the steel and the environment. Since it is a heavier coating, the Z1220 will add years of extended protection in environments where standard galvanized coatings can't be used.

Thermoplastic Copolymer

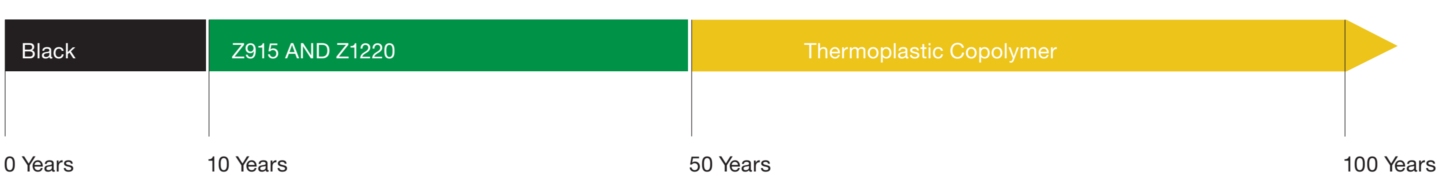
This unique solvent free two coat system gives two layers of protection. The base coat zinc layer provides outstanding corrosion resistance while being completely sealed from the environment by the top coat ethylene acrylic acid copolymer, which ensures superior resistance to impact, corrosion, abrasion and an inorganic acid or alkali (diluted). CorPlate structure with a thermoplastic copolymer coating is a great alternative to concrete because it is significantly lighter and offers a long-term service life from 75 to 100 years in aggressive environments.

Environmental Limits for Galvanized Steel and Thermoplatic Copolymer Coated Steel

Environmental Parameter	Suggested Limits Galvanized Steel	Suggested Limits for Thermoplastic Copolymer Coated Steel		
		50 Year EMSL	75 Year EMSL	100 Year EMSL
pH Preferred Range	5 - 9	3 to 12	4 to 9	5 to 9
Resistivity[1]	2,000 - 8,000 ohm-cm	> 100 ohm-cm	> 750 ohm-cm	> 1,500 ohm-cm
Chlorides	< 250 ppm	NA [1]	NA [1]	NA [1]
Sulfates	< 600 ppm	NA [1]	NA [1]	NA [1]
Hardness	> 80 ppm $CaCO_3$	NA [1]	NA [1]	NA [1]

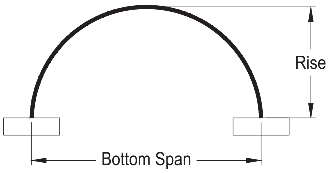
[1]*Resistivity is relative to total dissolved solids (TDS) and therefore may indicate the presence of chlorides, sulfates, calcium and other ions*

Estimated Material Service Life
(Typical Ranges) [2]



[2]*Actual estimated material service life (EMSL) is dependent on local environment conditions*

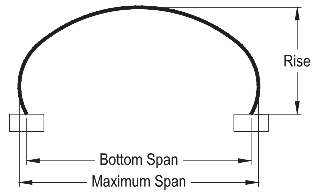
Arch



Structure #	Bottom Span (mm)	Rise (mm)	End Area (m^2)
CP-A-1	1520	810	0.98
CP-A-2	1830	840	1.16
CP-A-3	1830	970	1.39
CP-A-4	2130	860	1.39
CP-A-5	2130	1120	1.86
CP-A-6	2440	1020	1.86
CP-A-7	2440	1270	2.42
CP-A-8	2740	1180	2.46
CP-A-9	2740	1440	3.07
CP-A-10	3050	1350	3.16
CP-A-11	3050	1600	3.81
CP-A-12	3350	1360	3.44
CP-A-13	3350	1750	4.65
CP-A-14	3660	1520	4.18
CP-A-15	3660	1910	5.48
CP-A-16	3960	1680	5.02
CP-A-17	3960	2060	6.50
CP-A-18	4270	1840	5.95
CP-A-19	4270	2210	7.43
CP-A-20	4570	1870	6.41
CP-A-21	4570	2360	8.55
CP-A-22	4880	2030	7.43

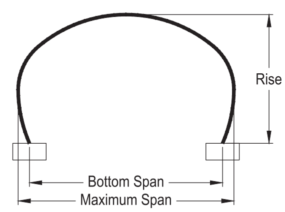
Structure #	Bottom Span (mm)	Rise (mm)	End Area (m^2)
CP-A-23	4880	2520	9.75
CP-A-24	5180	2180	8.55
CP-A-25	5180	2690	11.06
CP-A-26	5490	2210	9.01
CP-A-27	5490	2720	11.71
CP-A-28	5790	2360	10.22
CP-A-29	5790	2880	13.01
CP-A-30	6100	2530	11.52
CP-A-31	6100	3050	14.59
CP-A-32	6400	3195	16.04
CP-A-33	6400	2685	12.93
CP-A-34	6700	3350	17.64
CP-A-35	6700	2845	14.38
CP-A-36	7000	3510	19.31
CP-A-37	7000	3005	15.91
CP-A-38	7300	3670	21.06
CP-A-39	7300	3030	16.62
CP-A-40	7600	3825	22.89
CP-A-41	7600	3190	18.26
CP-A-42	8000	4080	25.76
CP-A-43	8000	3315	19.92

Low Profile Arch



Structure #	Max Span (mm)	Bottom Span (mm)	Rise (mm)	End Area (m^2)
CP-LPA-1	5920	5820	2080	9.75
CP-LPA-2	6120	6050	2290	11.18
CP-LPA-3	6550	6500	2360	12.39
CP-LPA-4	6780	6730	2410	13.01
CP-LPA-5	7010	6930	2440	13.64
CP-LPA-6	7240	7160	2490	14.29
CP-LPA-7	7470	7390	2540	14.94
CP-LPA-8	7670	7620	2570	15.62
CP-LPA-9	7900	7850	2620	16.30
CP-LPA-10	8310	8150	3280	22.04

High Profile Arch



Structure #	Max Span (mm)	Bottom Span (mm)	Rise (mm)	End Area (m^2)
CP-HPA-1	6300	5740	3680	19.85
CP-HPA-2	6550	6050	3560	19.93
CP-HPA-3	6780	6270	3610	20.85
CP-HPA-4	7010	6530	3660	21.78
CP-HPA-5	7240	6760	3680	22.71
CP-HPA-6	7670	7230	3740	24.61
CP-HPA-7	7870	6920	4655	31.56
CP-HPA-8	8100	7190	4650	32.78
CP-HPA-9	8560	7500	5020	36.92
CP-HPA-10	8590	7750	4630	34.09

Installation and Foundations

Installation

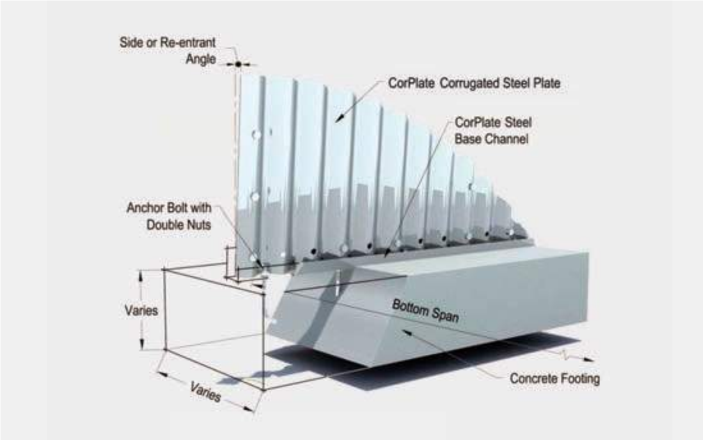
CorPlate structures are easy to assemble and backfill using local labour forces. Shop/assembly drawings, which are the clearest and most detailed assembly drawings in the industry, accompany every structure that is shipped to a jobsite. The drawings, along with a detailed installation guide and assistance from Canada Culvert, ensure that everyone from the contractor, owner and inspector know what is required for a successful installation.

Unloading

CorPlate structures are typically shipped to the job site on a flat deck truck. Since the corrugated plates are nested (stacked) in bundles and the bolts are in pails on skids, most typical structures can easily fit on one truck. Unloading is best done with a rubber tire loader that has forks.

Assembly

The most common practice is to assemble CorPlate structures component by component in the field. At the job site the structures can be assembled in the final location or preassembled in a staging area, then lifted into the final location with a crane. Sometimes it is desirable for small structures to be assembled in the shop by Canada Culvert and shipped as a single unit to the job site.



Foundation

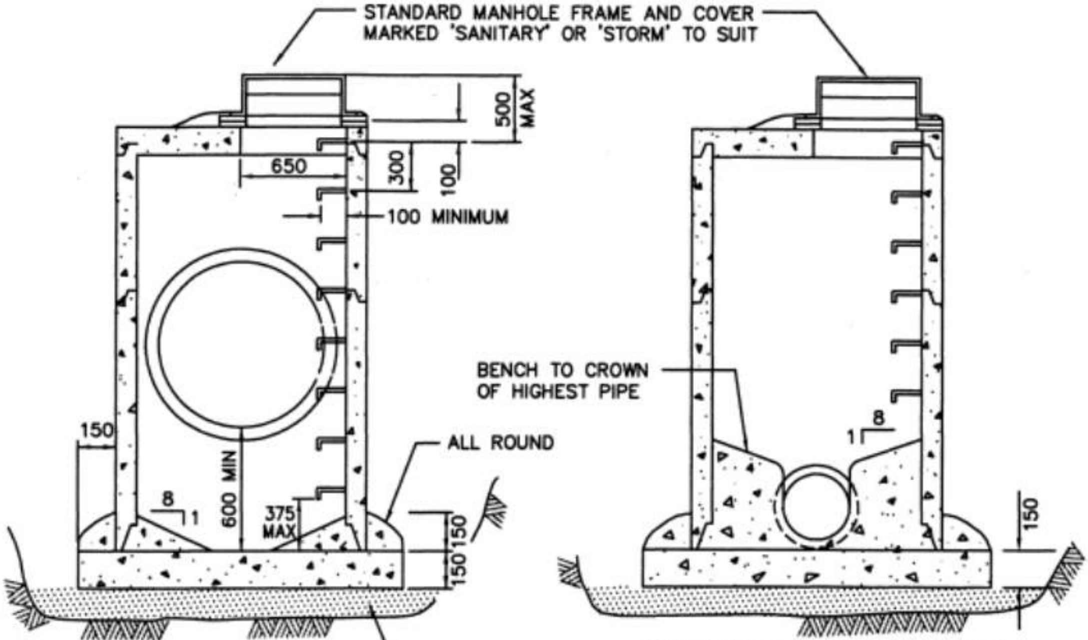
Concrete Footing

Cast-in-place or pre-cast concrete footings have the base channel embedded into the concrete using anchor bolts. These can be constructed in various configurations such as strip or stem footings.

Foundation

Corrugated Steel Footing

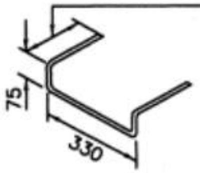
Corrugated steel footings are an excellent alternative solution to concrete footings for remote projects or where the speed of installation is very important to minimize the time of a road closure.



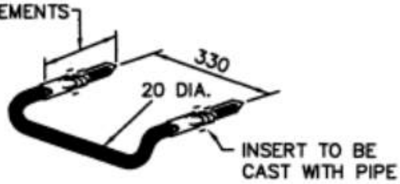
MANHOLE WITH SUMP

STANDARD 1050mm MANHOLE

INSIDE PIPE DIA.	INSIDE MANHOLE DIA.
450mm AND LESS	1050
525 AND 600	1200
675 AND 750	1350
900 AND 1050	1500
1200 AND OVER	RISER MANHOLE



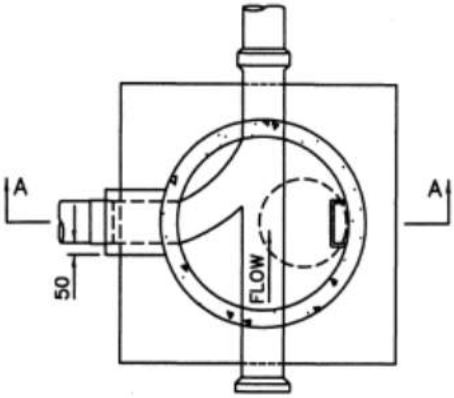
GALVANIZED LADDER RUNG TO BE CAST WITH PIPE



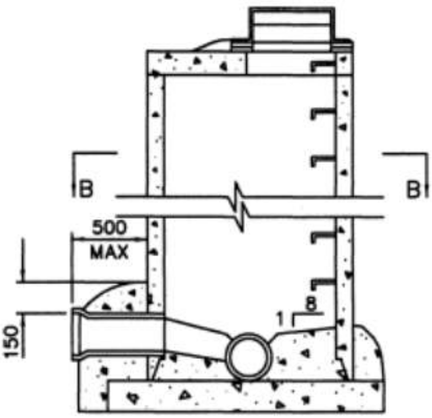
GALVANIZED, ALUMINUM OR POLY-ENCASED LADDER RUNG

NOTE:

1. DETAILS ARE DRAWN FOR PRECAST RISERS ON CAST-IN-PLACE BASE. PRECAST BASES APPROVED BY CONTRACT ADMINISTRATOR ARE ACCEPTABLE.
2. MAXIMUM DEPTH TO FIRST RUNG IS 500mm. WHEN HANDHOLD IS INSTALLED BETWEEN TOP AND FIRST RUNG, MAXIMUM DEPTH MAY BE INCREASED TO 660mm
3. FOR MANHOLES OVER 1200mm DIA. BASE THICKNESS TO BE 200mm.
4. REFER TO DRAWING S2 FOR CONNECTION DETAILS.
5. REFER TO CONTRACT DRAWINGS AND SECTION 02725 FOR DETAILED SPECIFICATIONS.



SECTION B–B



SECTION A–A

NOTE: 1. THIS DRAWING SHOWS CONNECTION DETAILS ONLY, REFER TO DRAWING S1 FOR ALL OTHER DETAILS PERTAINING TO MANHOLE REQUIREMENTS AND INSTALLATION

2. REFER TO CONTRACT DRAWINGS AND SECTION 02725 FOR DETAILED SPECIFICATIONS.

2001

STANDARD MANHOLE CONNECTION DETAILS

DRAWING NUMBER: **S2**

OCEAN Pipe

9265 Oak Street, Vancouver BC
Phone: (604) 269-6700
Fax: (604) 261-6751
www.oceanpipe.com

CUSTOMER: UBC

PROJECT: UBC South Campus

ORDER DATE: N/A

DATE REQUIRED: N/A

MANHOLE N°: S6D-S26B

TAKE OFF BY: Haley Oosterman

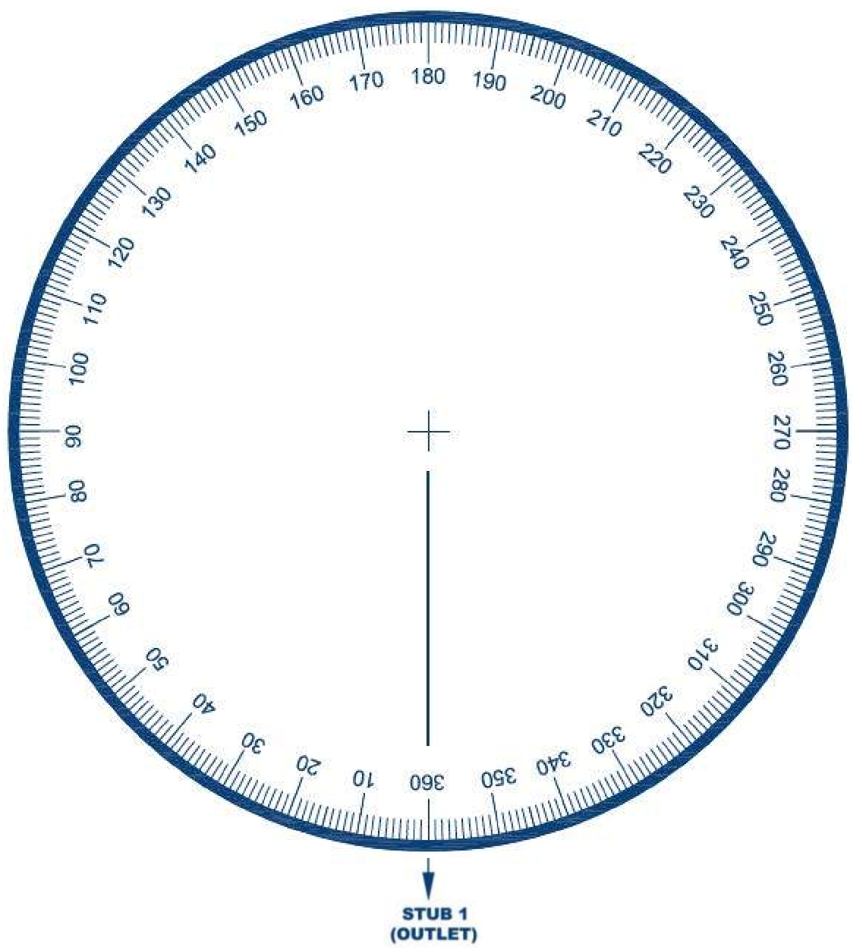
RIM ELEVATION
59.18

TYPE OF BASE	Prebenched Extended Base
DIAMETER OF MANHOLE	2400mm

SUMP
0 M

	STUB 1 Outlet	STUB 2 Select...	STUB 3 Select...	STUB 4 Select...	STUB 5 Select...
ALIGNMENT	0°	90 deg.	180 deg.		
DIAMETER	1050mm	1050mm	1050mm		
MATERIAL	CIV Concrete	CIV Concrete	CIV Concrete		
GRADE	2%	0.1%	2%		
INVERT	55.04m	54.89m	55.08		

NOTES:



These new Standard Installations identify four principal zones (which are critical to the pipe-soil system) surrounding the lower half of the pipe. The four zones – middle bedding, outer bedding, haunch and lower side – are shown in Figures 1 and 2 for trench and embankment installations. The type of material (based on soil characteristics) and level of compaction varies with the installation type, i.e., 1, 2, 3, or 4, and the material utilized in construction of these important zones.

Installation – Type 4 Type 4 is intended for installations where the most cost effective design approach is to specify minimal requirements for soil type and compaction, together with a pipe having sufficient strength to safely resist the increased structural effects that result from using low quality soils. Thus, Type 4 has little or no requirement for control of compaction and type of placed soil used in the bedding and haunch areas, except if silty clay soils are used in the haunch and outer bedding zones, they must be compacted. It is desirable to scarify (loosen) hard native soils before placing pipe.

Installation – Type 3 Type 3 permits the use of soils in the haunch and bedding zones having easily attained compaction requirements, justifying less stringent inspection requirements with granular and some native soils. Silty clays may be used in the haunch zone if adequately compacted. In addition to the foundation similar to Type 4, a bedding layer with a minimum thickness of 3 inches is required to avoid placing the pipe directly on hard or variable subgrade.

Installation – Type 2 Type 2 is a standard installation where certain native soils are permitted to be used with proper compaction in the haunch and bedding zones. Adequately compacted native silty granular soils or select granular soils may be used in the haunch and outer bedding zones. This is intended to allow the use of soil frequently found at a site. Any natural soil adjacent to the pipe should have a firmness equivalent to the placed soils. Foundation and bedding requirements are similar to Type 3.

Installation – Type 1 Type 1 requires well compacted, select granular soil to be placed in the haunch and bedding zones. The structural design of the pipe section then takes advantage of the support provided by this high quality soil envelope, making this installation often the most cost effective for pipe 60 inches in diameter and larger in deep fills.

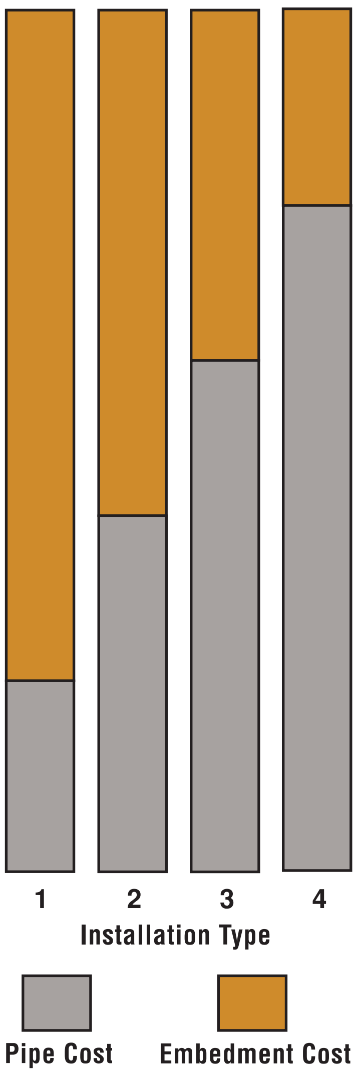
Beneficial Characteristics

Versatile - One can choose between installation types and pipe strengths (classes) to suit specific site conditions and budgetary constraints. The four standard installations can be used to optimize the total installed cost by evaluation of the ratio of pipe cost to backfill material cost.

Conservative - Analyses are based on the worst case (embankment) loadings, voids in the haunch zone, the greatest predicted loads, and measurable requirements that more accurately assess long-term performance of the system.

Quantifiable – Definite and measurable levels of acceptance are prescribed, which provides better direction for the designer and the contractor.

Relative Comparison Embedment vs Pipe Cost

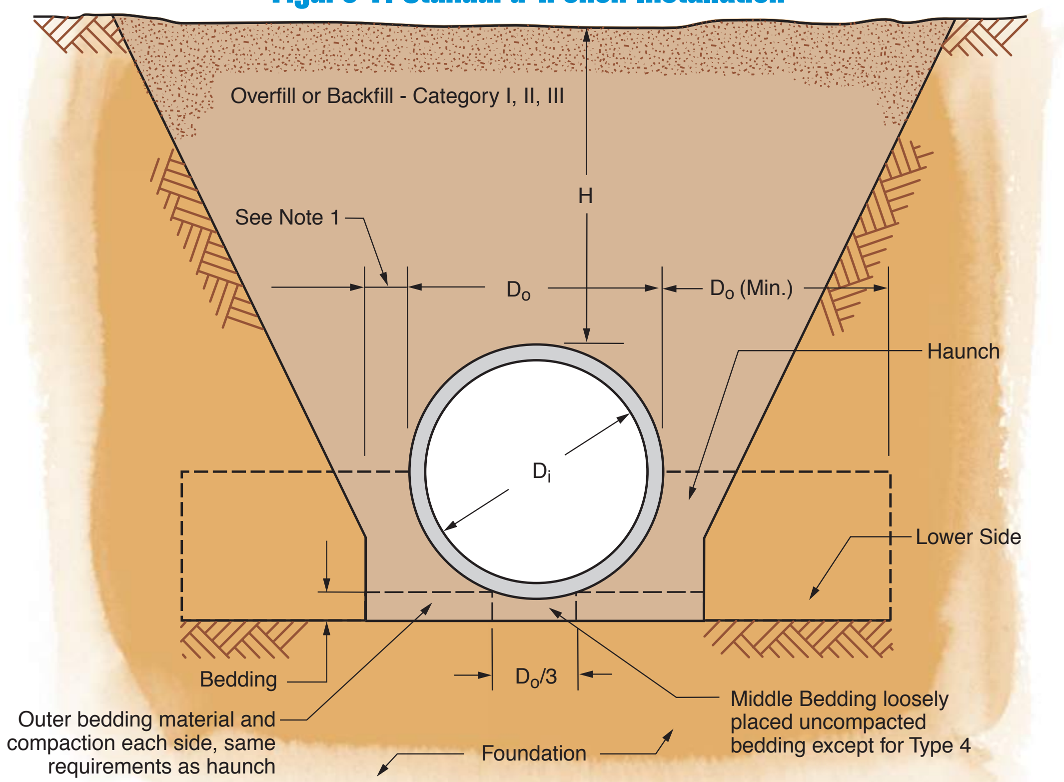


Equivalent USCS and AASHTO Soil Classifications for Soil Designations

Soil	Representative Soil Types		Percent Compaction	
	USCS ASTM D 2487	AASHTO M 145	Standard Proctor	Modified Proctor
Category I	Clean, course grained soils: SW, SP, GW, GP or any soil beginning with one of those symbols with 12% or less passing a #200 sieve	A-1, A-3	100 95 90 85	95 90 85 80
Category II	Course grained soils with fines: GM, GC, SM, SC or any soil beginning with one of these symbols, containing more than 12% passing a #200 sieve; Sandy or gravelly fine–grained soils: CL, ML, (or CL-ML, CL/ML, ML/CL) with 30% or more retained on a #200 sieve	A-2-4, A-2-5, A-2-6: or A-4 or A-6 soils with 30% or more retained on a #200 sieve	100 95 90 85	95 90 85 80
Category III	Fine-grained soils: CL, ML, (or CL-ML, CL/ML, ML/CL) with less than 30% retained on a #200 sieve	A-2-7: or A-4 or A-6 with less than 30% retained on a #200 sieve	100 95 90 85	90 85 80 75
Category IV but not allowed for haunch or bedding	MH, CH, OL, OH, PT	A-5, A-7	100 95 90	90 85 80

NOTE 1: Compaction Specifications:
Standard proctor density – AASHTO T 99, T 310, or Test Methods D 698
Modified proctor density – AASHTO T 180 or Test Methods D 1557

Figure 1. Standard Trench Installation



Note 1: Clearance between pipe and trench wall shall be adequate to enable specific compaction, but not less than $D_o/6$.

SOIL AND MINIMUM COMPACTION REQUIREMENTS

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	$D_0/24$ minimum; not less than 3 in. If rock foundation, use $D_0/12$ minimum; not less than 6 in.	95% Category I	Undisturbed natural soil with firmness equivalent to the following placed soils: 90% Category I, 95% Category II, or 100% Category III, or embankment to the same requirements
Type 2	$D_0/24$ minimum; not less than 3 in. If rock foundation, use $D_0/12$ minimum; not less than 6 in.	90% Category I or 95% Category II	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 3	$D_0/24$ minimum; not less than 3 in. If rock foundation, use $D_0/12$ minimum; not less than 6 in.	85% Category I, 90% Category II, or 95% Category III	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 4	No bedding required, except if rock foundation, use $D_0/12$ minimum; not less than 6 in.	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

Note 1. Compaction and soil symbols, i.e. 95% Category I, refer to a soil material category with a minimum standard proctor density. See Table on page 4 for equivalent modified proctor values and soil types.

Note 2. When the trench width specified must be exceeded, the owner shall be notified.

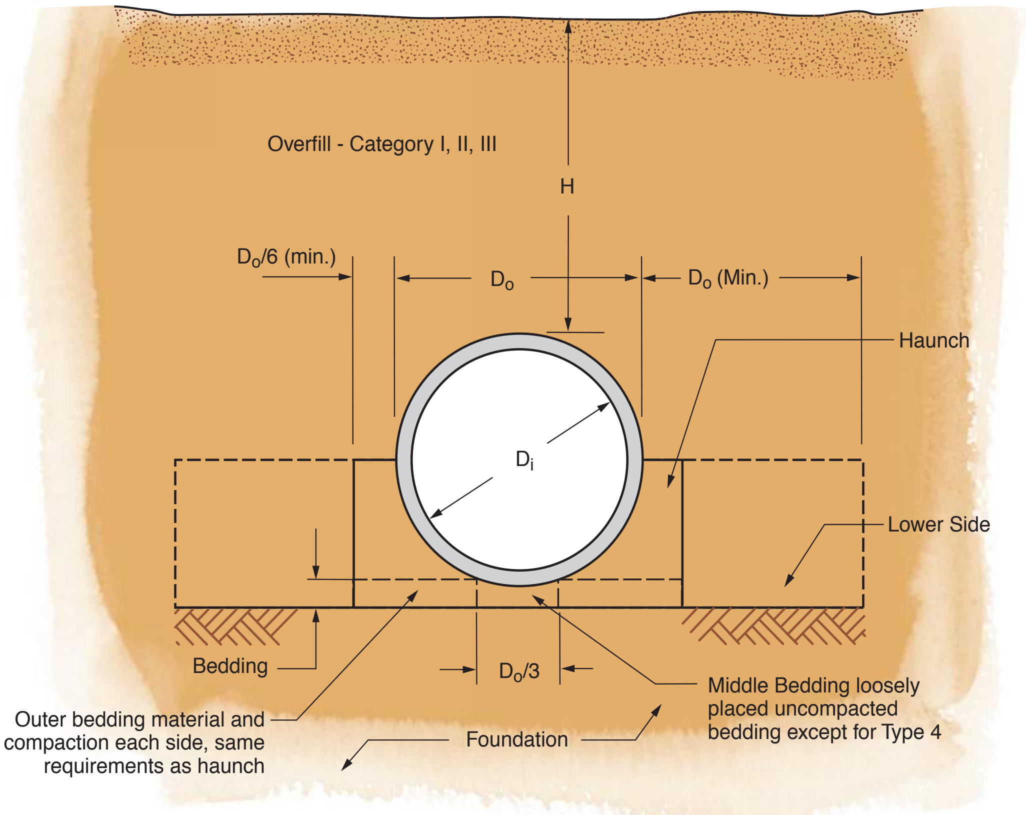
Note 3. The trench width shall be wider than shown if required for adequate space to attain the specified compaction in the haunch and bedding zones.

Note 4. Embankment loading shall be used when trench walls consist of embankment unless a geotechnical analysis is made and the soil in the trench walls is compacted to a higher level than the soil in the backfill zone.

Note 5. Required bedding thickness is the thickness of the bedding prior to placement of the pipe.

Note 6. "Dumped" material without additional compactive effort will not provide the design haunch support required for Type 1 and 2 installations and it should be checked for Type 3 installations.

Figure 2. Standard Embankment Installation



SOIL AND MINIMUM COMPACTION REQUIREMENTS

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	D_0/24 minimum; not less than 3 in. If rock foundation, use D_0/12 minimum; not less than 6 in.	95% Category I	90% Category I, 95% Category II, or 100% Category III
Type 2	D_0/24 minimum; not less than 3 in. If rock foundation, use D_0/12 minimum; not less than 6 i	90% Category I or 95% Category II	85% Category I, 90% Category II, or 95% Category III
Type 3	D_0/24 minimum; not less than 3 in. If rock foundation, use D_0/12 minimum; not less than 6 in.	85% Category I, 90% Category II, or 95% Category III	85% Category I, 90% Category II, or 95% Category III
Type 4	No bedding required, except if rock foundation, use D_0/12 minimum; not less than 6 in.	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

Note 1. Compaction and soil symbols, i.e. 95% Category I, refer to a soil material category with a minimum standard proctor density. See Table on page 4 for equivalent modified proctor values and soil types.

Note 2. Soil in the outer bedding, haunch, and lower side zones, except within D_O/3 from the pipe springline, shall be compacted to at least the same compaction as the majority of soil in the overfill zone.

Note 3. Required bedding thickness is the thickness of the bedding prior to placement of the pipe.

Note 4. A subtrench is defined as a trench with its top below finished grade by more than 0.1H or, for roadways, its top is at an elevation lower than 1 ft below the bottom of the pavement base material.
The minimum width of a subtrench shall be 1.33 D_O or wider, if required for adequate space to attain the specified compaction in the haunch and bedding zones.
For subtrenches, except within D_O/3 from the springline, any portion of the lower side zone in the subtrench wall shall be at least as firm as an equivalent soil placed to the compaction requirements specified for the lower side zone and as firm as the majority of soil in the overfill zone, or it shall be removed and replaced with soil compacted to the specified level.

Note 5. “Dumped” material without additional compactive effort will not provided the design haunch support required for Type 1 and 2 installations and it should be checked for Type 3 installations.

STANDARDS:

- ASTM C 1479 Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations
- AASHTO Standard Specifications for Highway Bridges
- ASCE 15 Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)

REFERENCES:

- Concrete Pipe Technology Handbook
- Concrete Pipe Design Manual
- Concrete Pipe Handbook
- Design Data 40
  (American Concrete Pipe Association Publications)

OCEAN Pipe
9265 Oak Street, Vancouver BC
Phone: (604) 269-6700
Fax: (604) 261-6751
www.oceanpipe.com

CUSTOMER: UBC
PROJECT: UBC South Campus
ORDER DATE: N/A
DATE REQUIRED: N/A
MANHOLE Nº: T6D-S25
TAKE OFF BY: Haley Oosterman

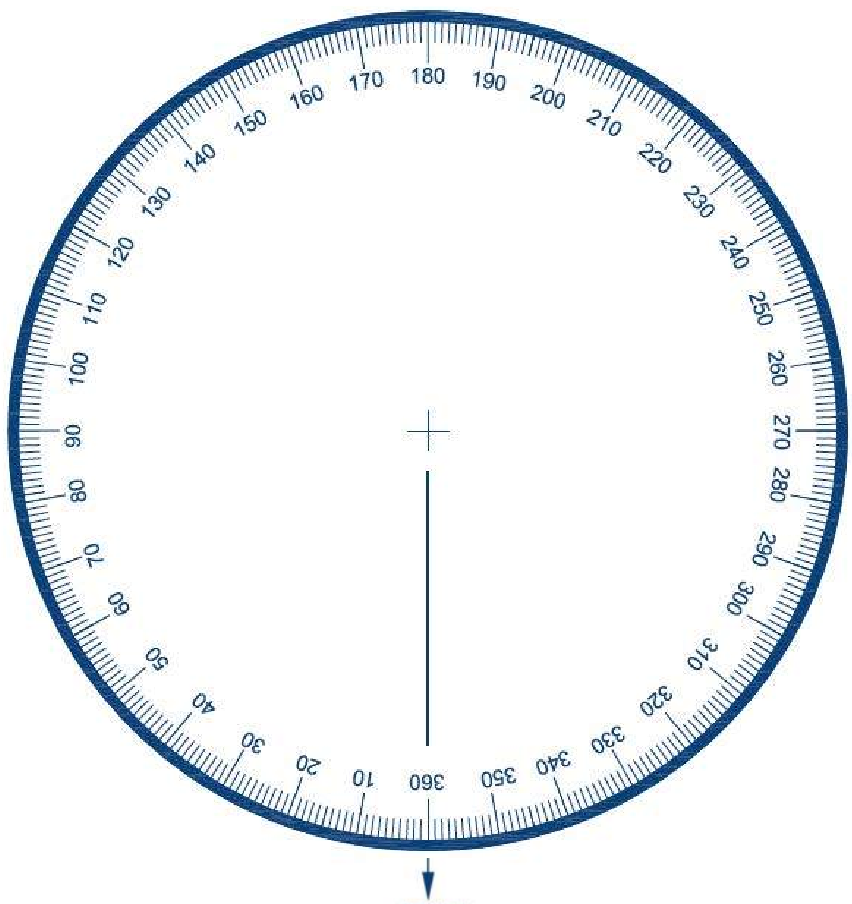
RIM ELEVATION
53.49

TYPE OF BASE	Prebenched Extended Base
DIAMETER OF MANHOLE	2400mm

SUMP
0 M

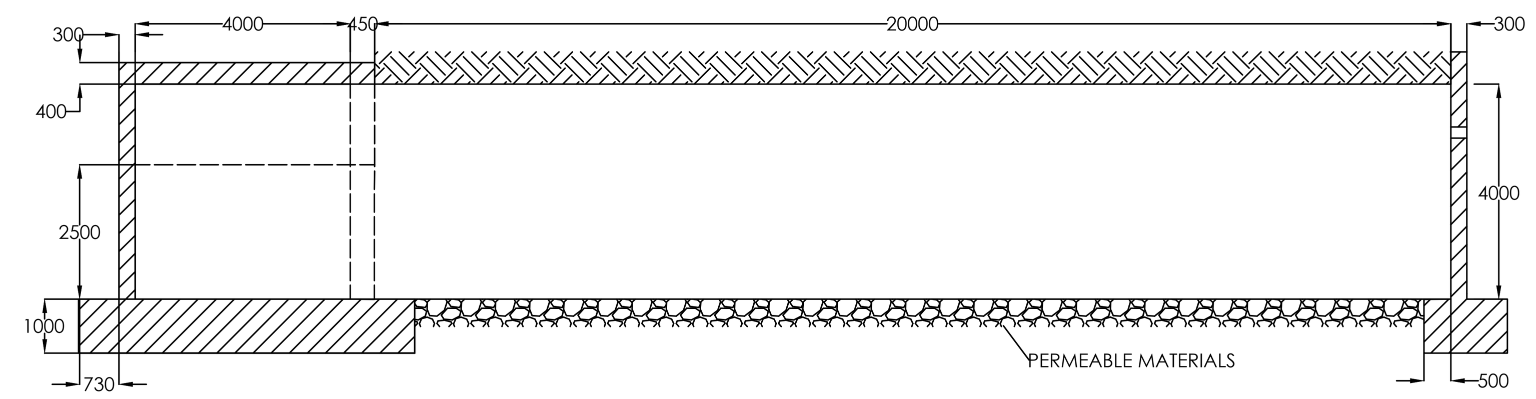
	STUB 1 Outlet	STUB 2 Inlet	STUB 3 Inlet	STUB 4 Select...	STUB 5 Select...
ALIGNMENT	0°	135 deg.	225 deg.		
DIAMETER	1050mm	750mm	1050mm		
MATERIAL	CIV Concrete	CIV Concrete	CIV Concrete		
GRADE	2%	0.5%	2%		
INVERT	51.21m	51.25m	51.25m		

NOTES:

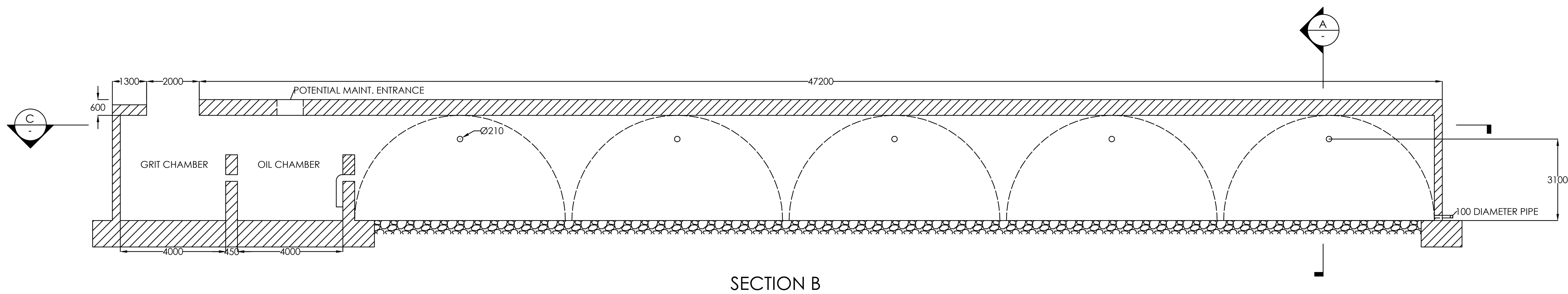


Appendix C: Engineering Drawings

PRODUCED BY AN AUTODESK STUDENT VERSION



SECTION A
SCALE: N/A



SECTION B
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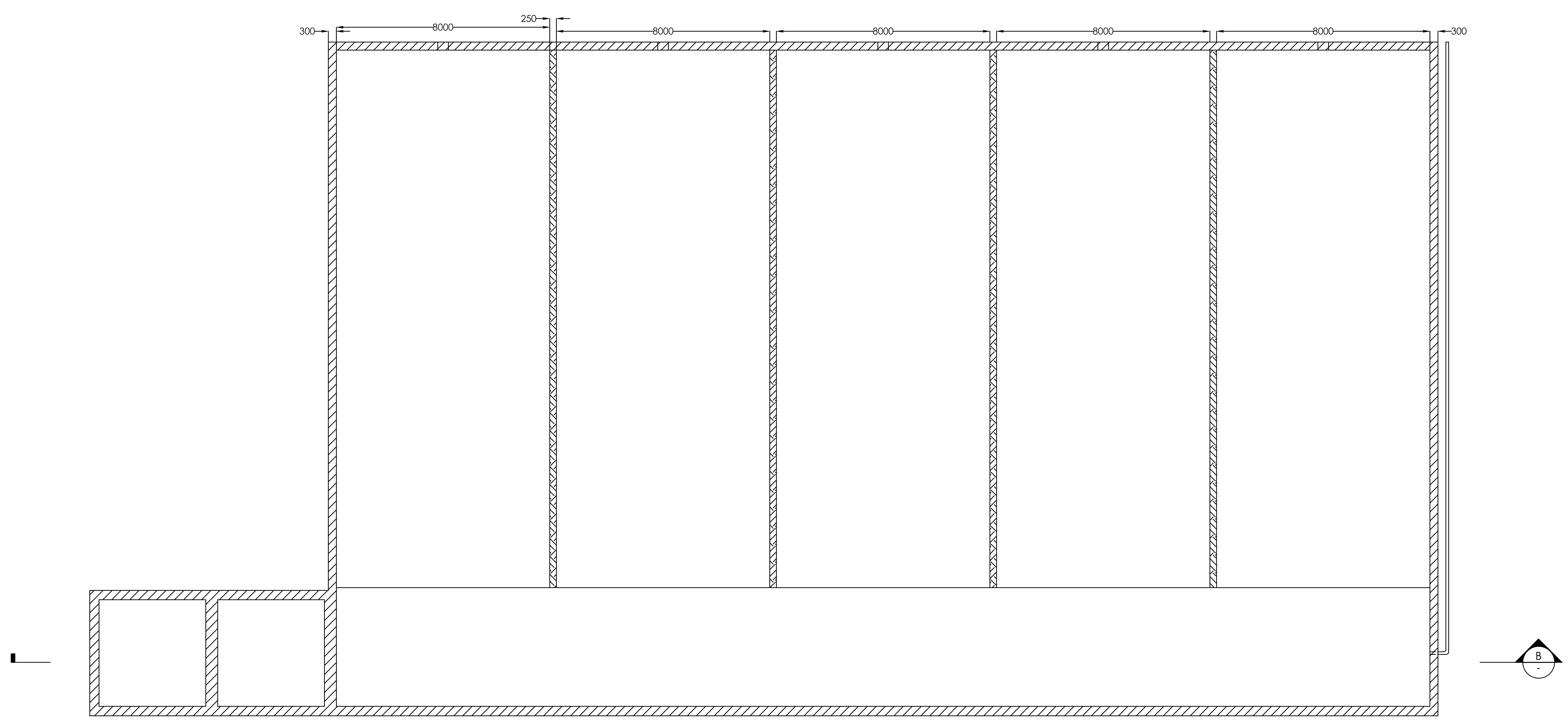


SECTION C
SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
D	FIXED OUTLET DIAMETERS & ADDED ANNOTATIONS	KM	11-28-2018
C	REVISED DIMENSIONS & ADDED ADDITIONAL DESIGN DETAILS	KM	11-26-2018
B	REMOVED PUMP INTAKE	KM	11-19-2018
A	PRELIMINARY DESIGN DRAFT	KM	11-13-2018

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

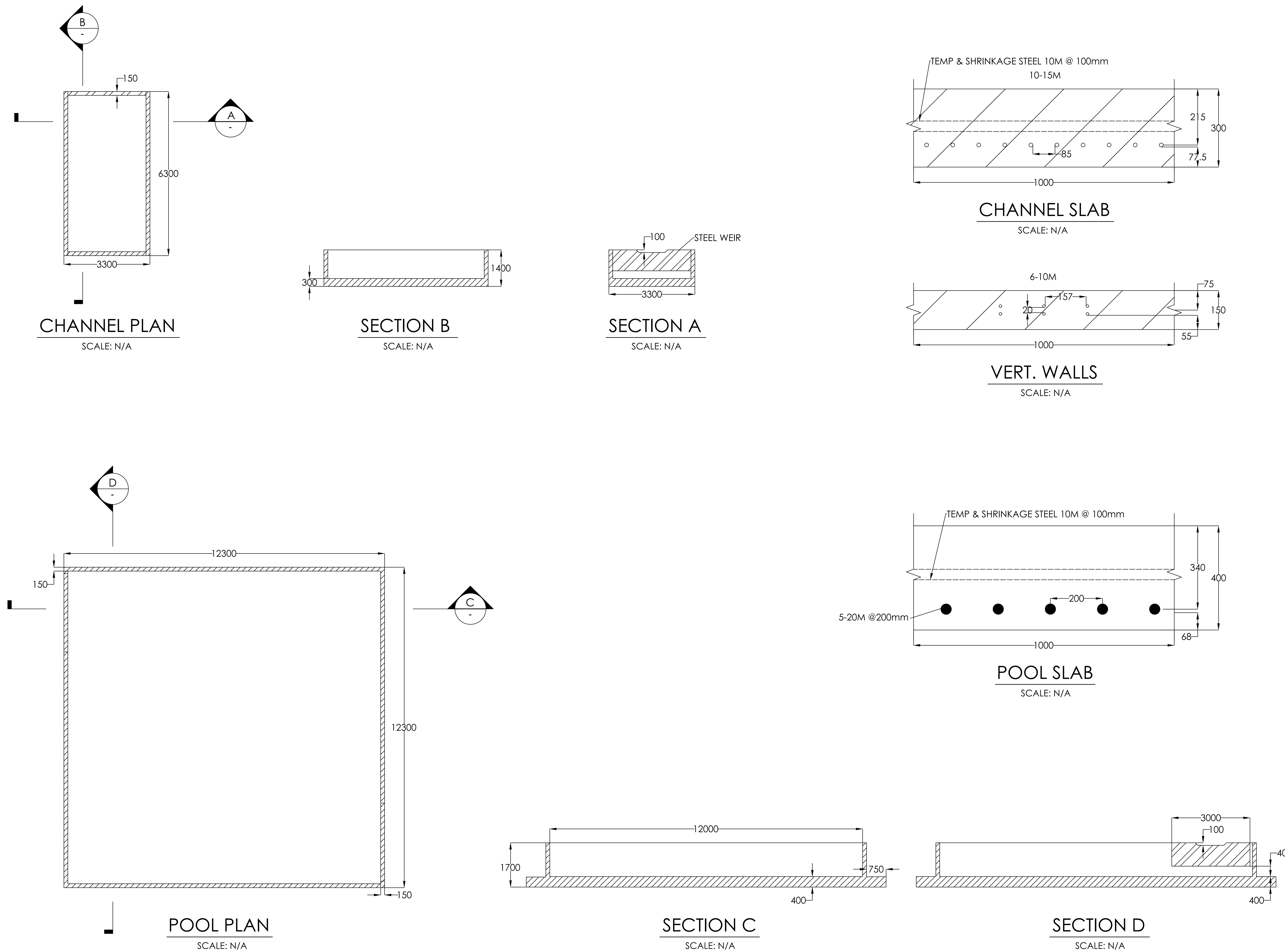
TITLE: STORMWATER TANK LAYOUT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-001	D

PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION



Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
D	ADDED TEMP. & SHRINKAGE STEEL	KM	02-03-2019
C	FIXED INCORRECT DIMENSIONS	KM	11-28-2018
B	ADDED WEIR	KM	11-27-2018
A	PRELIMINARY DESIGN DRAFT	KM	11-19-2018

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: SURFACE POOLS AND CHANNEL LAYOUTS

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-002	D

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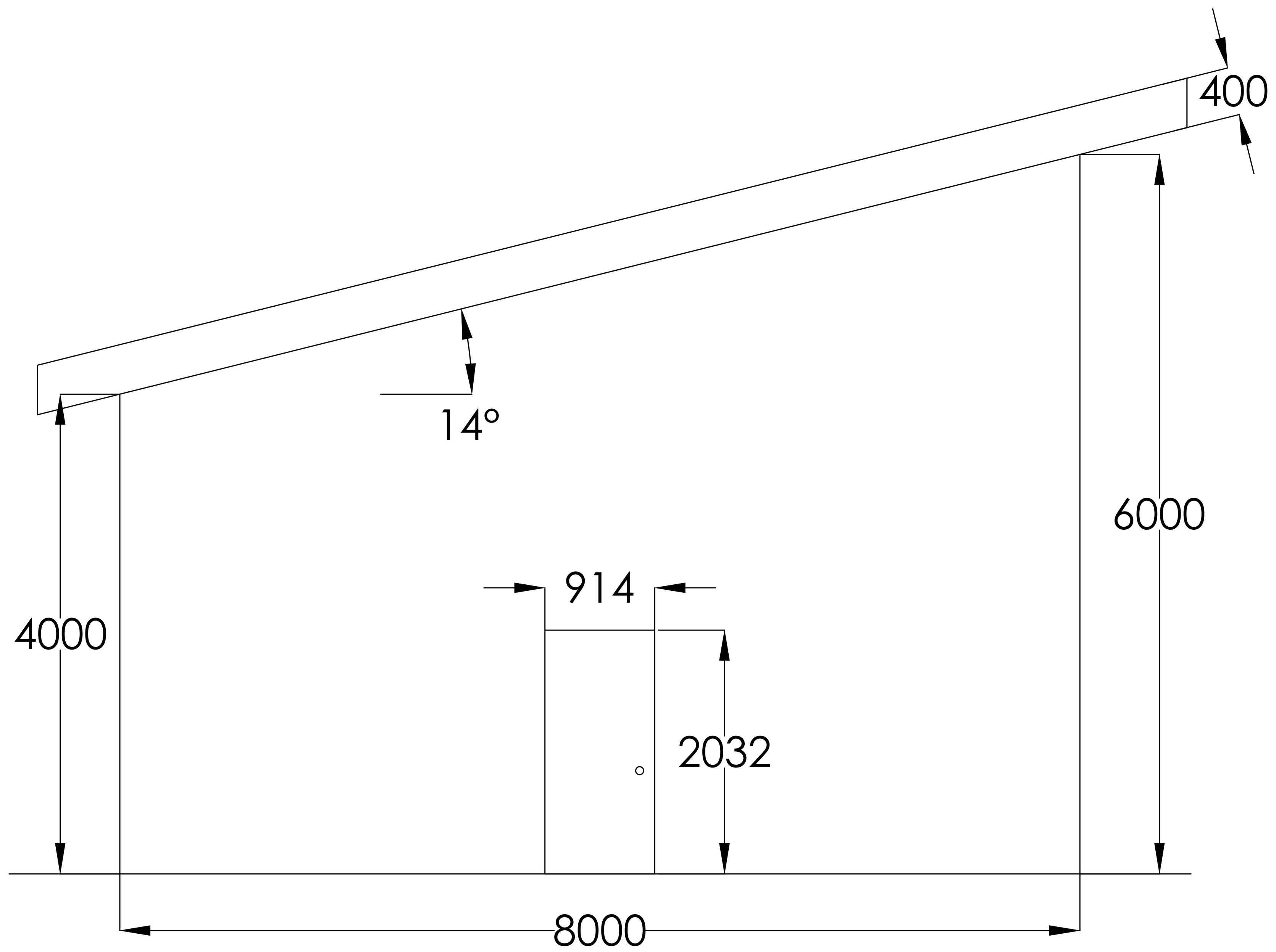
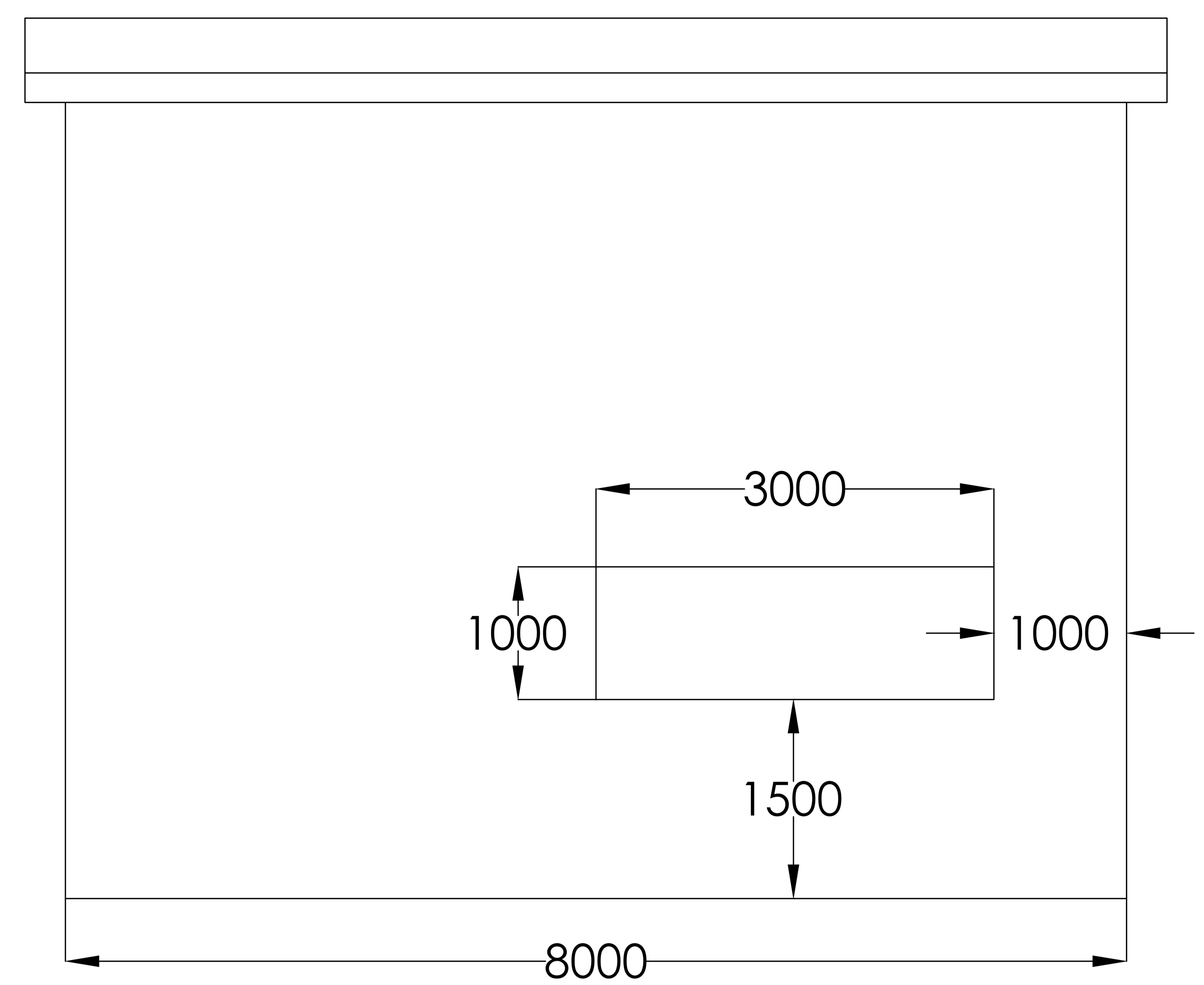


SIDE ELEVATION

SCALE: N/A



FRONT ELEVATION

SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	PRELIMINARY DESIGN DRAFT	KM	11-28-2018

STATUS: N.F.C.

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V6T 1W6
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2329 WEST MALL
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V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: OPERATION SHACK
ELEVATIONS

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-28-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-003	A

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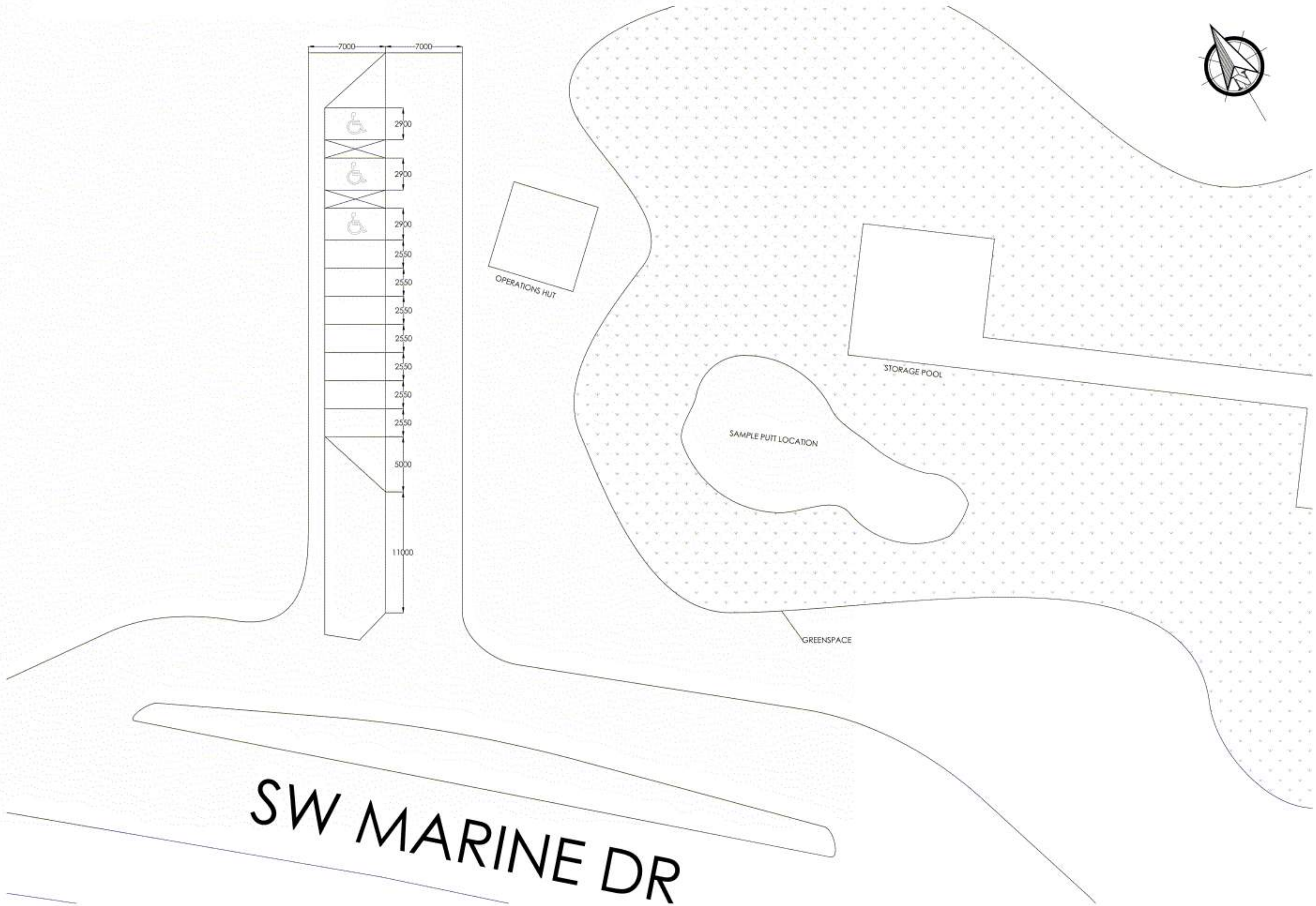

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	PRELIMINARY DESIGN DRAFT	KM	11-28-2018

STATUS: N.F.C.

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V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: PROPOSED PARKING LAYOUT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-28-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-004	A

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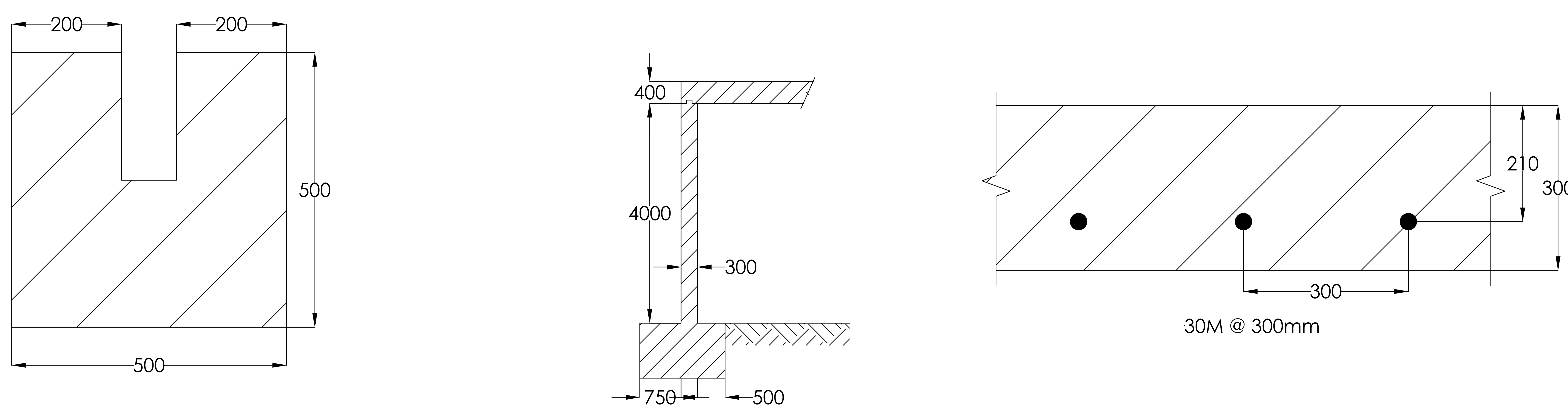
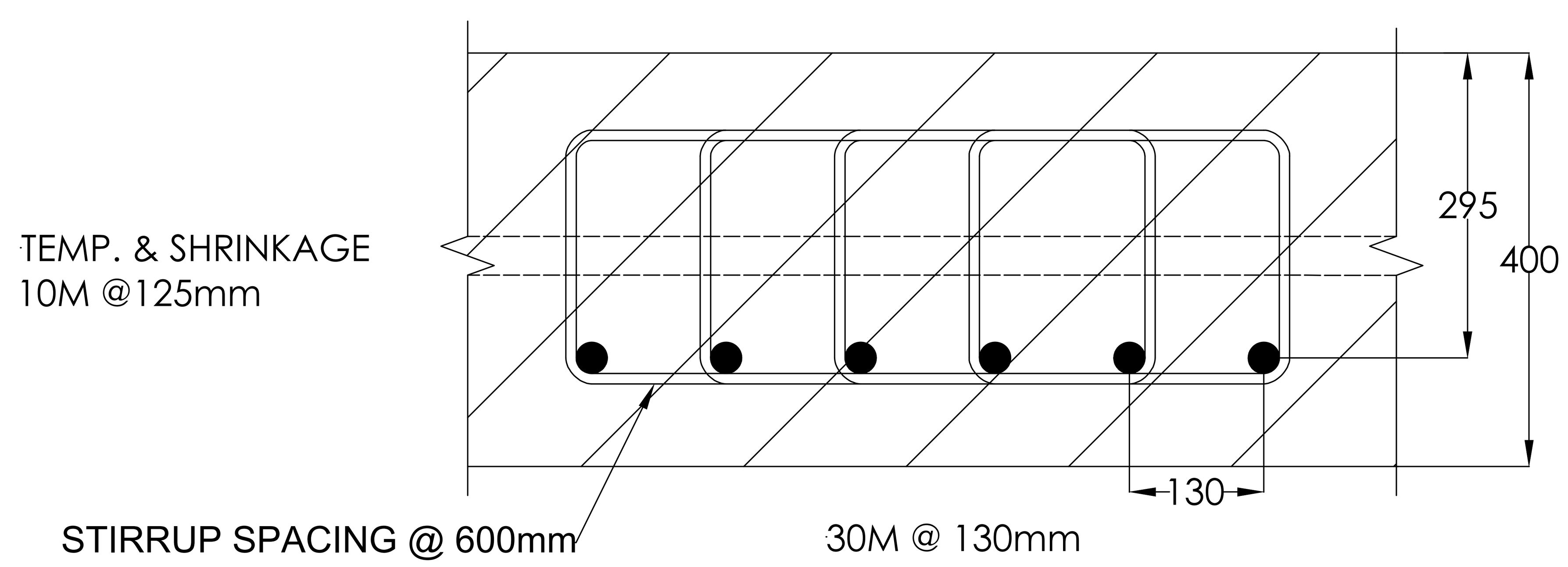
CONCRETE STRIP CONNECTION



TYP. WALLS & FOOTINGS

SCALE: N/A



TYP. ROOF SLAB

SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
E	CONCEPTUAL DESIGN	KM	02-03-2019

STATUS: N.F.C.

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Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: TYPICAL WALLS, FOOTINGS
& ROOF DETAIL

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-005	E

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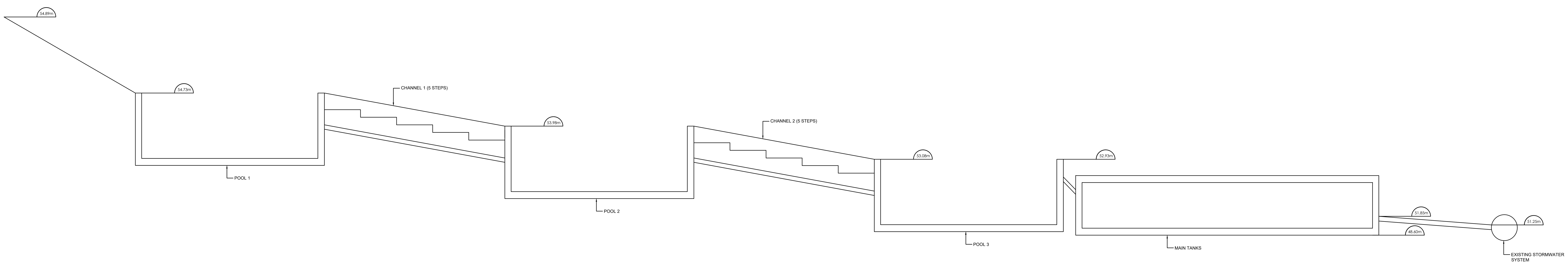

ELEVATIONS
SCALE: N/A

Notes:

1. ALL CHANNELS AND PONDS WILL BE AT GRADE
2. EACH CHANNEL HAS FOUR (4) 15cm STEPS
3. ALL UNITS IN METERS

REV:	DESCRIPTION:	BY:	DATE:
A	CONCEPTUAL DESIGN DRAFT	KM	02-03-2019

STATUS: N.F.C.

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V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: POND & TANK ELEVATION LAYOUT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-006	A

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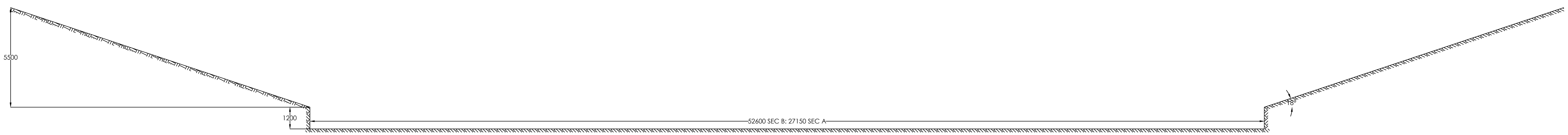
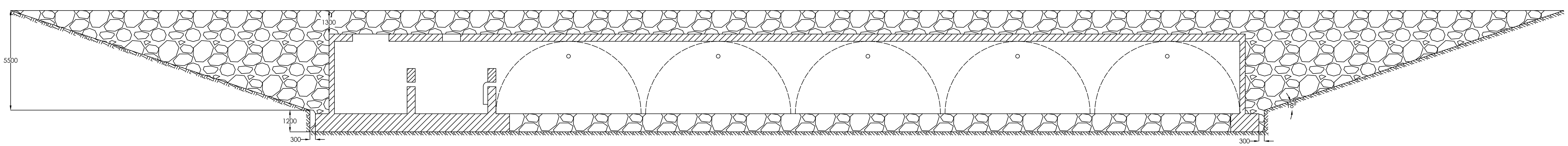
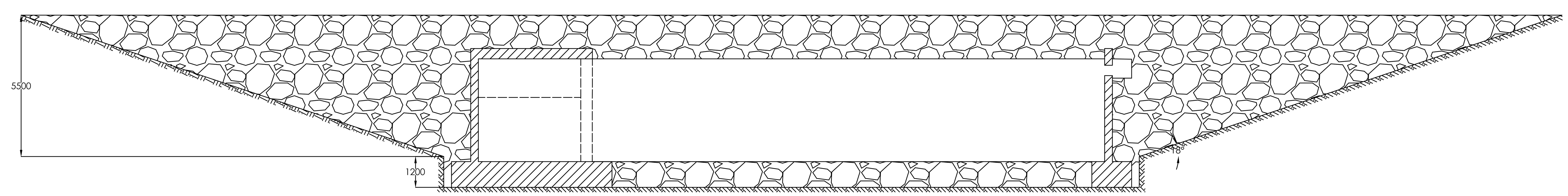




SEC B TANK EXCAVATION

SCALE: N/A



SEC A TANK EXCAVATION

SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	CONCEPTUAL DESIGN DRAFT	KM	02-03-2019

STATUS: N.F.C.

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V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
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ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: TANK EXCAVATION
LAYOUT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-007-02	A

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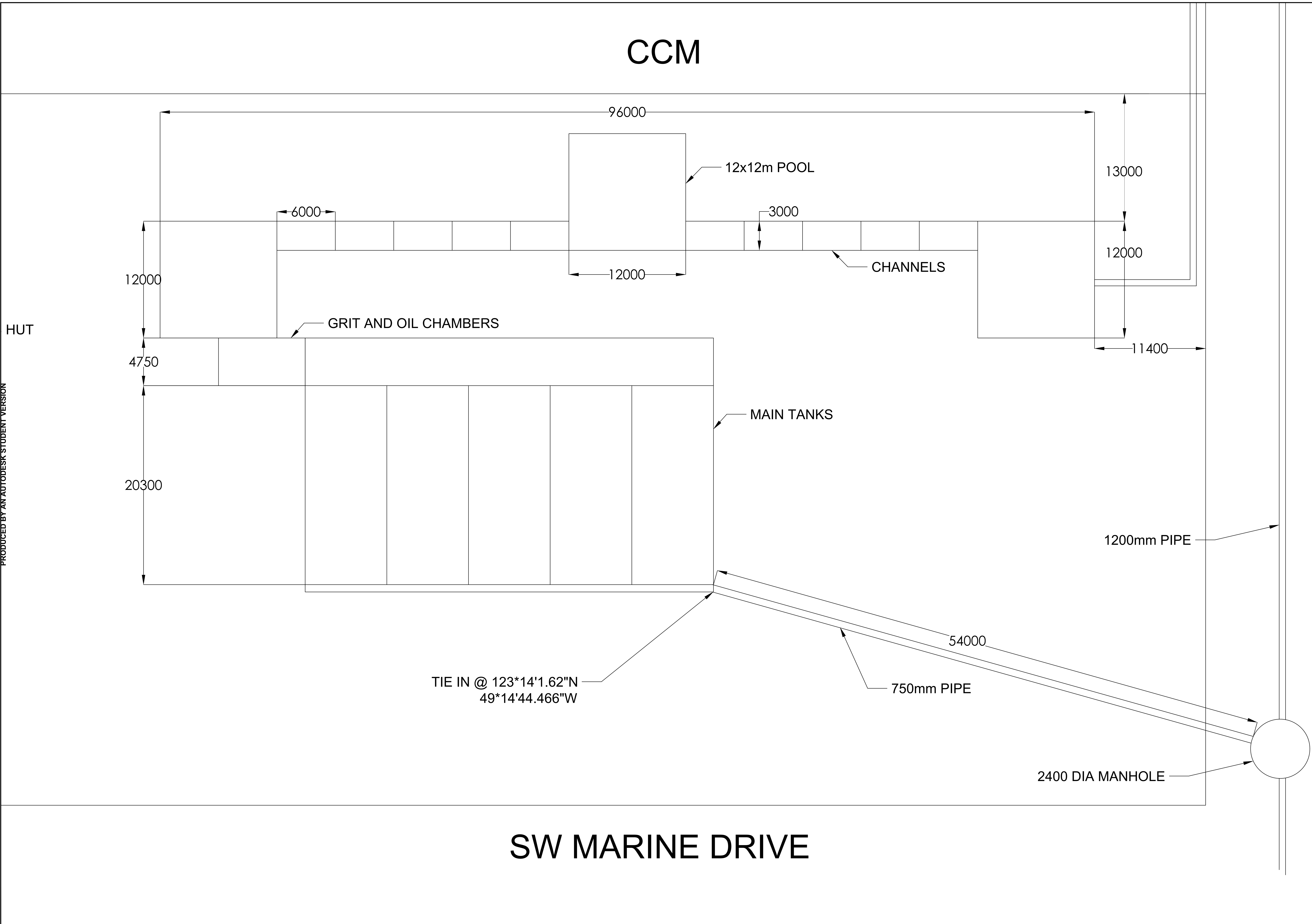

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	CONCEPTUAL DESIGN DRAFT	KM	02-03-2019

STATUS: N.F.C.

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V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: SITE LOCATION OVERVIEW

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM
PROJECT NO:	DRAWING NO:		REVISION:
2	11-008-01		A

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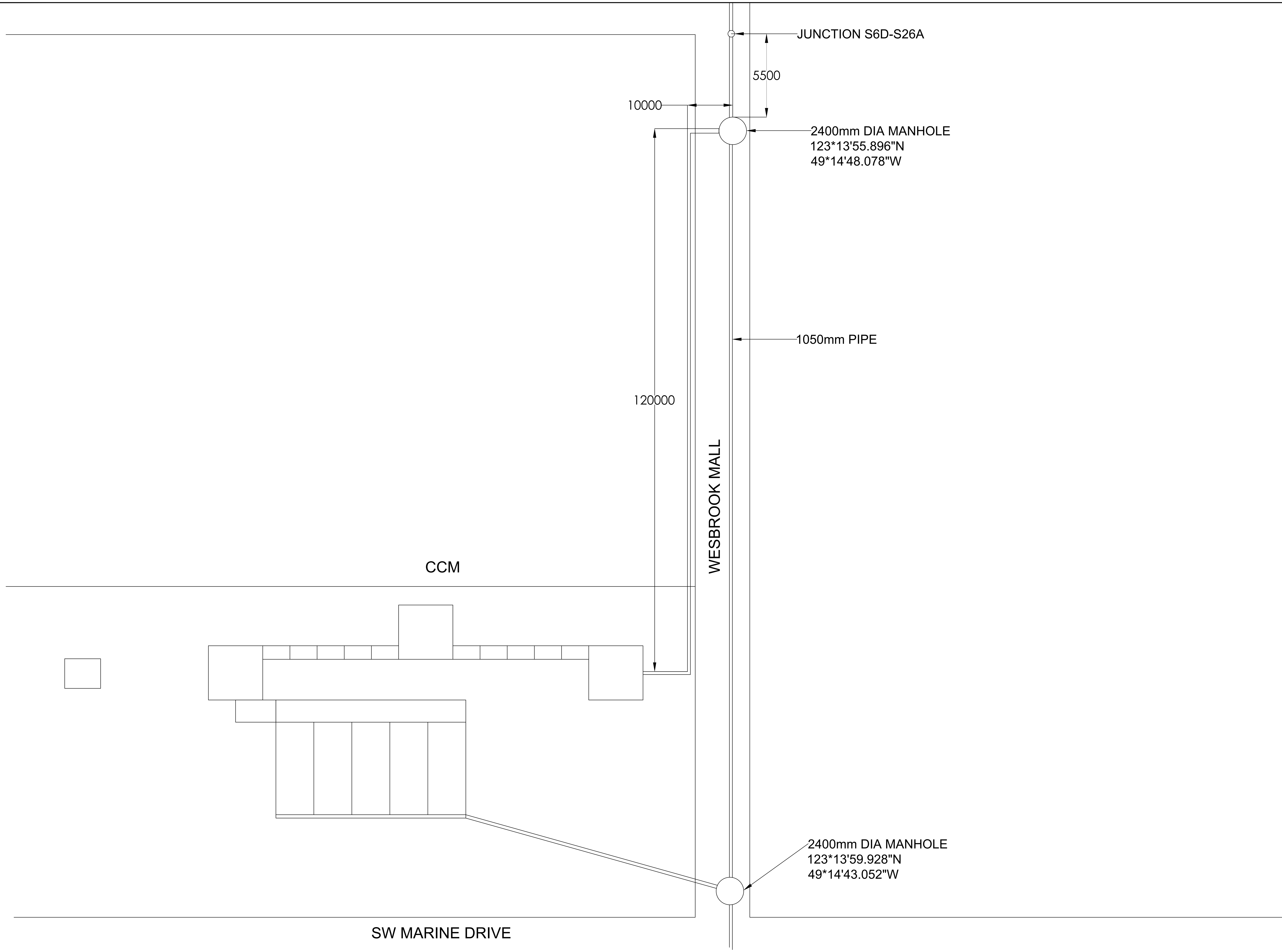

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	FINAL DESIGN DRAFT	KM	03-31-2019

STATUS: N.F.C.

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Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
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V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: SITE LOCATION OVERVIEW

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM
PROJECT NO:	DRAWING NO:		REVISION:
2	11-009-01		A

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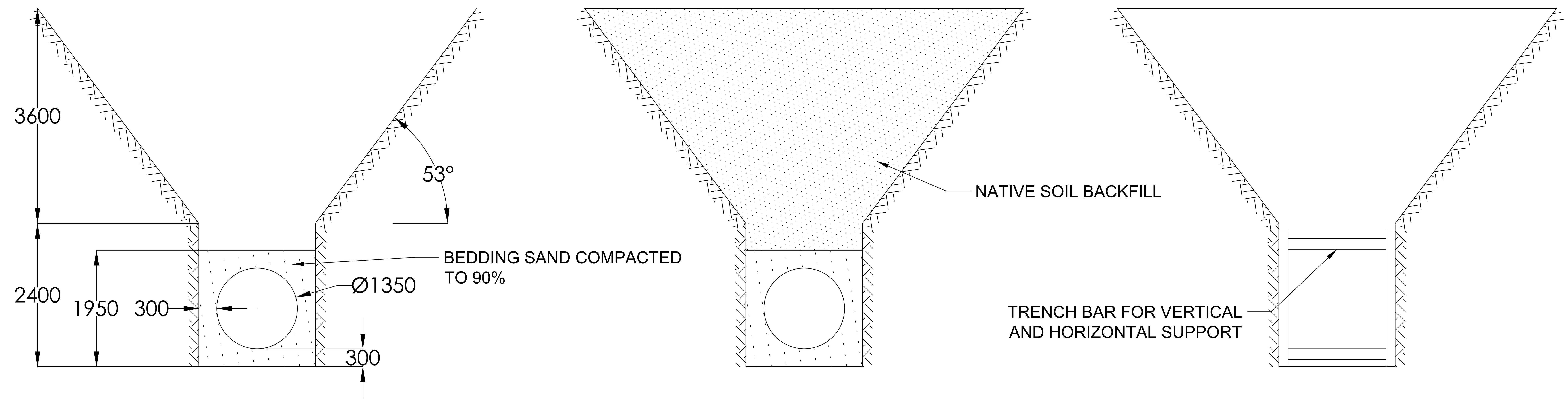

PIPE EXCAVATION

SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	FINAL DESIGN DRAFT	KM	03-31-2019

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: PIPE EXCAVATION
AND SUPPORT LAYOUTS

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-010	A

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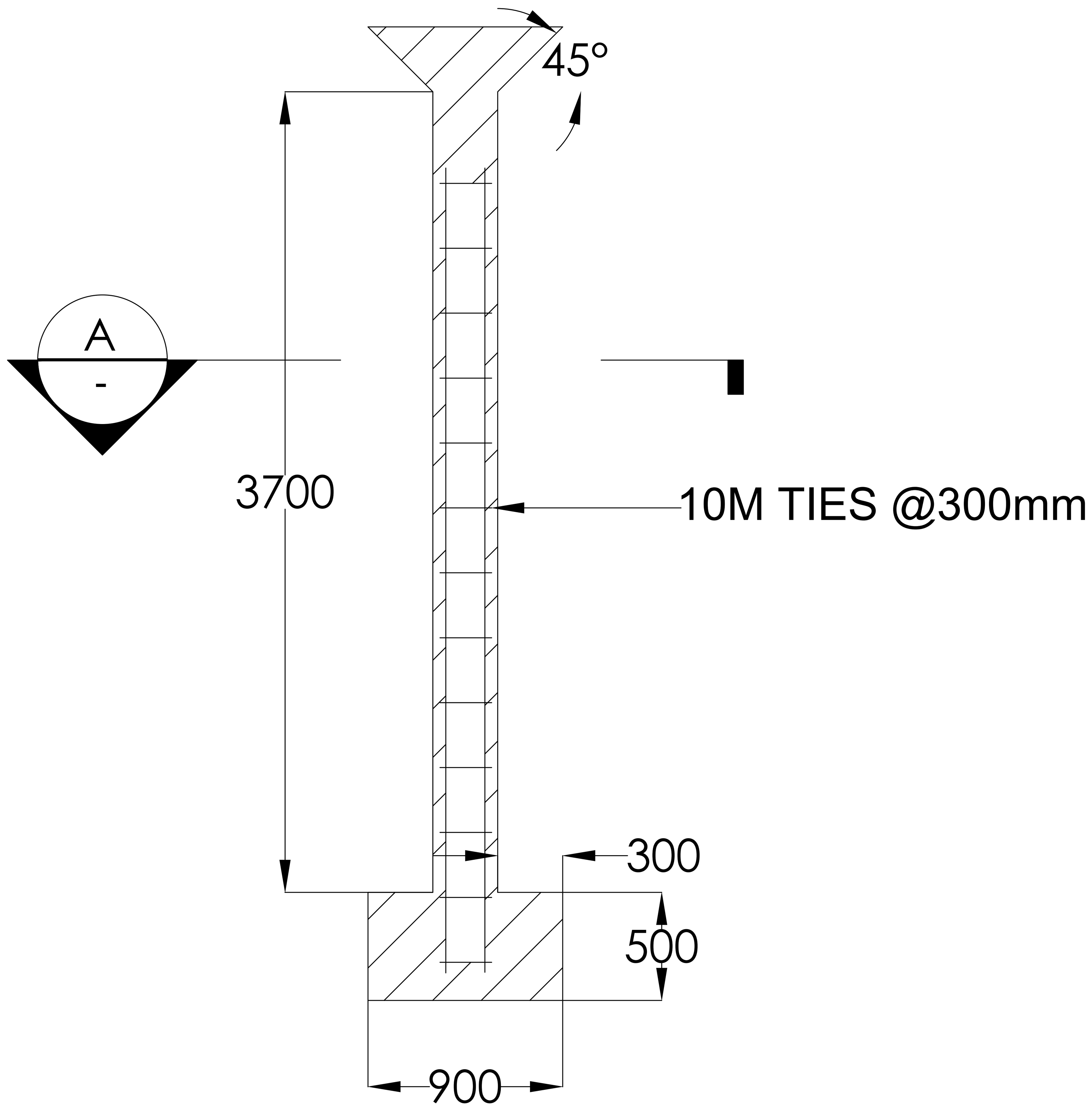
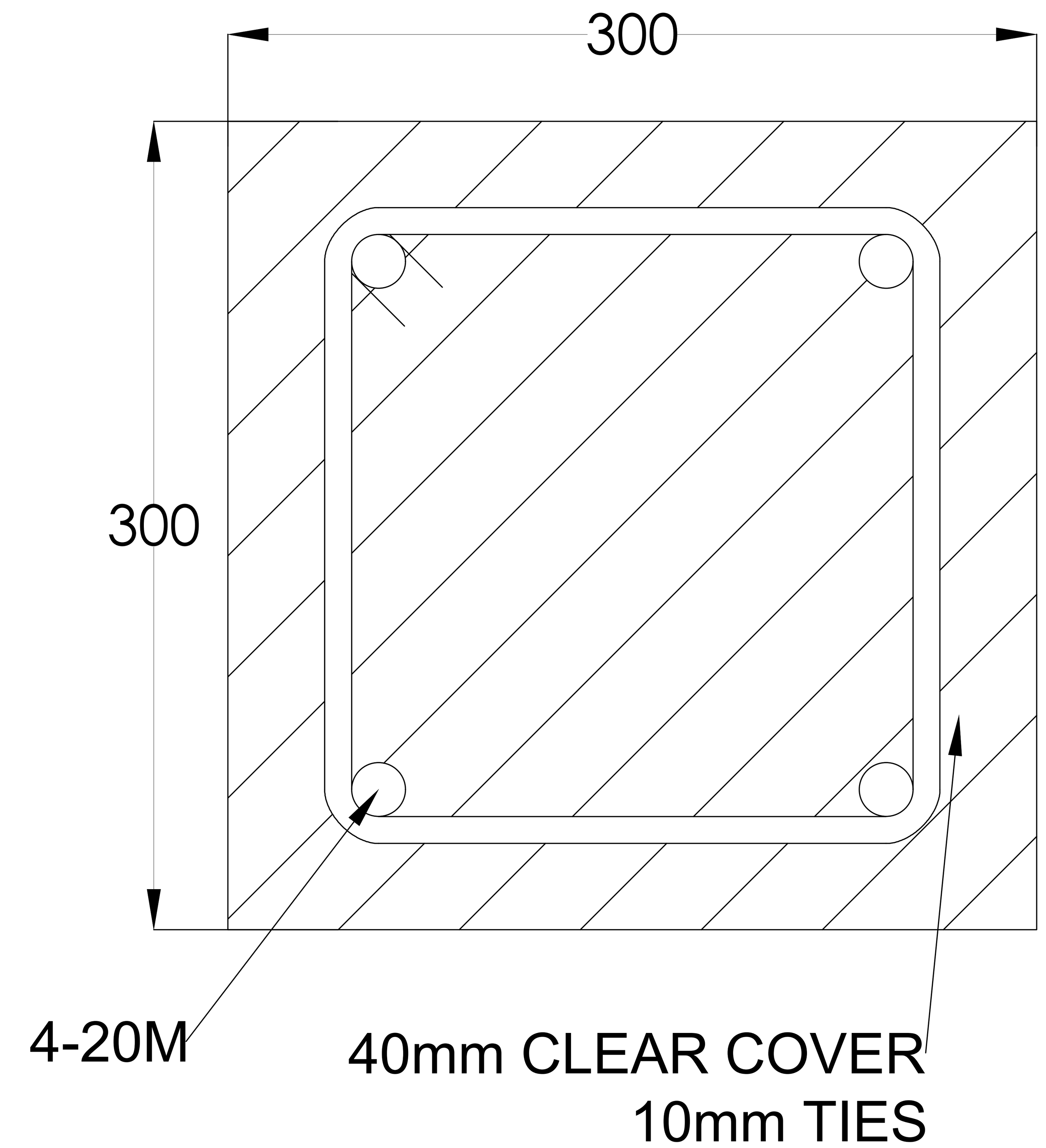


TANK COLUMN

SCALE: N/A



SECTION A

SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	FINAL DESIGN DRAFT	KM	03-31-2019

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: TANK COLUMN
AND REINFORCEMENT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-011	A

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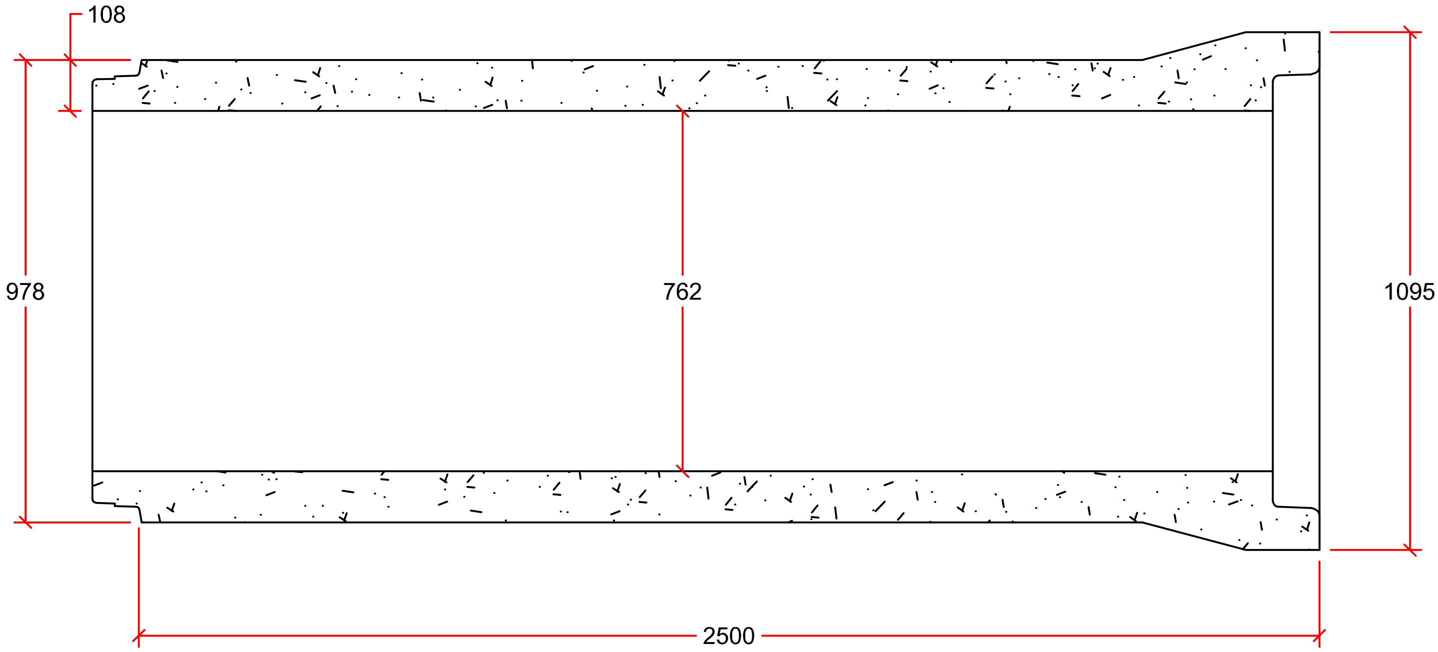
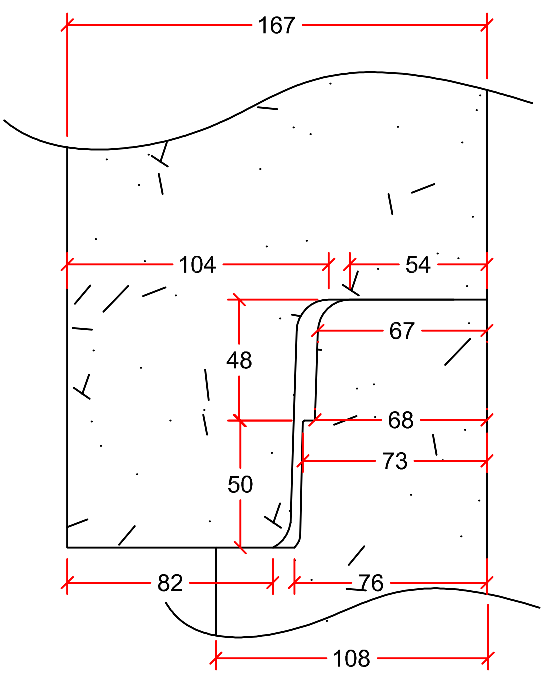
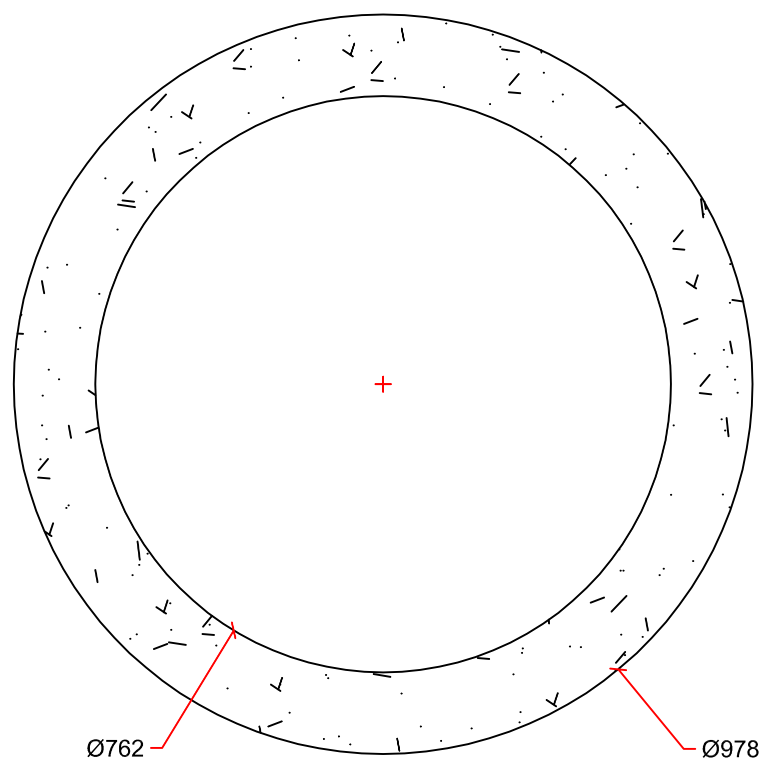


PIPE DETAIL

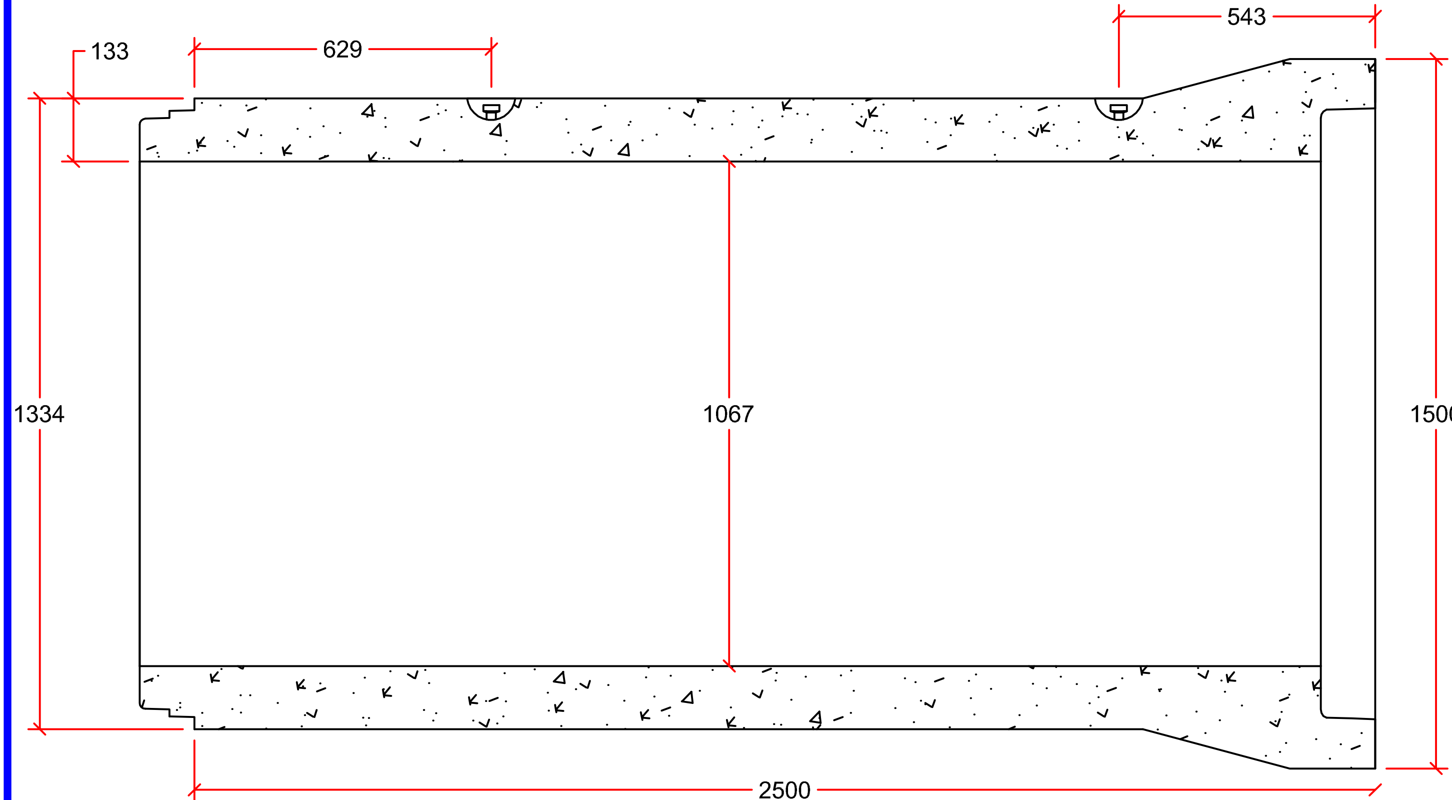


JOINT DETAIL

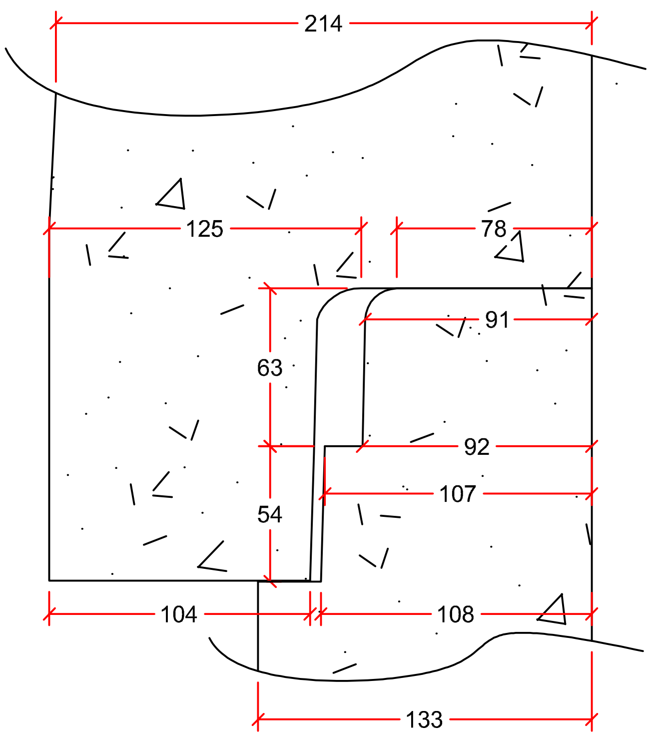


SECTION DETAIL

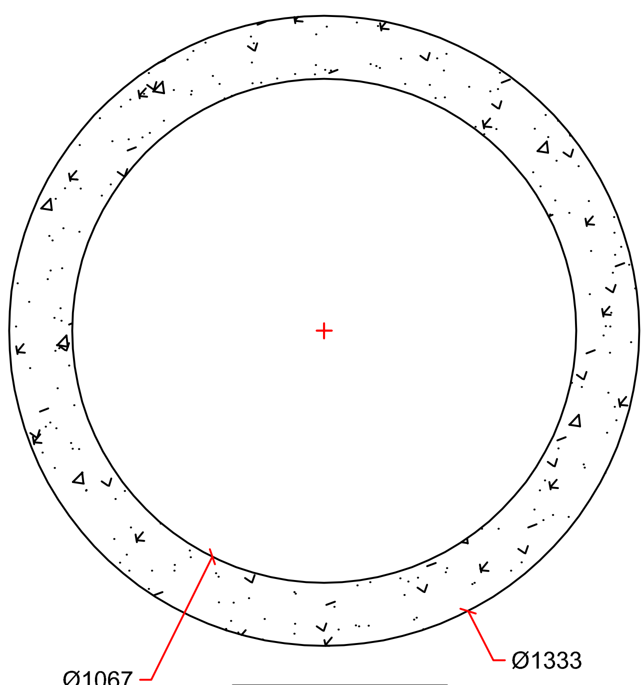
DRAWN BY:	AARON KLEMETS	750mm X 2.5m (TYP) PIPE	OCEAN Pipe
SCALE:	NTS		
DATE:	NOVEMBER 9, 2015	APPROXIMATE MASS: 2075kg ALL DIMENSIONS IN mm	
DRAWING #:	750mm X 2.5m (TYP) PIPE		
REVISION #:	REV. 0		9265 OAK ST. VANCOUVER B.C. PH: 604 269-6700 FAX: 604 261-6751
CHECKED BY:	TYSON DYCK		



PIPE DETAIL



JOINT DETAIL

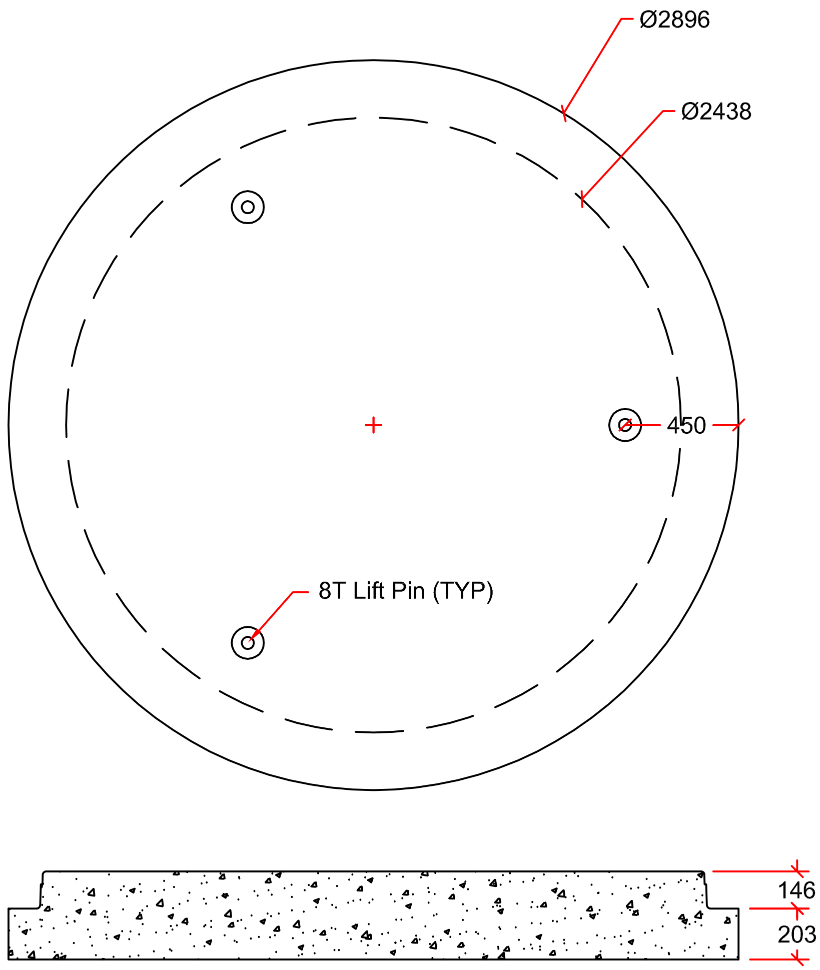


SECTION DETAIL

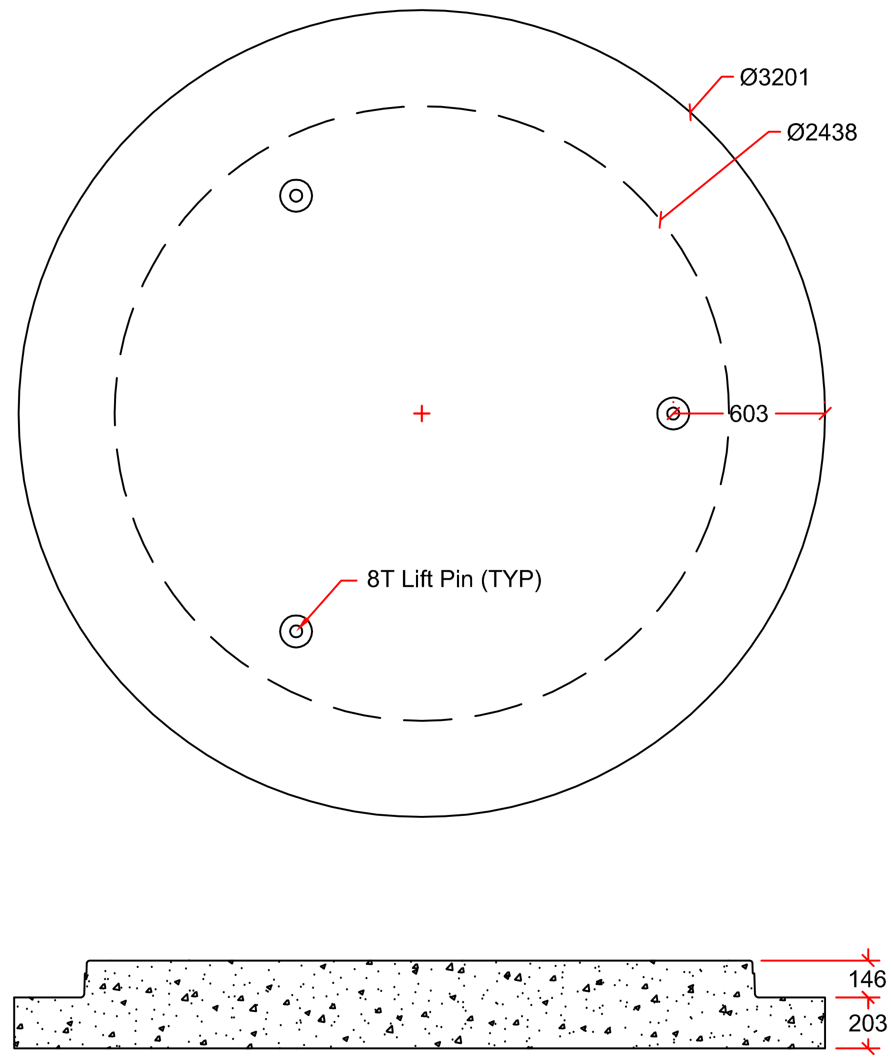
DRAWN BY:	AARON KLEMETS	1050mm x 2.5m (TYP) PIPE
SCALE:	NTS	
DATE:	NOVEMBER 9, 2015	APPROXIMATE MASS: 3500kg TWO 4T LIFT PINS PROVIDED AS SHOWN ALL DIMENSIONS IN mm
DRAWING #:	1050mm X 2.5m (TYP) PIPE	
REVISION #:	REV. 0	
CHECKED BY:	TYSON DYCK	

OCEAN Pipe

9265 OAK ST. VANCOUVER B.C.
PH: 604 269-6700 FAX: 604 261-6751



INNER POUR BASE
APPROXIMATE MASS: 3210 kg



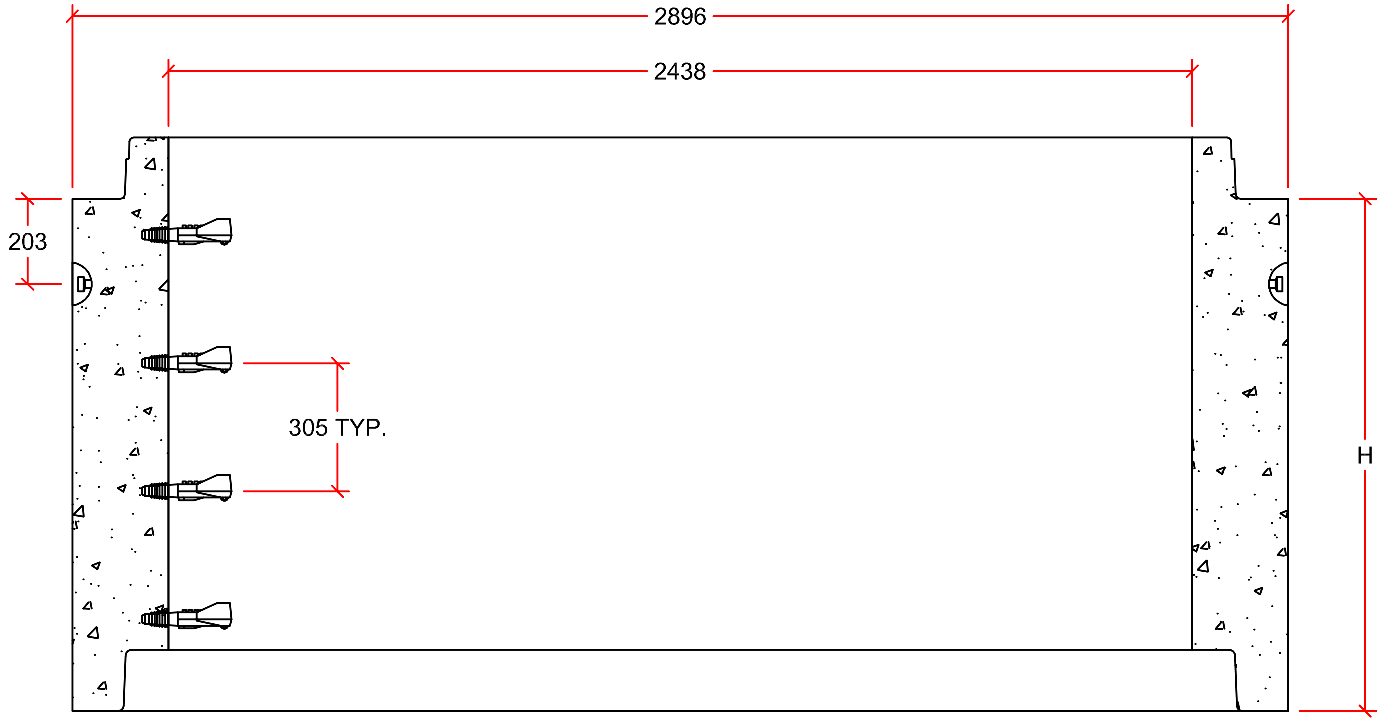
EXTENDED BASE
APPROXIMATE MASS: 3920 kg

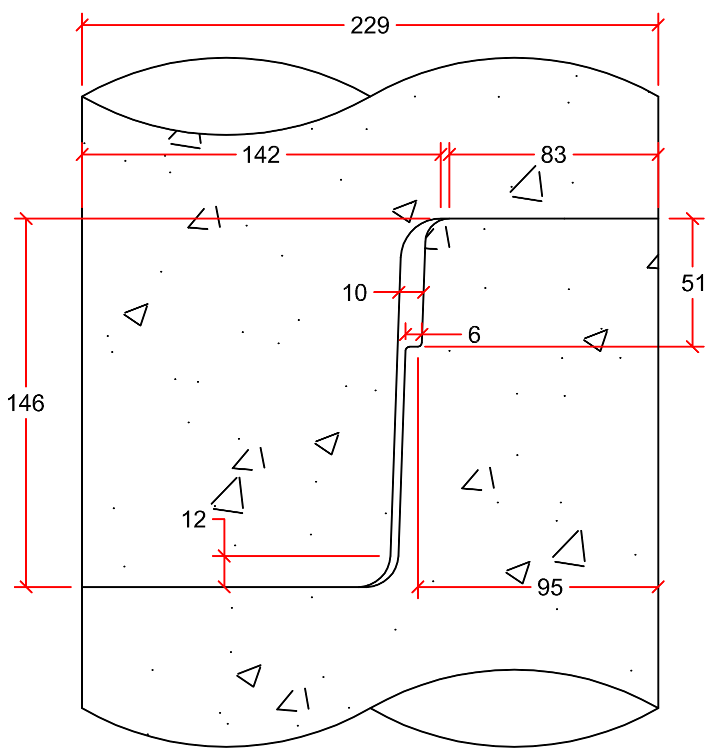
DRAWN BY:	AARON KLEMETS
SCALE:	NTS
DATE:	NOVEMBER 19, 2015
DRAWING #:	2400 MH BASES
REVISION #:	REV. 0
CHECKED BY:	TYSON DYCK

2400mm MANHOLES BASES

ALL DIMENSIONS IN mm
THREE 8T LIFT PINS PROVIDED AS SHOWN

OCEAN Pipe
9265 OAK ST. VANCOUVER B.C.
PH: 604 269-6700 FAX: 604 261-6751





JOINT DETAIL

AVAILABLE IN 0.3m, 0.6m, 0.9m,1.2m,
1.5m, 1.8m, 2.1m, & 2.5m HEIGHTS

HEIGHT (H) (mm)	MASS (kg)
300	1420
600	2840
900	4260
1200	5680
1500	7100
1800	8520
2100	9940
2500	11830

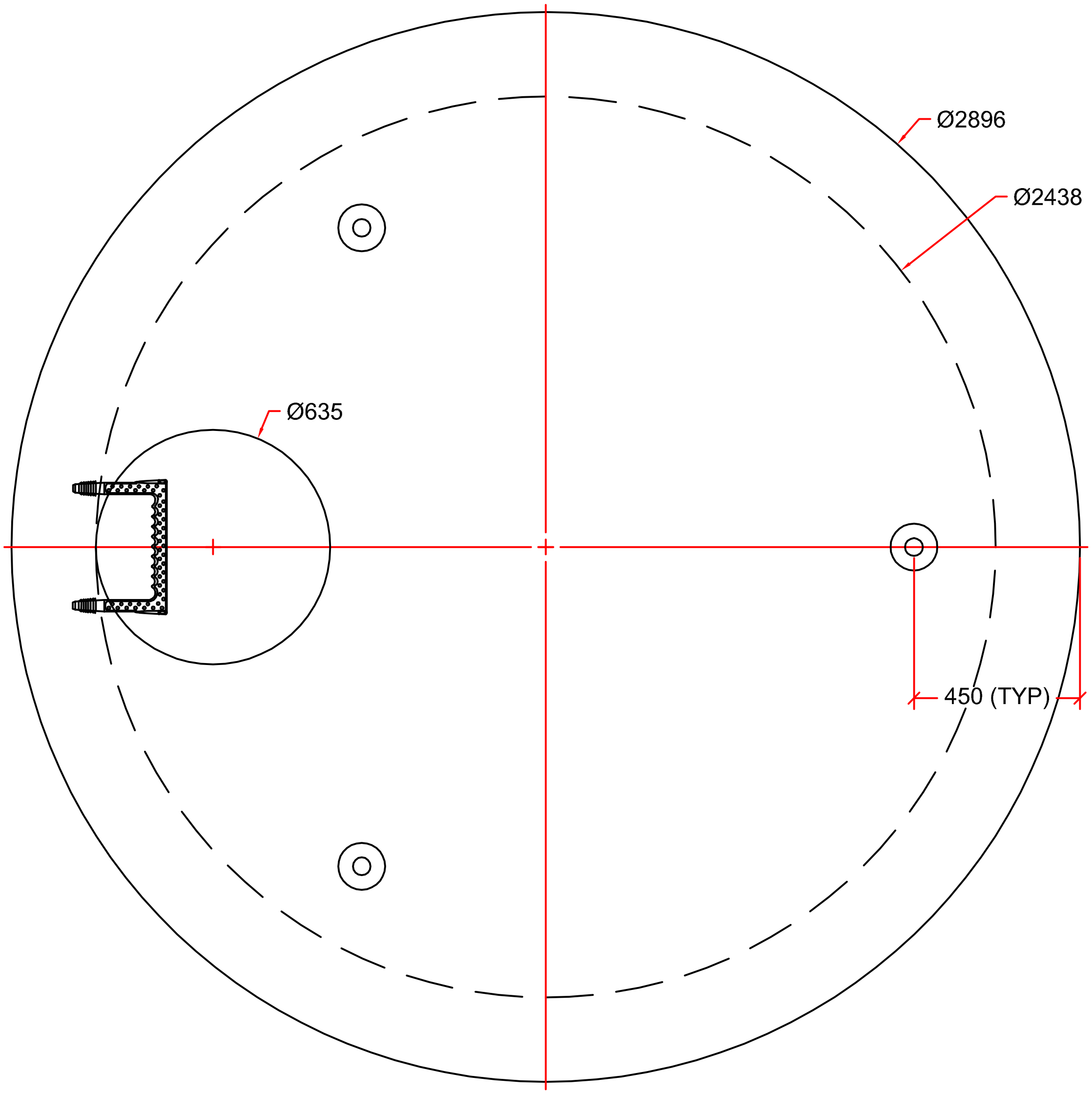
DRAWN BY:	AARON KLEMETS
SCALE:	NTS
DATE:	NOVEMBER 19, 2015
DRAWING #:	2400 MH RISER
REVISION #:	REV. 0
CHECKED BY:	TYSON DYCK

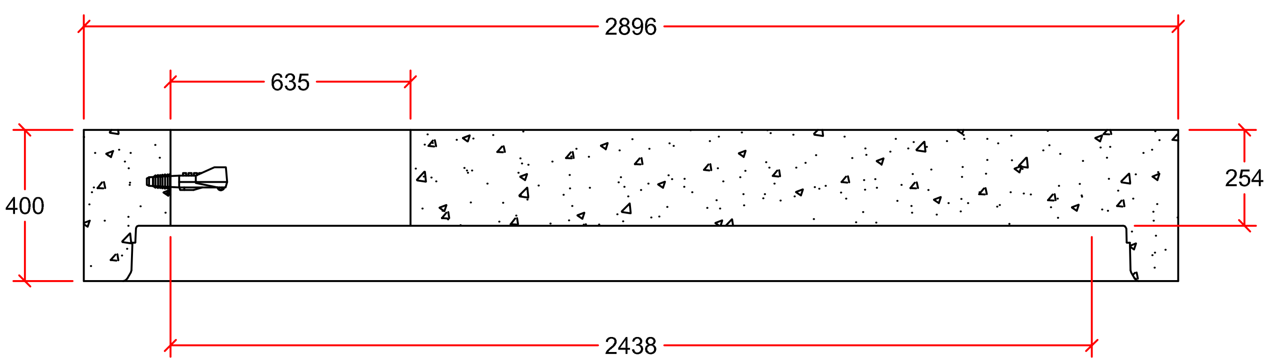
2400mm MANHOLE RISER

ALL DIMENSIONS IN mm
TWO 8T LIFT PINS PROVIDED AS SHOWN

OCEAN Pipe

9265 OAK ST. VANCOUVER B.C.
PH: 604 269-6700 FAX: 604 261-6751





AVAILABLE OPENING SIZES: 635mm & 900mm
CUSTOM OPENINGS AVAILABLE UPON REQUEST

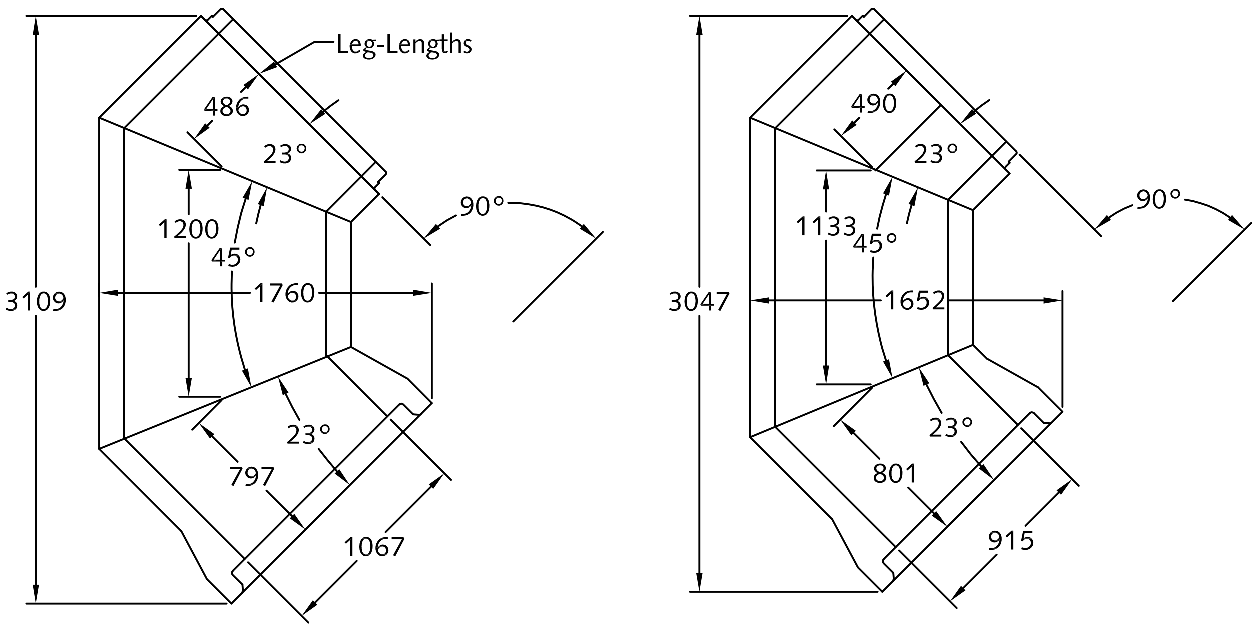
DRAWN BY:	AARON KLEMETS
SCALE:	NTS
DATE:	NOVEMBER 19, 2015
DRAWING #:	2400 MH SLAB TOP
REVISION #:	REV. 0
CHECKED BY:	TYSON DYCK

2400mm MANHOLE SLAB TOP

ALL DIMENSIONS IN mm
APPROXIMATE MASS: 4170 kg
THREE 8T LIFT PINS PROVIDED AS SHOWN

OCEAN Pipe

9265 OAK ST. VANCOUVER B.C.
PH: 604 269-6700 FAX: 604 261-6751



Notes:

1. Double mitre bends are achieved in typical arrangements as shown.
2. Shown are Ø1050 & 900mm bell and spigot pipe in double mitre bends.
3. Leg-Lengths of mitres are variable to modify Lay-Length.
4. Lay length of mitres are available up to max. 2.5m .
5. Min. concrete strength: Available in any class of pipe.
6. Minimum WWF yield strength: 448 MPa.
7. All dimensions are in millimeters.

The LANGLEY CONCRETE Group of Companies

DESCRIPTION:

1050 & 900 Pipe
Double Mitre-90°

www.langleyconcretegroup.com

DRAWN BY:	JAO	ORIGIN:	CHWK
CHK BY:	N/A	DWG NO:	DM-900_1050
DATE:	02/02/18	REV DATE:	
SCALE:	1:40		2. MAY/10/2010

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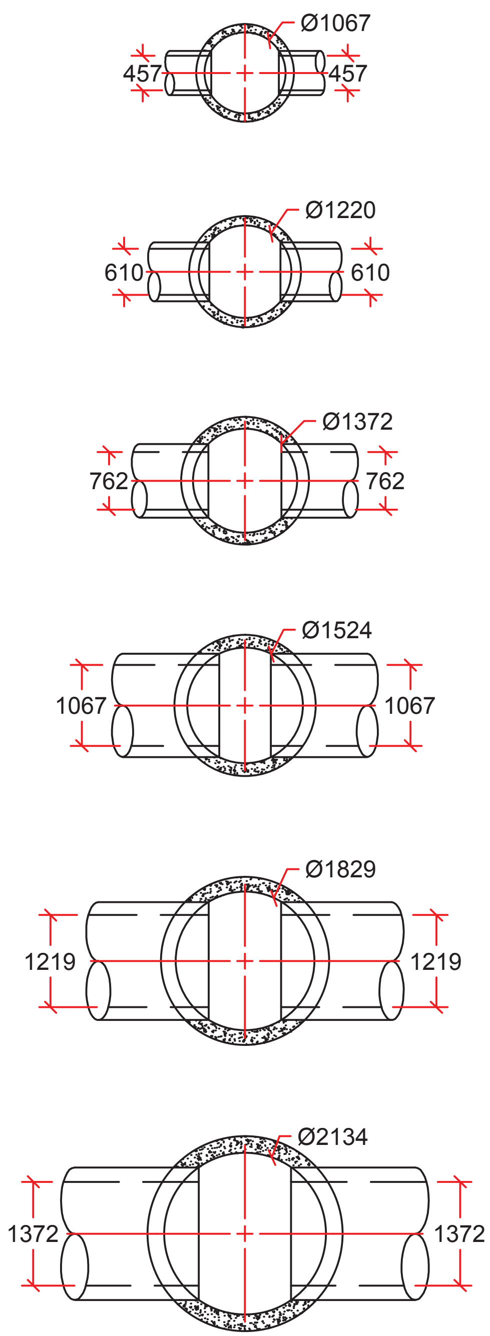
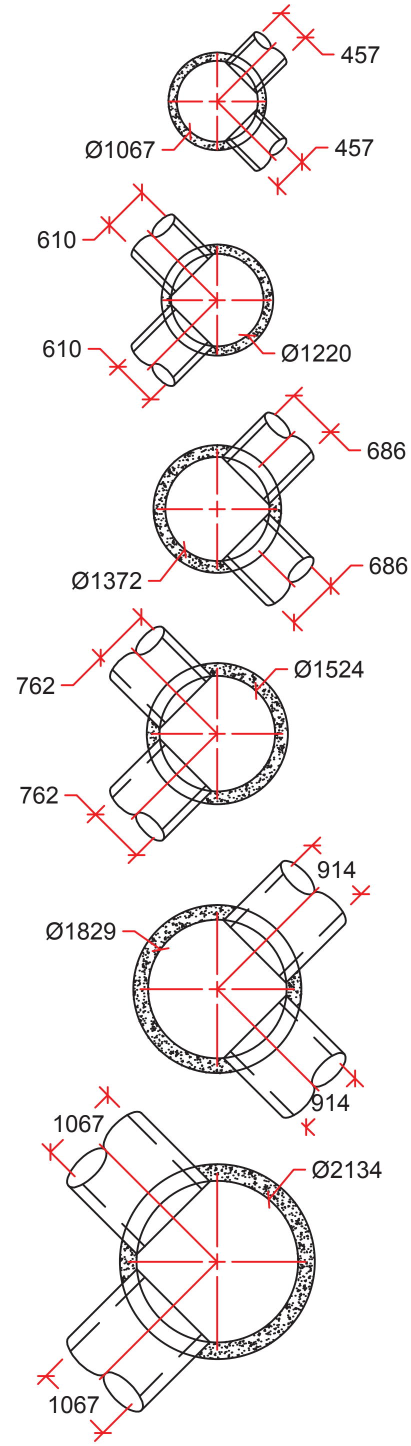
MAXIMUM PIPE SIZE FOR STRAIGHT THROUGH INSTALLATION



MAXIMUM PIPE SIZE FOR RIGHT ANGLE INSTALLATION



DRAWN BY:	Andrew Cortese
SCALE:	1:100
DATE:	May 27, 2014
DRAWING #:	MAX-MH-1050-2100
REVISION #:	Rev. 0
CHECKED BY:	

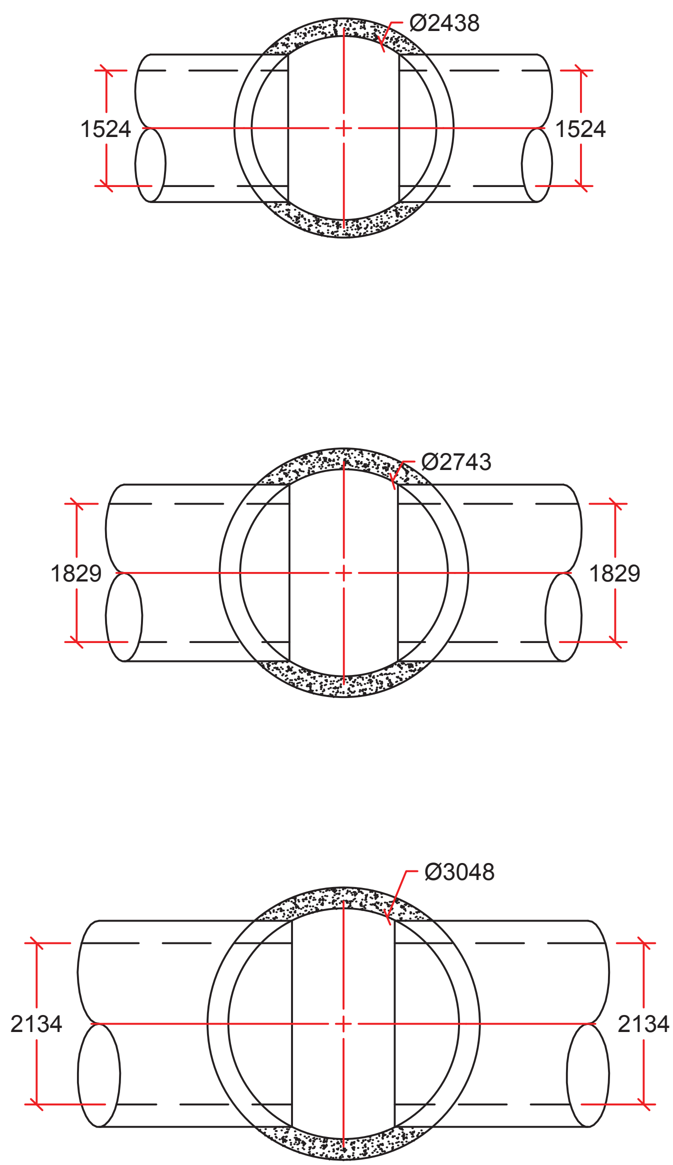
Maximum Pipe Sizes for Manholes

1050mm through 2100mm Manholes

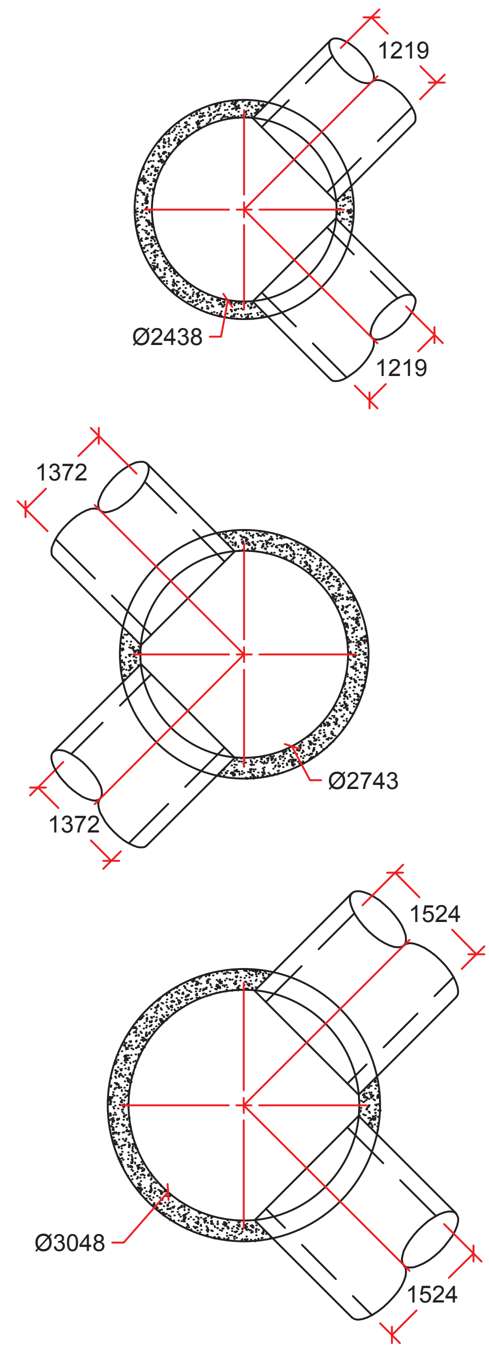
Non-standard angles possible, call for specific project situations

OCEAN Pipe
9265 OAK ST. VANCOUVER B.C.
PH: 604 269-6700 FAX: 604 261-6751

MAXIMUM PIPE SIZE FOR STRAIGHT THROUGH INSTALLATION



MAXIMUM PIPE SIZE FOR RIGHT ANGLE INSTALLATION



DRAWN BY:	Andrew Cortese	Maximum Pipe Sizes for Manholes	OCEAN Pipe
SCALE:	1:100		
DATE:	May 27, 2014	2400mm through 3050mm Manholes	
DRAWING #:	MAX-MH-2400-3050		
REVISION #:	Rev. 0	Non-standard angles possible, call for specific project situations	9265 OAK ST. VANCOUVER B.C. PH: 604 269-6700 FAX: 604 261-6751
CHECKED BY:			

Appendix D: Cost Estimate

PROJECT MANAGEMENT AND CONSTRUCTION COST ESTIMATE

		DESCRIPTION	UNIT	QTY	UNIT RATE	TOTAL
DIVISION 1	GENERAL REQUIREMENTS					
	1	Mobilization	LS	-	-	$ 15,000.00
	2	Temporary Facilities	LS	-	-	$ 2,500.00
	3	Temporary Traffic Management	LS	-	-	$ 500.00
	4	Waste Disposal	EA	24	$ 350.00	$ 8,400.00
	5	Engineering and Testing	LS	-	-	$ 75,000.00
	6	Plans and Specifications	LS	-	-	$ 15,000.00
	7	General Labour	LS	-	-	$ 5,000.00
	8	Rezoning Application	LS	-	-	$ 10,385.00
	9	Building Permit	LS	-	-	$ 2,400.00
				DIVISION 1	TOTAL	$ 134,185.00
DIVISION 2	SITE WORK					
	1	Clearing and Timber Salvage	HA	1	$ 17,500.00	$ 17,500.00
	2	Replanting and Landscaping	HA	1	$ 7,500.00	$ 7,500.00
				DIVISION 2	TOTAL	$ 25,000.00
DIVISION 3	CONCRETE					
	1	Concrete Placement (including formwork)	M3	1750	$ 207.00	$ 362,250.00
	2	Steel Reinforcement (Supply and Install)	M3	43.75	$ 250.00	$ 10,937.50
	3	Manhole Installation	EA	3	$ 4,000.00	$ 12,000.00
				DIVISION 3	TOTAL	$ 385,187.50
DIVISION 5	METALS					
	1	Steel weirs	M2	36	$ 50.00	$ 1,800.00
	2	Corrugated steel pipes (4m rad)	LM	100	$ 3,271.48	$ 327,148.00
				DIVISION 5	TOTAL	$ 328,948.00
DIVISION 6	WOOD, PLASTICS, AND COMPOSITES					

	1	PVC Pipe (Supply and Install)	M	20	$ 75.00	$ 1,500.00
	2	Geotextile (supply and install)	M2	960	$ 55.00	$ 52,800.00
				DIVISION 6	TOTAL	$ 54,300.00
DIVISION 31	EARTHWORK					
	1	Subgrade Excavation	M3	4560.0	$ 15.00	$ 68,400.00
	2	Granular Fill	M3	4560	$ 18.00	$ 82,080.00
	3	Subgrade Preparation	M2	1430	$ 1.75	$ 2,502.50
	4	Trenchbox Rental	EA	1	$ 1,250.00	$ 1,250.00
				DIVISION 31	TOTAL	$ 154,232.50
DIVISION 35	WATERWAY AND MARINE CONSTRUCTION					
	1	Sump (Grit and Oil) Chamber	EA	-	-	$ 7,500.00
	2	Concrete Stormwater Pipe	M	250	$ 315.00	$ 78,750.00
				DIVISION 35	TOTAL	$ 86,250.00
DIVISION 36	Special Construction					
	1	Mini-Putt Facilities	EA	-	-	$ 500,000.00
				DIVISION 36	TOTAL	$ 500,000.00
					GRAND TOTAL	$ 1,668,103.00

Constuction labour and material costs calculated using Unite Price Averages Report from the Alberta Infrastructure & Transportation

www.transportation.alberta.ca/Content/doctype257/production/unitpricelist.pdf

Professional Engineering Costs Derived from the ACEC BC Fee guidelines

https://www.acec-bc.ca/media/36630/acecbcfeeguide16.pdf

Appendix E: Construction Schedule

CONSTRUCTION SCHEDULE

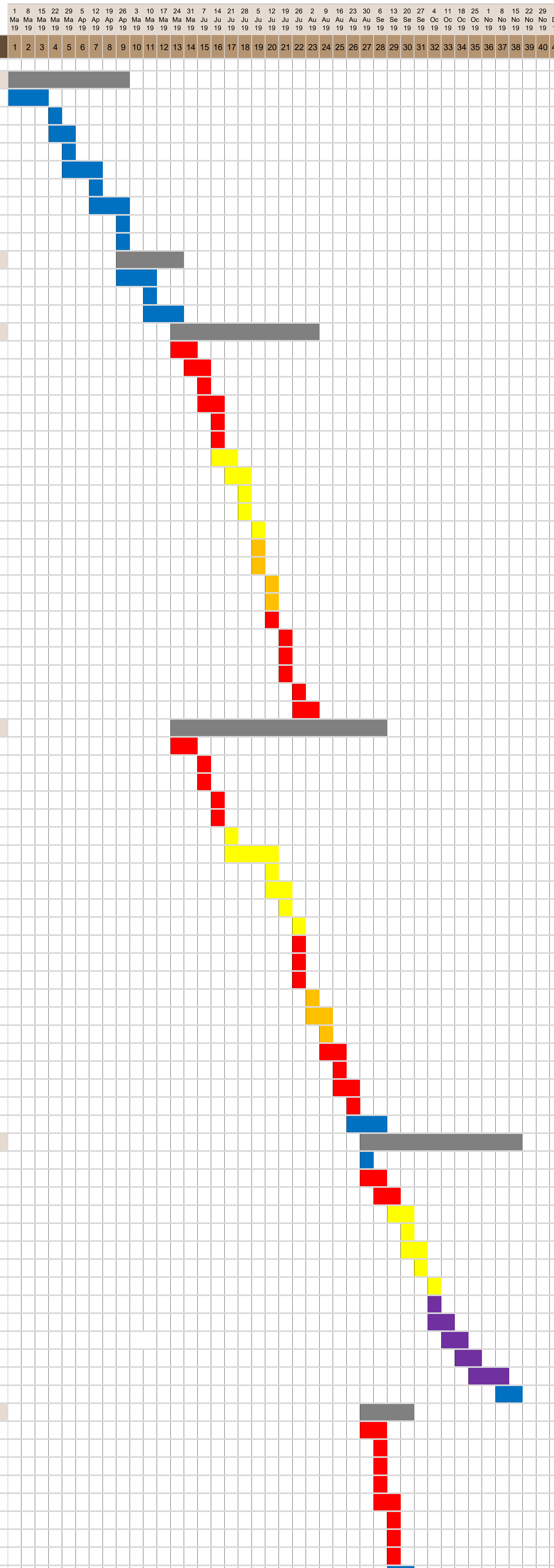
Black Tusk Engineering Ltd.

Project Start: 3/1/2019

Construction Start: 5/1/2019

Completion: #REF!

TASK DESCRIPTION	PLAN START	PLAN END	DIVISION
PRE-CONSTRUCTION AND PROCUREMENT	**3/1/2019**	**5/1/2019**	
Public Notices	3/1/2019	3/21/2019	B
Project Open-house - Pre-Construction Q&A	3/22/2019	3/22/2019	B
Design Approval and Modifications	3/23/2019	4/2/2019	B
Release for Tender	4/3/2019	4/3/2019	B
Tender Process	4/4/2019	4/14/2019	B
Contract Award	4/15/2019	4/15/2019	B
Permitting	4/16/2019	4/26/2019	B
Mobilization	4/27/2019	4/30/2019	B
Project Start-Up	5/1/2019	5/1/2019	B
SITE WORK	**5/1/2019**	**5/24/2019**	
Clearing Trees and Shrubbery	5/1/2019	5/11/2019	B
Removal of Tress and Shrubbery	5/11/2019	5/14/2019	B
Surveying	5/14/2019	5/24/2019	B
DETENTION TANK	**5/25/2019**	**8/2/2019**	
Excavation of Tank Pit	5/25/2019	6/4/2019	R
Installation of Shoring	6/5/2019	6/7/2019	R
Tank Pit Subgrade Preparation	6/8/2019	6/12/2019	R
Installation of Impermeable Geotextile Layer	6/13/2019	6/14/2019	R
Gravel Levelling Bed Placement	6/15/2019	6/17/2019	R
Installation of Second Geotextile Layer	6/18/2019	6/19/2019	R
Formwork Placement	6/20/2019	6/22/2019	Y
Rebar Placement	6/23/2019	6/28/2019	Y
Concrete Pour	6/29/2019	6/30/2019	Y
Concrete Curing and Waterproofing	7/1/2019	7/4/2019	Y
Formwork Removal	7/5/2019	7/6/2019	Y
Installation and Assembly of Tank Corrugated Pipes	7/7/2019	7/11/2019	O
Installation and Assembly of Tank and Grit Chamber Elements	7/7/2019	7/11/2019	O
Installation of Inflow and Outflow Piping Attachments	7/12/2019	7/14/2019	O
Seal Inlet and Outlet Connections	7/15/2019	7/16/2019	O
Shoring Removal	7/17/2019	7/18/2019	R
Laying Native Material Backfill	7/19/2019	7/21/2019	R
Laying Gravel Backfill	7/22/2019	7/23/2019	R
Installation of Impermeable Geotextile Layer	7/24/2019	7/25/2019	R
Laying Engineered Soil to Grade	7/26/2019	7/27/2019	R
Soil Compaction	7/28/2019	8/2/2019	R
PONDS AND CHANNELS	**5/25/2019**	**9/8/2019**	
Excavation of Full Perimeter	5/25/2019	5/31/2019	R
Installation of Shoring	6/7/2019	6/11/2019	R
Installation of Impermeable Geotextile Layer	6/12/2019	6/13/2019	R
Gravel Levelling Bed Placement	6/14/2019	6/18/2019	R
Installation of Second Geotextile Layer	6/19/2019	6/20/2019	R
Formwork Placement	6/21/2019	6/26/2019	Y
Rebar Placement	6/27/2019	7/12/2019	Y
Concrete Pour	7/13/2019	7/16/2019	Y
Concrete Curing and Waterproofing	7/17/2019	7/22/2019	Y
Formwork Removal	7/23/2019	7/25/2019	Y
Installation of Steel Weirs	7/26/2019	7/27/2019	Y
Installation of Drainage Membrane	7/27/2019	7/29/2019	R
Installation of Geotextile Layer	7/28/2019	7/29/2019	R
Laying Topsoil and Ballast	7/30/2019	8/1/2019	R
Planting Aquatic Vegetation	8/2/2019	8/6/2019	O
Installation of Inflow and Outflow Piping Attachments	8/7/2019	8/11/2019	O
Seal Inlet and Outlet Connections	8/12/2019	8/14/2019	O
Shoring Removal	8/15/2019	8/16/2019	R
Laying Gravel Backfill	8/17/2019	8/20/2019	R
Soil Compaction	8/21/2019	8/26/2019	R
Laying Rip-rap	8/27/2019	8/28/2019	R
Landscaping and Planting Vegetation	8/29/2019	9/8/2019	B
MINI-PUTT FACILITY	**8/31/2019**	**11/15/2019**	
Site Surveying	8/31/2019	9/4/2019	B
Site Grading	9/5/2019	9/10/2019	R
Excavation	9/11/2019	9/16/2019	R
Formwork Placement	9/17/2019	9/20/2019	Y
Rebar Placement	9/21/2019	9/24/2019	Y
Concrete Pour	9/25/2019	9/27/2019	Y
Concrete Curing	9/28/2019	10/3/2019	Y
Formwork Removal	10/4/2019	10/5/2019	Y
Grade preparation for Carpet Installation	10/6/2019	10/8/2019	P
Installation of Putting Carpet	10/9/2019	10/14/2019	P
Installation of Theme Elements and Props	10/15/2019	10/23/2019	P
Curb Installation	10/24/2019	10/29/2019	P
Trimming and Finishing	10/30/2019	11/9/2019	P
Landscaping and Planting Vegetation	11/10/2019	11/15/2019	B
PARKING LOT	**9/5/2019**	**9/20/2019**	
Site Grading	9/5/2019	9/7/2019	R
Excavation	9/8/2019	9/9/2019	R
Subgrade Preparation	9/9/2019	9/10/2019	R
Laying Engineered Soil	9/10/2019	9/11/2019	R
Soil Compaction	9/11/2019	9/13/2019	R
Installation of Impermeable Geotextile Layer	9/13/2019	9/14/2019	R
Gravel Levelling Bed Placement	9/14/2019	9/15/2019	R
Gravel Layer Compaction	9/15/2019	9/16/2019	R
Planting Grass Strip	9/16/2019	9/20/2019	B



Construction Schedule Template © 2017 by Vertex42.com

Construction Start: 5/1/2019

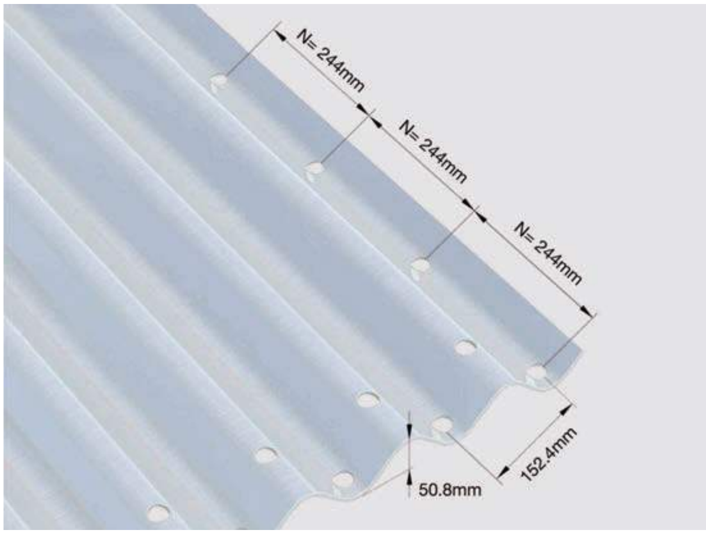
TASK DESCRIPTION	PLAN START	PLAN END	DIVISION
SYSTEM CONNECTIONS	**9/8/2019**	**11/8/2019**	
Air Valves Installation on Tank	9/8/2019	9/18/2019	O
Pipe Installation from Last Pond to Grit Chamber	9/19/2019	9/27/2019	O
Pipe Installation from Tank to Storm Main	9/28/2019	10/8/2019	O
Pipe Installation from Storm Main to First Pond	10/9/2019	10/23/2019	O
Manhole Construction at System Connections	10/24/2019	11/8/2019	Y
PROJECT COMPLETION	**11/15/2019**	**11/30/2019**	
Deficiencies	11/15/2019	11/25/2019	B
Commissioning	11/26/2019	11/28/2019	B
Demobilization	11/29/2019	11/30/2019	B
XXX			
Insert new rows ABOVE this one			

Week	Date
1	1 Ma 19
2	8 Ma 19
3	15 Ma 19
4	22 Ma 19
5	29 Ma 19
6	5 Ap 19
7	12 Ap 19
8	19 Ap 19
9	26 Ap 19
10	3 Ma 19
11	10 Ma 19
12	17 Ma 19
13	24 Ma 19
14	31 Ma 19
15	7 Ju 19
16	14 Ju 19
17	21 Ju 19
18	28 Ju 19
19	5 Ju 19
20	12 Ju 19
21	19 Ju 19
22	26 Ju 19
23	2 Au 19
24	9 Au 19
25	16 Au 19
26	23 Au 19
27	30 Au 19
28	6 Se 19
29	13 Se 19
30	20 Se 19
31	27 Se 19
32	4 Oc 19
33	11 Oc 19
34	18 Oc 19
35	25 Oc 19
36	1 No 19
37	8 No 19
38	15 No 19
39	22 No 19
40	29 No 19
41	6 De 19

Construction Schedule Template © 2017 Vertex42.com
https://www.vertex42.com/ExcelTemplates/construction-schedule.html

Engineering Parameters

Design Codes



CorPlate structures are engineered using industry recognized design codes for soil-metal buried structures. The analysis and design is completed in accordance with the specific requirements of Section Seven of the CAN/CSA S6 Canadian Highway Bridge Design Code pertaining to soil-metal structures.

For jurisdictions outside of Canada, or as requested by an owner, other industry accepted design codes are available:

- AISI (American Iron and Steel Institute)
- AASHTO (American Association of State Highway Transportation Officials)
- ASTM (American Society for Testing and Materials)

Section properties for Corrugated Structural Plate

Wall Thickness		Area	Tangent Length	Tangent Angle	Moment of Inertia	Section Modulus	Radius of Gyration
Specified	Design						
T	T	A	TL	↺	I	S	r
mm	mm	mm^2/mm	mm	Degrees	mm^4/mm	mm^3/mm	mm
3.0	2.84	3.522	47.876	44.531	1057.25	39.42	17.326
4.0	3.89	4.828	46.748	44.899	1457.56	53.30	17.375
5.0	4.95	6.149	45.582	45.286	1867.12	66.98	17.425
6.0	6.00	7.461	44.396	45.686	2278.31	80.22	17.475
7.0	7.00	8.712	43.237	46.083	2675.11	92.56	17.523

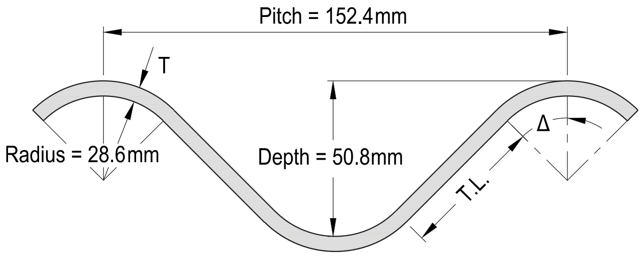
Dimensions are subject to manufacturing tolerances

Material and Manufacturing Specifications

The material and fabrication of Canada Culvert's CorPlate structures follows the requirements for structural plate in accordance with the most current version of the CSA Standard G401 – Corrugated Steel Pipe Products.

For specific components, the following specifications are used in accordance with the CSA G401 as previously described:

Reference Specifications	
Plates	ASTM A761/A761M
Bolts	ASTM A449
Nuts	ASTM A563
Hook Bolts	ASTM F1554
Galvanizing	CAN/CSA-G164-M92
Polymer Coating	CAN/CSA G401



Corrugation Profile: 152 x 51mm

Coatings

Coatings that stand up to any environment

Canada Culvert offers four finishes that provide a range of performance levels from temporary applications to severe environmental conditions. Black steel can be used for temporary or short-term applications; Z915 is the industry standard galvanized coating; Z1220 is a heavier galvanized coating, or a thermoplastic copolymer.

Black Steel

Black steel structures are ideal for temporary work or short-term projects where CorPlate structures will be removed. Since the structures are not coated in zinc, significant savings can be gained in both dollars and, delivery time.

Galvanized Z915

Z915 galvanized (915 g/m^2) is a hot-dip zinc coating that forms a superior barrier over steel. Calcium attracted from naturally hard water can aid in providing additional protection as it develops mineral scale on the pipe surface. As the zinc coating corrodes slowly over time, it galvanically protects the base steel as long as any zinc remains.

Galvanized Z1220

The Z1220 coating consists of 1220 g/m^2 zinc total on both sides. This heavier galvanized coating offers increased abrasion and corrosion resistance by forming an impervious barrier between the steel and the environment. Since it is a heavier coating, the Z1220 will add years of extended protection in environments where standard galvanized coatings can't be used.

Thermoplastic Copolymer

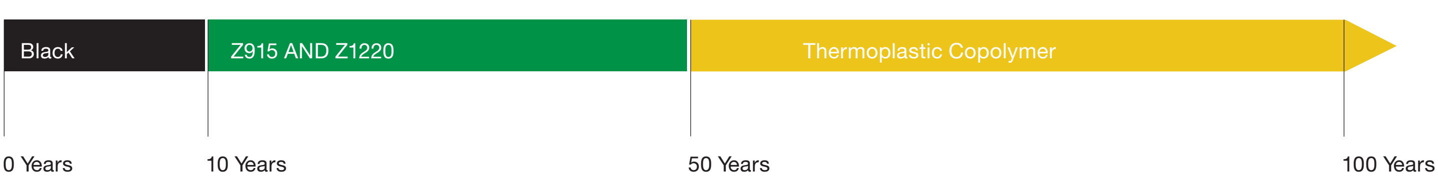
This unique solvent free two coat system gives two layers of protection. The base coat zinc layer provides outstanding corrosion resistance while being completely sealed from the environment by the top coat ethylene acrylic acid copolymer, which ensures superior resistance to impact, corrosion, abrasion and an inorganic acid or alkali (diluted). CorPlate structure with a thermoplastic copolymer coating is a great alternative to concrete because it is significantly lighter and offers a long-term service life from 75 to 100 years in aggressive environments.

Environmental Limits for Galvanized Steel and Thermoplatic Copolymer Coated Steel

Environmental Parameter	Suggested Limits Galvanized Steel	Suggested Limits for Thermoplastic Copolymer Coated Steel		
		50 Year EMSL	75 Year EMSL	100 Year EMSL
pH Preferred Range	5 - 9	3 to 12	4 to 9	5 to 9
Resistivity[1]	2,000 - 8,000 ohm-cm	> 100 ohm-cm	> 750 ohm-cm	> 1,500 ohm-cm
Chlorides	< 250 ppm	NA [1]	NA [1]	NA [1]
Sulfates	< 600 ppm	NA [1]	NA [1]	NA [1]
Hardness	> 80 ppm $CaCO_3$	NA [1]	NA [1]	NA [1]

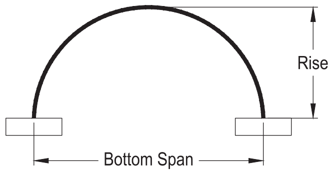
[1]Resistivity is relative to total dissolved solids (TDS) and therefore may indicate the presence of chlorides, sulfates, calcium and other ions

Estimated Material Service Life
(Typical Ranges) [2]



[2]Actual estimated material service life (EMSL) is dependent on local environment conditions

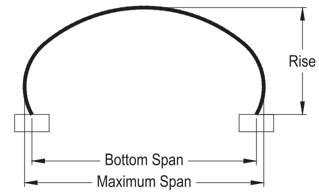
Arch



Structure #	Bottom Span (mm)	Rise (mm)	End Area (m^2)
CP-A-1	1520	810	0.98
CP-A-2	1830	840	1.16
CP-A-3	1830	970	1.39
CP-A-4	2130	860	1.39
CP-A-5	2130	1120	1.86
CP-A-6	2440	1020	1.86
CP-A-7	2440	1270	2.42
CP-A-8	2740	1180	2.46
CP-A-9	2740	1440	3.07
CP-A-10	3050	1350	3.16
CP-A-11	3050	1600	3.81
CP-A-12	3350	1360	3.44
CP-A-13	3350	1750	4.65
CP-A-14	3660	1520	4.18
CP-A-15	3660	1910	5.48
CP-A-16	3960	1680	5.02
CP-A-17	3960	2060	6.50
CP-A-18	4270	1840	5.95
CP-A-19	4270	2210	7.43
CP-A-20	4570	1870	6.41
CP-A-21	4570	2360	8.55
CP-A-22	4880	2030	7.43

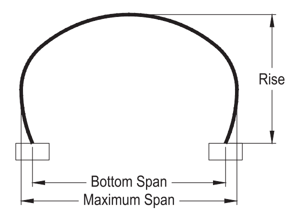
Structure #	Bottom Span (mm)	Rise (mm)	End Area (m^2)
CP-A-23	4880	2520	9.75
CP-A-24	5180	2180	8.55
CP-A-25	5180	2690	11.06
CP-A-26	5490	2210	9.01
CP-A-27	5490	2720	11.71
CP-A-28	5790	2360	10.22
CP-A-29	5790	2880	13.01
CP-A-30	6100	2530	11.52
CP-A-31	6100	3050	14.59
CP-A-32	6400	3195	16.04
CP-A-33	6400	2685	12.93
CP-A-34	6700	3350	17.64
CP-A-35	6700	2845	14.38
CP-A-36	7000	3510	19.31
CP-A-37	7000	3005	15.91
CP-A-38	7300	3670	21.06
CP-A-39	7300	3030	16.62
CP-A-40	7600	3825	22.89
CP-A-41	7600	3190	18.26
CP-A-42	8000	4080	25.76
CP-A-43	8000	3315	19.92

Low Profile Arch



Structure #	Max Span (mm)	Bottom Span (mm)	Rise (mm)	End Area (m^2)
CP-LPA-1	5920	5820	2080	9.75
CP-LPA-2	6120	6050	2290	11.18
CP-LPA-3	6550	6500	2360	12.39
CP-LPA-4	6780	6730	2410	13.01
CP-LPA-5	7010	6930	2440	13.64
CP-LPA-6	7240	7160	2490	14.29
CP-LPA-7	7470	7390	2540	14.94
CP-LPA-8	7670	7620	2570	15.62
CP-LPA-9	7900	7850	2620	16.30
CP-LPA-10	8310	8150	3280	22.04

High Profile Arch



Structure #	Max Span (mm)	Bottom Span (mm)	Rise (mm)	End Area (m^2)
CP-HPA-1	6300	5740	3680	19.85
CP-HPA-2	6550	6050	3560	19.93
CP-HPA-3	6780	6270	3610	20.85
CP-HPA-4	7010	6530	3660	21.78
CP-HPA-5	7240	6760	3680	22.71
CP-HPA-6	7670	7230	3740	24.61
CP-HPA-7	7870	6920	4655	31.56
CP-HPA-8	8100	7190	4650	32.78
CP-HPA-9	8560	7500	5020	36.92
CP-HPA-10	8590	7750	4630	34.09

Installation and Foundations

Installation

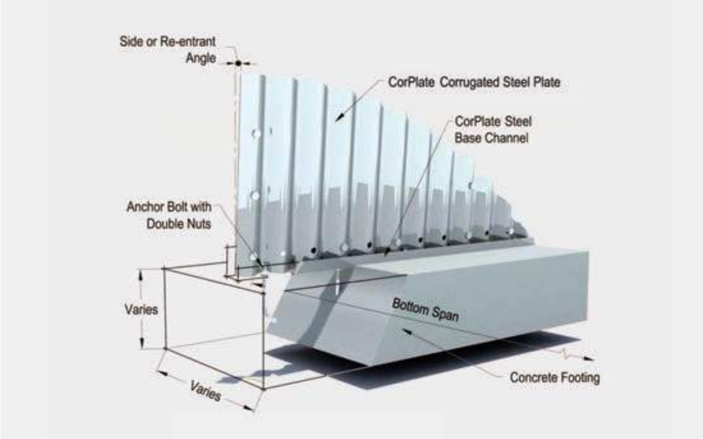
CorPlate structures are easy to assemble and backfill using local labour forces. Shop/assembly drawings, which are the clearest and most detailed assembly drawings in the industry, accompany every structure that is shipped to a jobsite. The drawings, along with a detailed installation guide and assistance from Canada Culvert, ensure that everyone from the contractor, owner and inspector know what is required for a successful installation.

Unloading

CorPlate structures are typically shipped to the job site on a flat deck truck. Since the corrugated plates are nested (stacked) in bundles and the bolts are in pails on skids, most typical structures can easily fit on one truck. Unloading is best done with a rubber tire loader that has forks.

Assembly

The most common practice is to assemble CorPlate structures component by component in the field. At the job site the structures can be assembled in the final location or preassembled in a staging area, then lifted into the final location with a crane. Sometimes it is desirable for small structures to be assembled in the shop by Canada Culvert and shipped as a single unit to the job site.



Foundation

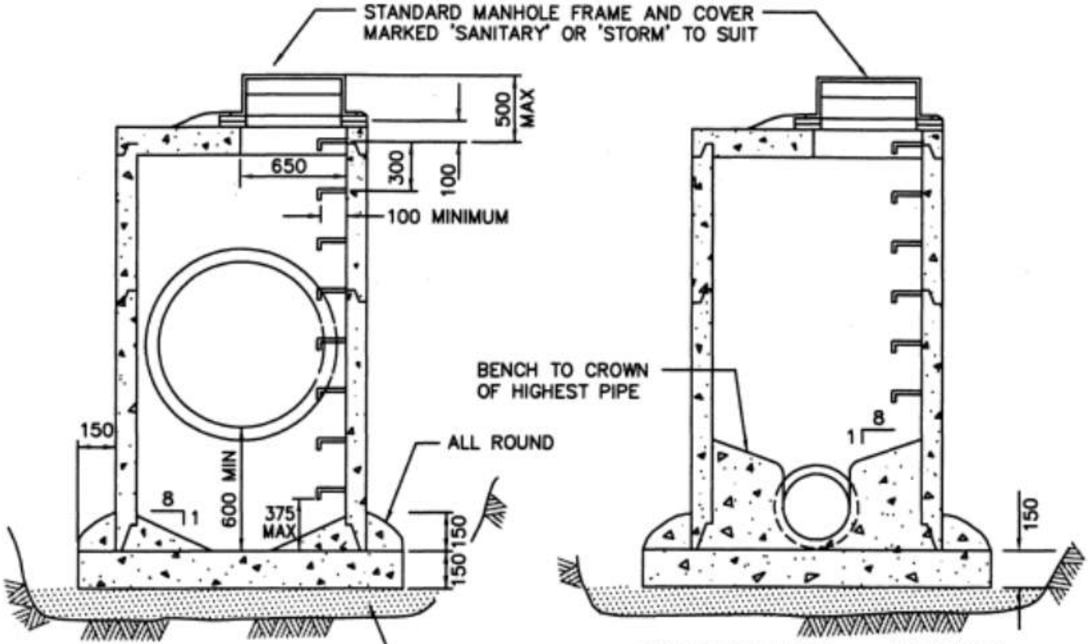
Concrete Footing

Cast-in-place or pre-cast concrete footings have the base channel embedded into the concrete using anchor bolts. These can be constructed in various configurations such as strip or stem footings.

Foundation

Corrugated Steel Footing

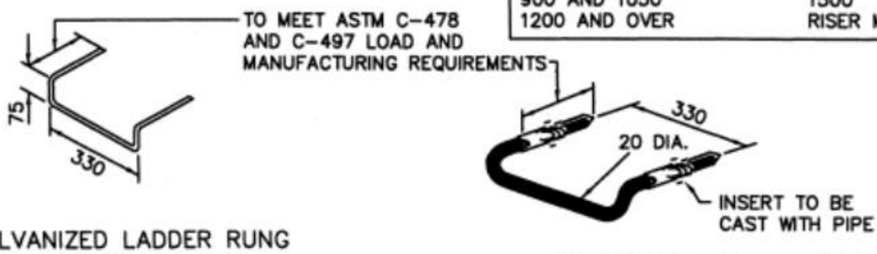
Corrugated steel footings are an excellent alternative solution to concrete footings for remote projects or where the speed of installation is very important to minimize the time of a road closure.



MANHOLE WITH SUMP

STANDARD 1050mm MANHOLE

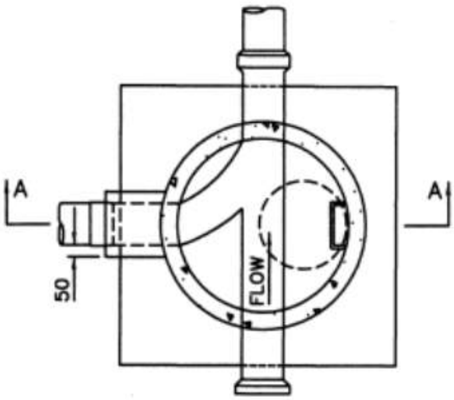
INSIDE PIPE DIA.	INSIDE MANHOLE DIA.
450mm AND LESS	1050
525 AND 600	1200
675 AND 750	1350
900 AND 1050	1500
1200 AND OVER	RISER MANHOLE



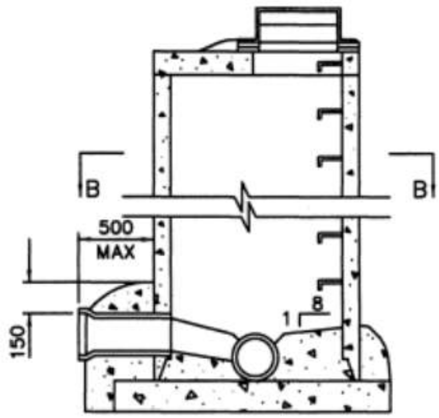
GALVANIZED LADDER RUNG TO BE CAST WITH PIPE

GALVANIZED, ALUMINUM OR POLY-ENCASED LADDER RUNG

NOTE:
1. DETAILS ARE DRAWN FOR PRECAST RISERS ON CAST-IN-PLACE BASE. PRECAST BASES APPROVED BY CONTRACT ADMINISTRATOR ARE ACCEPTABLE.
2. MAXIMUM DEPTH TO FIRST RUNG IS 500mm. WHEN HANDHOLD IS INSTALLED BETWEEN TOP AND FIRST RUNG, MAXIMUM DEPTH MAY BE INCREASED TO 660mm
3. FOR MANHOLES OVER 1200mm DIA. BASE THICKNESS TO BE 200mm.
4. REFER TO DRAWING S2 FOR CONNECTION DETAILS.
5. REFER TO CONTRACT DRAWINGS AND SECTION 02725 FOR DETAILED SPECIFICATIONS.



SECTION B–B



SECTION A–A

NOTE: 1. THIS DRAWING SHOWS CONNECTION DETAILS ONLY, REFER TO DRAWING S1 FOR ALL OTHER DETAILS PERTAINING TO MANHOLE REQUIREMENTS AND INSTALLATION

2. REFER TO CONTRACT DRAWINGS AND SECTION 02725 FOR DETAILED SPECIFICATIONS.

STANDARD MANHOLE CONNECTION DETAILS

DRAWING NUMBER: **S2**

OCEAN Pipe

9265 Oak Street, Vancouver BC
Phone: (604) 269-6700
Fax: (604) 261-6751
www.oceanpipe.com

CUSTOMER: UBC
PROJECT: UBC South Campus
ORDER DATE: N/A
DATE REQUIRED: N/A
MANHOLE Nº: S6D-S26B
TAKE OFF BY: Haley Oosterman

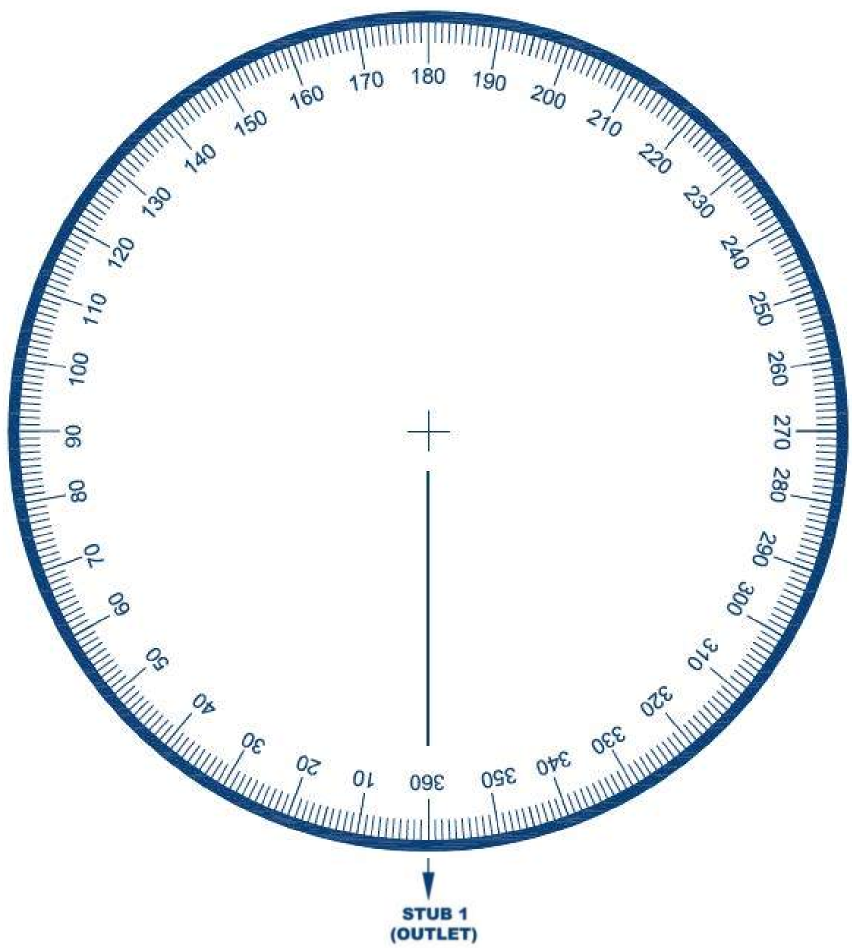
RIM ELEVATION
59.18

TYPE OF BASE	Prebenched Extended Base
DIAMETER OF MANHOLE	2400mm

SUMP
0 M

	STUB 1 Outlet	STUB 2 Select...	STUB 3 Select...	STUB 4 Select...	STUB 5 Select...
ALIGNMENT	0°	90 deg.	180 deg.		
DIAMETER	1050mm	1050mm	1050mm		
MATERIAL	CIV Concrete	CIV Concrete	CIV Concrete		
GRADE	2%	0.1%	2%		
INVERT	55.04m	54.89m	55.08		

NOTES:



These new Standard Installations identify four principal zones (which are critical to the pipe-soil system) surrounding the lower half of the pipe. The four zones – middle bedding, outer bedding, haunch and lower side – are shown in Figures 1 and 2 for trench and embankment installations. The type of material (based on soil characteristics) and level of compaction varies with the installation type, i.e., 1, 2, 3, or 4, and the material utilized in construction of these important zones.

Installation – Type 4 Type 4 is intended for installations where the most cost effective design approach is to specify minimal requirements for soil type and compaction, together with a pipe having sufficient strength to safely resist the increased structural effects that result from using low quality soils. Thus, Type 4 has little or no requirement for control of compaction and type of placed soil used in the bedding and haunch areas, except if silty clay soils are used in the haunch and outer bedding zones, they must be compacted. It is desirable to scarify (loosen) hard native soils before placing pipe.

Installation – Type 3 Type 3 permits the use of soils in the haunch and bedding zones having easily attained compaction requirements, justifying less stringent inspection requirements with granular and some native soils. Silty clays may be used in the haunch zone if adequately compacted. In addition to the foundation similar to Type 4, a bedding layer with a minimum thickness of 3 inches is required to avoid placing the pipe directly on hard or variable subgrade.

Installation – Type 2 Type 2 is a standard installation where certain native soils are permitted to be used with proper compaction in the haunch and bedding zones. Adequately compacted native silty granular soils or select granular soils may be used in the haunch and outer bedding zones. This is intended to allow the use of soil frequently found at a site. Any natural soil adjacent to the pipe should have a firmness equivalent to the placed soils. Foundation and bedding requirements are similar to Type 3.

Installation – Type 1 Type 1 requires well compacted, select granular soil to be placed in the haunch and bedding zones. The structural design of the pipe section then takes advantage of the support provided by this high quality soil envelope, making this installation often the most cost effective for pipe 60 inches in diameter and larger in deep fills.

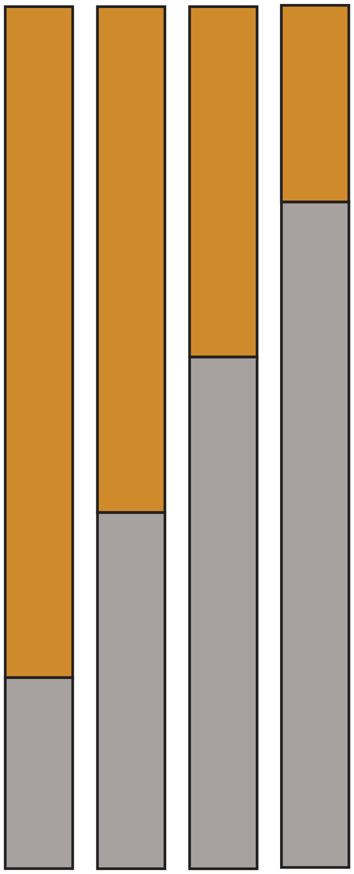
Beneficial Characteristics

Versatile - One can choose between installation types and pipe strengths (classes) to suit specific site conditions and budgetary constraints. The four standard installations can be used to optimize the total installed cost by evaluation of the ratio of pipe cost to backfill material cost.

Conservative - Analyses are based on the worst case (embankment) loadings, voids in the haunch zone, the greatest predicted loads, and measurable requirements that more accurately assess long-term performance of the system.

Quantifiable – Definite and measurable levels of acceptance are prescribed, which provides better direction for the designer and the contractor.

Relative Comparison Embedment vs Pipe Cost

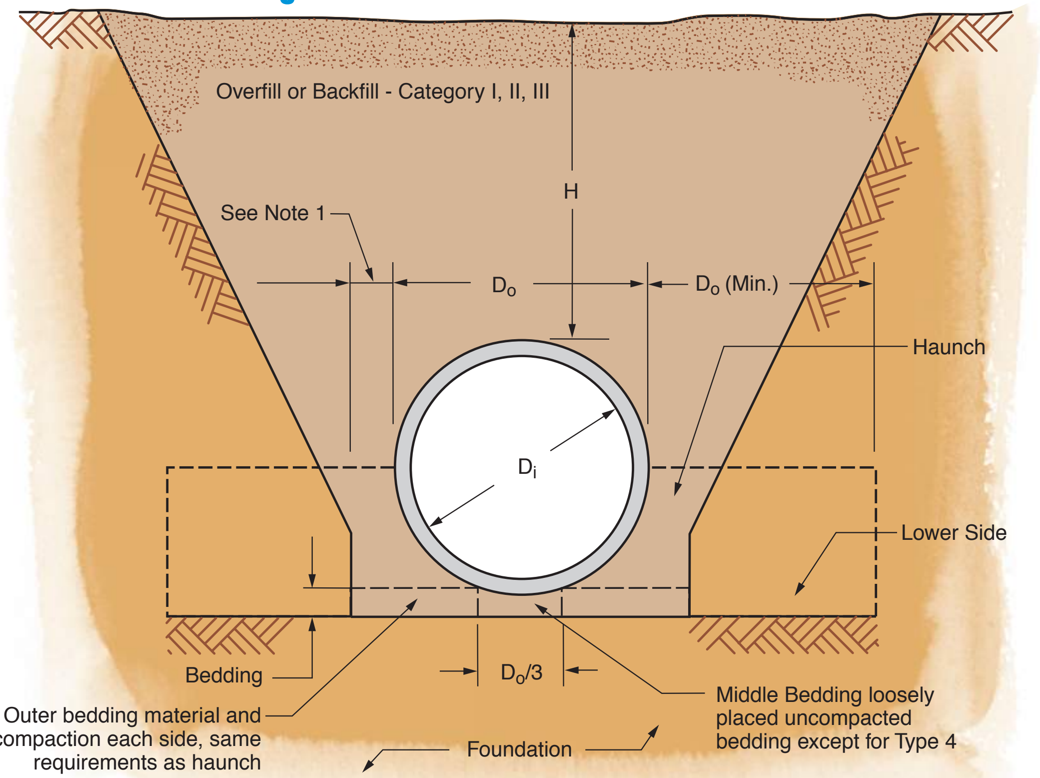


Equivalent USCS and AASHTO Soil Classifications for Soil Designations

Soil	Representative Soil Types		Percent Compaction	
	USCS ASTM D 2487	AASHTO M 145	Standard Proctor	Modified Proctor
Category I	Clean, course grained soils: SW, SP, GW, GP or any soil beginning with one of those symbols with 12% or less passing a #200 sieve	A-1, A-3	100 95 90 85	95 90 85 80
Category II	Course grained soils with fines: GM, GC, SM, SC or any soil beginning with one of these symbols, containing more than 12% passing a #200 sieve; Sandy or gravelly fine–grained soils: CL, ML, (or CL-ML, CL/ML, ML/CL) with 30% or more retained on a #200 sieve	A-2-4, A-2-5, A-2-6: or A-4 or A-6 soils with 30% or more retained on a #200 sieve	100 95 90 85	95 90 85 80
Category III	Fine-grained soils: CL, ML, (or CL-ML, CL/ML, ML/CL) with less than 30% retained on a #200 sieve	A-2-7: or A-4 or A-6 with less than 30% retained on a #200 sieve	100 95 90 85	90 85 80 75
Category IV but not allowed for haunch or bedding	MH, CH, OL, OH, PT	A-5, A-7	100 95 90	90 85 80

NOTE 1: Compaction Specifications:
Standard proctor density – AASHTO T 99, T 310, or Test Methods D 698
Modified proctor density – AASHTO T 180 or Test Methods D 1557

Figure 1. Standard Trench Installation



Note 1: Clearance between pipe and trench wall shall be adequate to enable specific compaction, but not less than $D_o/6$.

SOIL AND MINIMUM COMPACTION REQUIREMENTS

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	$D_0/24$ minimum; not less than 3 in. If rock foundation, use $D_0/12$ minimum; not less than 6 in.	95% Category I	Undisturbed natural soil with firmness equivalent to the following placed soils: 90% Category I, 95% Category II, or 100% Category III, or embankment to the same requirements
Type 2	$D_0/24$ minimum; not less than 3 in. If rock foundation, use $D_0/12$ minimum; not less than 6 in.	90% Category I or 95% Category II	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 3	$D_0/24$ minimum; not less than 3 in. If rock foundation, use $D_0/12$ minimum; not less than 6 in.	85% Category I, 90% Category II, or 95% Category III	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 4	No bedding required, except if rock foundation, use $D_0/12$ minimum; not less than 6 in.	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

Note 1. Compaction and soil symbols, i.e. 95% Category I, refer to a soil material category with a minimum standard proctor density. See Table on page 4 for equivalent modified proctor values and soil types.

Note 2. When the trench width specified must be exceeded, the owner shall be notified.

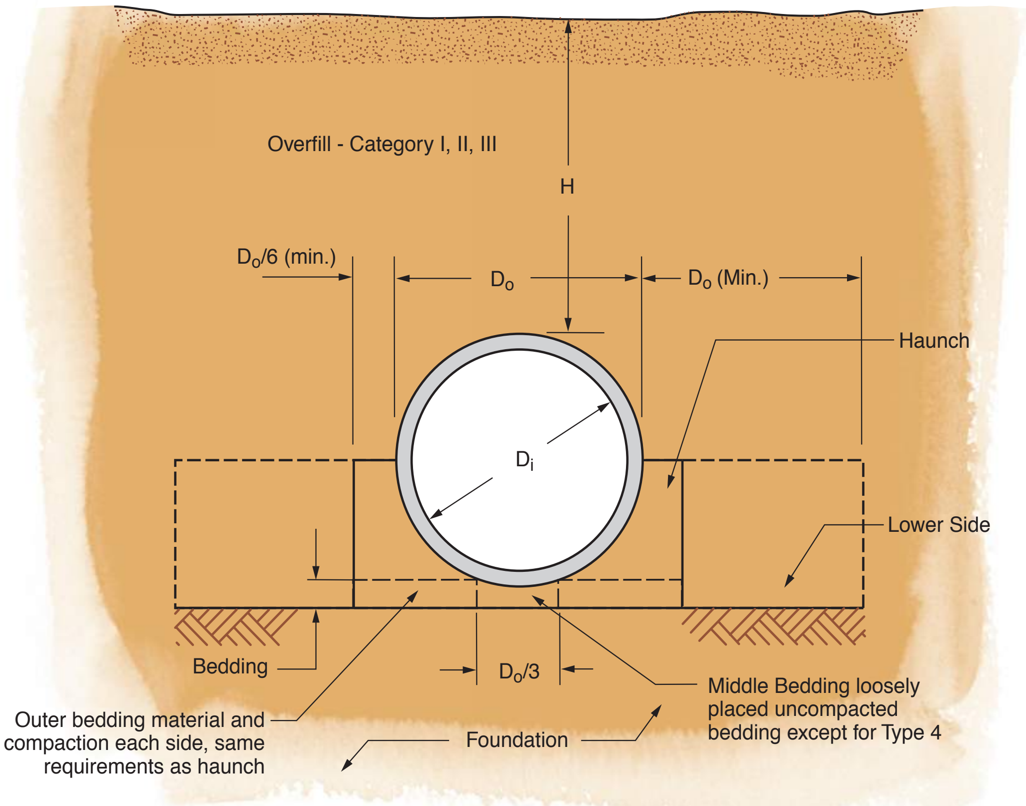
Note 3. The trench width shall be wider than shown if required for adequate space to attain the specified compaction in the haunch and bedding zones.

Note 4. Embankment loading shall be used when trench walls consist of embankment unless a geotechnical analysis is made and the soil in the trench walls is compacted to a higher level than the soil in the backfill zone.

Note 5. Required bedding thickness is the thickness of the bedding prior to placement of the pipe.

Note 6. "Dumped" material without additional compactive effort will not provide the design haunch support required for Type 1 and 2 installations and it should be checked for Type 3 installations.

Figure 2. Standard Embankment Installation



SOIL AND MINIMUM COMPACTION REQUIREMENTS

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	D_0/24 minimum; not less than 3 in. If rock foundation, use D_0/12 minimum; not less than 6 in.	95% Category I	90% Category I, 95% Category II, or 100% Category III
Type 2	D_0/24 minimum; not less than 3 in. If rock foundation, use D_0/12 minimum; not less than 6 i	90% Category I or 95% Category II	85% Category I, 90% Category II, or 95% Category III
Type 3	D_0/24 minimum; not less than 3 in. If rock foundation, use D_0/12 minimum; not less than 6 in.	85% Category I, 90% Category II, or 95% Category III	85% Category I, 90% Category II, or 95% Category III
Type 4	No bedding required, except if rock foundation, use D_0/12 minimum; not less than 6 in.	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

Note 1. Compaction and soil symbols, i.e. 95% Category I, refer to a soil material category with a minimum standard proctor density. See Table on page 4 for equivalent modified proctor values and soil types.

Note 2. Soil in the outer bedding, haunch, and lower side zones, except within D_O/3 from the pipe springline, shall be compacted to at least the same compaction as the majority of soil in the overfill zone.

Note 3. Required bedding thickness is the thickness of the bedding prior to placement of the pipe.

Note 4. A subtrench is defined as a trench with its top below finished grade by more than 0.1H or, for roadways, its top is at an elevation lower than 1 ft below the bottom of the pavement base material.
The minimum width of a subtrench shall be 1.33 D_O or wider, if required for adequate space to attain the specified compaction in the haunch and bedding zones.
For subtrenches, except within D_O/3 from the springline, any portion of the lower side zone in the subtrench wall shall be at least as firm as an equivalent soil placed to the compaction requirements specified for the lower side zone and as firm as the majority of soil in the overfill zone, or it shall be removed and replaced with soil compacted to the specified level.

Note 5. "Dumped" material without additional compactive effort will not provided the design haunch support required for Type 1 and 2 installations and it should be checked for Type 3 installations.

STANDARDS:

- ASTM C 1479 Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations
- AASHTO Standard Specifications for Highway Bridges
- ASCE 15 Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)

REFERENCES:

- Concrete Pipe Technology Handbook
- Concrete Pipe Design Manual
- Concrete Pipe Handbook
- Design Data 40 (American Concrete Pipe Association Publications)

OCEAN Pipe

9265 Oak Street, Vancouver BC
Phone: (604) 269-6700
Fax: (604) 261-6751
www.oceanpipe.com

CUSTOMER: UBC
PROJECT: UBC South Campus
ORDER DATE: N/A
DATE REQUIRED: N/A
MANHOLE Nº: T6D-S25
TAKE OFF BY: Haley Oosterman

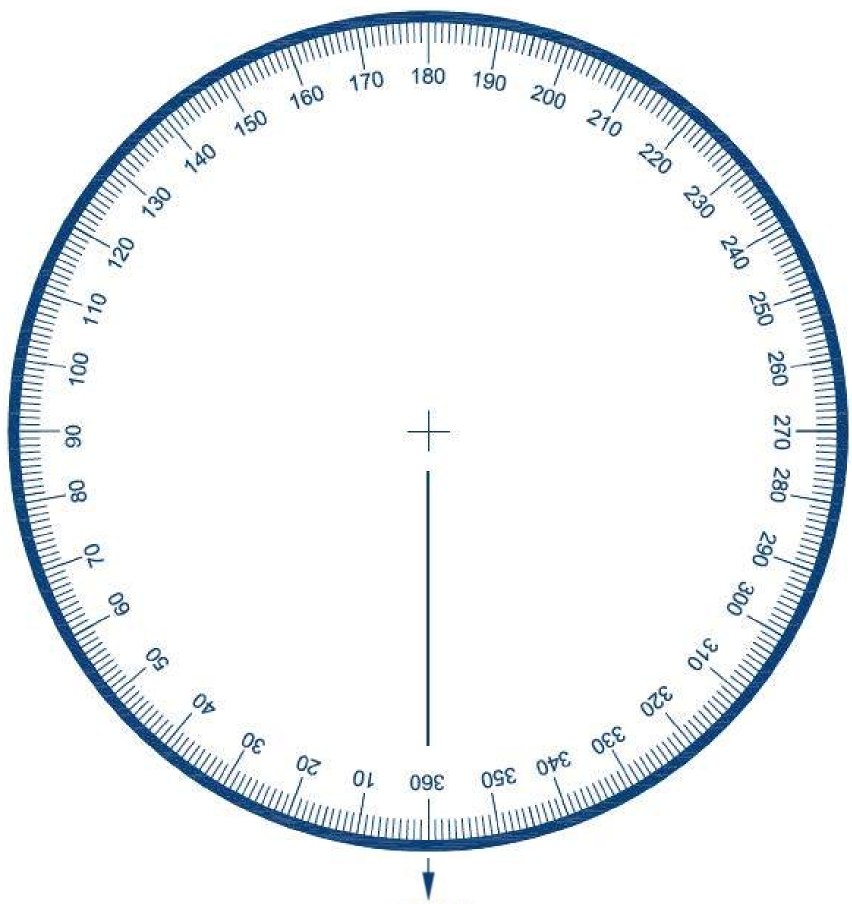
RIM ELEVATION
53.49

TYPE OF BASE	Prebenched Extended Base
DIAMETER OF MANHOLE	2400mm

SUMP
0 M

	STUB 1 Outlet	STUB 2 Inlet	STUB 3 Inlet	STUB 4 Select...	STUB 5 Select...
ALIGNMENT	0°	135 deg.	225 deg.		
DIAMETER	1050mm	750mm	1050mm		
MATERIAL	CIV Concrete	CIV Concrete	CIV Concrete		
GRADE	2%	0.5%	2%		
INVERT	51.21m	51.25m	51.25m		

NOTES:



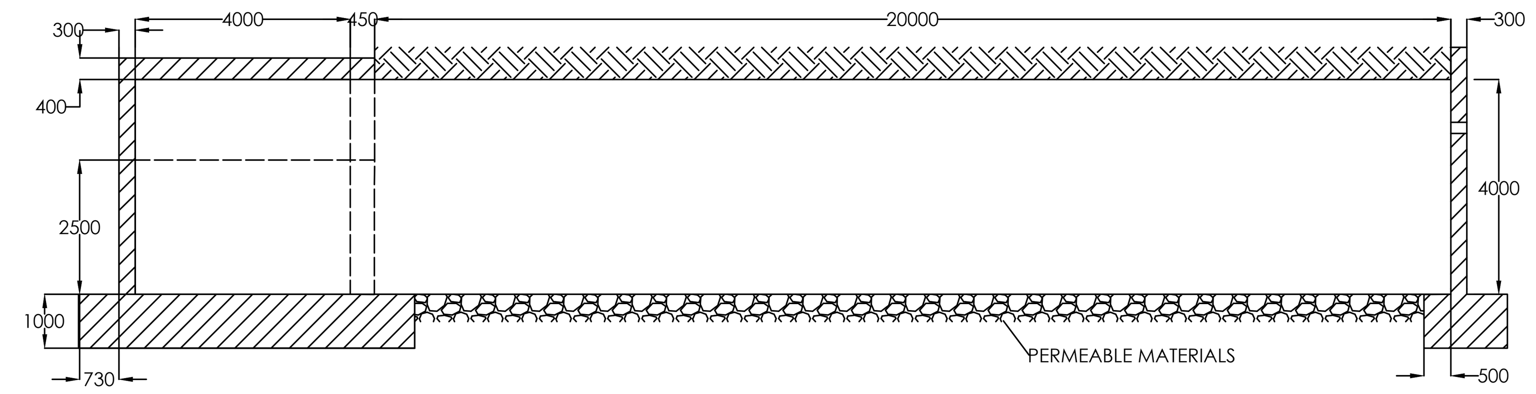
STUB 1 (OUTLET)

Appendix C: Engineering Drawings

PRODUCED BY AN AUTODESK STUDENT VERSION

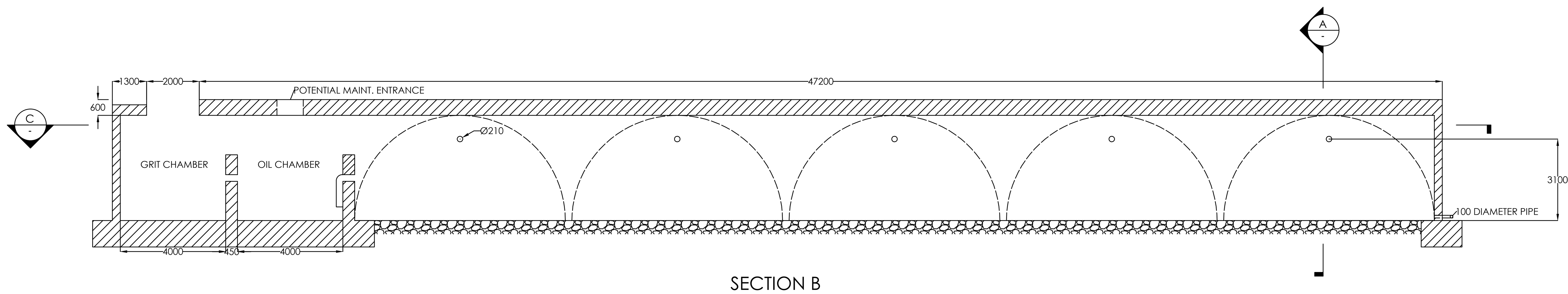
Notes:

ALL UNITS IN mm



SECTION A

SCALE: N/A



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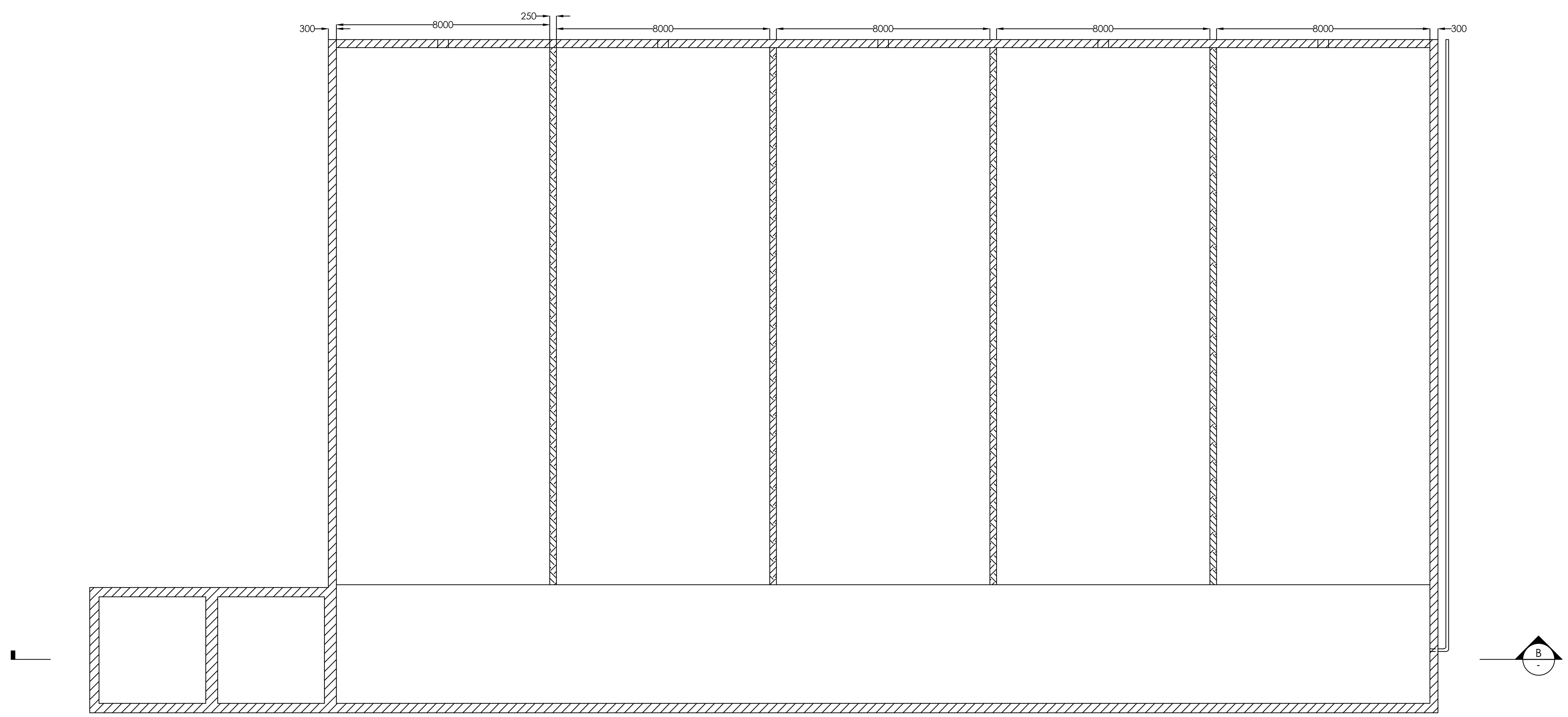

SECTION C

SCALE: N/A

REV:	DESCRIPTION:	BY:	DATE:
D	FIXED OUTLET DIAMETERS & ADDED ANNOTATIONS	KM	11-28-2018
C	REVISED DIMENSIONS & ADDED ADDITIONAL DESIGN DETAILS	KM	11-26-2018
B	REMOVED PUMP INTAKE	KM	11-19-2018
A	PRELIMINARY DESIGN DRAFT	KM	11-13-2018

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: STORMWATER TANK LAYOUT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-001	D

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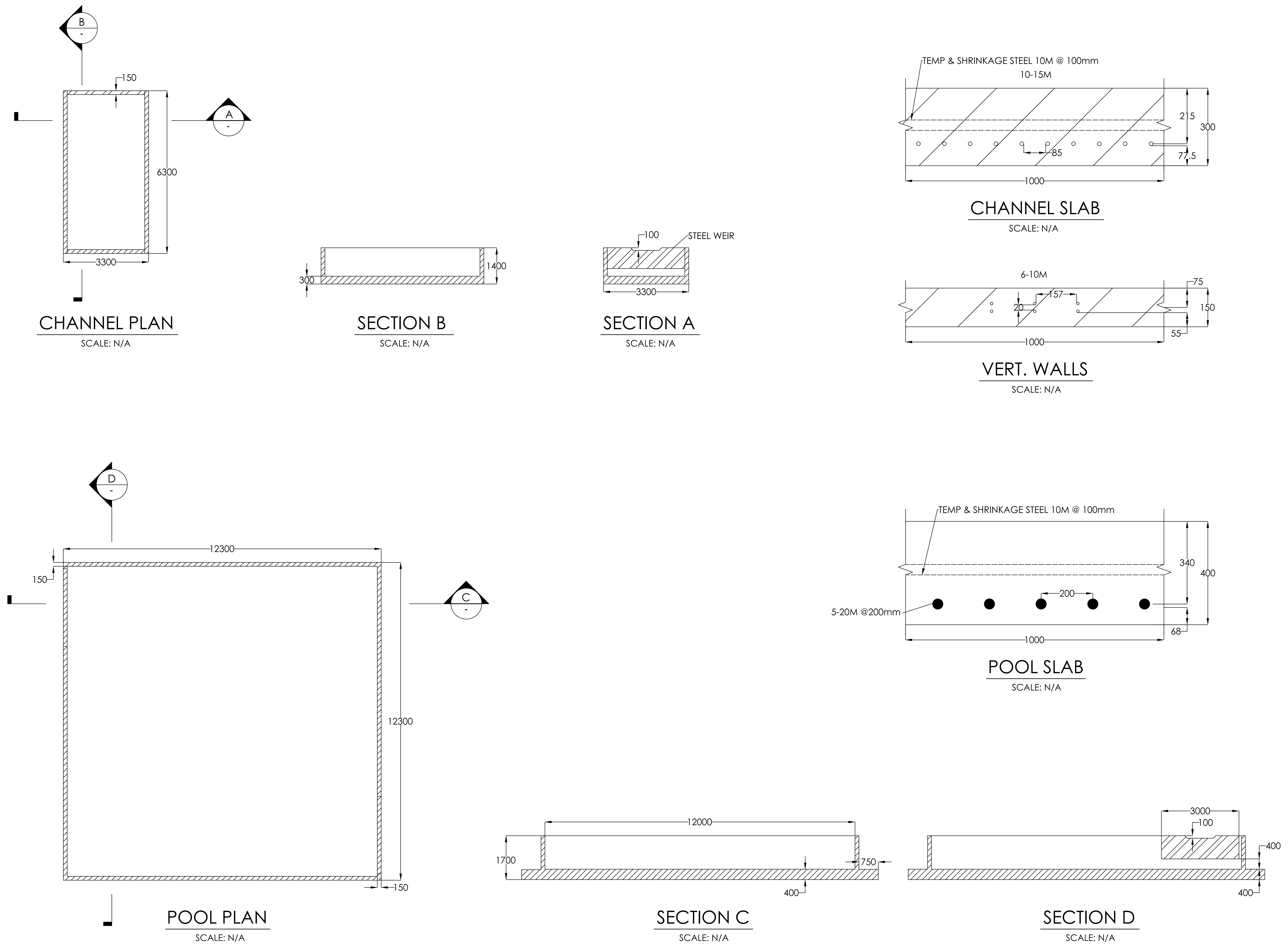

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
D	ADDED TEMP. & SHRINKAGE STEEL	KM	02-03-2019
C	FIXED INCORRECT DIMENSIONS	KM	11-28-2018
B	ADDED WEIR	KM	11-27-2018
A	PRELIMINARY DESIGN DRAFT	KM	11-19-2018

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: SURFACE POOLS AND CHANNEL LAYOUTS

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM
PROJECT NO: 2	DRAWING NO: 11-002		REVISION: D

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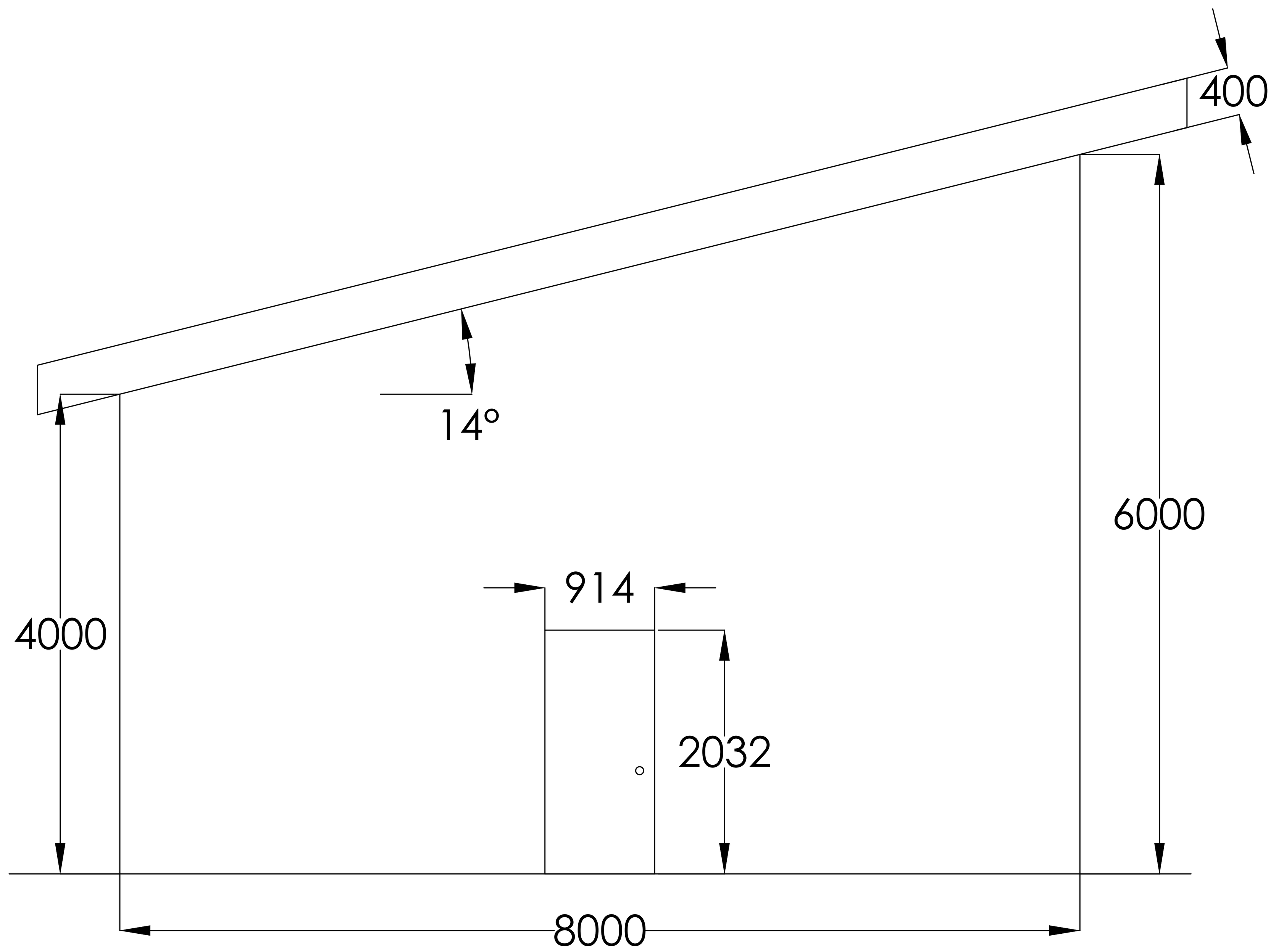
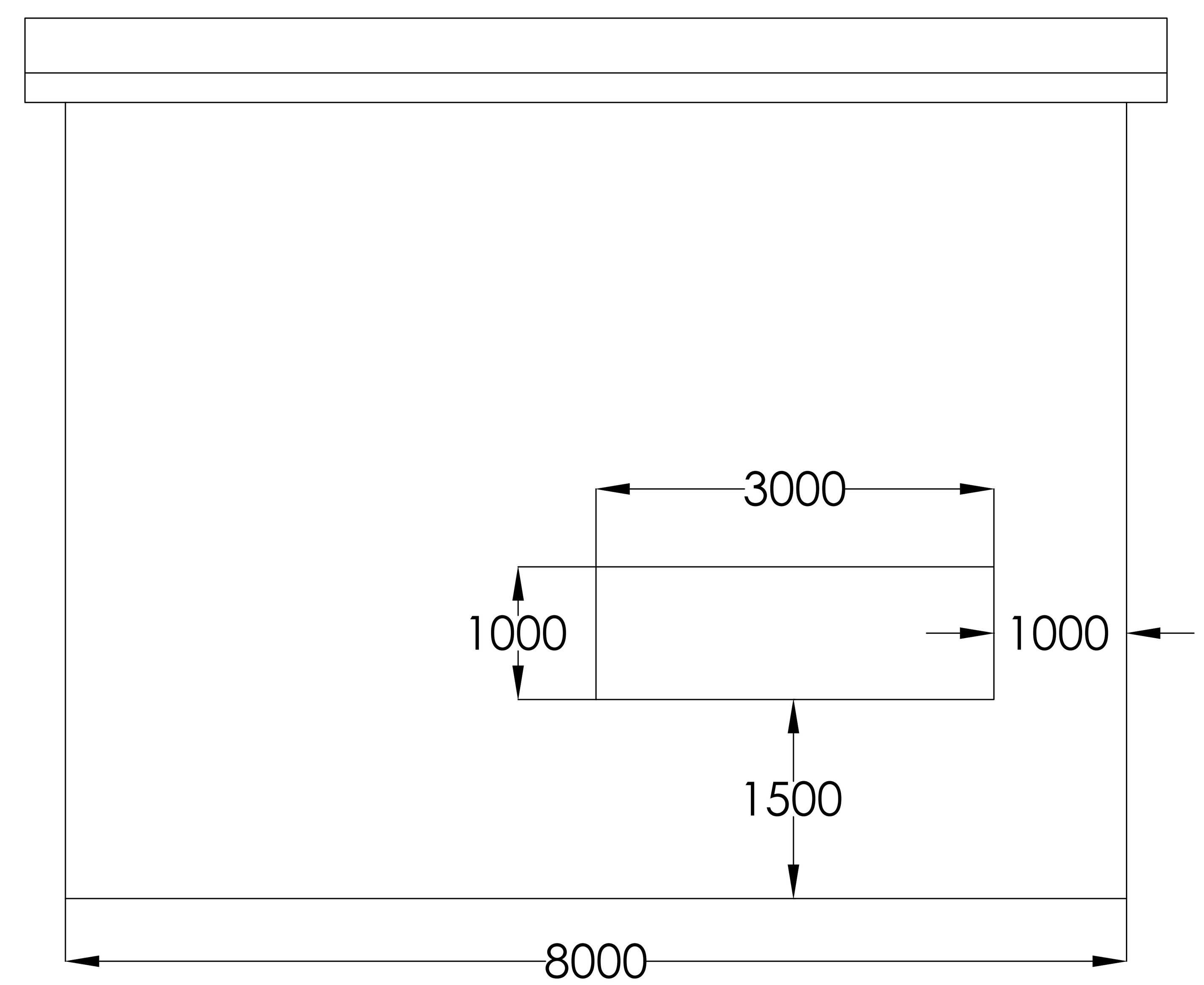


SIDE ELEVATION

SCALE: N/A



FRONT ELEVATION

SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	PRELIMINARY DESIGN DRAFT	KM	11-28-2018

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: OPERATION SHACK
ELEVATIONS

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-28-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-003	A

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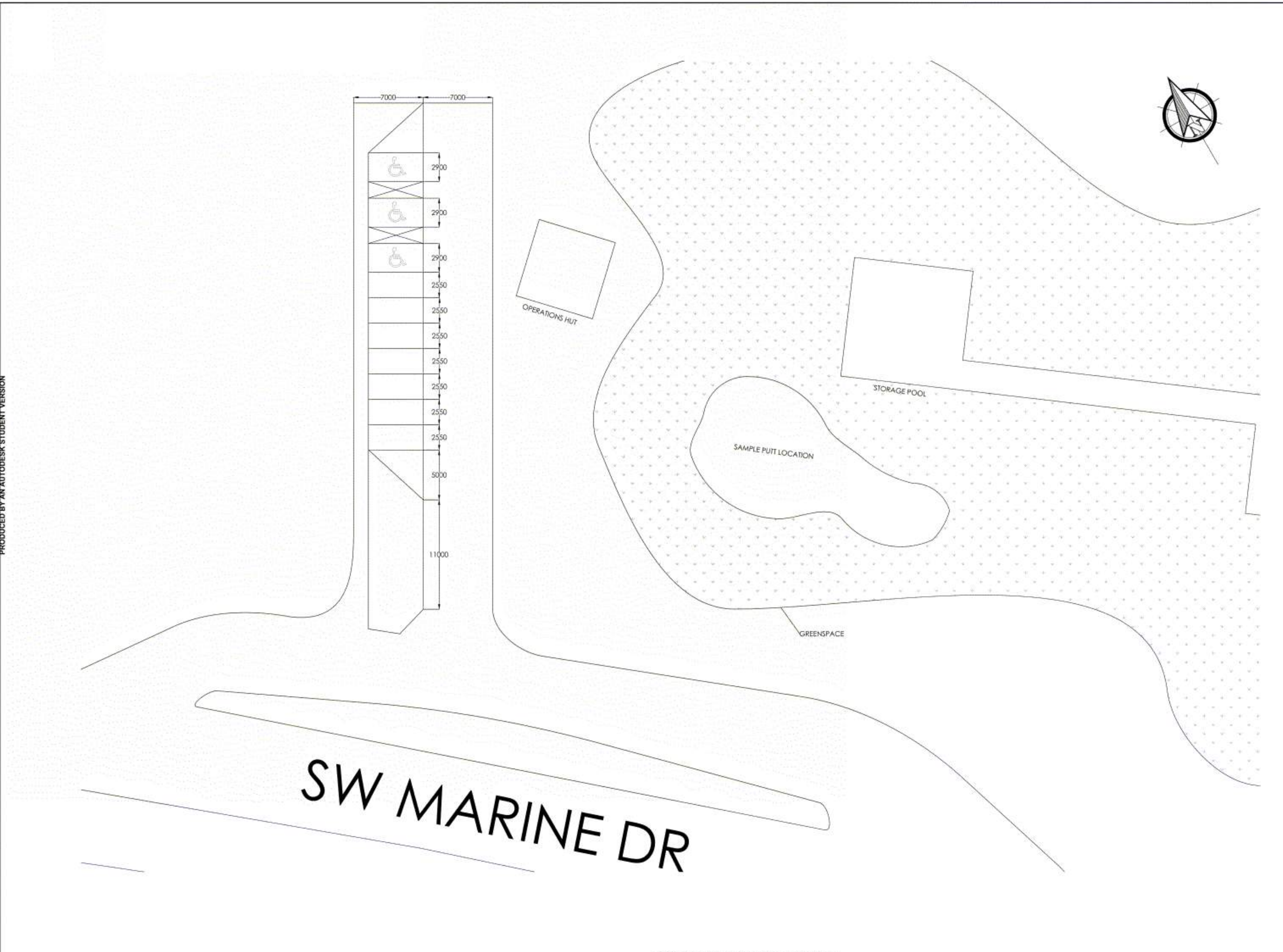

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	PRELIMINARY DESIGN DRAFT	KM	11-28-2018

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: PROPOSED PARKING LAYOUT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-28-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-004	A

PRODUCED BY AN AUTODESK STUDENT VERSION
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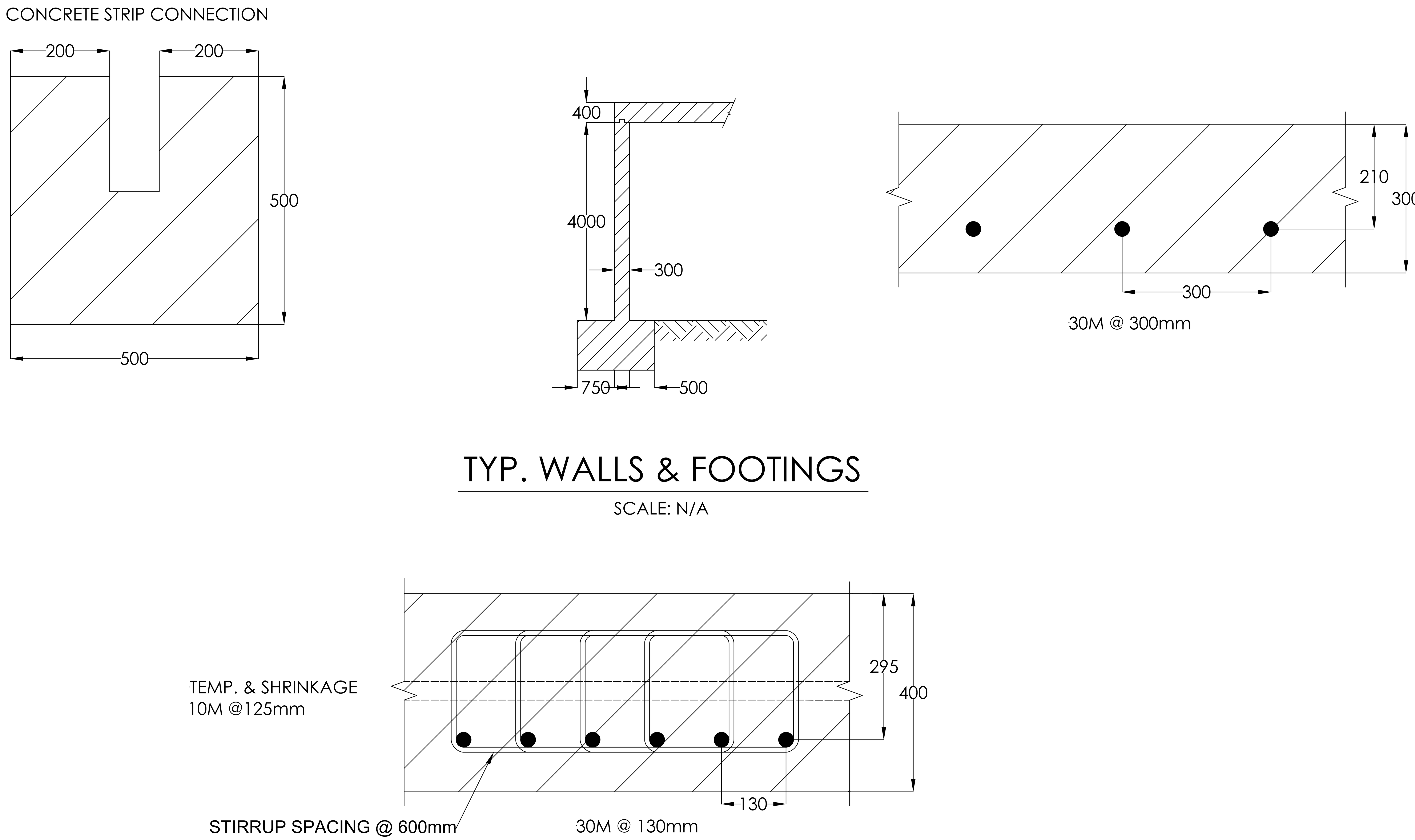
PRODUCED BY AN AUTODESK STUDENT VERSION



TYP. WALLS & FOOTINGS

SCALE: N/A

TYP. ROOF SLAB

SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
E	CONCEPTUAL DESIGN	KM	02-03-2019

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: TYPICAL WALLS, FOOTINGS
& ROOF DETAIL

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-005	E

PRODUCED BY AN AUTODESK STUDENT VERSION
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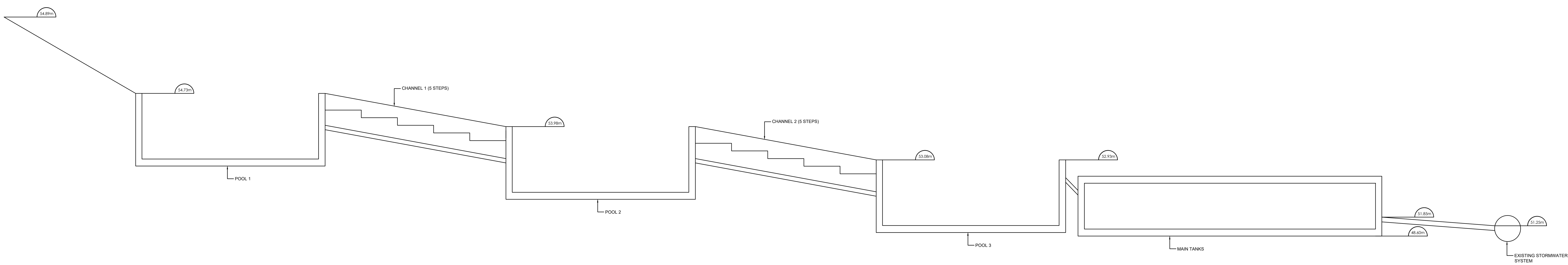
PRODUCED BY AN AUTODESK STUDENT VERSION



ELEVATIONS

SCALE: N/A

Notes:

1. ALL CHANNELS AND PONDS WILL BE AT GRADE
2. EACH CHANNEL HAS FOUR (4) 15cm STEPS
3. ALL UNITS IN METERS

REV:	DESCRIPTION:	BY:	DATE:
A	CONCEPTUAL DESIGN DRAFT	KM	02-03-2019

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: POND & TANK ELEVATION LAYOUT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM
PROJECT NO:	DRAWING NO:		REVISION:
2	11-006		A

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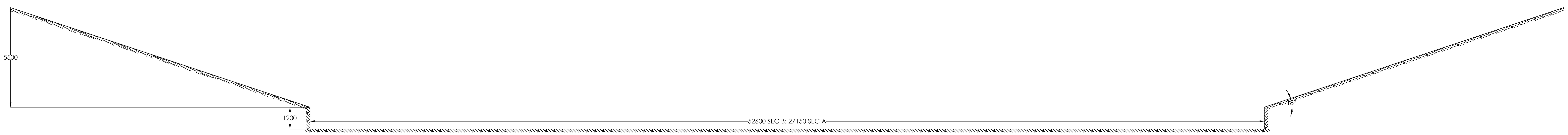
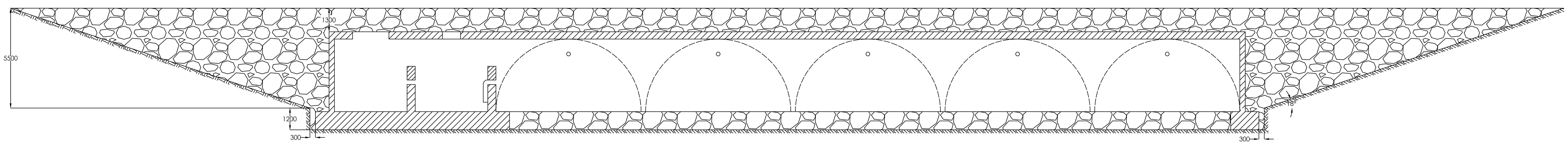
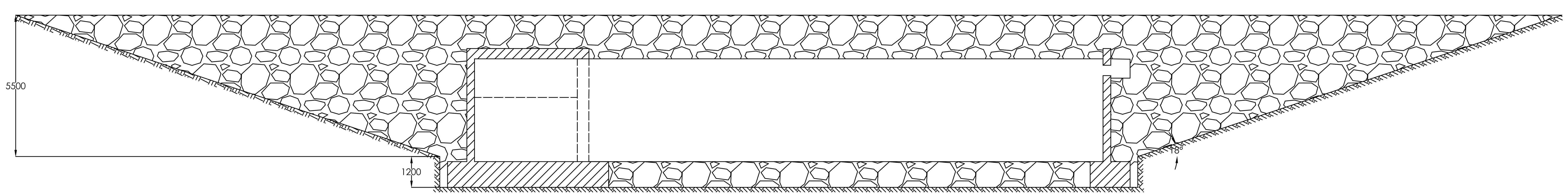
PRODUCED BY AN AUTODESK STUDENT VERSION





SEC B TANK EXCAVATION

SCALE: N/A



SEC A TANK EXCAVATION

SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	CONCEPTUAL DESIGN DRAFT	KM	02-03-2019

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: TANK EXCAVATION
LAYOUT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM
PROJECT NO:	DRAWING NO:		REVISION:
2	11-007-02		A

PRODUCED BY AN AUTODESK STUDENT VERSION
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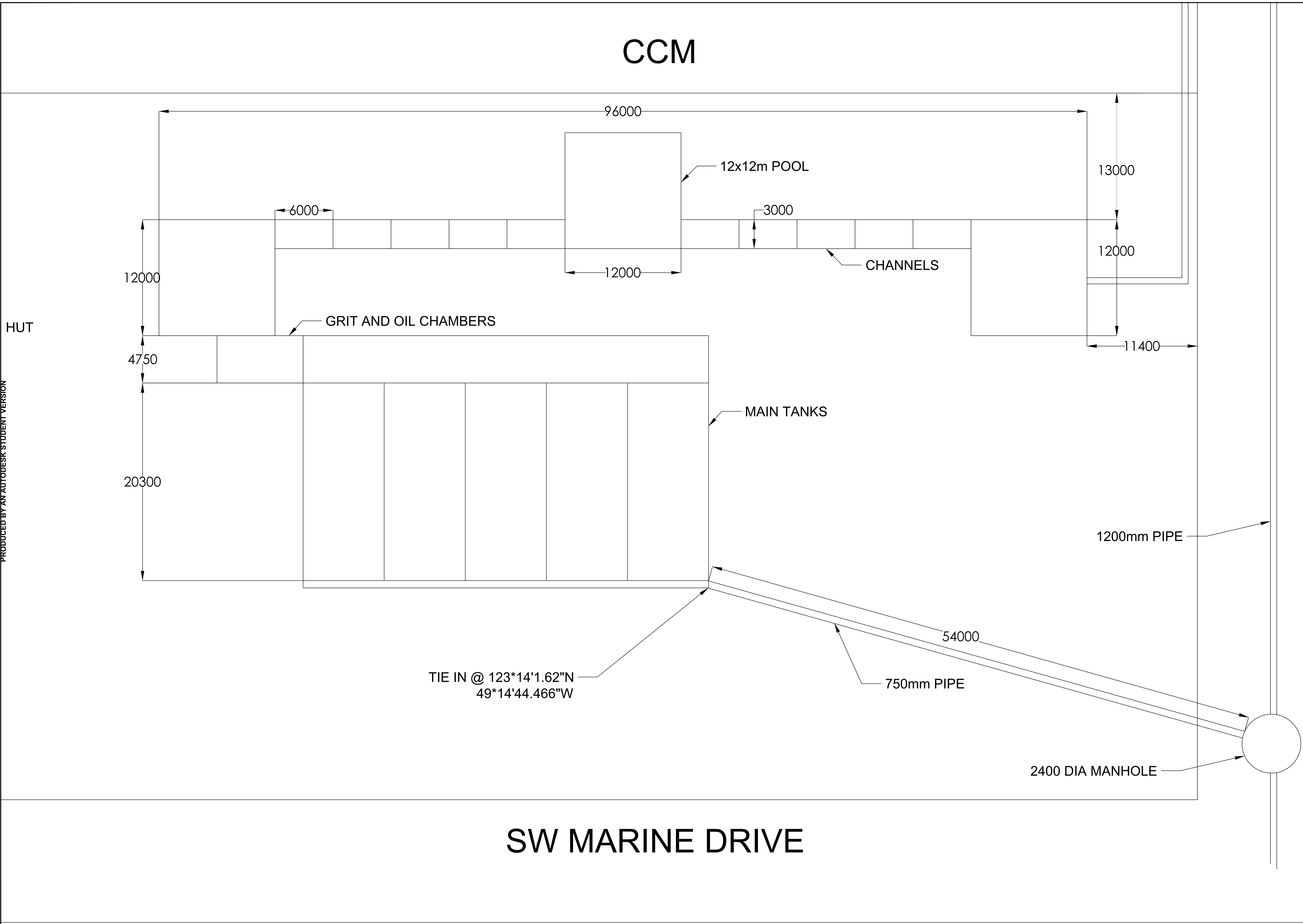
PRODUCED BY AN AUTODESK STUDENT VERSION



Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	CONCEPTUAL DESIGN DRAFT	KM	02-03-2019

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: SITE LOCATION OVERVIEW

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

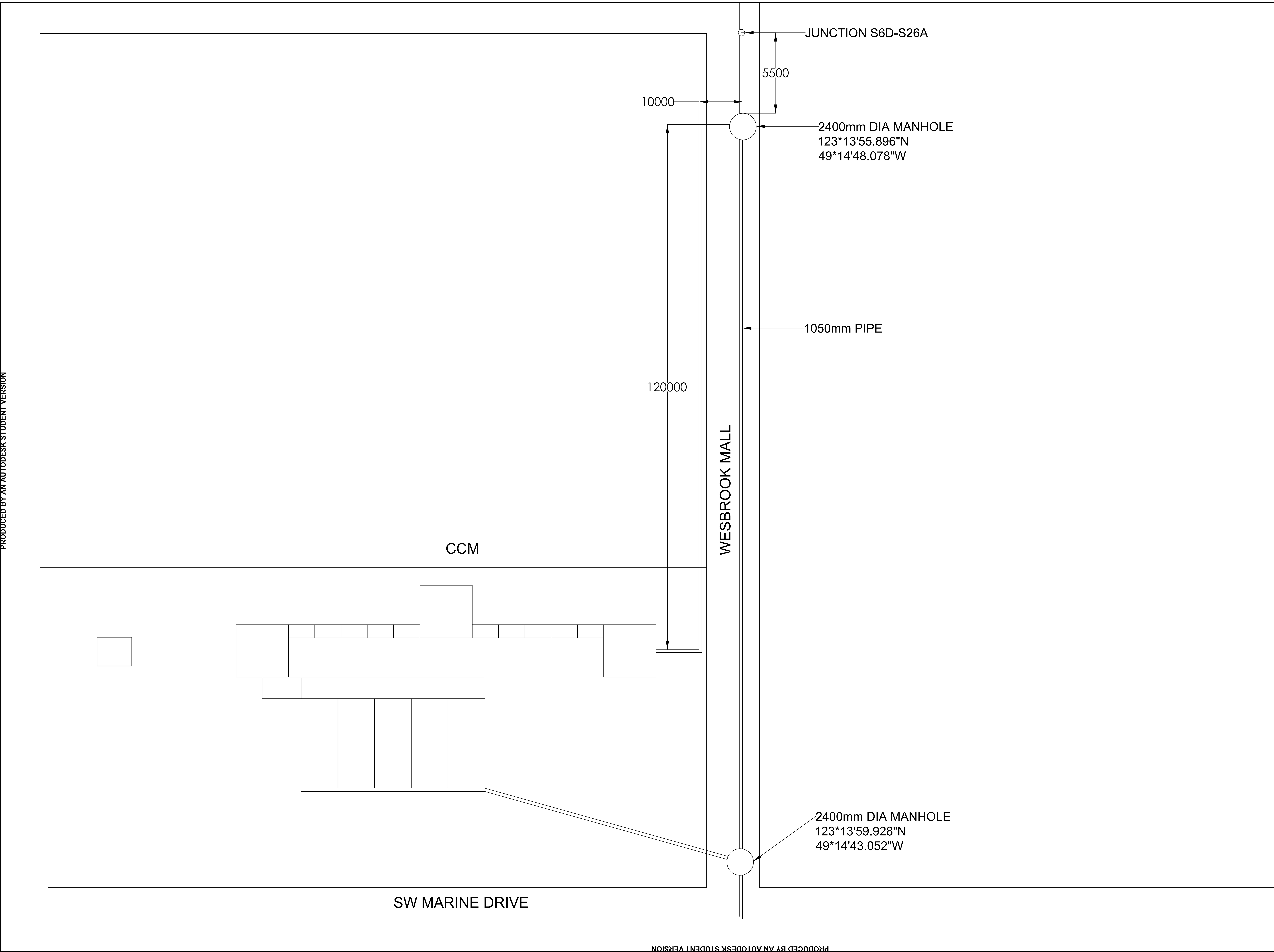
PROJECT NO:	DRAWING NO:	REVISION:
2	11-008-01	A

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION



Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	FINAL DESIGN DRAFT	KM	03-31-2019

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

TITLE: SITE LOCATION OVERVIEW

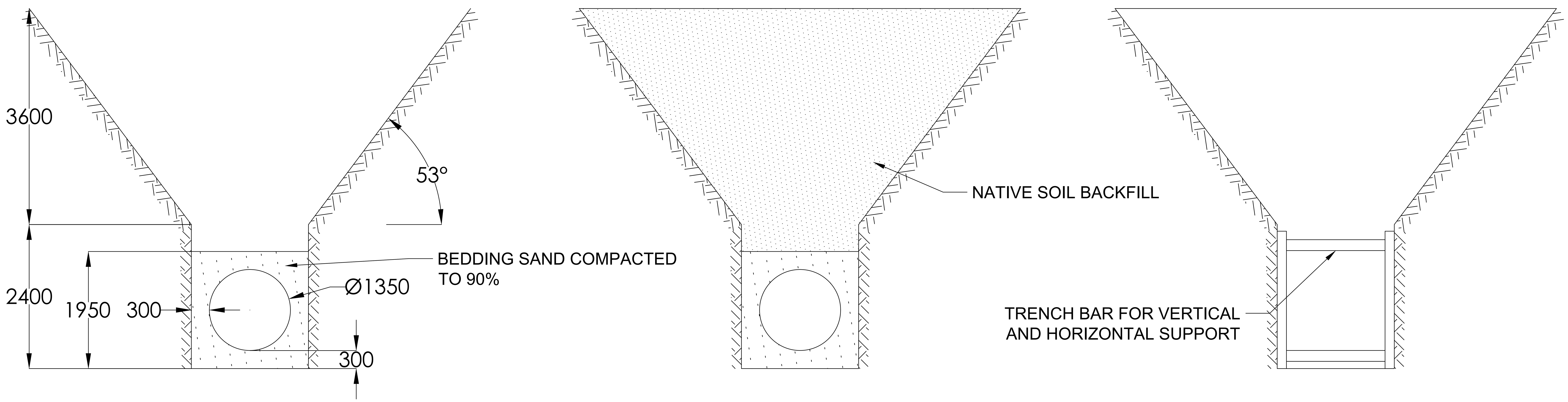
SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM
PROJECT NO:	DRAWING NO:		REVISION:
2	11-009-01		A

PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

Notes:

ALL UNITS IN mm



PIPE EXCAVATION

SCALE: N/A

REV:	DESCRIPTION:	BY:	DATE:
A	FINAL DESIGN DRAFT	KM	03-31-2019

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
btengineering@gmail.com

CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

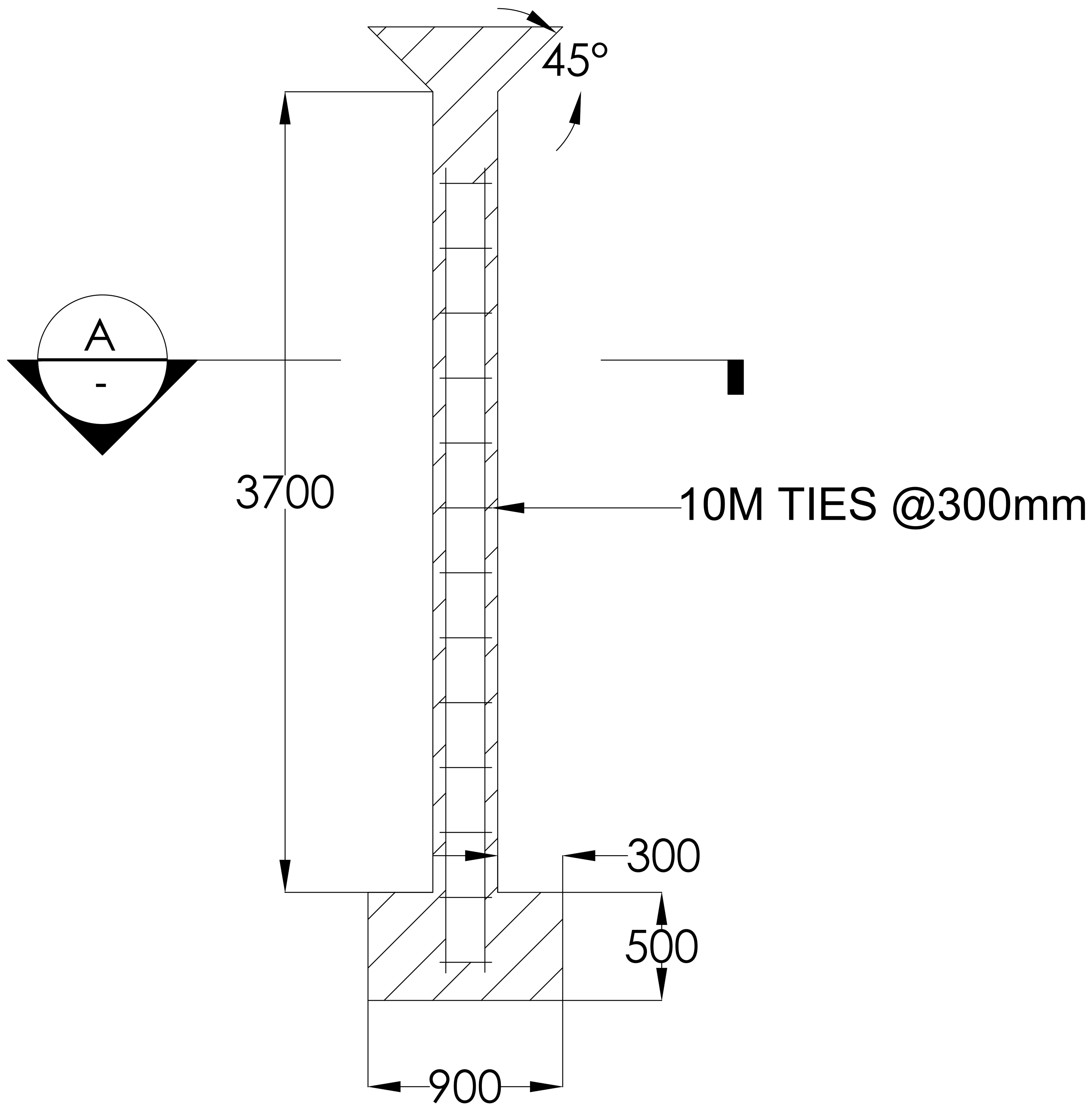
TITLE: PIPE EXCAVATION
AND SUPPORT LAYOUTS

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM

PROJECT NO:	DRAWING NO:	REVISION:
2	11-010	A

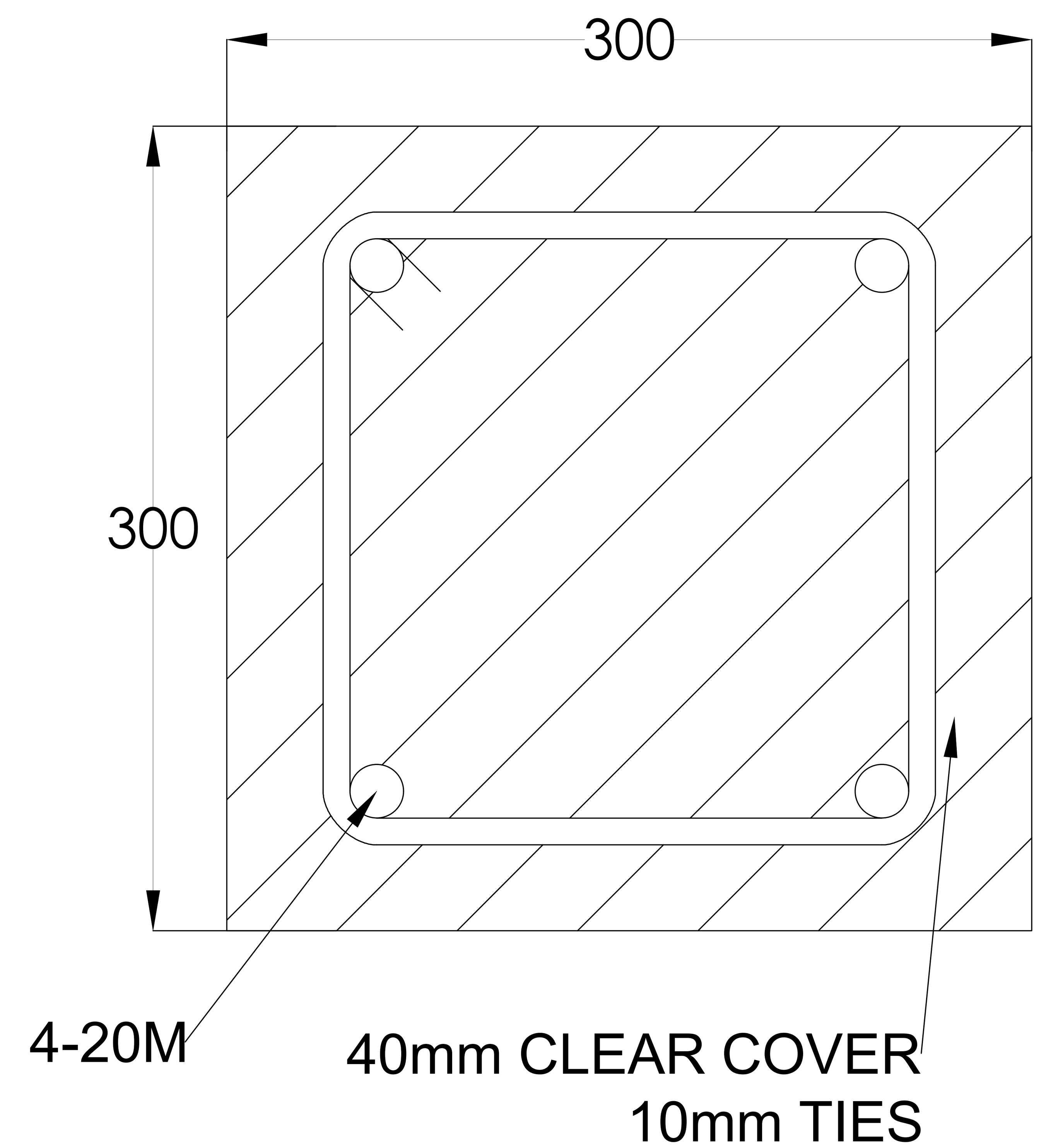
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION



TANK COLUMN

SCALE: N/A



SECTION A

SCALE: N/A

Notes:

ALL UNITS IN mm

REV:	DESCRIPTION:	BY:	DATE:
A	FINAL DESIGN DRAFT	KM	03-31-2019

STATUS: N.F.C.

Black Tusk Engineering
2250 Wesbrook Mall
Vancouver, BC
V6T 1W6
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CLIENT: UBC
2329 WEST MALL
VANCOUVER, BC
V6T 1Z4

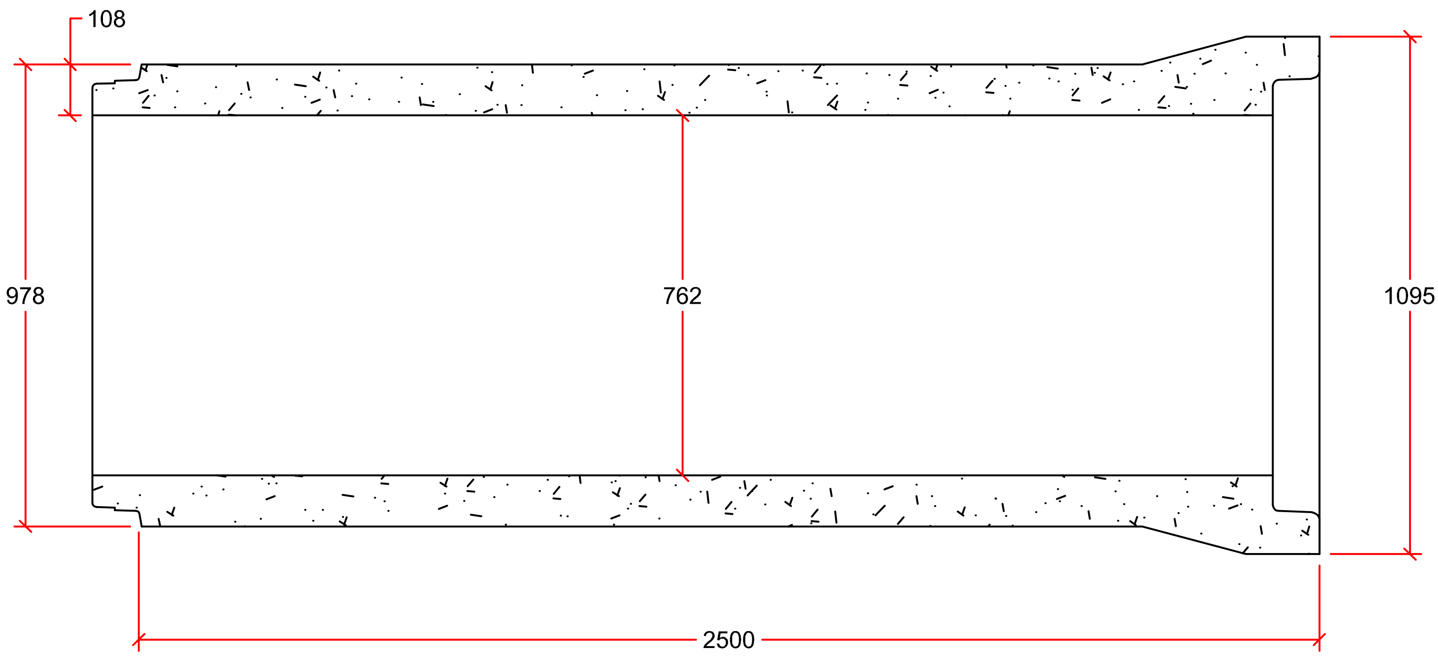
ARCHITECT: BLACK TUSK ENGINEERING
2250 WESBROOK MALL
VANCOUVER, BC
V6T 1W6

SITE: UBC CCM
SW MARINE & WESBROOK

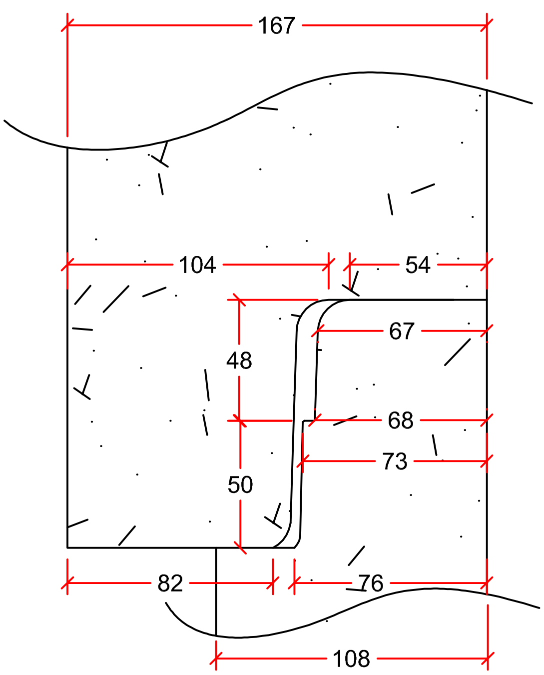
TITLE: TANK COLUMN
AND REINFORCEMENT

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
N/A	11-26-2018	KM	KM
PROJECT NO: 2	DRAWING NO: 11-011		REVISION: A

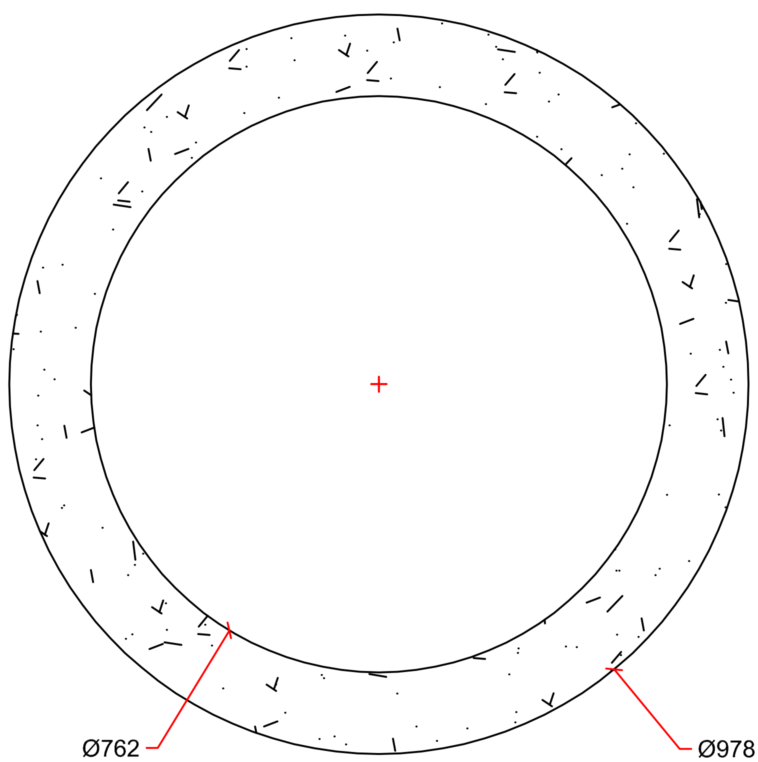
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION



PIPE DETAIL

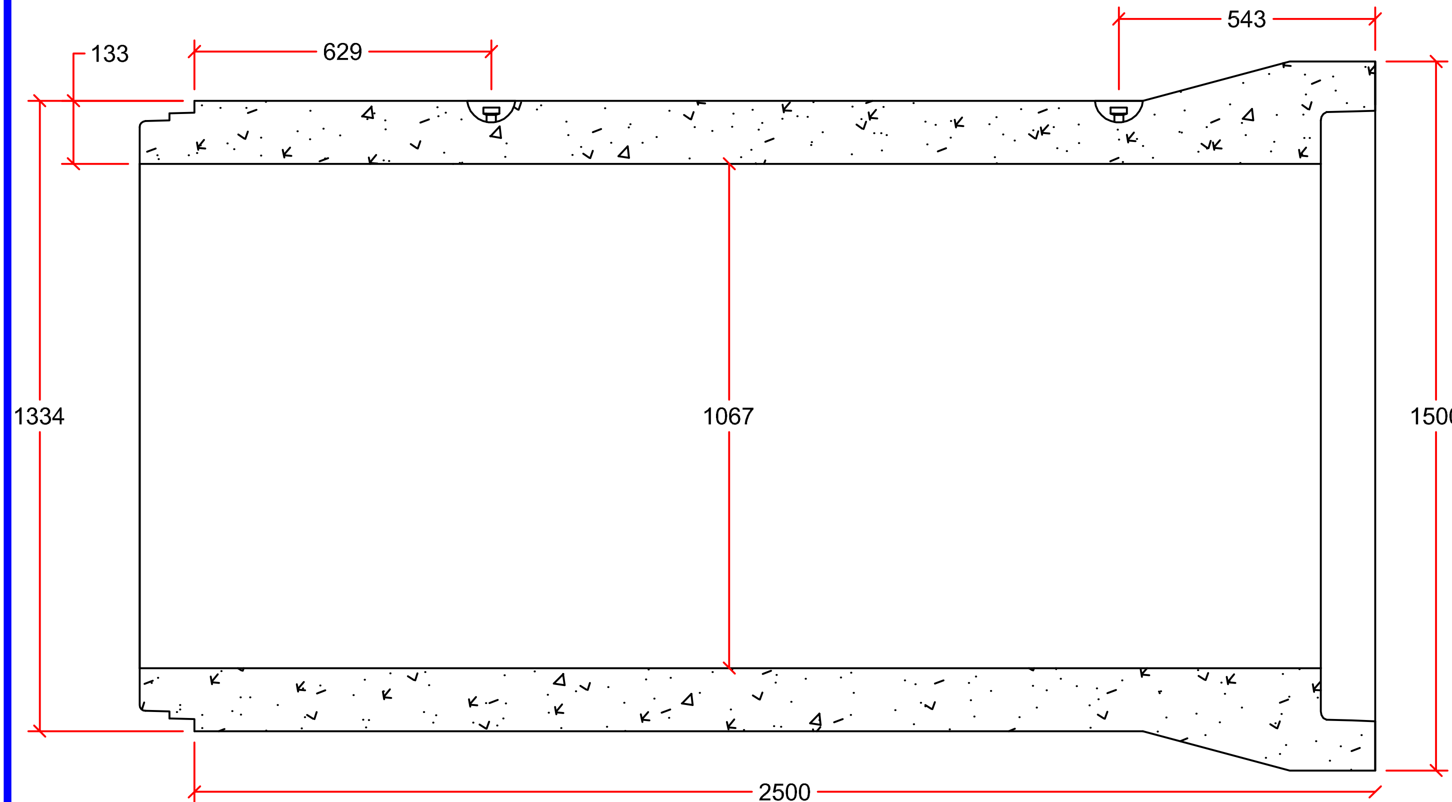


JOINT DETAIL

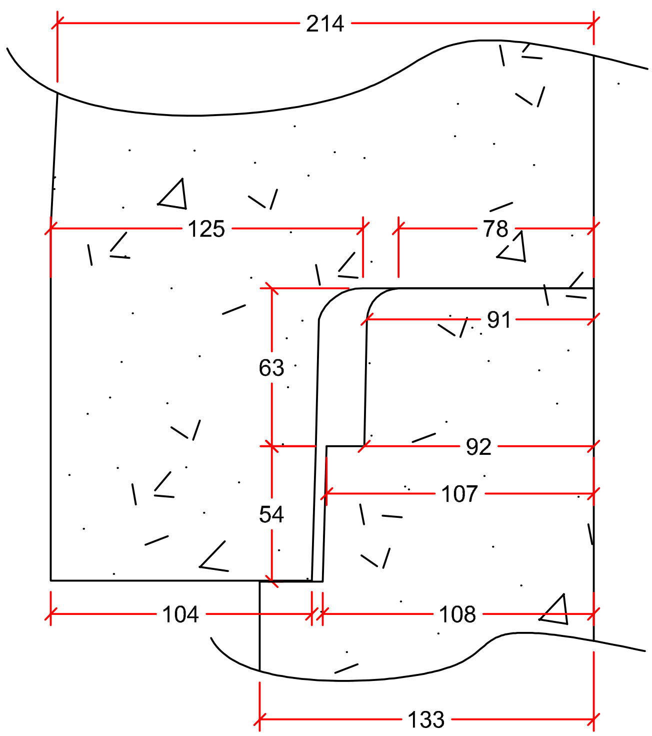


SECTION DETAIL

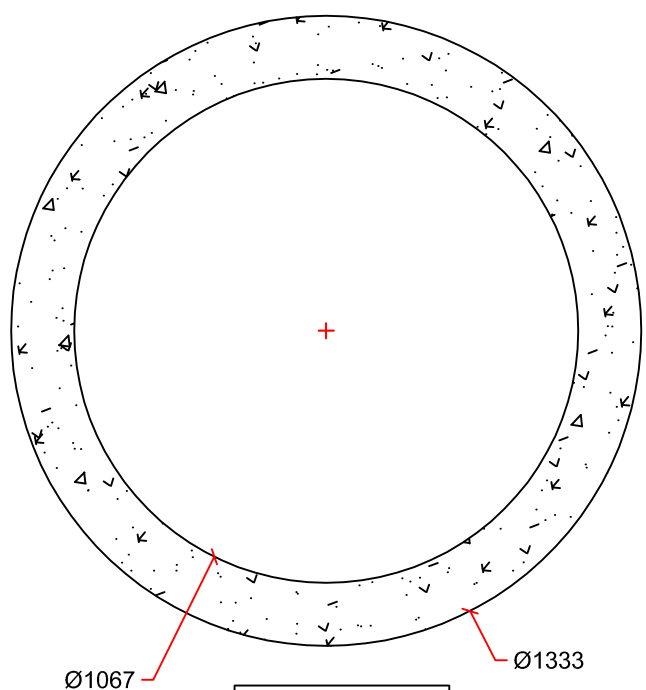
DRAWN BY:	AARON KLEMETS	750mm X 2.5m (TYP) PIPE	OCEAN Pipe
SCALE:	NTS		
DATE:	NOVEMBER 9, 2015	APPROXIMATE MASS: 2075kg ALL DIMENSIONS IN mm	
DRAWING #:	750mm X 2.5m (TYP) PIPE		
REVISION #:	REV. 0		9265 OAK ST. VANCOUVER B.C. PH: 604 269-6700 FAX: 604 261-6751
CHECKED BY:	TYSON DYCK		



PIPE DETAIL

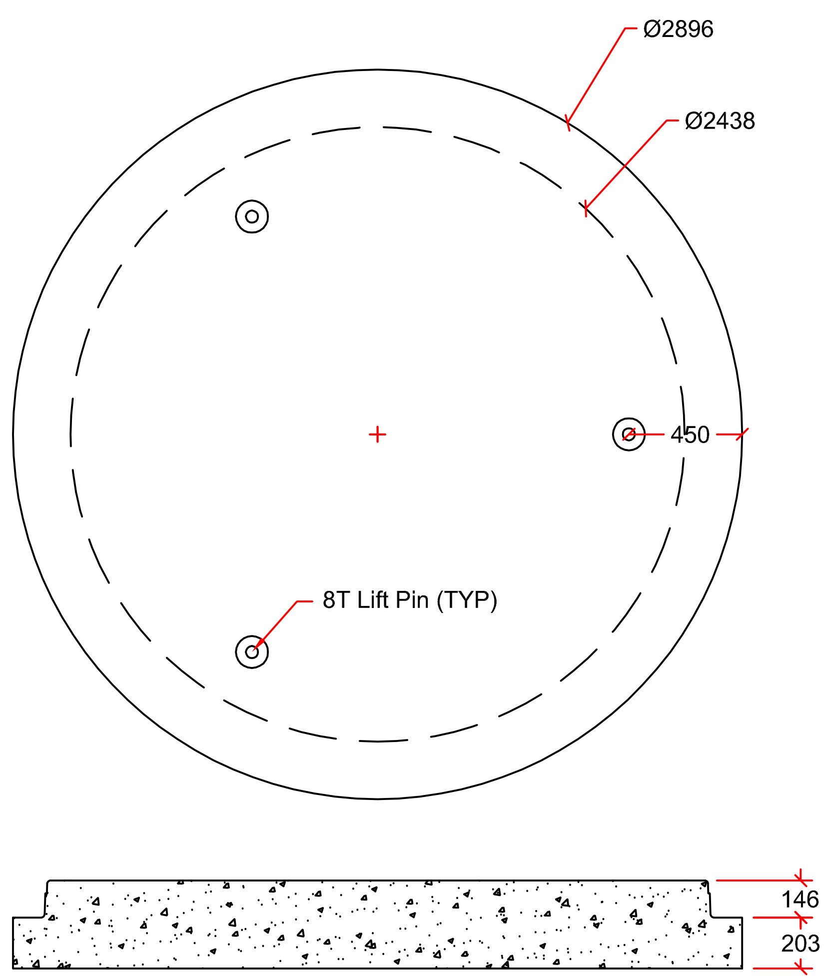


JOINT DETAIL

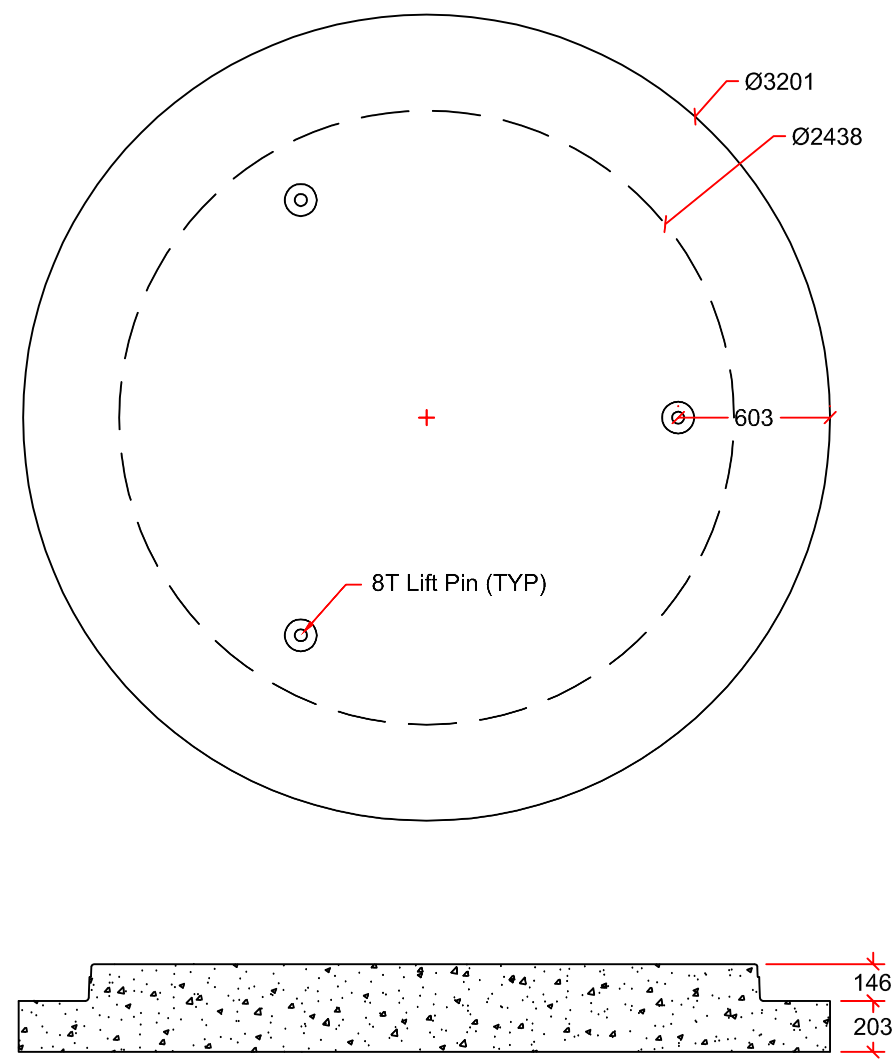


SECTION DETAIL

DRAWN BY:	AARON KLEMETS	1050mm x 2.5m (TYP) PIPE	OCEAN Pipe
SCALE:	NTS		
DATE:	NOVEMBER 9, 2015	APPROXIMATE MASS: 3500kg TWO 4T LIFT PINS PROVIDED AS SHOWN ALL DIMENSIONS IN mm	
DRAWING #:	1050mm X 2.5m (TYP) PIPE		
REVISION #:	REV. 0		9265 OAK ST. VANCOUVER B.C. PH: 604 269-6700 FAX: 604 261-6751
CHECKED BY:	TYSON DYCK		



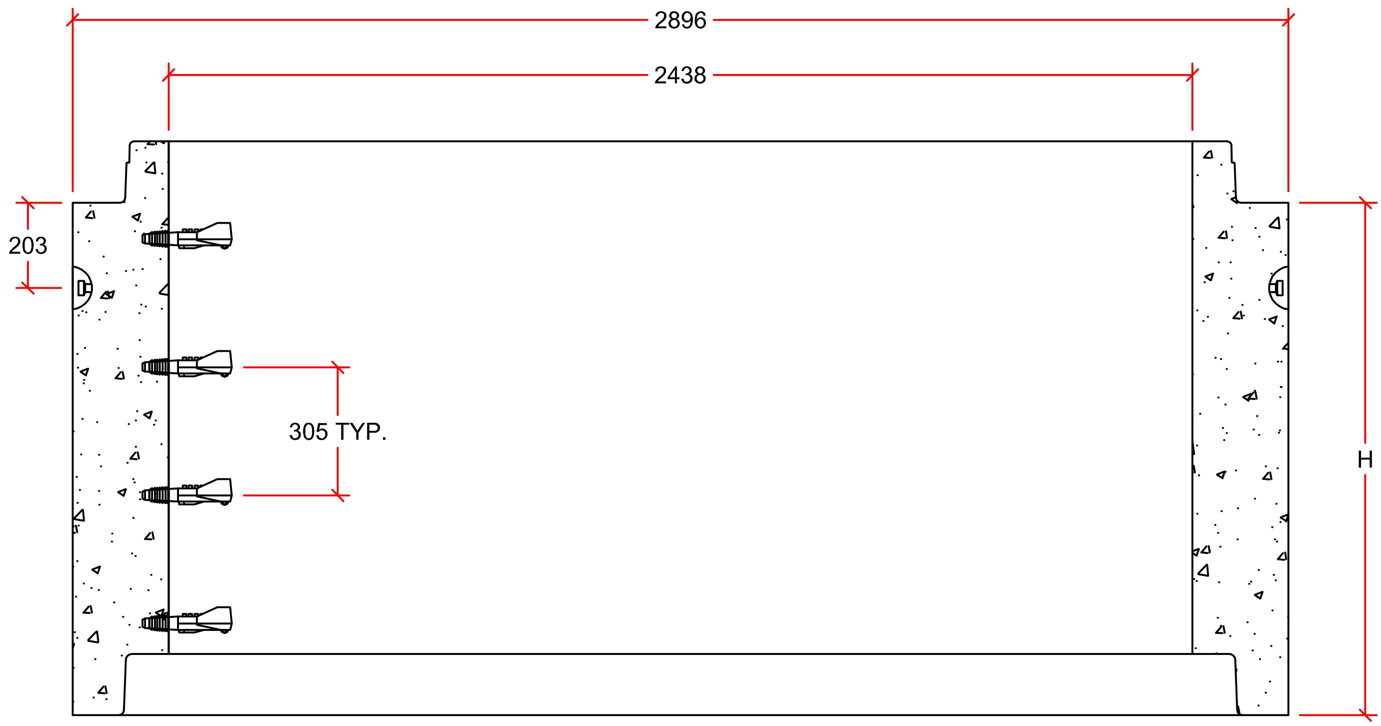
INNER POUR BASE
APPROXIMATE MASS: 3210 kg

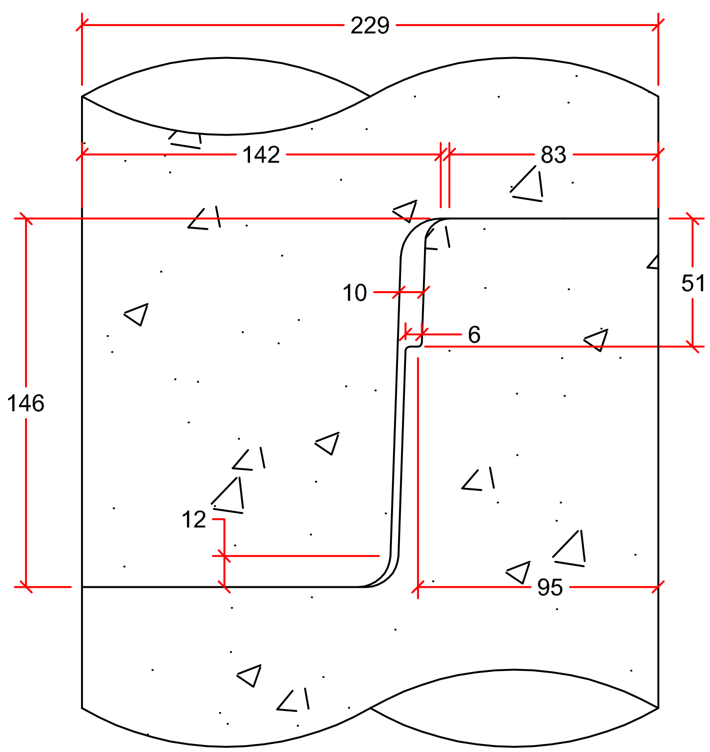


EXTENDED BASE
APPROXIMATE MASS: 3920 kg

DRAWN BY:	AARON KLEMETS	2400mm MANHOLES BASES
SCALE:	NTS	
DATE:	NOVEMBER 19, 2015	ALL DIMENSIONS IN mm THREE 8T LIFT PINS PROVIDED AS SHOWN
DRAWING #:	2400 MH BASES	
REVISION #:	REV. 0	
CHECKED BY:	TYSON DYCK	

OCEAN Pipe
9265 OAK ST. VANCOUVER B.C.
PH: 604 269-6700 FAX: 604 261-6751





JOINT DETAIL

AVAILABLE IN 0.3m, 0.6m, 0.9m,1.2m, 1.5m, 1.8m, 2.1m, & 2.5m HEIGHTS

HEIGHT (H) (mm)	MASS (kg)
300	1420
600	2840
900	4260
1200	5680
1500	7100
1800	8520
2100	9940
2500	11830

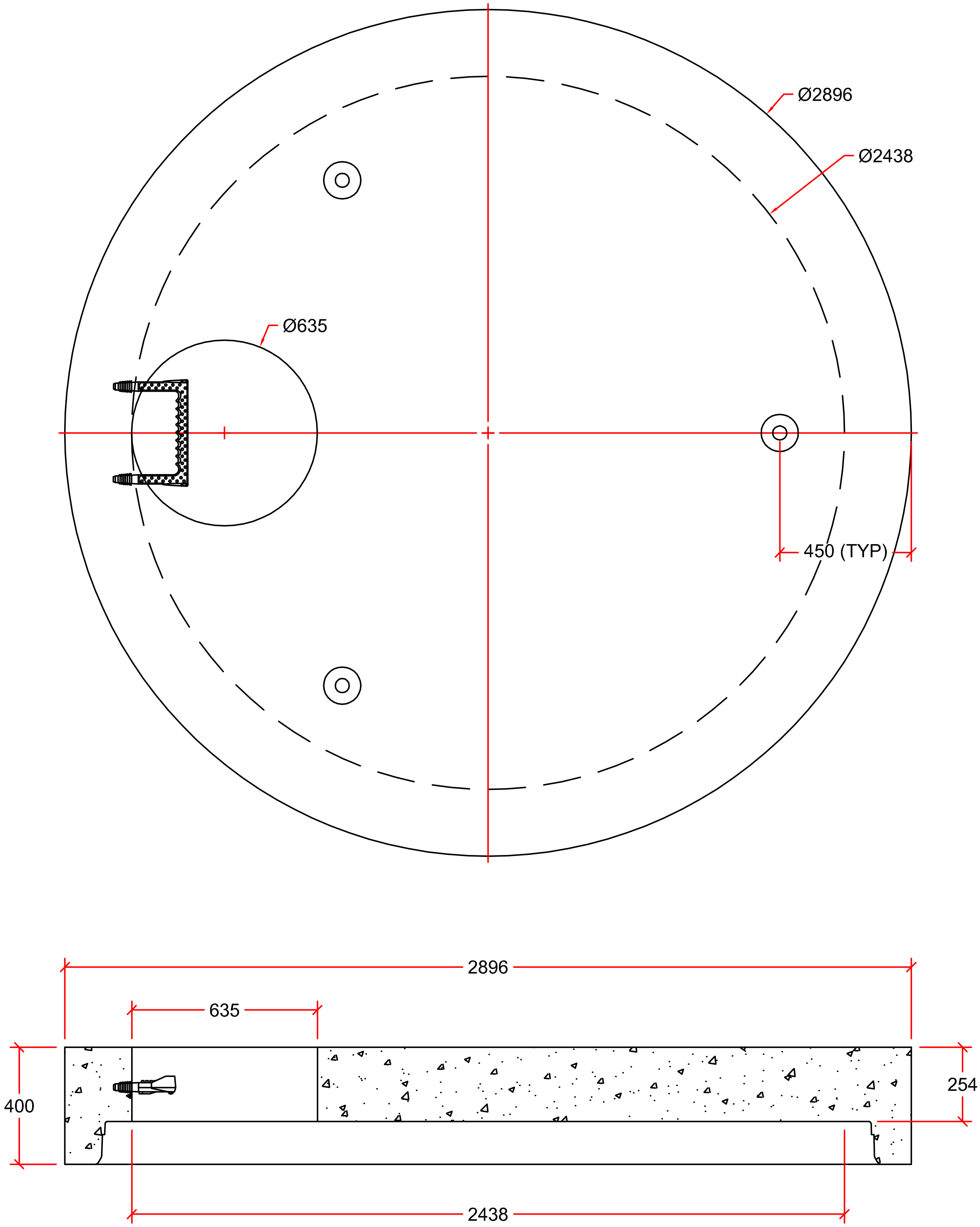
DRAWN BY:	AARON KLEMETS
SCALE:	NTS
DATE:	NOVEMBER 19, 2015
DRAWING #:	2400 MH RISER
REVISION #:	REV. 0
CHECKED BY:	TYSON DYCK

2400mm MANHOLE RISER

ALL DIMENSIONS IN mm
TWO 8T LIFT PINS PROVIDED AS SHOWN

OCEAN Pipe

9265 OAK ST. VANCOUVER B.C.
PH: 604 269-6700 FAX: 604 261-6751



AVAILABLE OPENING SIZES: 635mm & 900mm
CUSTOM OPENINGS AVAILABLE UPON REQUEST

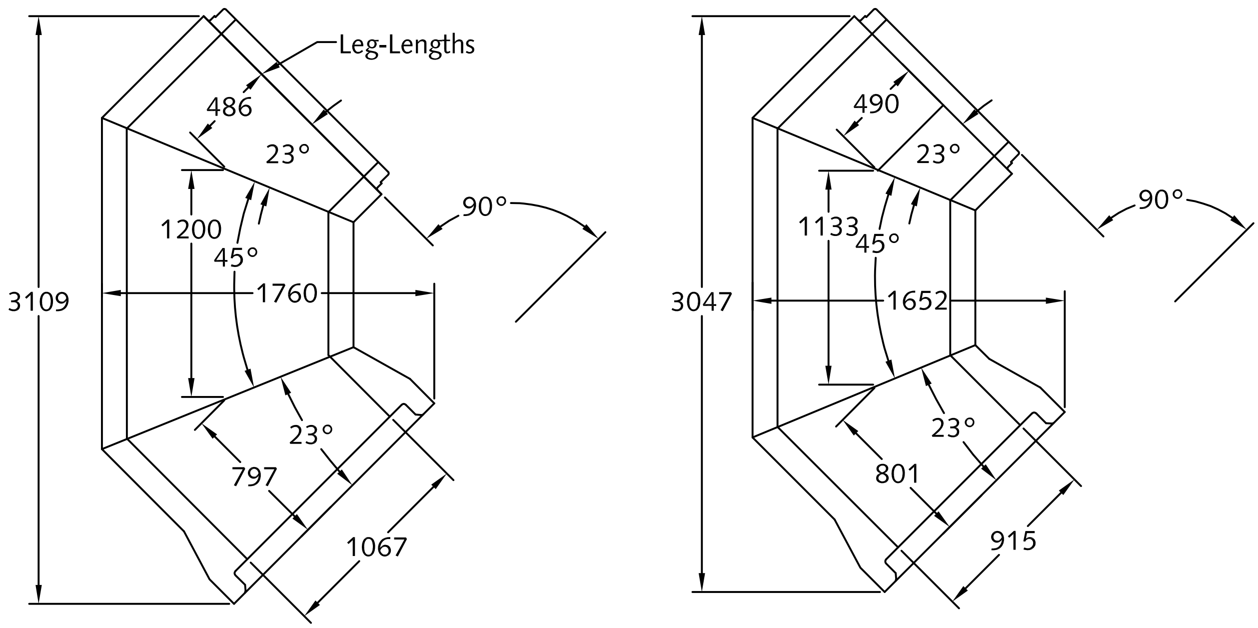
DRAWN BY:	AARON KLEMETS
SCALE:	NTS
DATE:	NOVEMBER 19, 2015
DRAWING #:	2400 MH SLAB TOP
REVISION #:	REV. 0
CHECKED BY:	TYSON DYCK

2400mm MANHOLE SLAB TOP

ALL DIMENSIONS IN mm
APPROXIMATE MASS: 4170 kg
THREE 8T LIFT PINS PROVIDED AS SHOWN

OCEAN Pipe

9265 OAK ST. VANCOUVER B.C.
PH: 604 269-6700 FAX: 604 261-6751



Notes:
1. Double mitre bends are achieved in typical arrangements as shown.
2. Shown are Ø1050 & 900mm bell and spigot pipe in double mitre bends.
3. Leg-Lengths of mitres are variable to modify Lay-Length.
4. Lay length of mitres are available up to max. 2.5m .
5. Min. concrete strength: Available in any class of pipe.
6. Minimum WWF yield strength: 448 MPa.
7. All dimensions are in millimeters.

THE Langley CONCRETE GROUP
The LANGLEY CONCRETE Group of Companies

DESCRIPTION:

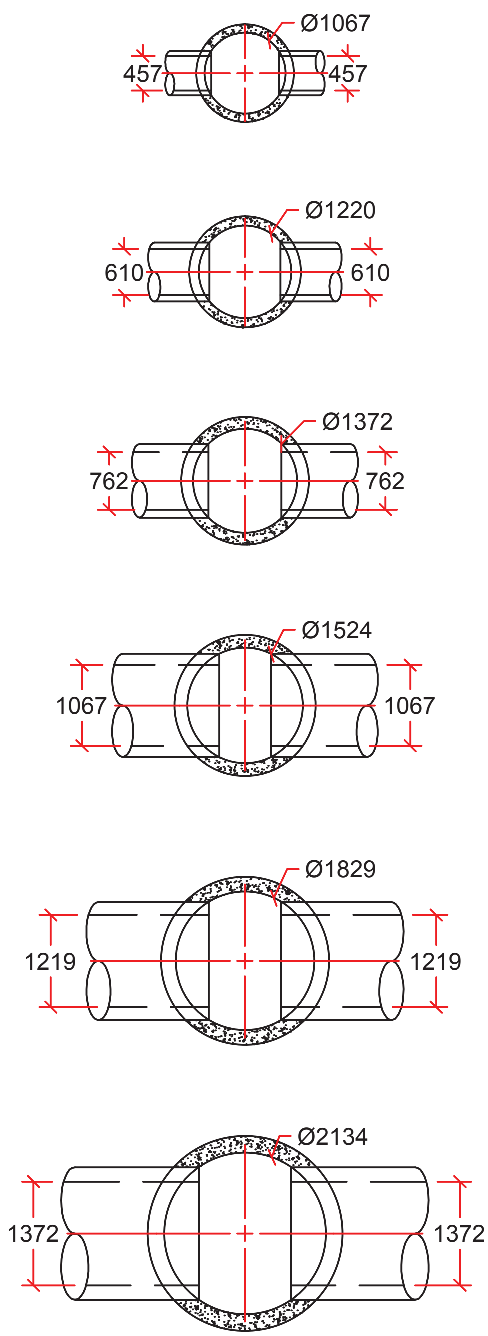
1050 & 900 Pipe
Double Mitre-90°

www.langleyconcretegroup.com

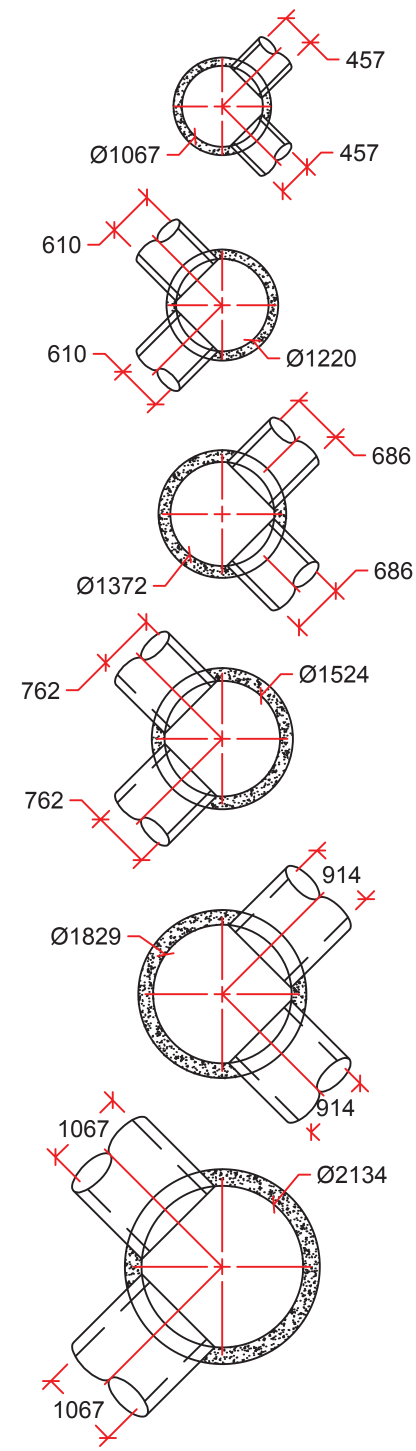
DRAWN BY:	JAO	ORIGIN:	CHWK
CHK BY:	N/A	DWG NO:	DM-900_1050
DATE:	02/02/18	REV DATE:	
SCALE:	1:40	2. MAY/10/2010	

This drawing is the property of the Langley Concrete Group of Companies.
All information contained herein is confidential and may not be used in whole or in part without written permission from the owner

MAXIMUM PIPE SIZE FOR STRAIGHT THROUGH INSTALLATION

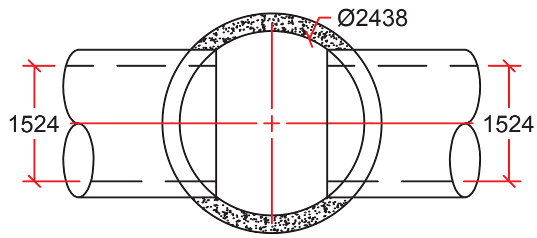


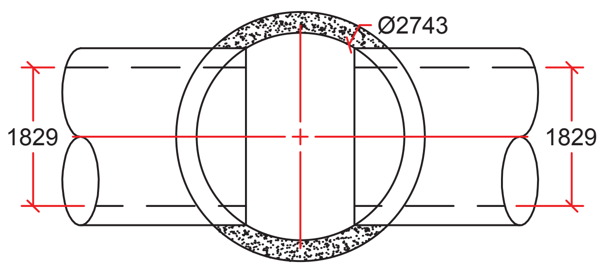
MAXIMUM PIPE SIZE FOR RIGHT ANGLE INSTALLATION

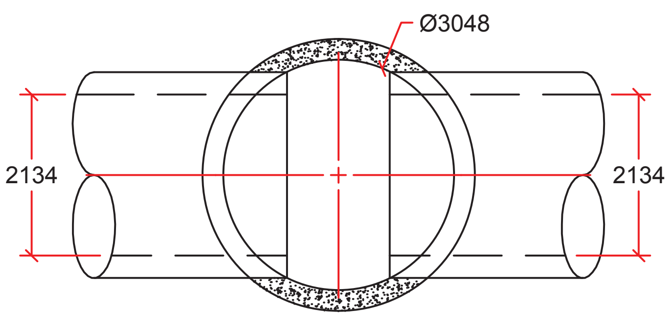


DRAWN BY:	Andrew Cortese	Maximum Pipe Sizes for Manholes	OCEAN Pipe
SCALE:	1:100		
DATE:	May 27, 2014	1050mm through 2100mm Manholes	
DRAWING #:	MAX-MH-1050-2100		
REVISION #:	Rev. 0	Non-standard angles possible, call for specific project situations	9265 OAK ST. VANCOUVER B.C. PH: 604 269-6700 FAX: 604 261-6751
CHECKED BY:			

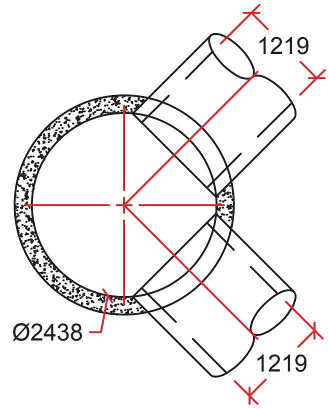
MAXIMUM PIPE SIZE FOR STRAIGHT THROUGH INSTALLATION

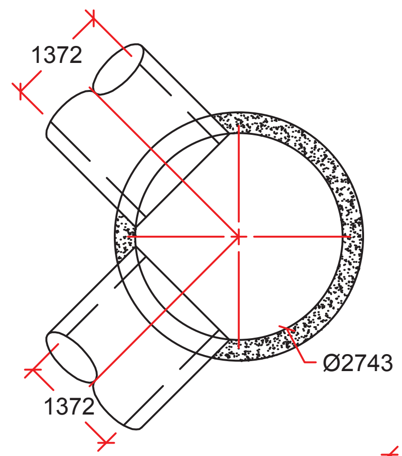


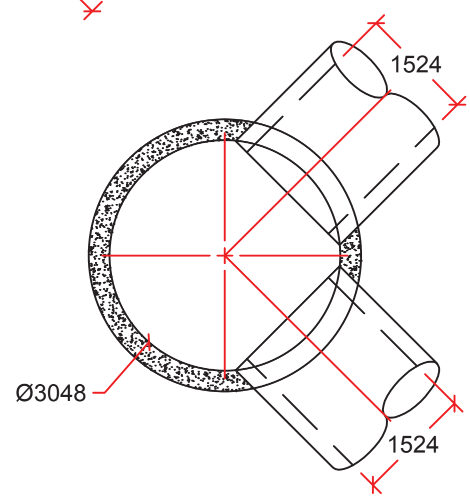




MAXIMUM PIPE SIZE FOR RIGHT ANGLE INSTALLATION







DRAWN BY:	Andrew Cortese	Maximum Pipe Sizes for Manholes
SCALE:	1:100	
DATE:	May 27, 2014	2400mm through 3050mm Manholes
DRAWING #:	MAX-MH-2400-3050	
REVISION #:	Rev. 0	Non-standard angles possible, call for specific project situations
CHECKED BY:		

OCEAN Pipe

9265 OAK ST. VANCOUVER B.C.
PH: 604 269-6700 FAX: 604 261-6751

Appendix D: Cost Estimate

PROJECT MANAGEMENT AND CONSTRUCTION COST ESTIMATE

		DESCRIPTION	UNIT	QTY	UNIT RATE		TOTAL
DIVISION 1	GENERAL REQUIREMENTS						
	1	Mobilization	LS	-	-	$	15,000.00
	2	Temporary Facilities	LS	-	-	$	2,500.00
	3	Temporary Traffic Management	LS	-	-	$	500.00
	4	Waste Disposal	EA	24	$ 350.00	$	8,400.00
	5	Engineering and Testing	LS	-	-	$	75,000.00
	6	Plans and Specifications	LS	-	-	$	15,000.00
	7	General Labour	LS	-	-	$	5,000.00
	8	Rezoning Application	LS	-	-	$	10,385.00
	9	Building Permit	LS	-	-	$	2,400.00
				DIVISION 1	TOTAL	$	134,185.00
DIVISION 2	SITE WORK						
	1	Clearing and Timber Salvage	HA	1	$ 17,500.00	$	17,500.00
	2	Replanting and Landscaping	HA	1	$ 7,500.00	$	7,500.00
				DIVISION 2	TOTAL	$	25,000.00
DIVISION 3	CONCRETE						
	1	Concrete Placement (including formwork)	M3	1750	$ 207.00	$	362,250.00
	2	Steel Reinforcement (Supply and Install)	M3	43.75	$ 250.00	$	10,937.50
	3	Manhole Installation	EA	3	$ 4,000.00	$	12,000.00
				DIVISION 3	TOTAL	$	385,187.50
DIVISION 5	METALS						
	1	Steel weirs	M2	36	$ 50.00	$	1,800.00
	2	Corrugated steel pipes (4m rad)	LM	100	$ 3,271.48	$	327,148.00
				DIVISION 5	TOTAL	$	328,948.00
DIVISION 6	WOOD, PLASTICS, AND COMPOSITES						

	1	PVC Pipe (Supply and Install)	M	20	$ 75.00	$	1,500.00
	2	Geotextile (supply and install)	M2	960	$ 55.00	$	52,800.00
				DIVISION 6	TOTAL	$	54,300.00
DIVISION 31	EARTHWORK						
	1	Subgrade Excavation	M3	4560.0	$ 15.00	$	68,400.00
	2	Granular Fill	M3	4560	$ 18.00	$	82,080.00
	3	Subgrade Preparation	M2	1430	$ 1.75	$	2,502.50
	4	Trenchbox Rental	EA	1	$ 1,250.00	$	1,250.00
				DIVISION 31	TOTAL	$	154,232.50
DIVISION 35	WATERWAY AND MARINE CONSTRUCTION						
	1	Sump (Grit and Oil) Chamber	EA	-	-	$	7,500.00
	2	Concrete Stormwater Pipe	M	250	$ 315.00	$	78,750.00
				DIVISION 35	TOTAL	$	86,250.00
DIVISION 36	Special Construction						
	1	Mini-Putt Facilities	EA	-	-	$	500,000.00
				DIVISION 36	TOTAL	$	500,000.00
					GRAND TOTAL	$	1,668,103.00

Constuction labour and material costs calculated using Unite Price Averages Report from the Alberta Infrastructure & Transportation
www.transportation.alberta.ca/Content/doctype257/production/unitpricelist.pdf

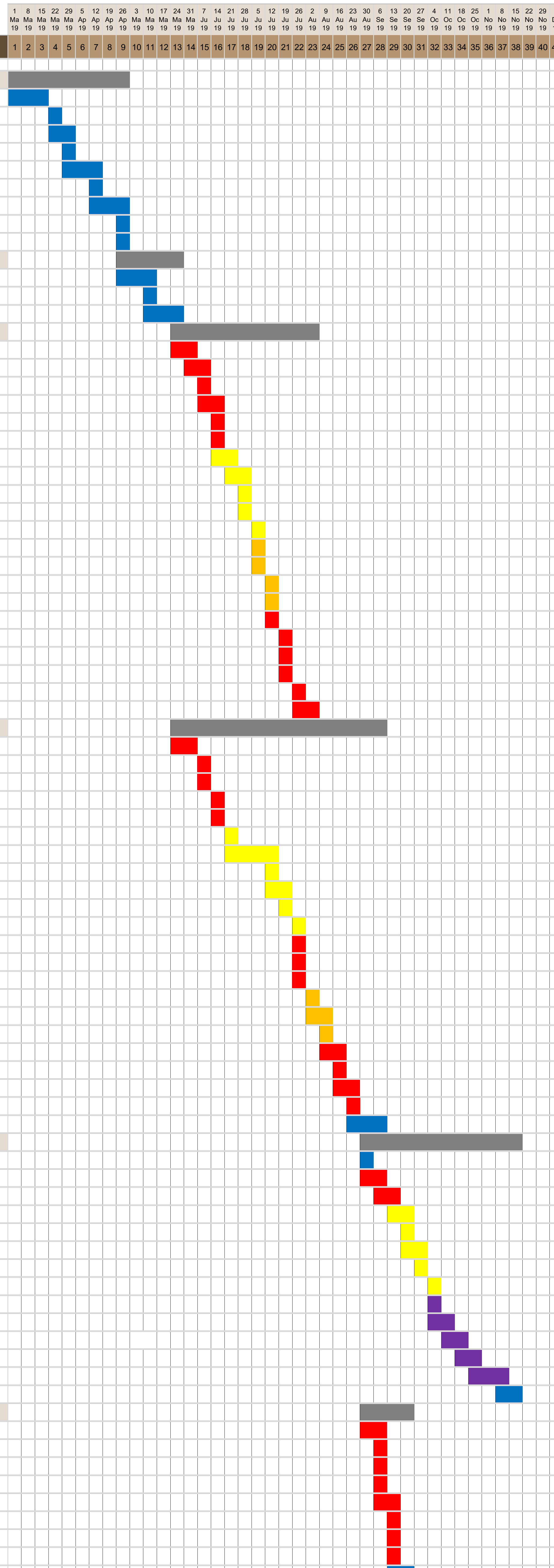
Professional Engineering Costs Derived from the ACEC BC Fee guidelines
https://www.acec-bc.ca/media/36630/acecbcfeeguide16.pdf

Appendix E: Construction Schedule

CONSTRUCTION SCHEDULE
Black Tusk Engineering Ltd.

Project Start: 3/1/2019 Completion: #REF!
Construction Start: 5/1/2019

TASK DESCRIPTION	PLAN START	PLAN END	DIVISION
PRE-CONSTRUCTION AND PROCUREMENT	**3/1/2019**	**5/1/2019**	
Public Notices	3/1/2019	3/21/2019	B
Project Open-house - Pre-Construction Q&A	3/22/2019	3/22/2019	B
Design Approval and Modifications	3/23/2019	4/2/2019	B
Release for Tender	4/3/2019	4/3/2019	B
Tender Process	4/4/2019	4/14/2019	B
Contract Award	4/15/2019	4/15/2019	B
Permitting	4/16/2019	4/26/2019	B
Mobilization	4/27/2019	4/30/2019	B
Project Start-Up	5/1/2019	5/1/2019	B
SITE WORK	**5/1/2019**	**5/24/2019**	
Clearing Trees and Shrubbery	5/1/2019	5/11/2019	B
Removal of Tress and Shrubbery	5/11/2019	5/14/2019	B
Surveying	5/14/2019	5/24/2019	B
DETENTION TANK	**5/25/2019**	**8/2/2019**	
Excavation of Tank Pit	5/25/2019	6/4/2019	R
Installation of Shoring	6/5/2019	6/7/2019	R
Tank Pit Subgrade Preparation	6/8/2019	6/12/2019	R
Installation of Impermeable Geotextile Layer	6/13/2019	6/14/2019	R
Gravel Levelling Bed Placement	6/15/2019	6/17/2019	R
Installation of Second Geotextile Layer	6/18/2019	6/19/2019	R
Formwork Placement	6/20/2019	6/22/2019	Y
Rebar Placement	6/23/2019	6/28/2019	Y
Concrete Pour	6/29/2019	6/30/2019	Y
Concrete Curing and Waterproofing	7/1/2019	7/4/2019	Y
Formwork Removal	7/5/2019	7/6/2019	Y
Installation and Assembly of Tank Corrugated Pipes	7/7/2019	7/11/2019	O
Installation and Assembly of Tank and Grit Chamber Elements	7/7/2019	7/11/2019	O
Installation of Inflow and Outflow Piping Attachments	7/12/2019	7/14/2019	O
Seal Inlet and Outlet Connections	7/15/2019	7/16/2019	O
Shoring Removal	7/17/2019	7/18/2019	R
Laying Native Material Backfill	7/19/2019	7/21/2019	R
Laying Gravel Backfill	7/22/2019	7/23/2019	R
Installation of Impermeable Geotextile Layer	7/24/2019	7/25/2019	R
Laying Engineered Soil to Grade	7/26/2019	7/27/2019	R
Soil Compaction	7/28/2019	8/2/2019	R
PONDS AND CHANNELS	**5/25/2019**	**9/8/2019**	
Excavation of Full Perimeter	5/25/2019	5/31/2019	R
Installation of Shoring	6/7/2019	6/11/2019	R
Installation of Impermeable Geotextile Layer	6/12/2019	6/13/2019	R
Gravel Levelling Bed Placement	6/14/2019	6/18/2019	R
Installation of Second Geotextile Layer	6/19/2019	6/20/2019	R
Formwork Placement	6/21/2019	6/26/2019	Y
Rebar Placement	6/27/2019	7/12/2019	Y
Concrete Pour	7/13/2019	7/16/2019	Y
Concrete Curing and Waterproofing	7/17/2019	7/22/2019	Y
Formwork Removal	7/23/2019	7/25/2019	Y
Installation of Steel Weirs	7/26/2019	7/27/2019	Y
Installation of Drainage Membrane	7/27/2019	7/29/2019	R
Installation of Geotextile Layer	7/28/2019	7/29/2019	R
Laying Topsoil and Ballast	7/30/2019	8/1/2019	R
Planting Aquatic Vegetation	8/2/2019	8/6/2019	O
Installation of Inflow and Outflow Piping Attachments	8/7/2019	8/11/2019	O
Seal Inlet and Outlet Connections	8/12/2019	8/14/2019	O
Shoring Removal	8/15/2019	8/16/2019	R
Laying Gravel Backfill	8/17/2019	8/20/2019	R
Soil Compaction	8/21/2019	8/26/2019	R
Laying Rip-rap	8/27/2019	8/28/2019	R
Landscaping and Planting Vegetation	8/29/2019	9/8/2019	B
MINI-PUTT FACILITY	**8/31/2019**	**11/15/2019**	
Site Surveying	8/31/2019	9/4/2019	B
Site Grading	9/5/2019	9/10/2019	R
Excavation	9/11/2019	9/16/2019	R
Formwork Placement	9/17/2019	9/20/2019	Y
Rebar Placement	9/21/2019	9/24/2019	Y
Concrete Pour	9/25/2019	9/27/2019	Y
Concrete Curing	9/28/2019	10/3/2019	Y
Formwork Removal	10/4/2019	10/5/2019	Y
Grade preparation for Carpet Installation	10/6/2019	10/8/2019	P
Installation of Putting Carpet	10/9/2019	10/14/2019	P
Installation of Theme Elements and Props	10/15/2019	10/23/2019	P
Curb Installation	10/24/2019	10/29/2019	P
Trimming and Finishing	10/30/2019	11/9/2019	P
Landscaping and Planting Vegetation	11/10/2019	11/15/2019	B
PARKING LOT	**9/5/2019**	**9/20/2019**	
Site Grading	9/5/2019	9/7/2019	R
Excavation	9/8/2019	9/9/2019	R
Subgrade Preparation	9/9/2019	9/10/2019	R
Laying Engineered Soil	9/10/2019	9/11/2019	R
Soil Compaction	9/11/2019	9/13/2019	R
Installation of Impermeable Geotextile Layer	9/13/2019	9/14/2019	R
Gravel Levelling Bed Placement	9/14/2019	9/15/2019	R
Gravel Layer Compaction	9/15/2019	9/16/2019	R
Planting Grass Strip	9/16/2019	9/20/2019	B



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Construction Start: 5/1/2019

				1 Ma 19	8 Ma 19	15 Ma 19	22 Ma 19	29 Ma 19	5 Ap 19	12 Ap 19	19 Ap 19	26 Ap 19	3 Ma 19	10 Ma 19	17 Ma 19	24 Ma 19	31 Ma 19	7 Ju 19	14 Ju 19	21 Ju 19	28 Ju 19	5 Ju 19	12 Ju 19	19 Ju 19	26 Ju 19	2 Au 19	9 Au 19	16 Au 19	23 Au 19	30 Au 19	6 Se 19	13 Se 19	20 Se 19	27 Se 19	4 Oc 19	11 Oc 19	18 Oc 19	25 Oc 19	1 No 19	8 No 19	15 No 19	22 No 19	29 No 19	6 De 19
TASK DESCRIPTION	**PLAN START**	**PLAN END**	**DIVISION**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
SYSTEM CONNECTIONS	**9/8/2019**	**11/8/2019**																																										
Air Valves Installation on Tank	9/8/2019	9/18/2019	O																																									
Pipe Installation from Last Pond to Grit Chamber	9/19/2019	9/27/2019	O																																									
Pipe Installation from Tank to Storm Main	9/28/2019	10/8/2019	O																																									
Pipe Installation from Storm Main to First Pond	10/9/2019	10/23/2019	O																																									
Manhole Construction at System Connections	10/24/2019	11/8/2019	Y																																									
PROJECT COMPLETION	**11/15/2019**	**11/30/2019**																																										
Deficiencies	11/15/2019	11/25/2019	B																																									
Commissioning	11/26/2019	11/28/2019	B																																									
Demobilization	11/29/2019	11/30/2019	B																																									
XXX																																												
Insert new rows ABOVE this one																																												

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