UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Corridor Redesign of Chancellor Boulevard - Team 19

Daniel Adria, Mark Andruk, Behrad Keshavarz, Aaron Klemets, Benjamin Loewen, Geoffrey Wright

University of British Columbia

CIVL 445

Themes: Transportation, Community, Land

April 9, 2018

Executive Summary

This report provides conceptual details for the redesign of the Chancellor Boulevard Corridor, from Acadia to Drummond Drive, upon the request of UBC Campus and Community Planning. The 1.8 km stretch of road that is being redesigned falls under the jurisdiction of the Ministry of Transportation and Infrastructure (MOTI). There are three key issues regarding Chancellor Boulevard that this project will aim to address. First, is addressing the excessive speeding along Chancellor Boulevard, and working to improve safety for all modes of transportation. Second, the new design must accommodate increasing travel demands as the university population grows. Third, the design will address existing pooling of water along the corridor. The redesign is split into three main sections: transportation design, structural elements at the underpass, and drainage re-evaluation.

The design includes reducing Chancellor Boulevard from two travel lanes in each direction to one, allowing for the second lane to be converted to a protected bike lane. To encourage speed reduction, median and boulevard trees will be planted as well as reducing the width of travel lanes to 3.3 m, following Transportation Association of Canada (TAC) guidelines. These changes will allow for growth in all modes of transportation, and increase overall safety of Chancellor Boulevard. Minimal changes will be made to the Hamber Road intersection; however, conflict paint will be used to ensure clear cyclist right of way. A cast-in-place concrete pedestrian underpass will be constructed at the Pioneer trail providing safe crossing for cyclists and pedestrians. The median will be removed above the underpass to shorten the span of the tunnel and reduce construction costs. The tunnel will be accessible to all users and will span 9 m across. The crossing will be 5 m wide to promote usage and allow for dedicated bike and pedestrian lanes. Regarding the drainage design, the new system is designed to withstand a 5-year storm event, with 100-year events following the overland path on the road. A suitable catchment was determined, including design consideration to accommodate the golf course runoff located south of the roadway. The existing drainage infrastructure will be utilized, with minor pipe upgrades required. Installation of high capacity filter catch basins is recommended. This upgraded system will resolve the current issue of water pooling on the roadway.

This project is estimated to cost $2.6 million. Construction is expected to take five months, with a start date of May 1, 2018.

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1.0 Introduction

1.1 Project Context

Chancellor Boulevard is a provincially owned roadway connecting the University Endowment Lands to the Point Grey neighborhood in Vancouver. It is an essential road that provides access to the University of British Columbia and University Hill Elementary School. The current corridor does not accommodate future demands for alternate modes of travel, and excessive speeds have been noted along Chancellor Boulevard.

The objectives of this project include redesign of the Chancellor Boulevard corridor to improve level of service, and safety for all modes of transportation. The new design prioritizes sustainable modes of transportation including busses, cycling, and walking. Existing issues with drainage along the corridor have been addressed. It is imperative that costs be minimized while maximizing safety for all users of the corridor. Alongside the corridor redesign, a design for a pedestrian underpass has been included in the location with the highest demand.

1.2 Site Overview

The site is bounded by Drummond Drive to the east, Acadia Road to the west, and Pacific Spirit Park to north and south. It extends 1.8 km from the intersection of Acadia Road to the intersection of Drummond Drive. There is a T-intersection near the western edge allowing access to the school through Hamber Road. The topography generally slopes down gently toward the north, away from the site. For the following sub sections, please refer to Figure 1: Site Overview Map, and Figure 2 for the geography of the site.

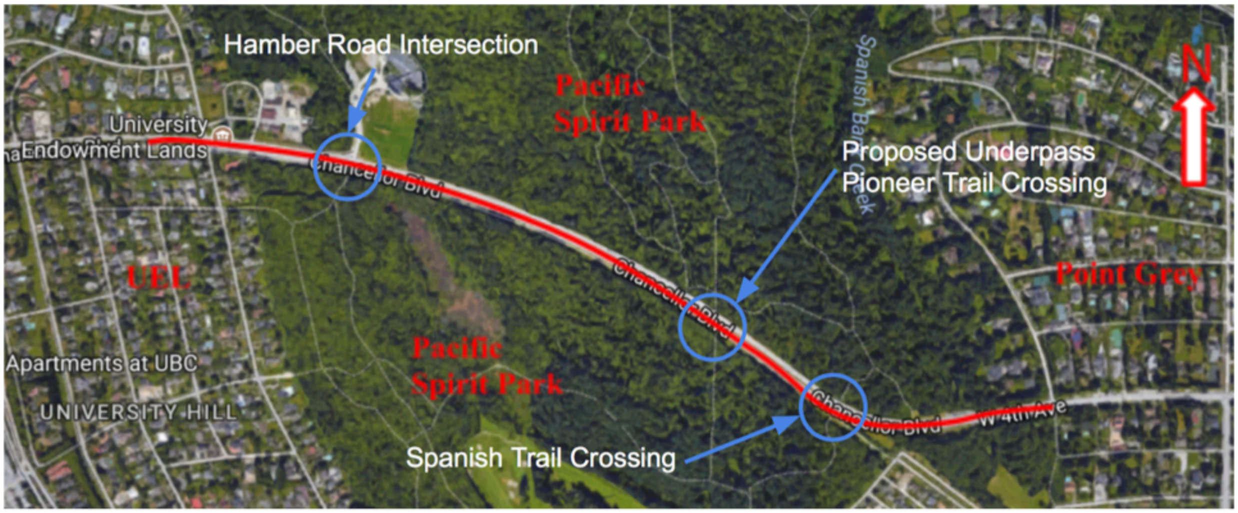


Figure 1: Site Overview Map

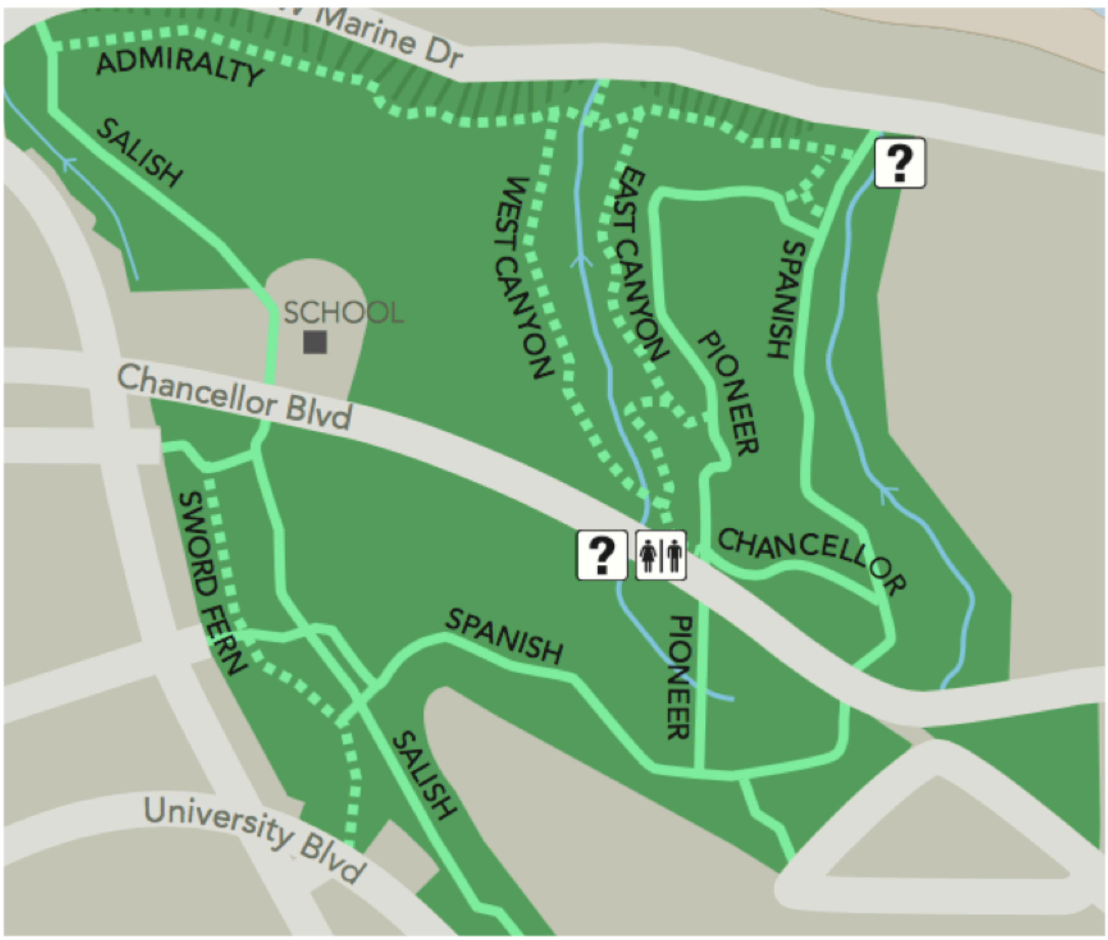


Figure 2: Trail and Creek Map

2.0 Transportation

The pre-redesign corridor infrastructure utilizes two travel lanes in each direction with bus services on the corridor. The east and west bound lanes are separated by a 6.0 m wide grass and curb median. Pedestrians and cyclists have access to a multi-use path on the south side of the roadway from Acadia Road to the Spanish Trail Crossing. The existing asphalt of the multi-use path requires maintenance and it is too narrow to effectively accommodate both pedestrian and cyclist traffic.

A T-intersection exists at Chancellor Boulevard and Hamber Road in order to access University Hill Elementary School to the north. The intersection currently makes use of a pedestrian controlled signal for north-south crossing, this is the highest level of controlled pedestrian crossing. The intersection has two dedicated turn lanes, one for eastbound left turns and another for southbound right turns. Two other crossing points for pedestrians are at the Pioneer Trail and Spanish Trail intersections. Both Trail crossings are used but unmarked to both pedestrians and vehicles.

2.1 Design Criteria

The redesign of Chancellor Boulevard must achieve the following criteria:

1. Accommodate projected travel demands for all modes of transportation in a safe and efficient way.
2. Prioritize busing, biking and walking modes of transportation.
3. Minimize cost and maximize safety for all road users.

In addition to this, the following secondary criteria has been outlined by Right of Way Engineering:

1. AAA bike facilities
2. Improve safety at all crossing locations
3. Utilize existing infrastructure

2.2 Standards and Software Packages

Transportation infrastructure for Chancellor Boulevard is designed to meet criteria outlined by the Transportation Association of Canada, TAC, the Ministry of Transportation Infrastructure, MoTI, and the National Building Code of Canada, NBCC. The following requirements are met in accordance with the standards in Table 1. Design and alignment components were completed using AutoCAD 2018 software. Licensing was obtained through student Autodesk accounts.

Table 1: Transportation Standards

Design component	Dimension	Standard
Lane Width	Min 3.3 m	TAC – Geometric Design Guide
Curve Radius	Min 125 m	TAC – Geometric Design Guide 2.1.2
Underpass Ramp Slope	Min 1:12	MoTI – Bridge Standards and Procedures Manual 1.5.2.3
Underpass Stairs	Rise: 125-200 mm Run: 255-355 mm	NBCC 9.8.1
Sidewalk width	Pedestrian Only: 1.5 m Pedestrian and cyclist Uni-Directional: 2.5 m	MoTI – Bridge Standards and Procedures Manual 1.5.2.1

2.3 Technical Considerations and Design Output

Chancellor Boulevard Road Cross Section

The design of the road cross section focuses on utilizing the existing infrastructure while achieving the overall design goals. Utilizing the existing road surface allows this design to achieve the highest possible cost benefit ratio. With keeping cost in mind, this design promotes bicycle use and increase safety. Vehicles speed will be reduced without impacting the ability to accommodate current and future vehicle demands. Pedestrian accessibility will be improved through maintenance and additional sidewalk infrastructure.

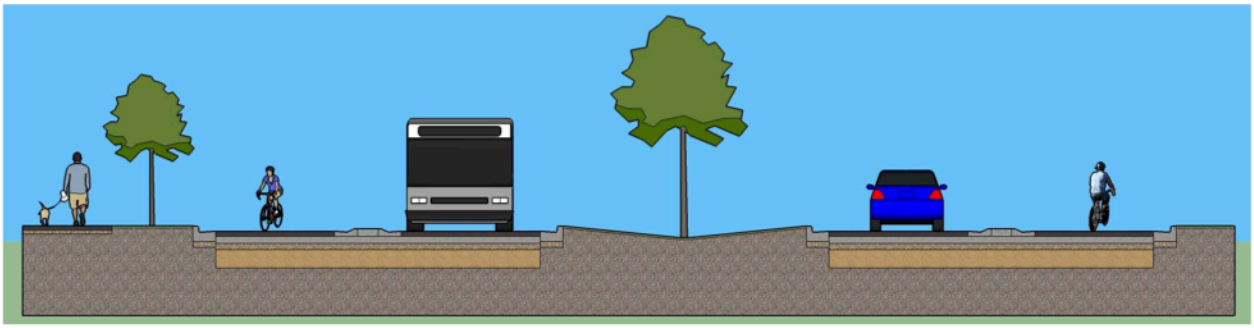


Figure 3: Typical Road Cross Section

As seen in Figure 3, with the new Chancellor Boulevard, there will be one vehicle travel lane in each direction, and each of these lanes are 3.3 m wide. This is a reduction from the current two 4.0m wide travel lanes in each direction. TAC guidelines show that 3.3 m is the optimal lane width for speed reduction and will not impede large vehicles such as trucks, buses, or emergency vehicles that require the use of Chancellor Boulevard. The existing median will remain with the addition of large deciduous trees planted along its center. On the south of the roadway, boulevard trees will be planted between the protected bike lane and the sidewalk. Adding landscaping to the road cross section is a proven method for reducing speeds and improving safety on a roadway. This meets the design criteria of speed reduction for Chancellor Boulevard.

This design will allow for people of all ages and abilities to take advantage of the protected pavement-level bike lanes. Concrete barriers will provide a physical barrier for cyclists from vehicles while wide 1.8 m lanes will improve the level of service of the facility. The barriers will consist of 1.5 m wide roll-over curbs that will allow for a vehicle to pull-over in the event of an breakdown or emergency vehicle passing.

For this design, the existing multi-use pathway is replaced by an asphalt sidewalk. The multi-use path is no longer needed, as cyclists have been moved to the protected bike lanes. Additionally, the surface of the current path is severely damaged due to cracking and settlement - showing a lack of proper granular base underneath the pathway. The new design will include a proper base and sub-base, to ensure the maximum amount of durability for the sidewalk. The base will be 100mm of 19mm crushed gravel, and the sub-base will be 150mm of 30mm crushed gravel. Included with the new sidewalk is an extension from the Spanish Trail crossing to Drummond Drive. The grass in this area is downtrodden with use, therefore a sidewalk would be of use here both to the current and additional foot traffic along Chancellor Boulevard.

Hamber Road Intersection

The design for the Hamber road intersection allows for minimal changes to be made to the intersection. The existing pedestrian intersection control will remain in place. Utilizing the existing control allows this design option to minimize costs and achieve the highest cost/benefit ratio, while still achieving design goals. The current pedestrian-controlled signal is adequate for the large disparity between traffic travelling straight through the intersection on Chancellor Boulevard and traffic turning from Hamber Road.

Figure 4: Intersection Design Concept

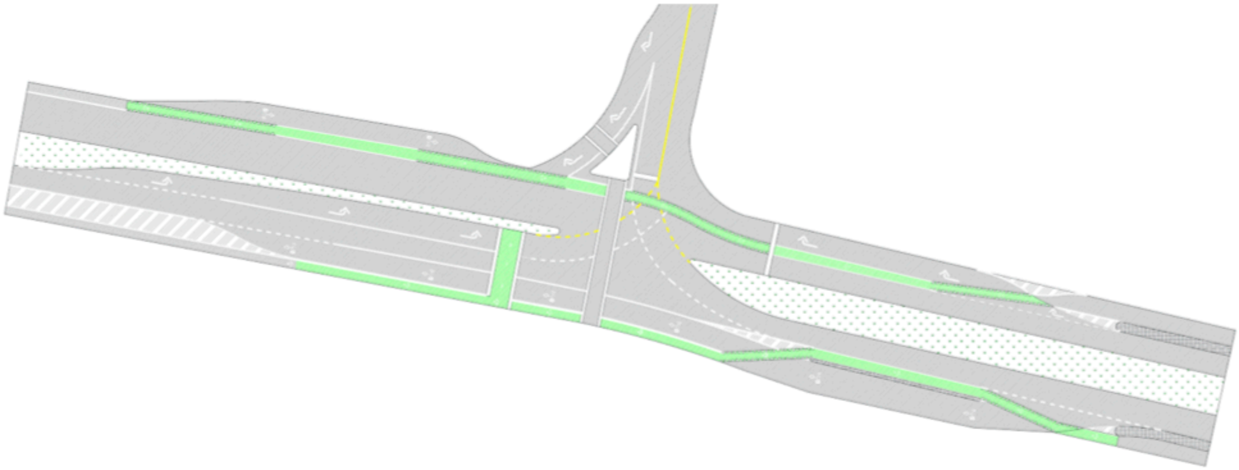


Figure 5: Final Intersection Design

At the intersection the separated bike lanes will join the main roadway and be differentiated by green asphalt and elephants feet markings (large white dashed lines) in conflict zones. The bike lanes will maintain a minimum 1.5m of width and a large bike box will be established for turning left onto Hamber Road. Travel lanes maintain a minimum 3.3m through the intersection and a bus lane will be created to segregate bus traffic before entering the intersection in the eastbound direction. Bikes stopping ahead of other traffic and the bus lane allows ample time and viewing angles for bus operators to identify cyclists and safely cross the lane and enter the bus stop in the eastbound direction. The shown configuration was chosen since moving the bus stop to the other side of the bike lane such as at Cornwall Ave and Cypress St in Vancouver would involve much more concrete work and there was currently not enough road width. For the westbound direction right turning vehicles must cross the bike lane and have clear sightlines to accomplish this safely. Busses must do the same after crossing the intersection and once again have excellent sightlines.

The right-hand turn lane off of Hamber Rd to westbound Chancellor Blvd has been made a much steeper angle (about 70 degrees) to force turning vehicles to slow down and have better viewing angles for pedestrians and westbound traffic. There is over one car length (6.5m) of space between the crosswalk and the west bound bike lane so that turning vehicles will not block either when waiting to turn. A majority of the pedestrian refuge island and the curb around the corner will be changed with sidewalk space being gained at the corner and lost along the turn lane entrance to the north along Hamber Rd. This longer turn lane has been added so cars waiting to turn left impede right hand turns less. New road markings will be added as shown to make the use of the intersection clear to users. A drawing with more measurement details and treatment info can be found in Appendix D.

Underpass Transportation

The area surrounding the pedestrian underpass contains components to convey the safe movement of vehicles, cyclists and pedestrians. A simple 3D model (Figure 6) has been created in addition to the drawings for clarity.

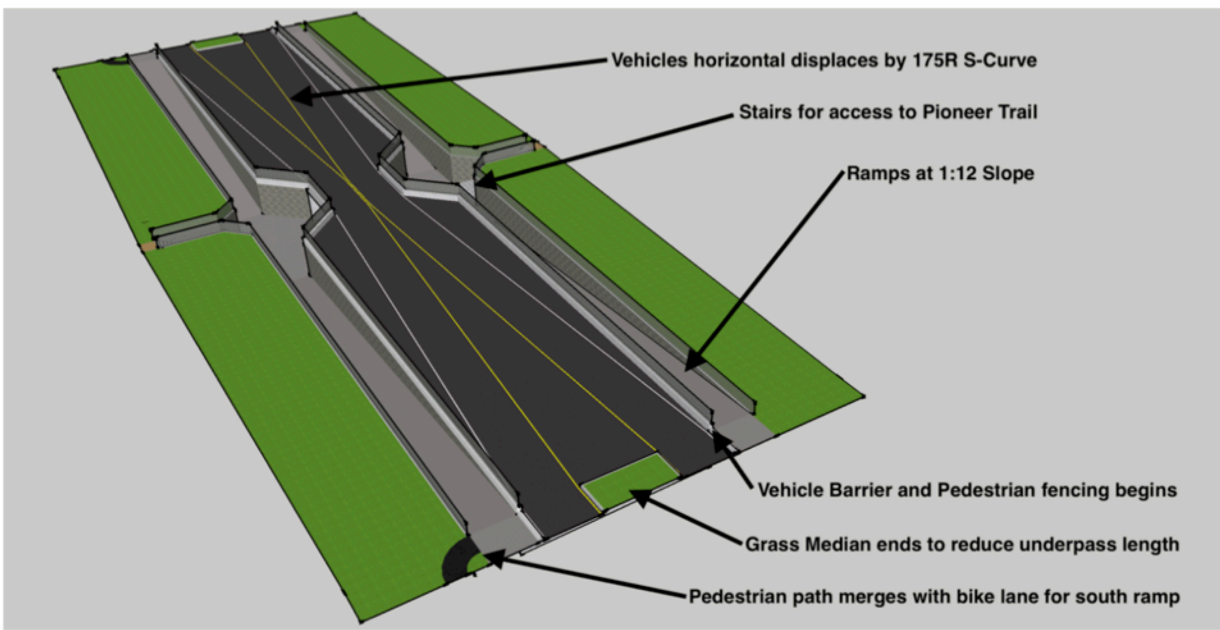


Figure 6: Underpass Model

For vehicle movements, travel lanes will be horizontally displaced toward the center of the road by removing the 6.0 m wide median. This has the additional benefit of allowing for a shorter pedestrian crossing in the underpass. This horizontal displacement uses horizontal curves with a 175 m radius. The horizontal displacement will also act as a speed reduction measure in this area. Lane widths are 3.3 meters and a 0.4 meter painted median separates travel directions.

Pedestrians continue from the south sidewalk onto a 42 m long, 3.5 m wide ramp shared with a dedicated cyclist lane. This ramp will maintain a 1:12 slope allowing for the minimum required accessibility. A lower slope is not used due to the low accessibility of the site. Stairs with a 280 mm run and 180 mm rise are on the north and south side of the intersection to access Pioneer Trail. A 1.5 m landing is located at the center of the stairs. To improve cyclist access a bike rail is installed on each side of the steps.

The protected bike lanes continue down the underpass ramp for both crossing and through directions. On the north side of Chancellor Boulevard, the ramp is 3 m wide and is for cyclist access only. A higher than minimum width on this ramp promotes comfort at higher depths.

To improve safety at this location Vehicle barriers located at the sides of travel lanes and pedestrian fencing at both sides of ramps and stairs. At cyclist-pedestrian conflict zones, clear signage indicates dedicated lanes, travel directions, and pedestrian crossing points.

Spanish Trail Protected Median

To improve the overall walkability of Chancellor Boulevard and Pacific Spirit Park, the existing unmarked crossing at the Spanish Trail will be upgraded to a marked median refuge two-stage crossing. This will involve the placement of 0.75 m high log fencing around the perimeter of the median at Spanish Trail creating a 5.5 m by 12 m refuge box. To encourage safe procedure the crossing displaces pedestrians to the right at the median, allowing for pedestrians to face oncoming traffic before walking onto travel lanes. A marked crosswalk will not be installed at this location due to the low pedestrian demand. If pedestrians are not regularly using a crosswalk, vehicles will not recognize the crossing when in use. With pedestrians not recognizing the lack of driver awareness, a more dangerous scenario exists when compared to an unmarked crossing.

2.4 Transportation Maintenance Plan

Maintenance for the transportation portion of the Chancellor Boulevard redesign includes repaving, sidewalk repair, line painting, pothole repair, light servicing and tree maintenance. Road repaving will be completed every 15 years with any required sidewalk repair or line painting also completed at the same time. This work should be completed during summer semester months when weather is suitable and Chancellor Boulevard can be closed to vehicle traffic. Pothole repair and light servicing will be completed as needed. Tree trimming, and any other landscaping repair, will be completed every 4 years, unless required earlier. During trimming, any travel lanes beneath the tree should be closed off to prevent any damage to property or the public.

3.0 Utilities

3.1 Design Criteria

The existing drainage infrastructure along Chancellor Boulevard currently has pooling issues. Site inspection shows that there are existing catch basins on both sides of Chancellor Boulevard. A plan of the storm, sanitary, and water systems provided by the client indicates two separate storm outfalls exist on site: one by Hamber road and another by Pioneer Trail in the center. The design has focused on the central storm outfall by Pioneer Trail, as that is where the pooling issues mainly occur. The storm sewer system is to be designed for the 5-year storm event using the Rational Method and Weibull distribution, with the 100-year storm event to be conveyed overland

Site Hydrology

Three sub-catchments, as shown in Figure 7: Topography and Catchment Areas, lead to the boulevard. The catchments include areas of the park and the University Golf Course. The surface runoff then continues to the low point of the boulevard at the Pioneer Trail crossing, also shown in Figure 7.

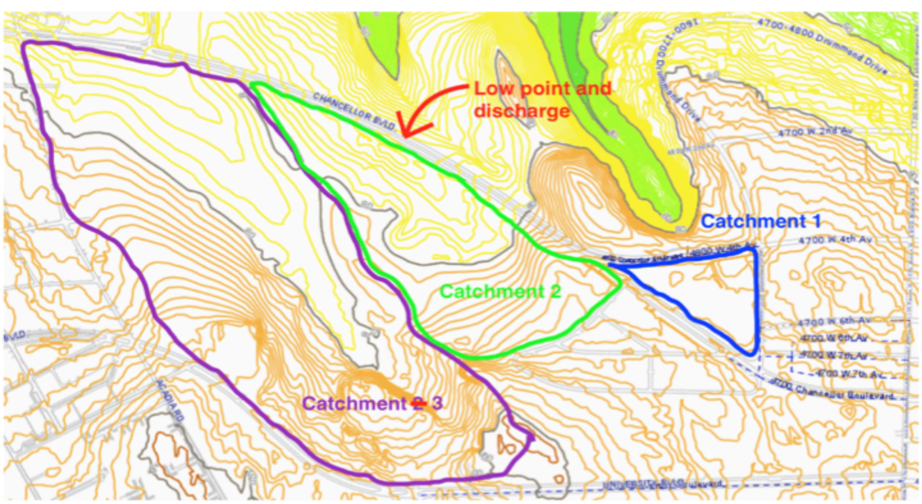


Figure 7: Topography and Catchment Areas

Using Figure 7, a catchment area of 700,000 m^2 was identified. Rainfall data, obtained from a Government of Canada weather collection station located at UBC, shows that the max rainfall intensity for the 5-year flow is 13.2 mm/hr. This results in a design flow of 6.1 L/s. A runoff coefficient was determined to be 0.13 to account for the mostly dense forested area within the catchment.

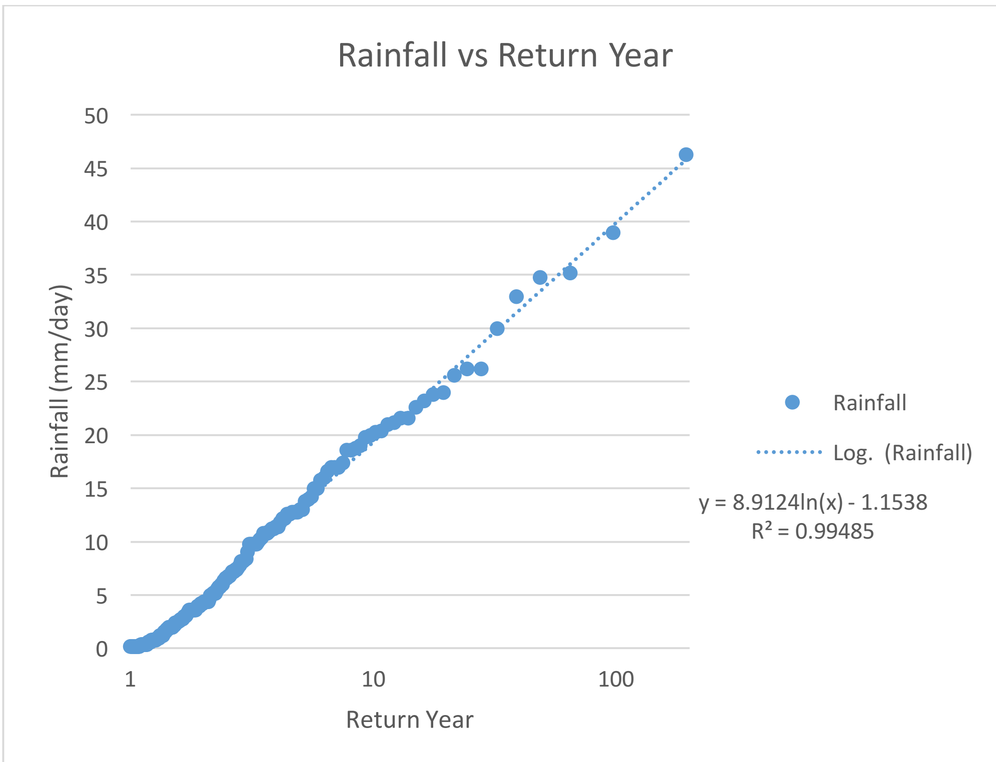


Figure 8: Rainfall vs Return Year Distribution

Canyon Creek, which begins at the drainage low point, runs north to the shoreline (refer to Figure 2: Trail and Creek Map). This creek may begin on the south side of the boulevard, but this was unable to be confirmed on site. The creek may have been buried in a culvert under the road, therefore ground penetrating radar or other explorative options should be considered. The creek is currently not fish bearing, however Metro Vancouver's goal is to rejuvenate creeks in the greater Vancouver area.

Utility Standards and Software

The Surrey Design Criteria Manual was used for the drainage standards. The following codes were addressed when considering the utilities for the corridor:

- 5.4.2.1 - minimum diameter pipe size
- 5.4.2.3 - minimum pipe cover of at least 1.5 m
- 5.4.2.5 - pipe grade requirement of 1%
- 5.2.1 - pump regulations
- 5.2.2 - tributary catchment area regulations
- 5.3.3 - run-off coefficient parameters
- 5.4.4.1 - manhole spacing requirements for diameters less than 0.9 m
- 5.4.5.2 - 5-year peak flow requirements
- 5.4.7.3 - Safety Provision code for catch basins
- 5.4.10 - Overland roadside channel flow depth requirements

Microsoft Excel was used to perform statistical analysis on the Environment Canada rainfall data, and to determine the hydraulic capacity of the existing pipe system. The City of Vancouver's Geographical Information System was used for the contour and topographic data.

3.2 Technical Considerations and O&M

Existing System

Given the information on the current drainage line and including calculations for specific return periods, the preferred option is to utilize the existing infrastructure and make upgrades where needed. Using the 5-year return period as a design parameter, Microsoft Excel was used to determine if the pipes had capacity. After calculations were completed, it was determined that a single pipe will need to be upgraded from 200 mm to 250 mm in order to convey the 5-year flow. The remaining existing system meets appears to meet the design criteria outlined above, however a full survey is required to confirm this. It was assumed that the pipes were at the minimum depth and followed the surface slopes. The existing manhole structures follow the 150m spacing for pipe diameters less than 0.9m. There are no major junction bends along the corridor, so the extra head loss measures where not needed in calculating water flow values.

Due to the lack of surveying, drawings, or other information, roadside channels for the overland flow path were assumed to meet the flow depth requirements set, such as the minimum freeboard depths of 150 mm and maximum ponding depth of 350 mm.

From our analysis, the basic drainage system meets the conveyance capacity regulations for the 5-year return period storm without the need for overland surface runoff mitigation parameters. Under the 100-year storm event however, the pipe network is at capacity and the overland flow will follow the natural contours to the underpass where it will need to be dealt with. Furthermore, as the existing pipe system is to be used, the pooling issues must be addressed in a different fashion. The following sections describe the proposed detailed design solution.

Catch Basins

As determined above, the pipe system is not the limiting element contributing to the pooling. Therefore, the catch basins must over capacity and need to be upgraded to handle the flow. The Filterra Bio-retention catch basin (Figure) is the recommended solution.

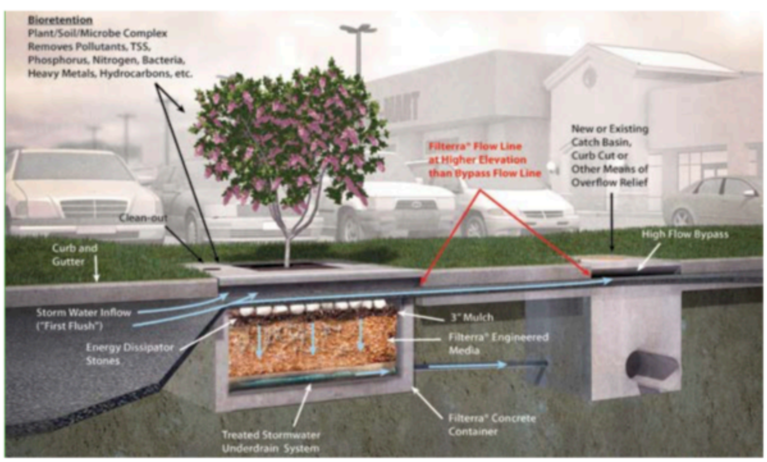


Figure 9: Filterra Catch Basin

It consists of a large curb side inlet, which is better for cyclists along the corridor, incorporated flora, and specialized soil filter media. The Filterra catch basin is able to handle large flows and efficiently remove a wide variety of particles and suspended solids. Particulates are of concern due to the golf course maintenance program which may include nitrogen and phosphorous. The discharge stream likely will become fish bearing in the future which would result in strict effluent regulations therefore it is best to include consideration for fish now. It is a compact system and that incorporates trees as desired by the road design, and an equivalent design as not been found, leading to the recommendation of this specific product. All manholes will be replaced as well, as the existing surface infrastructure is currently in a state of disrepair and unable to keep up with existing demands.

Underpass and Pump Station

At the underpass, the flow (from both directions) will divert from the existing pipe and follow the pedestrian ramp down to the middle of the north side. There it will be stored in a lift station and regularly pumped to the head of Canyon Creek.

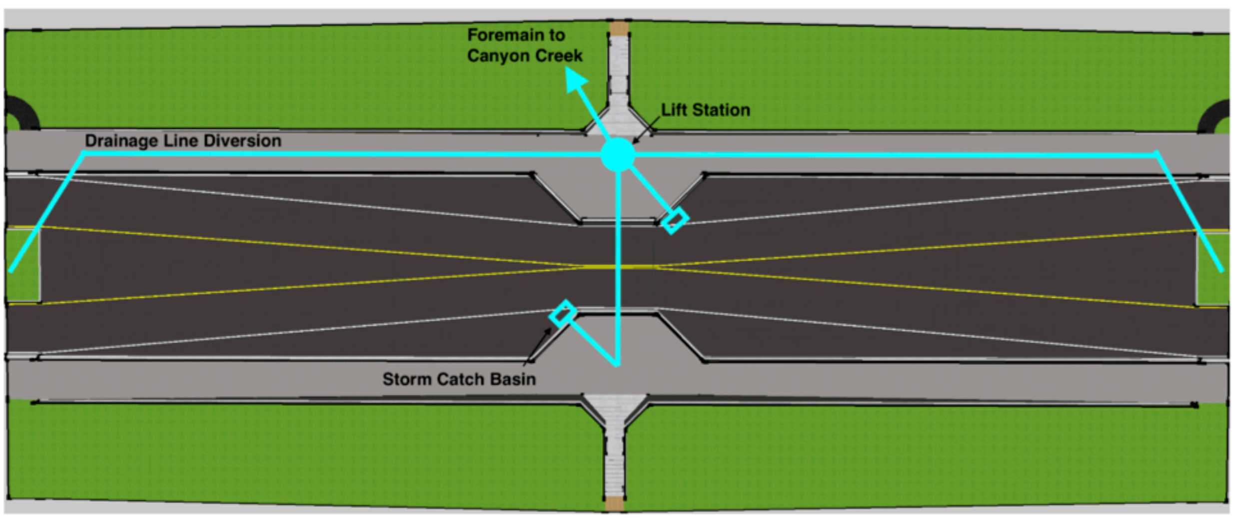


Figure 10: Underpass Pipe Detail and Lift Station Plan View

The pump sizing parameters include being able to handle the flow from a 200-year storm. The wet well that of the lift station must have 100 L of storage capacity, or enough to contain the 200-year storm. From this point, all the storm water will pump using a 200 mm DI forcemain to Canyon Creek, near the West Canyon Trail. This discharge pipe will follow the trail path until the creek head is reached. The lift station will have a single stage centrifugal pump that meets the follow specifications: 48 L/s, 5.6 m H20, 4.8 kW @ 400 V. Assuming a pre-development flow rate of 7 L/s/ha, with the 7 ha catchment area the maximum allowable pumped flow is 49 L/s to prevent damage to the creek environment.

Under the 100-year return period, an overflow land route will be utilized. The pipe network itself will be at capacity and all excess will be routed along the road. This overland flow will follow the natural contours of the land and will flow to the underpass. Two extra catch basins above the overpass at road level will be installed, one westbound and one eastbound along the corridor where flow will then be added to the detention storage in the storm water lift station.

Maintenance plan

The Filterra catch basins and the lift station will need servicing, as well as monitoring the condition of pipe system. Typically, storm drains should be inspected via robotic CCTV cameras every 20 years, or more often if infiltration, structural, or other issues are found. Various companies specialize in CCTV inspection for pipes and can easily be contracted when required. The Filterra catch basins will need to be serviced twice a year: once in the spring and once in the fall. Each unit takes approximately 30 minutes and unskilled staff, and simply involves removing any accumulated debris and the old topsoil mulch. Then the filter media is checked, and new topsoil is added. The filter media needs only replacing approximately 5 years, depending on the pollutants encountered. The lift station requires an inspection every 2 week by trained operators. The pump should be installed on a coupling and rail to be able to be removed from the wet well for inspection. Due to the confined space, the wet well should never be entered, and only inspected from above. Additional maintenance issues regarding the lift station should be consulted with an experienced operator and a mechanical engineer.

4.0 Underpass Structure

4.1 Design Criteria

Geotechnical Considerations

The geotechnical evaluation of the site has been based on observations done by our team during site visits as well as geotechnical reports of sites in the vicinity; see Appendix D. The subsurface conditions generally consist of compacted layers of granular materials (crushed stone and sand) as well as a silty sand for the road subgrade. These fill layers were placed to create a suitable road base for the existing road along Chancellor Boulevard. Additionally, there is topsoil with varying amounts of silt and vegetation along the sidewalks on the north and south near the forest area. The topsoil as well as the road base extend to a depth of 1.0m. From 1.0 to 1.5m, sand is the predominant material with batches of silt and silty sand. The moisture content at this depth is 20 to 30%. Below 2m, there is dense, till-like material with some gravel. Generally, in this area, the static groundwater table will not be present. Instead, the presence of perched groundwater near the till-like soil at depths of 0.9 to 1.5 m is expected.

Our team recommends the road base currently in place to be used for the proposed road and bike lane design. This further reduces material costs as we find the road base suitable for our design. Furthermore, at the location of the underpass (at the Pioneer trail), the till-like material needs to be excavated and replaced with compacted granular fills that will be suitable for the underpass foundation.

Structural Design Criteria

The underpass will be located at the crossing of Pioneer Trail and Chancellor Boulevard. It will be 10 m long, 5 m wide and will have 3 m of headroom clearance. The large width of the tunnel will accommodate a bi-directional bike lane, dedicated pedestrian lane and prevent a claustrophobic feel in the underpass. The proposed height is to provide cyclists adequate clearance. The length is the minimum distance to cross underneath the road lanes.

The underpass is designed for a 50-year design life and will be constructed with cast-in-place reinforced concrete specified at 30 MPa compressive strength and 20 mm max aggregate size. The structure is designed to carry loads from passing heavy trucks and Transit busses as well as the road structure laid on top of it. Table 2 summarizes the specified design loads for the structural components of the underpass.

Table 2: Design Loadings for the Underpass

Component	Dead load	Live Load	Surcharge
Roof Slab	13.6 kPa	12 kPa	-
Walls	41 kN/m	36 kN/m	12 kPa
Slab-on-Grade Foundation	50 kN/m	36 kN/m	-

Additionally, Table 3 below is a summary of all geotechnical parameters utilized in the design of the underpass. These parameters were extracted from previous bore holes and geotechnical reports of the area provided to our design team by the client's representative (i.e. Dr. Yahya Nazhat). Note that due to lack of geotechnical information at the exact location of the underpass, engineering judgement was used to approximate soil properties based off available data.

Table 3: Geotechnical Parameters Utilized in the Design of the Underpass

Parameter	Value	Unit
Unit weight of soil	20	kN/m
Resting Coefficient	0.5	-
Water Table Depth	24 below grade	m
Ultimate Bearing Capacity	190	kPa

Standards and Software Packages

The standards used in the design of the superstructure were the Canadian Standards Association CAN/CSA A23.1 as well the National Building Code of Canada, NBCC 2015. The structure was predominantly designed in Microsoft Excel with a few additional checks to ensure overall stability in SAP 2000, and reinforcement adequacy in Bentley's RAM Concept Structural Software.

For the retaining wall, the design was governed primarily by the British Columbia Building Code, BCBC 2012, and Canadian Standards Association CAN/CSA-S6-06, Canadian Highway Bridge Design Code. Additional design guidelines were consulted in the US Department of Transportation Federal Highway Administration publication "Design and Construction of Mechanically Stabilized Earth Walls and Soil Slopes".

4.2 Technical Considerations and Design Output

The roof of the underpass is designed as a 300 mm one-way slab. It is reinforced with 20M reinforcement at 150 mm spacing running in the short span and 20M bars at 500 mm spacing running north south as shrinkage and temperature bars. The walls are designed to be 200 mm thick, reinforced with 15M bars spaced at 300 mm vertical and 400 mm horizontals. At the corners of the walls, standard 90-degree hooks are designed to dowel in to the roof and foundation slabs to ensure continuity of the walls and the slabs. Wall corners have a 40 mm chamfer to reduce stress concentration and cracking at the corners. Moreover, a 60 mm x 40 mm shear key is placed at the stem of the wall to increase lateral stability. Vapour barriers are placed on the outside face of the walls to preventing moisture penetration from the backfilled soil behind the walls.

The foundation is designed for a 190 kPa soil bearing capacity and considering the water table is located at 24m below grade (according to geotechnical reports). The slab will be 250 mm thick and reinforced with 20M bars at 100 mm spacing in the short span and a 20M shrinkage and temperature reinforcement at 500 mm spacing placed in the longer span. Similar to the walls, vapour barriers will be placed below the foundation to prevent moisture penetration from the soil. Table 4 below summarizes the structural design:

Table 4: Sizing and Reinforcement of the Structural Components

Component	Loading (Specified)			Thickness (mm)	Reinforcement
	Live Load	Dead Load	Surcharge		
Roof Slab	23 kPa	13.6 kPa	-	300	20M @ 150 20M @ 500
Walls	36 kN/m	41 kN/m	12 kPa	200	15M @ 300V 15M @ 400H
Slab on Grade Foundation	36 kN/m	50 kN/m	-	250	20M @ 100 20M @ 500

Underpass Ramp Earth Walls

Surrounding the underpass superstructure, grade separating the roadway and the ramps leading to the underpass, is a 3.5 m tall mechanically stabilized earth wall. The wall was designed using the geotechnical parameters described previously and a traffic surcharge of 12 kPa. The wall is designed with six layers of 30 kPa Ultimate Tensile Strength geotextile material, placed 0.6 m on center. The bottom most layer is 0.3 m from the base of the wall. There is a 0.3 m wide drain rock chimney directly behind the face of the wall to facilitate drainage. Precast concrete facade panels are placed at the front of the wall to protect the soil and geotextile material against erosion.

Maintenance and Service Life

Periodically, the underpass superstructure shall be checked for cracking. Due to the uncertainty associated with the live loads, there is potential for cracks to form and propagate over time. Aesthetic cracks can be filled with grout, but structural cracks will require a more rigorous approach. However, it is not expected that any structural cracks will form under normal conditions. To prevent freeze-thaw cracks, preventative measures such as sealing compounds and coatings are recommended to be used on any exposed surface. Alternatively, epoxy and latex paint may be used to prevent weathering of exposed concrete.

Due to the secluded nature of the tunnel, graffiti could be a problem in the underpass. As this is not harmful to the structure of finish of the concrete, it is not imperative that the graffiti be removed. A graffiti removal schedule can be set by the owner/operator of the tunnel.

5.0 Design Issues and Recommendations

There are four main issues that were identified with this project:

The first issue was the limited soil information at the underpass location at Pioneer Trail. There was borehole information for two holes that were previously bored at either end of Chancellor Boulevard, but there was no information directly at the proposed underpass location. For the project, the soil characteristics had to be interpolated to properly analyze the structural aspects for the underpass. To overcome this issue, it is recommended that additional bore holes be drilled at the underpass site to achieve the most accurate soil characteristic results.

The second issue is the scheduling limitations due to the university access stipulations set out in the guidelines of this projects. All major road construction activities that complete shuts down or restricts vehicle access must be conducted in the summer months to limit disruption during the fall and winter semesters. Bus routes will need to be diverted and alternate routes will need to be set up for commuters, since the total volume flow during the summer months is significantly less.

The third issue is the poor proximity to neighboring power routes. There is currently no street lighting along the Chancellor Boulevard, and as such, there is presently no power being supplied along the corridor. Under the proposed design, power will be needed to supply energy to the street lighting, the pump that is housed at the lift station, and the underpass lighting. To be the most efficient and economic, laying and routing power for all these needs at once will be beneficial. This will also allow cost sharing for the installation of electrical conduit for each of these utilities.

The fourth issue is the lack of location information for the existing utilities. The utility drawings provided in the client package were only partial in their information regarding pipe specification and details. There is a need for further surveying of the storm mains to obtain invert and exact slope data. Surveying of the manholes will also help in the installation of the new catchbasins along the corridor.

6.0 Cost estimate

The total cost for this project is estimated at $2.6 million. Broken down by design element, the costs are summarized in the following table. This table shows the positive impact of a design that utilizes existing road features to reduce road designs impact on cost. In addition to this it should be recognized that the underpass structure has a large impact on the project cost. If funding cannot be acquired for the total amount the underpass may be removed to meet budget restrictions. A more detailed work breakdown structure and cost estimate can be found in Appendix B.

Table 5: Cost Estimate by Element

Item	Cost
Drainage	**$466,195.00**
Pipes	$41,635.00
Catchbasins	$44,560.00
Pump Station	$100,000.00
Demolition	$40,000
O&M Costs (20 Years)	$240,000
Transportation	**$922,830.00**
Asphalt Paving	$418,280.00
Curbs and Concrete	$325,000.00
Signage and Pavement Markings	$8,550.00
Landscaping	$71,000.00
O&M Costs (20 Years)	$100,000.00
Structural	**$316,195.00**
Earthworks	$106,095.00
Concrete Work	$95,600.00
Reinforcement	$14,500.00
O&M Costs for 20 years	$100,000.00
Additional Fees	**$852,500.00**
Total	**$2,557,720.00**

7.0 Schedule

For a start date of May 1, 2018, construction is estimated to take 5 months to complete. The proposed schedule will close traffic on Chancellor Boulevard from May 1st to August 31st, with preliminary work during April. Work will be carried out by three crews working in parallel and a subcontractor for landscaping.

The three crews will be divided into roadwork, underpass and drainage work. The scheduling will focus on completing the underpass construction due to restrictions on road access and paving abilities prior to its completion. In parallel to the construction of the underpass, drainage work will begin at the Hamber road crossing moving east, eliminating delays on the road crew. The road crew will complete asphalt removal prior to the road closure date. They will commence bike curb and pedestrian path installation from the west and work up to the underpass. Concrete work will be carried out at the Hamber intersection next. Once complete in the west, access to the underpass will be from the west and the road crew will work on the median crossing and bike curb and pedestrian path up to the underpass from the east. After work at the underpass is finished Final paving will occur at the intersection and underpass and road markings and signage added.

At the Underpass excavation will start after being surveyed and laid out, then drainage components will be installed. The concrete structure will be cast in place and once cured sufficiently it will be backfilled and landscaping and surface finishing can occur.
See Figure 10 below for a more detailed sequencing of tasks and estimated durations, not accounting for unforeseeable delays. From experience the estimated completion period of 5 months is expected to account for some delay. Due to the magnitude of the project and the tight window we hope to achieve construction in, ensuring crews are not being held back by other work will be crucial. It would be possible to create an accelerated schedule with the addition of more crews if necessary.

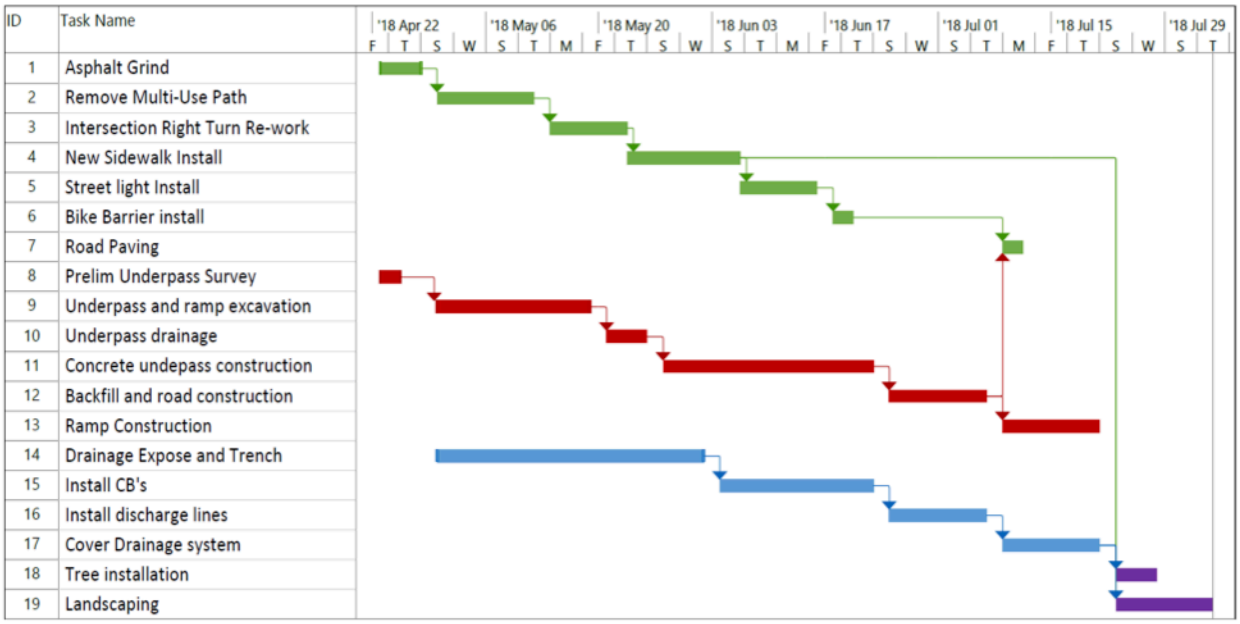


Figure 11: Schedule Gantt Chart

Appendix A: Reports and References

- Geotechnical reports of nearby sites:
  - EXP Consulting. (2015). Block F, Acadia and University Blvd., UBC Acadia and Toronto Roads Updated Preliminary Geotechnical Report (Tech. No. VAN-00213751-01). Retrieved November 22, 2017, from http://www.universityendowmentlands.gov.bc.ca/library/_Appendix%20D%20-%20Geotechnical%20Report.pdf
  - Geo Pacific Consulting. (2014). (Tech. No. 12203). Retrieved November 22, 2017, from http://rezoning.vancouver.ca/applications/3365commercial/documents/geotechreport.PDF
- Pacific Spirit Park. (n.d.). Retrieved November 03, 2017, from http://pacificspiritparksociety.org/about-the-park/pacific-spirit-park/
- Road Material Costs (Rep.). (2010, November). Retrieved November 24, 2017, from City of Barrie website: https://www.barrie.ca/assets/engineering/nov2010/Appendix%20L%20-%20Costs%20per%20metre.pdf

Appendix B: Cost Estimate

Item	Description	Unit	Estimated Quantity	Unit Rate	Total Price	Comment
1	**Utilities**					
1.01	100 mm dia. Pipe	m	31	$85.00	$2,635.00	Underpass Storm grate lines
1.02	200 mm dia. Pipe	m	100	$125.00	$12,500.00	Forcemain Pipe
1.03	250 mm dia. Pipe	m	75	$140.00	$10,500.00	Pipe 3 Upgrade
1.04	300 mm dia. Pipe	m	100	$160.00	$16,000.00	Underpass storm drain diversion
1.05	Manhole	ea	9	$3,000.00	$27,000.00	
1.06	Double Catch Basin	ea	2	$280.00	$560.00	CBs on road at underpass
1.07	Filterra Catch Basin	ea	18	$750.00	$13,500.00	To be confirmed by Manufacturer quote
1.08	Surface grate	m	20	$175.00	$3,500.00	Surface Grates at underpass ramps
1.09	Lift Station	ea	1	$100,000.00	$100,000.00	Estimated cost - To be confirmed by contractor
1.10	Demolition	ea	1	$40,000.00	$40,000.00	Estimated cost - To be confirmed by contractor
1.11	O&M Costs for 20 years	yr	20	$12,000.00	$240,000.00	Estimated Annual Cost - To be confirmed by Operations & Maintenance group
				SUBTOTAL	$466,000.00	
2	**Transportation**					
2.01	Asphalt Demolision	m^2	8810	$4.00	$35,240.00	Curbs for bike lanes, intersection, pathway
2.02	Asphalt Paving	m	6860	$50.00	$343,000.00	Repave intersection and pathway
2.03	Street Trees	ea	120	$400.00	$48,000.00	Plant deciduous tree in median and south side of road, every 25m
2.04	Painted Road Lines	m	1800	$1.00	$1,800.00	Repaint marking lane markings
2.05	Painted Road Symbols	ea	70	$25.00	$1,750.00	Paint new turn dashes, crosswalks and bike markings
2.06	19mm Granular Base (150mm thick)	m^2	2860	$6.00	$17,160.00	For pathway
2.07	30mm Granular Subbase (300mm thick)	m^2	2860	$8.00	$22,880.00	For pathway
2.08	Sidewalk Lighting	ea	23	$1,000.00	$23,000.00	Install lighting for pedestrans on new sidwalk
2.09	Bike Lane Curbs	m	3000	$100.00	$300,000.00	Form and pour curbs and patterned concrete.
2.10	Intersection Right Turn Lane	ea	1	$15,000.00	$15,000.00	Change angle of attack and pedestrian crossing point
2.11	Signage	ea	50	$100.00	$5,000.00	Ensure proper signage present and in appropriate locations
2.12	Protected Median Crossing	ea	1	$10,000.00	$10,000.00	"Sheeps-pen" crossing at Spanish Trail
2.13	O&M Costs for 20 years	yr	20	$5,000.00	$100,000.00	Estimated Annual Cost - To be confirmed by Operations & Maintenance group
				SUBTOTAL	$923,000.00	
3	**Structural**					
3.01	Shoring and Excavation	m^3	2000	$45.00	$90,000.00	Estimated cost - To be confirmed by contractor
3.02	Concrete	m^3	100	$180.00	$18,000.00	
3.03	Concrete Placement	m^2	200	$21.00	$4,200.00	
3.04	Concrete Finish and Paint	m2	200	$45.00	$9,000.00	
3.05	Formwork	m^2	500	$44.00	$22,000.00	1 month with a crew of 4 carpenters
3.06	Shoring Rental	ea	20	$100.00	$2,000.00	
3.07	Shoring Engineering	ea	1	$500.00	$500.00	subcontracted engineering for shoring
3.08	Reinforcement and installation	ft	5000	$2.90	$14,500.00	1 month with a crew of 4 carpenters
3.09	Foundation base compaction and placement	hr	40	$18.00	$720.00	1 month with a crew of 4 carpenters
3.10	Foundaion base granular material (1/2" crushed)	m^3	15	$25.00	$375.00	
3.11	Geotextile	m^2	3000	$5.00	$15,000.00	
3.12	Concrete Facade Panels	ea	570	$70.00	$39,900.00	
3.13	O&M Costs for 20 years	yr	20	$5,000.00	$100,000.00	Estimated Annual Cost - To be confirmed by Operations & Maintenance group
				SUBTOTAL	$316,000.00	
	CONSTRUCTION SUBTOTAL				$1,705,000.00	
	Bonding/insurance	5%			$85,250.00	
	Mob/Demob	5%			$85,250.00	
	Engineering & Construction Management	25%			$426,250.00	
	Contingencies	15%			$255,750.00	
	TOTAL				**$2,558,000**	

Appendix C: Specifications

UNIVERISTY OF BRITISH COLUMBIA

SOCIAL ECOLOGICAL ECONOMIC DEVELOPMENT STUDIES (SEEDS) SUSTAINABILITY PROGRAM

CHANCELLOR BOULEVARD REDESIGN

Chancellor Boulevard
Vancouver, BC

PROJECT SPECIFICATIONS

ISSUED FOR CONSTRUCTION

April 9, 2018

Project Contact List

Client	UBC SEEDS Centre for Interactive Research on Sustainability 2260 West Mall, 2nd Floor Vancouver BC V6T 1Z4	T 604 827 1552 Krista.Falkner@ubc.ca
Design Consultant	Right of Way Engineering Ltd. 6250 Applied Science Ln Vancouver, BC V6T 1Z4 April 6, 2018	T 778 354 9670 F 778 354 9540 gwright@rightofwayeng.ca
Project Management	TBD	-
Contractor	TBD	-

Division 1 – Transportation

1-1 References and Standards

1. All Referenced standards shall be the current edition of or the edition referenced by the applicable building code in force at the time of development permit application
2. TAC Geometric Design Guide
3. MOTI Standards

1-2 Submittals

1. Provide submittals to the construction engineer in PDF format
2. Required submittals:
    a. Signage
    b. Concrete mix
    c. Asphalt mix
    d. Road Marking Shop Markings
    e. Test and Inspection Report
    f. Erosion and Sediment Control Plan

1-3 Materials and Products

1. Use 30 MPa concrete with 20 mm aggregate
2. Signs must be design according to the TAC Manual of Uniform Traffic Control Devices
3. Pavement markings must use thermoplastic paint
4. All curbs will adhere to City of Vancouver spec due to intergration with their system.
5. Hard curbs will be to Type A (Formed) spec on drawing MF137-A-1
6. Roll-over curbs will be to Type C (Formed) spec on drawing MF137-A-3

1-4 Quality Control / Quality Assurance

1. Asphalt CBR must meet AASHTO (1993) Guide for the Design of Pavement Structures
2. Geotechnical Engineer will test all lifts of road base and sub-base material, and give approval for the contractor to continue
3. All sub-base must meet 95% Standard Proctor Density

1-5 Installment Procedure

1. All Signage must remain covered prior to the infrastructure being completed
2. All Road base material must be compacting in 150 mm lifts
3. 28 day set time for concrete curbs prior to vehicle loading
4. All road works near open water channels must implement measures to prevent sediment movement into the channel.

1-6 Inspection and Testing

1. Two copies of all inspection reports must be submitted to the engineer
2. Asphalt must be tested for compressive strength according to CSA standards
3. Concrete must be tested for slump, air content, and compressive strength according to CSA standards
4. Road base and sub-base material will be tested to meet 95% standard proctor compaction

1-7 Required Mockups

1. Streetlights
2. Fencing
3. Signage

Division 2 – Utilities

2-1 References and Standards

1.0 All Referenced standards shall be the current edition of or the edition referenced by the applicable building code in force at the time of development permit application
2.0 Surrey Design Criteria

2-2 Submittals

1.0 Shop Drawings
2.0 MSDS for pumps and pipes
3.0 Filterra Catchbasin information and Specification Sheets
4.0 Mitigation and safety plans for any leaching or contamination from particulates like phosphates, nitrates, and oils from the surrounding golf course and road
5.0 Installation schedule that fits into the critical path of the entire project

2-3 Materials and Products

1.0 Pipe materials to be designed to pressure capacities
2.0 Pump to be designed to meet a given flow volume value

3.0 Filterra Catchbasins and equivalent

2-4 Quality Control / Quality Assurance

1.0 Water site at outfall into the stream must be added to the water quality control testing site location list

2-5 Installment Procedure

1.0 Pipe replacement and installation must adhere to the trench slope and shoring guidelines

2-6 Inspection and Testing

1.0 Regular testing for particulates and run-off contaminants on a weekly and monthly basis

Division 3 – Structural

3-1 References and Standards

1. All Referenced standards shall be the current edition of or the edition referenced by the applicable building code in force at the time of development permit application.
2. NBCC 2015
3. Canadian Standard Association (CSA):
   3.1. CSA A23.1/A23.2, Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete.
   3.2. CSA A283, Qualification Code for Concrete Testing Laboratories.
   3.3. CSA A3000, Cementitious Materials Compendium (Consists of A3001, A3002, A3003, A3004 and A3005).
4. ASTM requirements:
   4.1. ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

3-2 Submittals

1. Shop Drawings: Indicate formwork construction including forming material joints, form tie locations, inserts and embedments, reveal strips (rustication strips) including method of fixing, construction and contraction joints, form joint-sealant details, cutouts, cleanout panels, and other items that visually affect architectural concrete.
2. Submit concrete test results including air test, slump test and cylinder test
3. Submit concrete mixture information sheet to the consultant 10 days prior to concrete pour.

4. Submit MSDS for any concrete mixture added to the original concrete mix

3-3 Materials and Products

1. 30 MPa compressive strength concrete with 20 mm maximum aggregate size to be used for the construction of underpass.
2. Deformed reinforcement complying CSA-G30.18-09 with to be used as per IFC drawings.

3-4 Placing Concrete

1. Place concrete in accordance with CSA A23.1
2. Deliver and place concrete with minimum re-handling
3. If concrete is pumped, control discharge velocity to prevent segregation of concrete mixture.
4. Do not overload forms
5. Vibrate concrete as required
6. Cast the roof slab at least 7 days after pouring the walls
7. Ensure bottom slab of the underpass is cast with slopes as per IFC drawings
8. Ensure exposed surfaces are finished properly

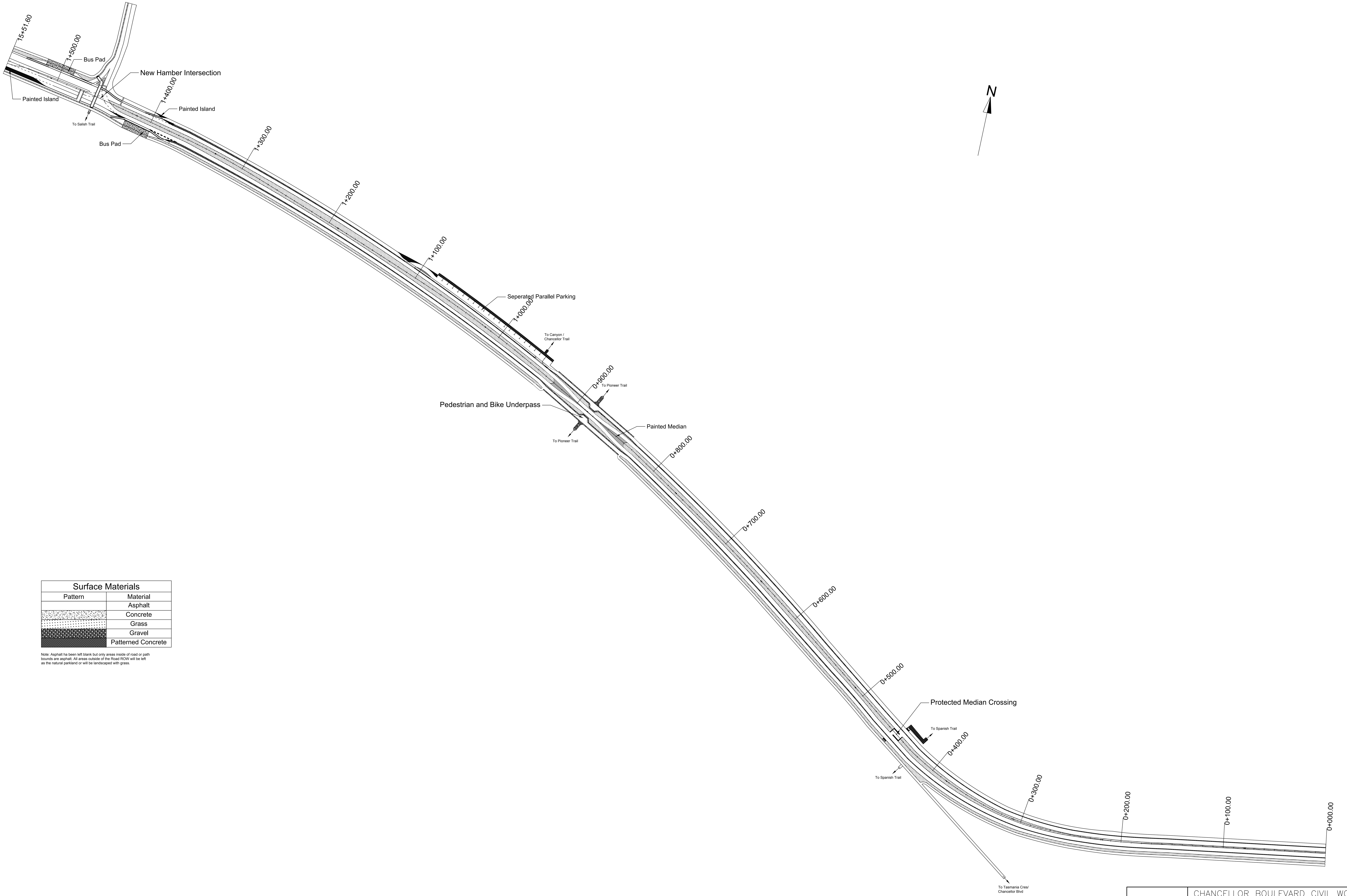
3-5 Inspection and Testing

1. An independent Inspection and Testing Agency (certified under CSA A283 with category to suit testing provided) will be appointed to carry out inspection and testing of concrete and concrete materials and check conformance with applicable Standards and Contract documents.
2. Sampling, storing, curing and testing of concrete to be in accordance with CSA A23.1/A23.2.
3. One concrete test is required for each 30 cubic meters of concrete (i.e. 3 trucks)
4. Provide results of concrete testing to the consultants upon request.

1-6 Mockups

1. Prove two (2) samples of the concrete fascia panels to be used on the exposed face of the retaining walls at the underpass.

Appendix D: Design Drawings

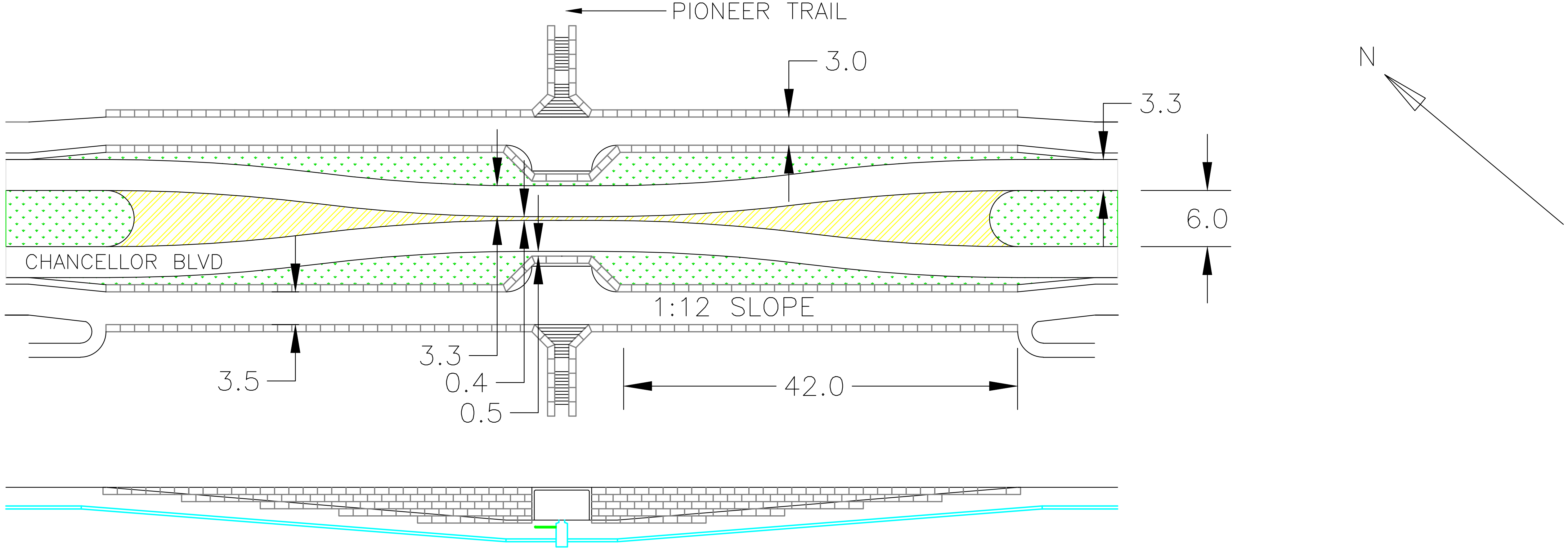


Surface Materials	
Pattern	Material
	Asphalt
	Concrete
	Grass
	Gravel
	Patterned Concrete

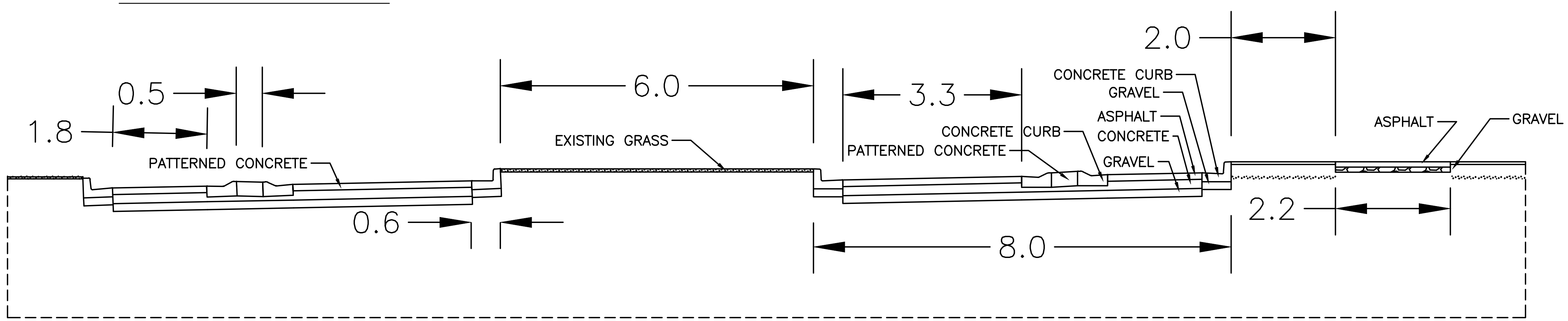
Note: Asphalt ha been left blank but only areas inside of road or path bounds are asphalt. All areas outside of the Road ROW will be left as the natural parkland or will be landscaped with grass.

CHANCELLOR BOULEVARD CIVIL WORKS OVERVIEW		
UNIVERSITY OF BRITISH COLUMBIA	DESIGNED BY AK	DRAWN BY MA
	CHECKED BY GW	DATE 27/03/2018
CHANCELLOR BLVD DREDESIGN	UNITS M	SHEET C.1
	SCALE 1:1200	

HAMBER INTERSECTION DETAILS		
UNIVERSITY OF BRITISH COLUMBIA	DESIGNED BY GW	DRAWN BY MA
	CHECKED BY AK	DATE 27/02/2018
CHANCELLOR BLVD DREDESIGN	UNITS M	SHEET C.2
	SCALE 1:200	

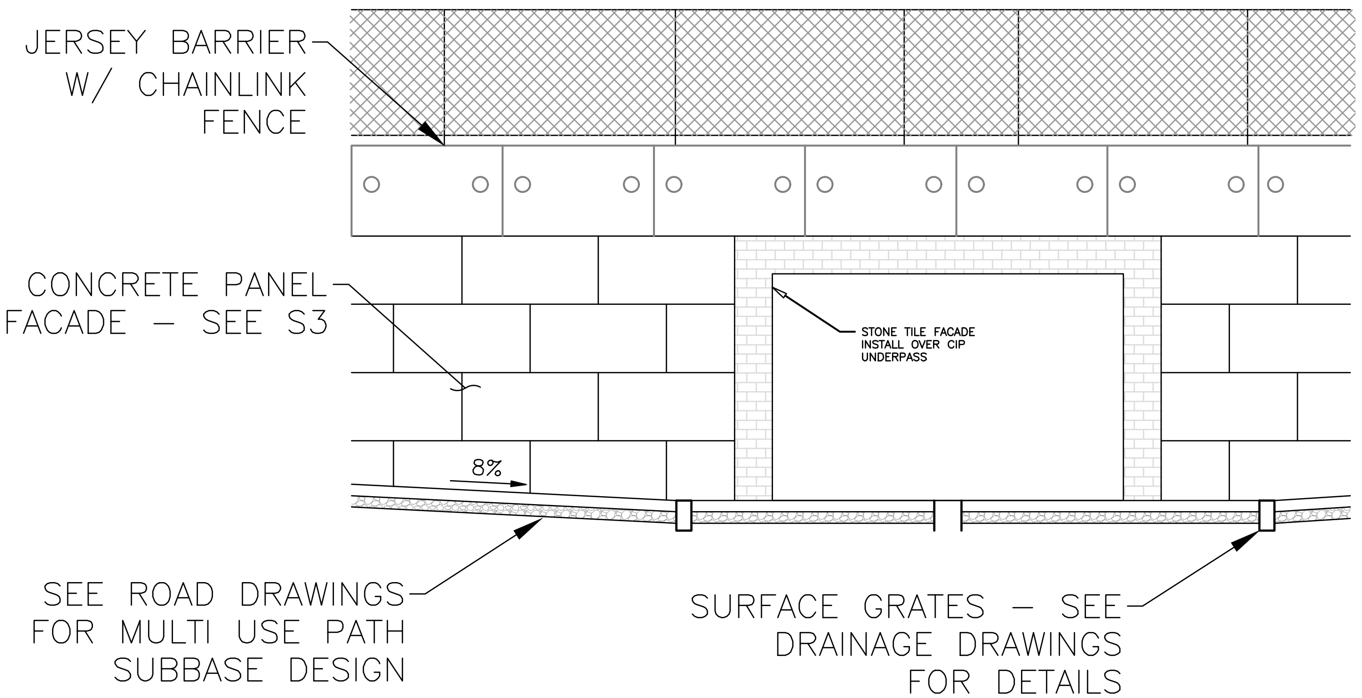


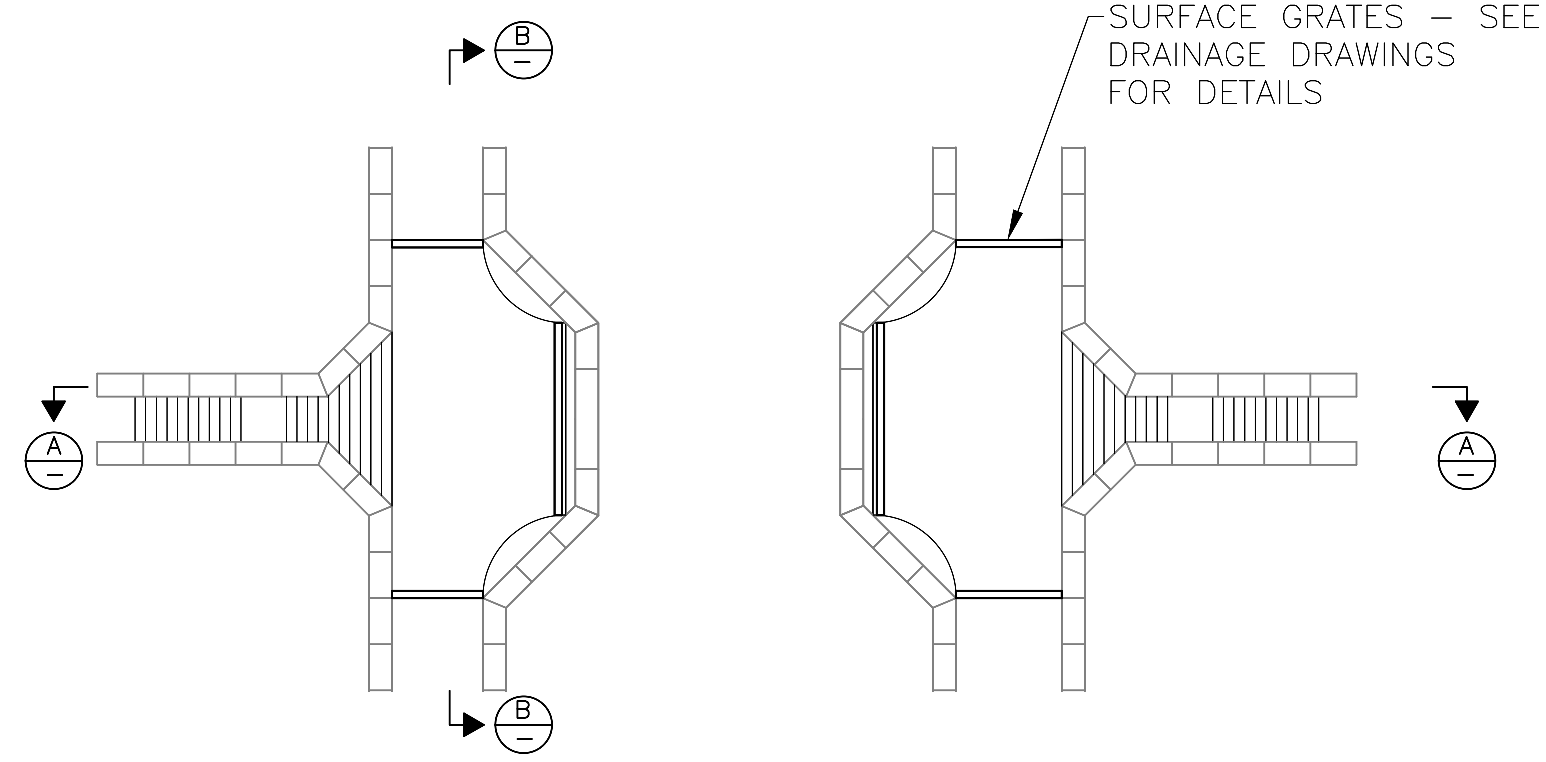
UNDERPASS TRAFFIC
PLAN & PROFILE



TYPICAL ROAD
CROSS SECTION

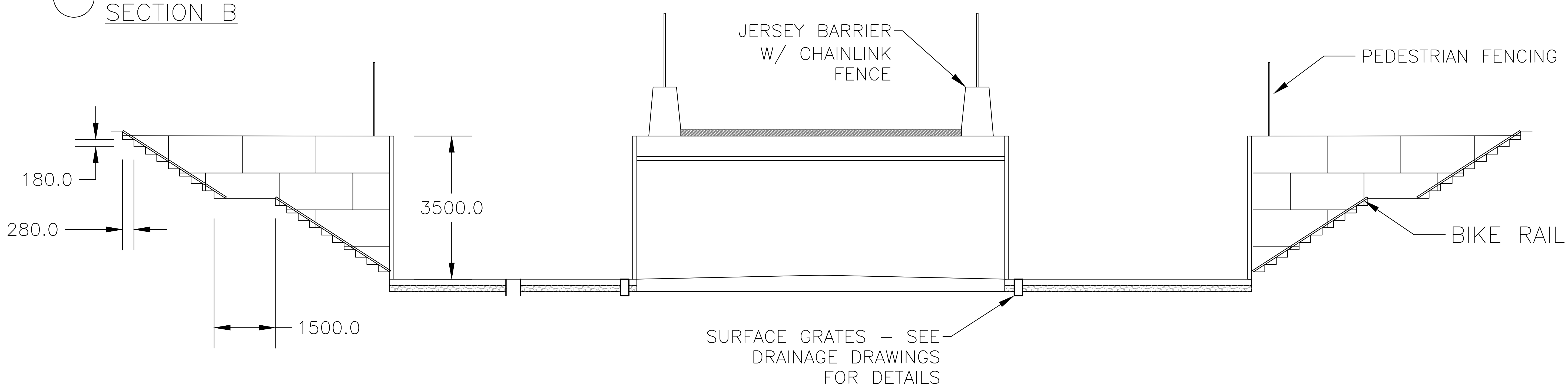
UNDERPASS TRANSPORTATION		
UNIVERSITY OF BRITISH COLUMBIA	DESIGNED BY GW	DRAWN BY GW
	CHECKED BY DA	DATE 23/11/2017
CHANCELLOR BLVD DREDESIGN	UNITS M	SHEET C1
	SCALE 1:1000	





UNDERPASS DRAINAGE
PLAN

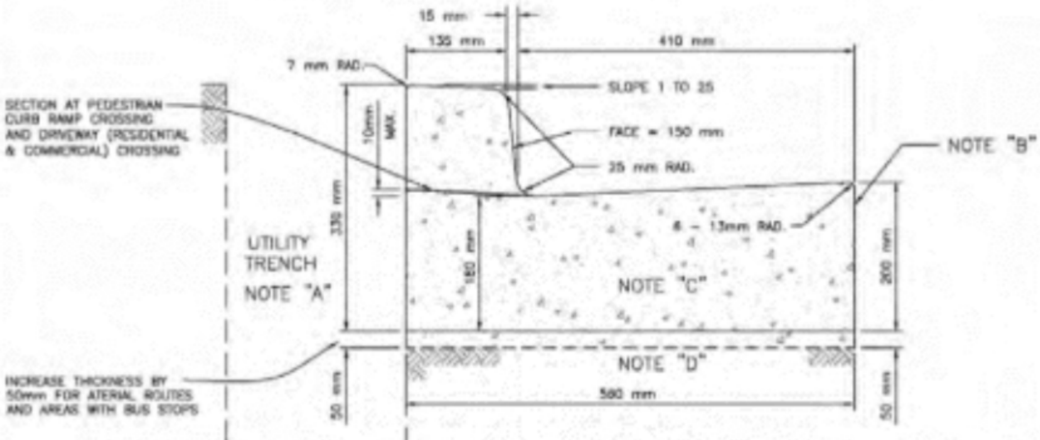
B UNDERPASS DRAINAGE
SECTION B



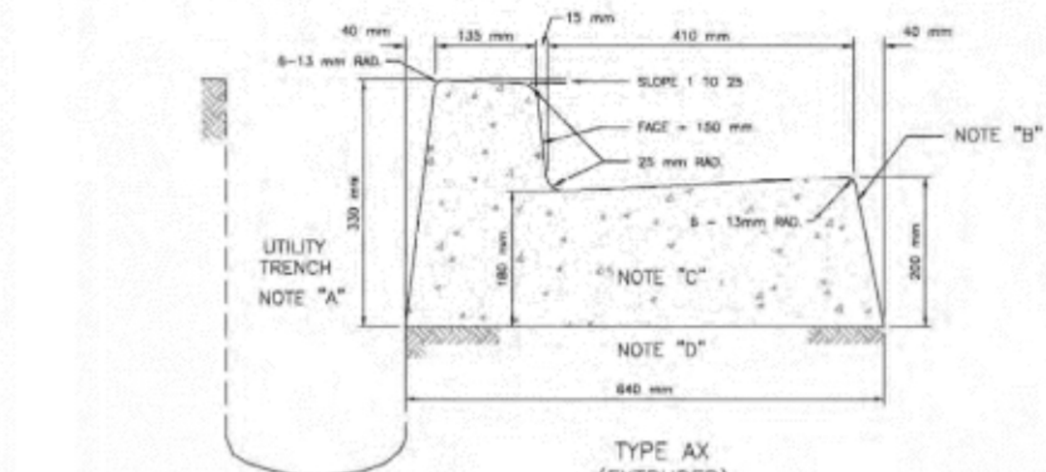
A UNDERPASS DRAINAGE
SECTION A

RAMP UNDERPASS DETAILS		
UNIVERSITY OF BRITISH COLUMBIA	DESIGNED BY GW	DRAWN BY GW
	CHECKED BY DA	DATE 23/11/2017
CHANCELLOR BLVD DREDESIGN	UNITS MM	SHEET C2
	SCALE 1:200	

ISSUE (DATE) APPROVED	DETAILS OF CURBS NOT TO SCALE	STANDARD SECTION PAGE



TYPE A
(FORMED)



TYPE AX
(EXTRUDED)

NOTE "A" FOR DETAILS SEE STANDARDS DRAWING MF 137–B–1

NOTE "B" WHERE P.C. CONCRETE PAVEMENT BASE IS USED, CURB CONSTRUCTION SHALL BE AS SHOWN ON STANDARDS DRAWING MF 137–D–1

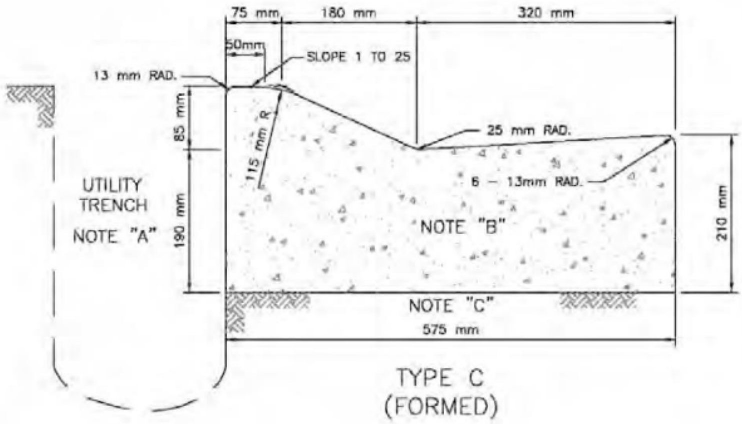
NOTE "C" CONTROL JOINTS CUT AT 4500 mm INTERVALS (MIN. 50 mm DEPTH)

NOTE "D" PLACE A MINIMUM OF 150mm GRANULAR BASE AT 95% MPD (20mm MINUS GRANULAR) EXCAVATE 1.2m WIDE FOR CURB & GUTTER

APPROVED GENERAL MANAGER OF ENGINEERING SERVICES	08/04/28 84/03/07 78/07/12 REVISED TO LATEST DATE SHOWN

CITY OF VANCOUVER ENGINEERING SERVICES	STREETS – STANDARDS	MF137–A–1

ISSUE (DATE) APPROVED	DETAILS OF CURBS NOT TO SCALE	STANDARD SECTION PAGE



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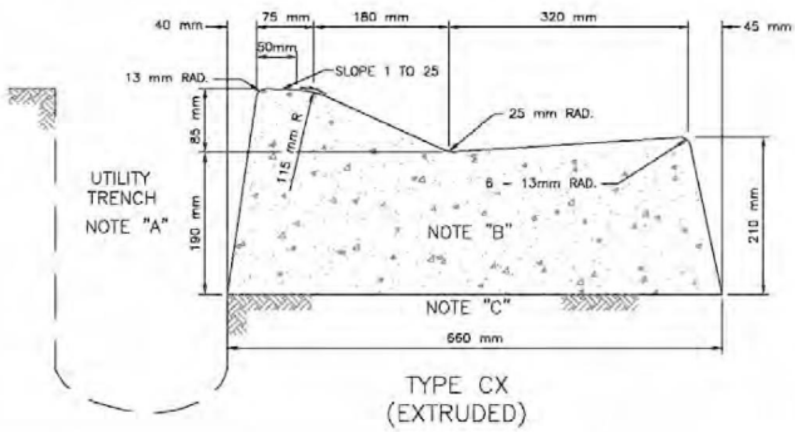
(FORMED)



TYPE CX
(EXTRUDED)

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NOTE "B" CONTROL JOINTS CUT AT 4500 mm INTERVALS (MIN. 50 mm DEPTH)

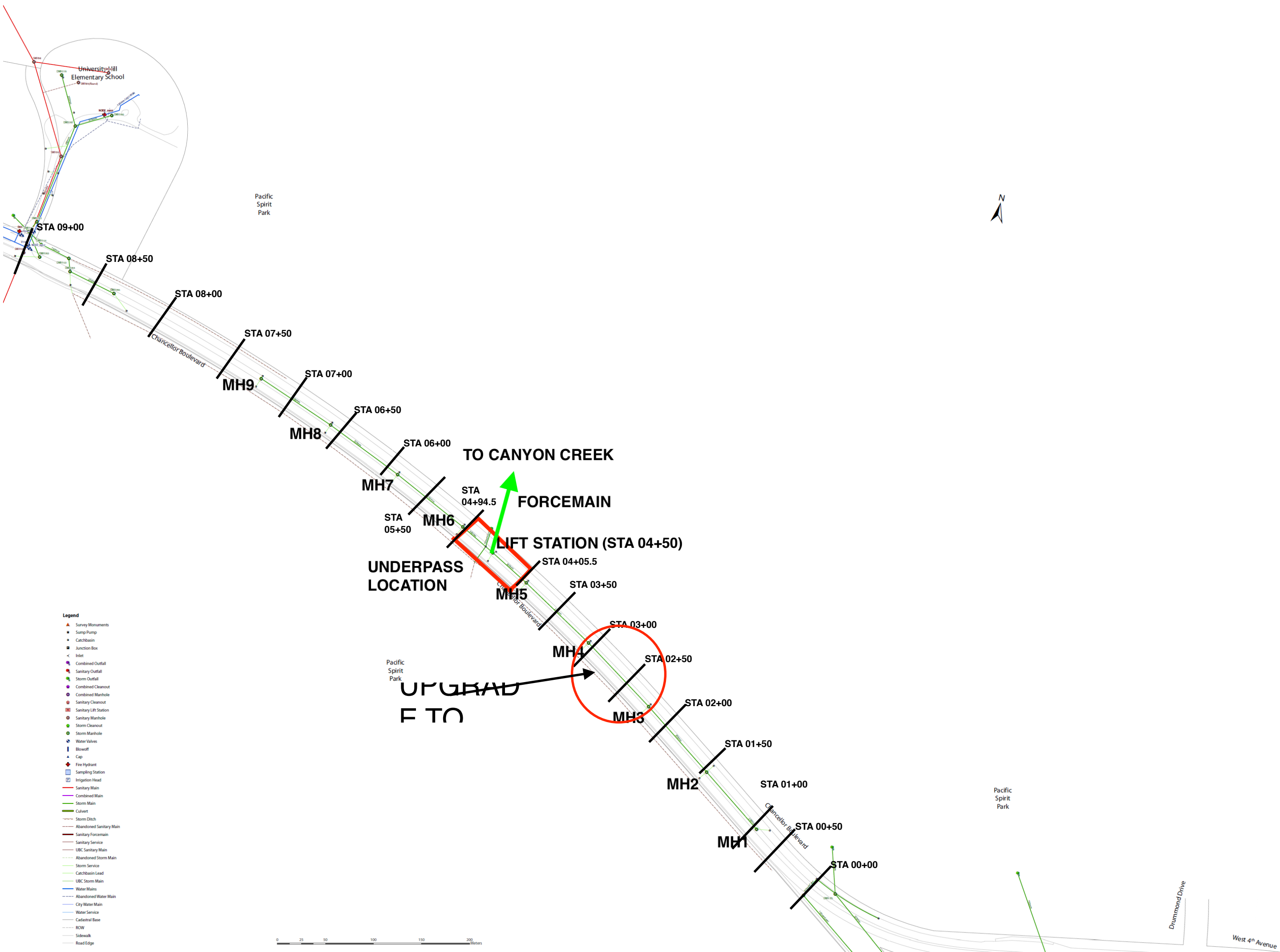
NOTE "C" PLACE A MIMIMUM OF 150mm GRANULAR BASE AT 95% MPD (20mm MINUS GRANULAR)
EXCAVATE 1.2m WIDE FOR CURB & GUTTER

08/04/24
84/05/25
78/07/12
REVISED TO LATEST DATE SHOWN

APPROVED

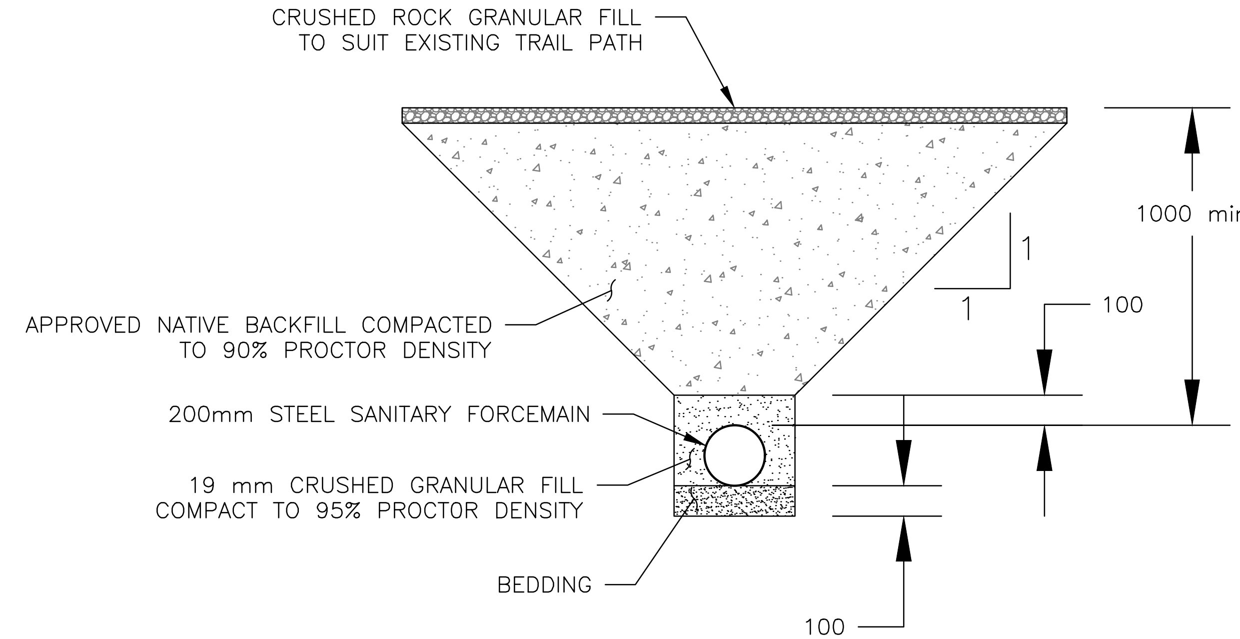
GENERAL MANAGER OF ENGINEERING SERVICES

CITY OF VANCOUVER ENGINEERING SERVICES	STREETS – STANDARDS	MF137-A-3



STATION 00+00 TO BE TAKEN FROM MANHOLE AT EAST END OF BOULEVARD, ON SOUTH SIDE

DRAINAGE SYSTEM OVERVIEW



TYPICAL DRAINAGE TRENCH
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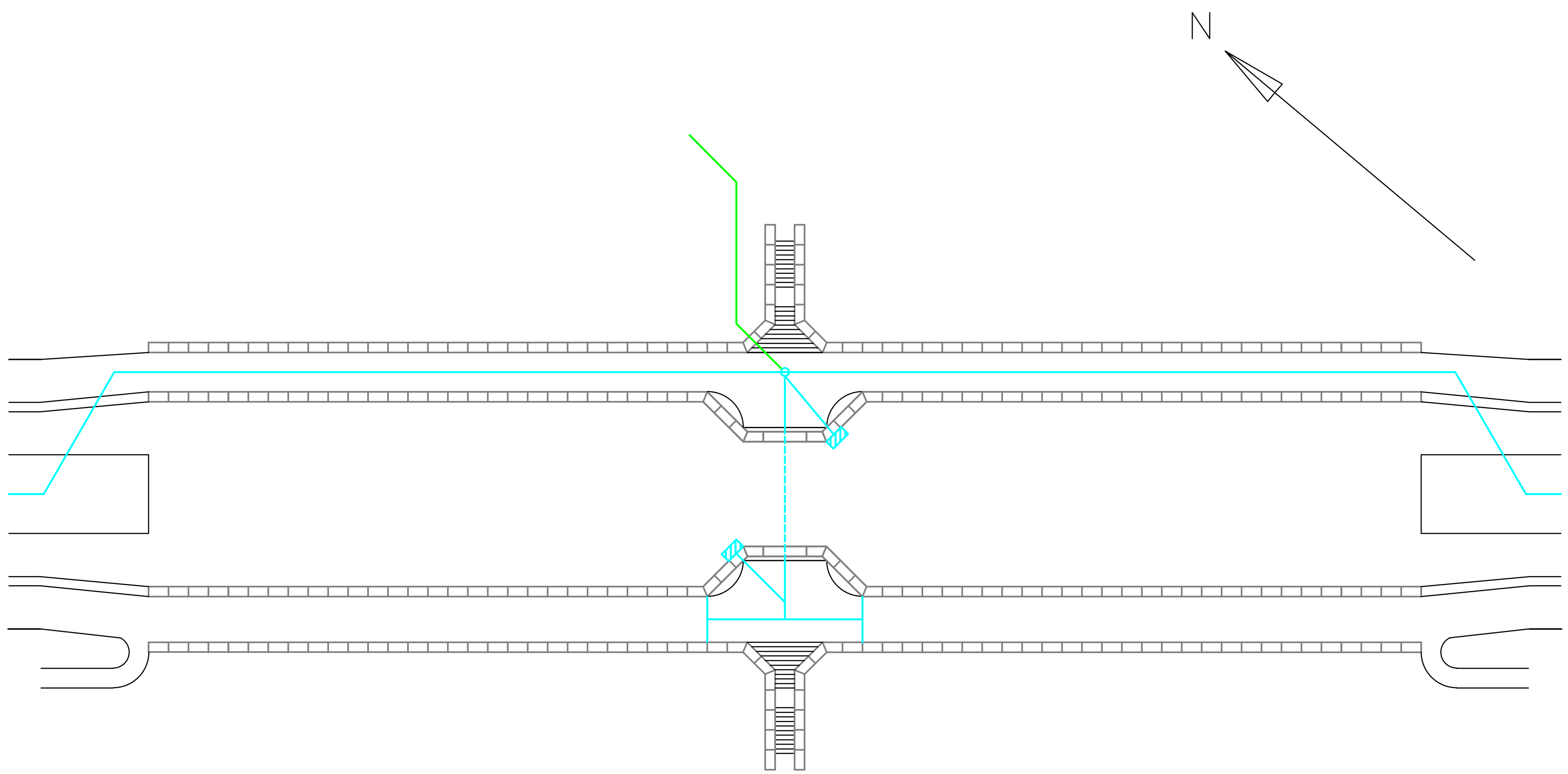
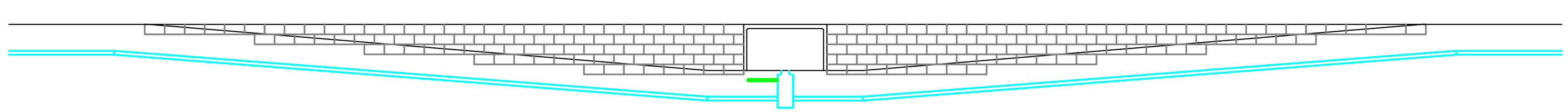


UNDERPASS PLAN
SCALE 1:1000



RAMP PROFILE
SCALE 1:1000

UNDERPASS DRAINAGE OVERVIEW		
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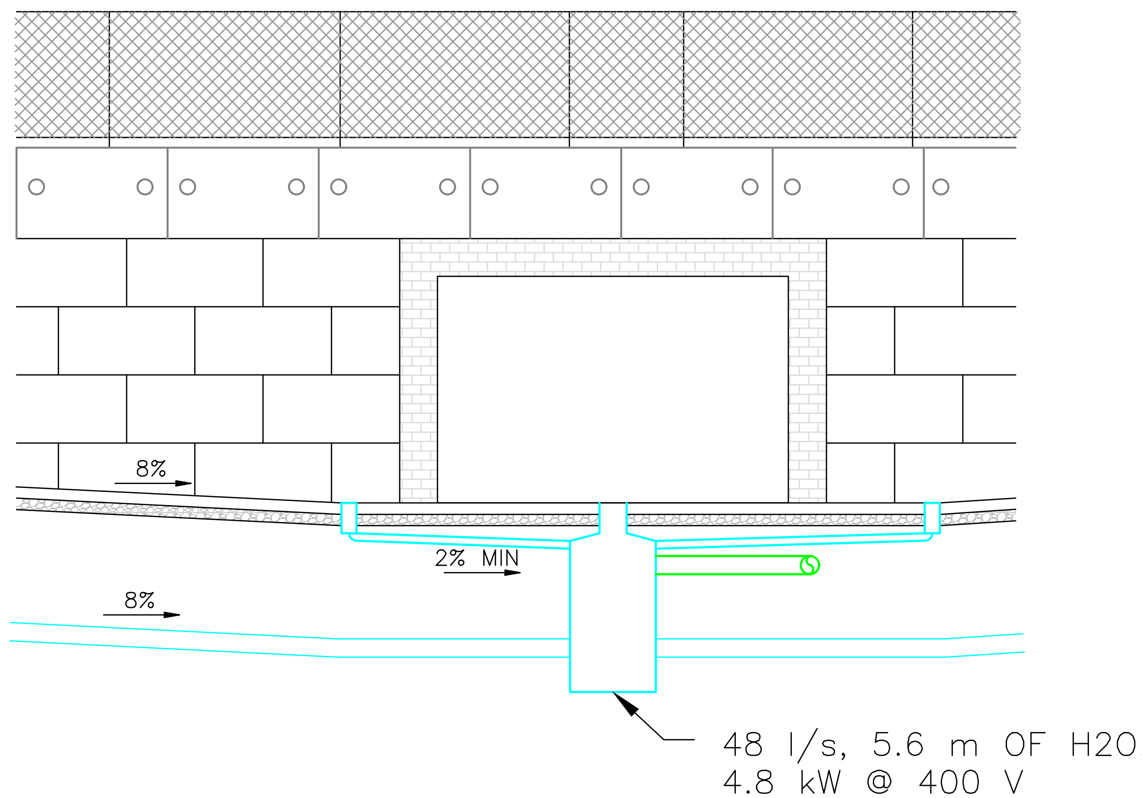
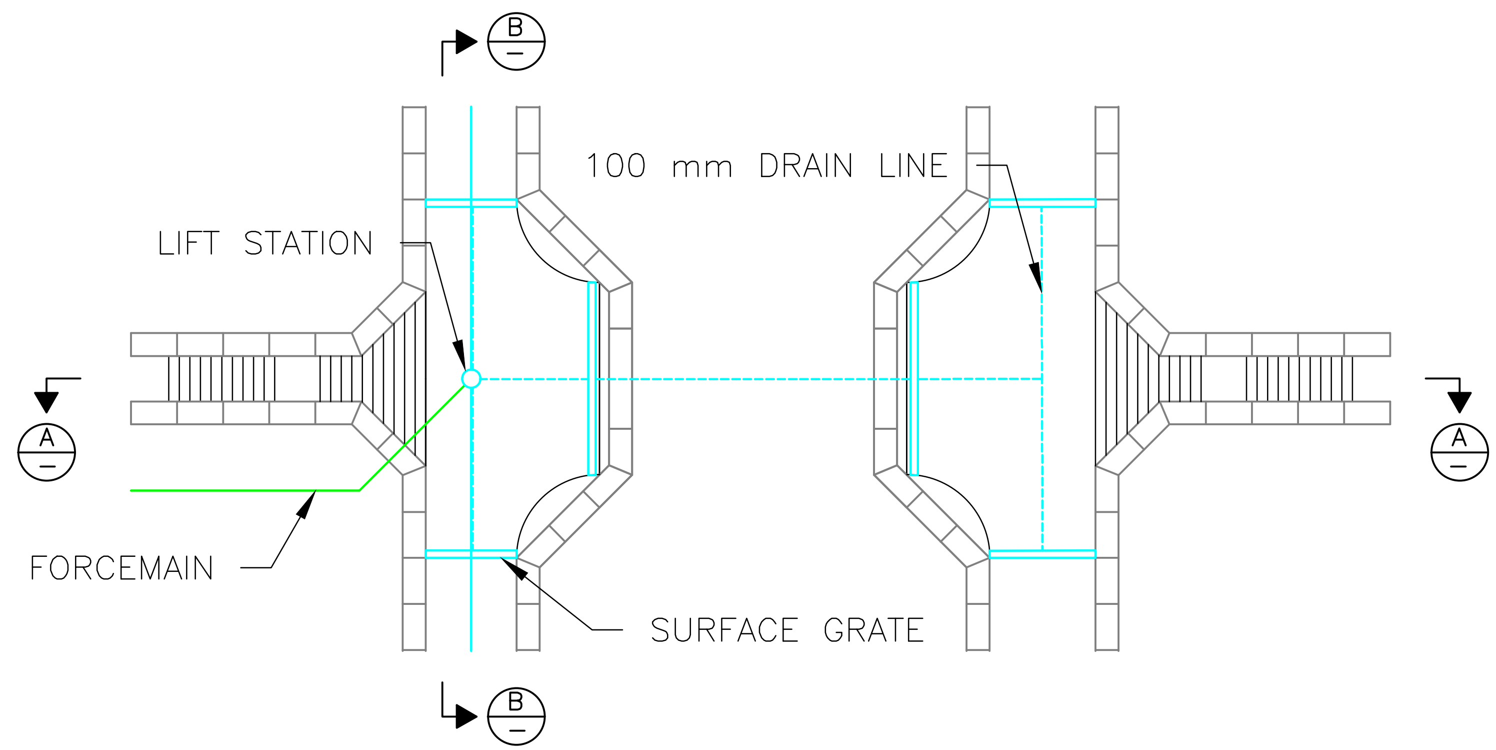
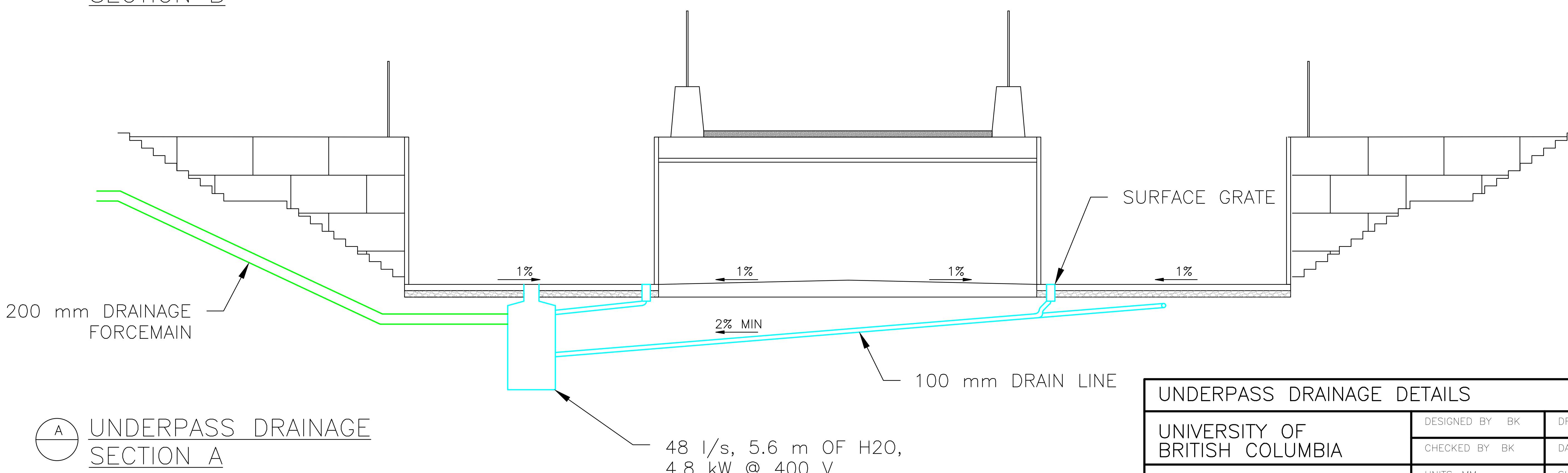
	CHECKED BY AA	DATE 23/11/2017
CHANCELLOR BLVD DREDESIGN	UNITS MM	SHEET U1
	SCALE 1:1000	



B UNDERPASS DRAINAGE SECTION B



UNDERPASS DRAINAGE PLAN



A UNDERPASS DRAINAGE SECTION A

UNDERPASS DRAINAGE DETAILS		
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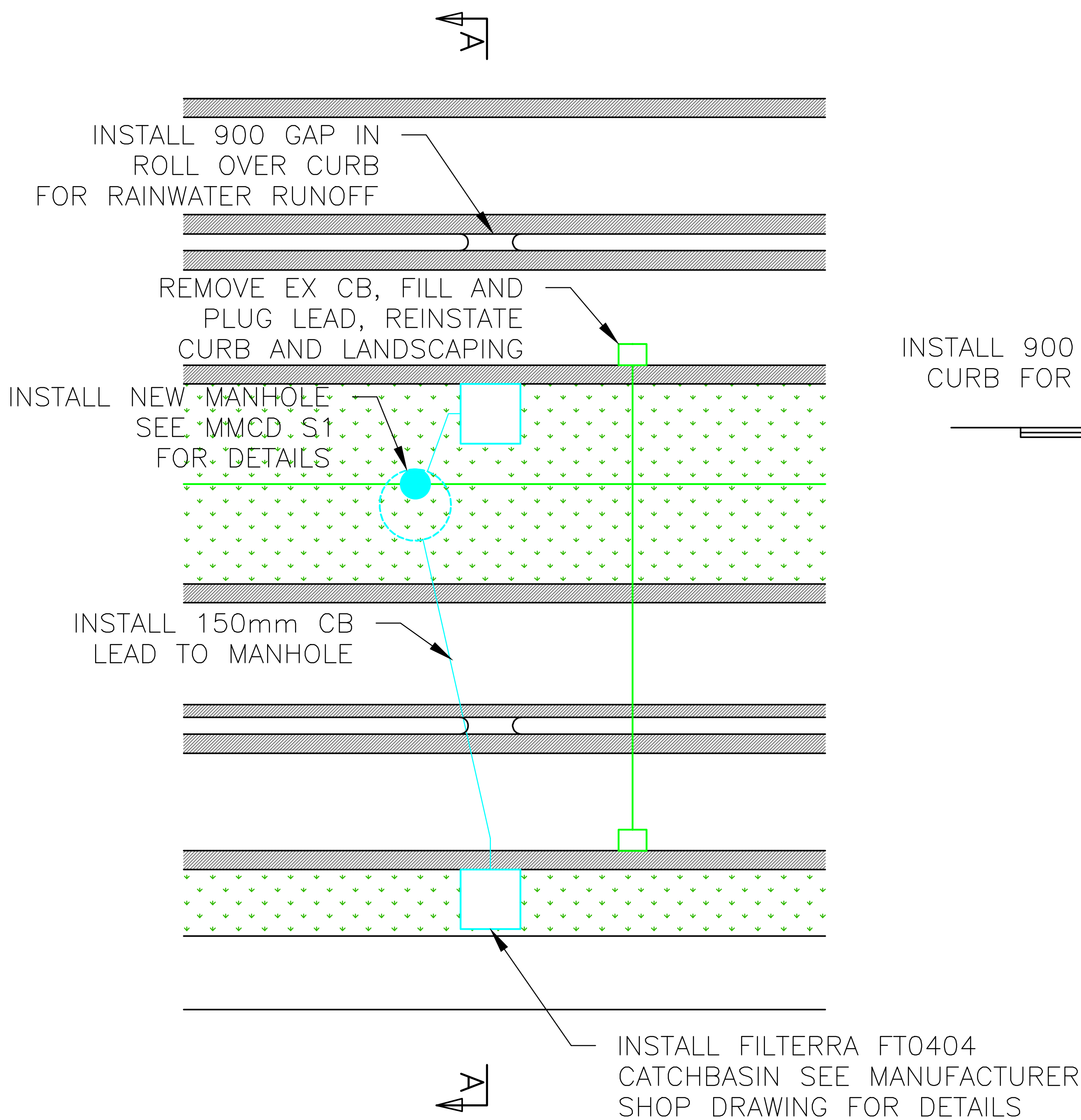
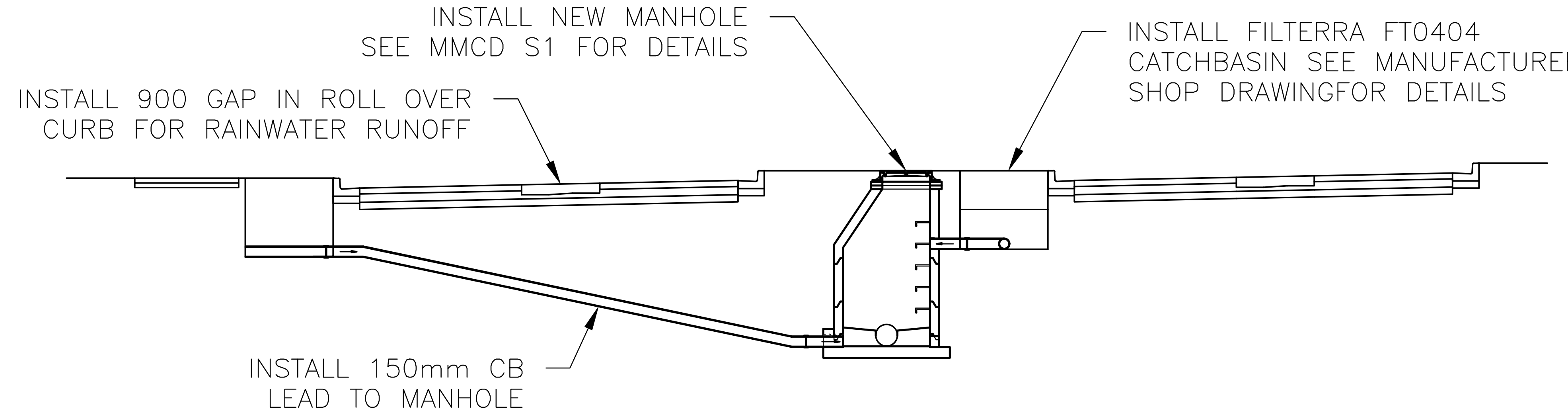
	CHECKED BY BK	DATE 23/11/2017
CHANCELLOR BLVD DREDESIGN	UNITS MM	SHEET U2
	SCALE 1:100	

GENERAL NOTES

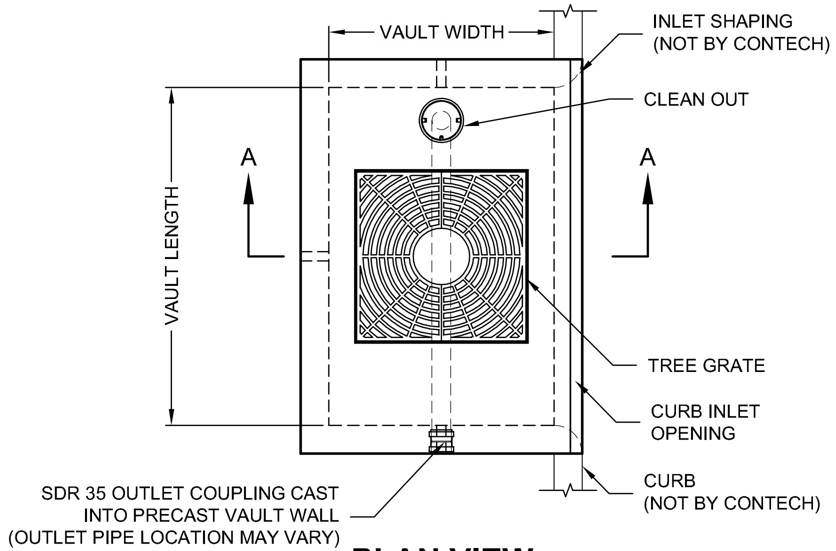
1) EXISTING DRAIN LINE, CB, CB LEAD LOCATIONS APPROXIMATE, TO BE CONFIRMED ON SITE
2) SEE SHEET XX FOR ROADWAY DETAILS
3)



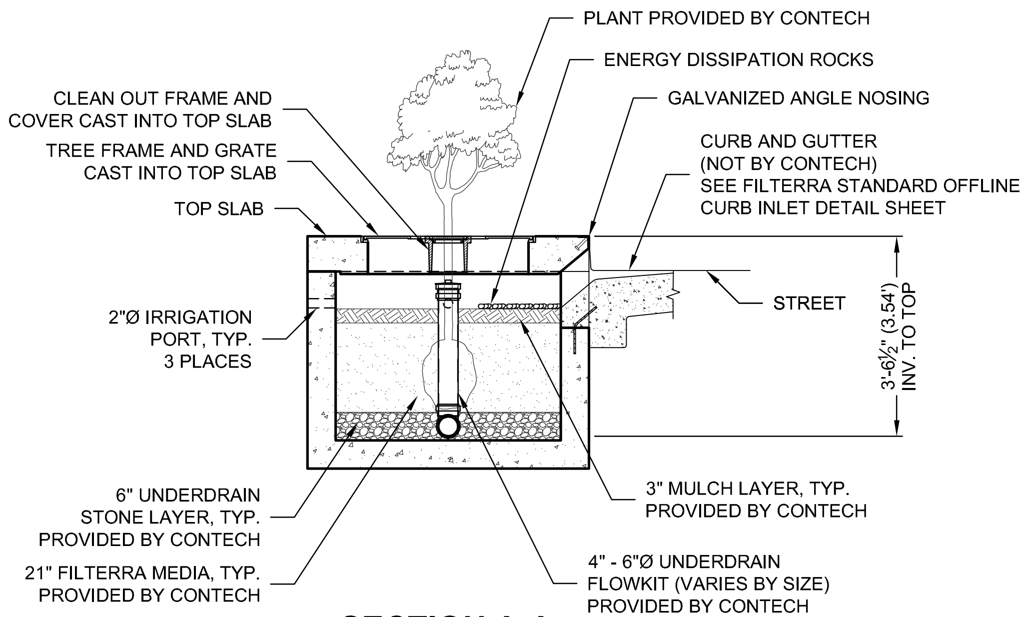


SECTION AA

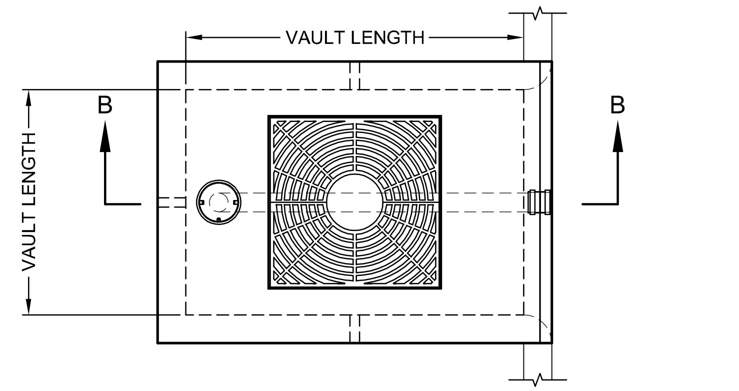
CATCHBASIN REPLACEMENT PLAN AND SECTION		
UNIVERSITY OF BRITISH COLUMBIA	DESIGNED BY DA	DRAWN BY DA
	CHECKED BY BL	DATE 23/11/2017
CHANCELLOR BLVD DREDESIGN	UNITS MM	SHEET U3
	SCALE 1:250	



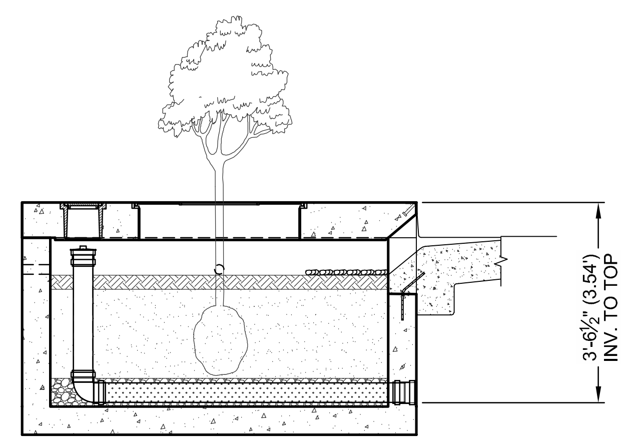
PLAN VIEW



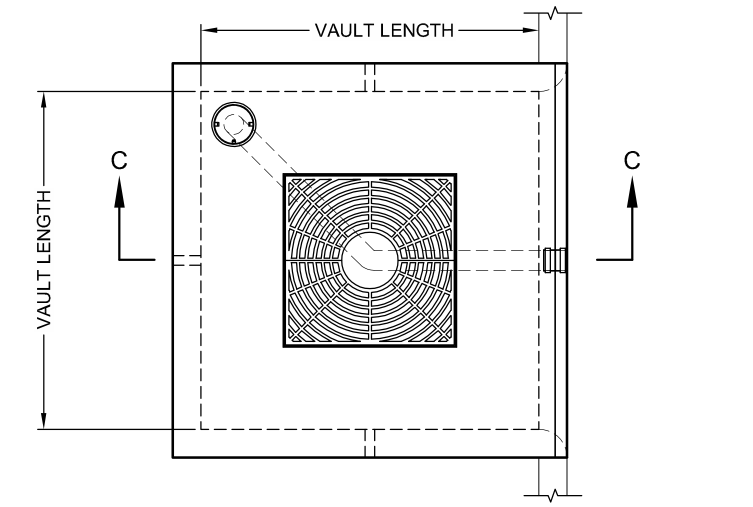
SECTION A-A



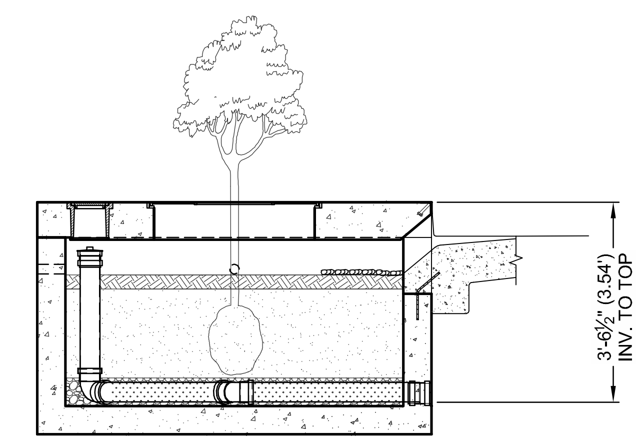
PLAN VIEW



SECTION B-B



PLAN VIEW



SECTION C-C

FT LONG SIDE INLET CONFIGURATION

DESIGNATION	AVAILABILITY	MEDIA BAY SIZE	VAULT SIZE (L x W)	OUTLET PIPE DIA	TREE GRATE QTY & SIZE
FT0604	N/A CA	6 x 4	6 x 4	4" SDR 35	(1) 3' x 3'
FT06504	CA ONLY	6.5 x 4	6.5 x 4	4" SDR 35	(1) 3' x 3'
FT078045	MID-ATL ONLY	7.83 x 4.5	7.83 x 4.5	4" SDR 35	(1) 3' x 3'
FT0804	N/A MID-ATL	8 x 4	8 x 4	4" SDR 35	(1) 3' x 3'
FT0806	ALL	8 x 6	8 x 6	4" SDR 35	(1) 4' x 4'
FT1006	ALL	10 x 6	10 x 6	6" SDR 35	(1) 4' x 4'
FT1206	ALL	12 x 6	12 x 6	6" SDR 35	(2) 4' x 4'
FT1307	ALL	13 x 7	13 x 7	6" SDR 35	(2) 4' x 4'
FT1408	CALL CONTECH	14 x 8	14 x 8	6" SDR 35	(2) 4' x 4'
FT1608	CALL CONTECH	16 x 8	16 x 8	6" SDR 35	(2) 4' x 4'
FT1808	CALL CONTECH	18 x 8	18 x 8	6" SDR 35	(2) 4' x 4'
FT2008	CALL CONTECH	20 x 8	20 x 8	6" SDR 35	(3) 4' x 4'
FT2208	CALL CONTECH	22 x 8	22 x 8	6" SDR 35	(3) 4' x 4'

N/A = NOT AVAILABLE

FT SHORT SIDE INLET CONFIGURATION

DESIGNATION	AVAILABILITY	MEDIA BAY SIZE	VAULT SIZE (W x L)	OUTLET PIPE DIA	TREE GRATE QTY & SIZE
FT0406	N/A CA	4 x 6	4 x 6	4" SDR 35	(1) 3' x 3'
FT04065	CA ONLY	4 x 6.5	4 x 6.5	4" SDR 35	(1) 3' x 3'
FT0408	N/A MID-ATL	4 x 8	4 x 8	4" SDR 35	(1) 3' x 3'
FT045078	MID-ATL ONLY	4.5 x 7.83	4.5 x 7.83	4" SDR 35	(1) 3' x 3'
FT0608	ALL	6 x 8	6 x 8	4" SDR 35	(1) 4' x 4'
FT0610	ALL	6 x 10	6 x 10	6" SDR 35	(1) 4' x 4'
FT0612	ALL	6 x 12	6 x 12	6" SDR 35	(2) 4' x 4'
FT0713	ALL	7 x 13	7 x 13	6" SDR 35	(2) 4' x 4'

N/A = NOT AVAILABLE

FT SQUARE INLET CONFIGURATION

DESIGNATION	AVAILABILITY	MEDIA BAY SIZE	VAULT SIZE (W x L)	OUTLET PIPE DIA	TREE GRATE QTY & SIZE
FT0404	ALL	4 x 4	4 x 4	4" SDR 35	(1) 3' x 3'
FT0606	ALL	6 x 6	6 x 6	4" SDR 35	(1) 3' x 3'

N/A = NOT AVAILABLE

INTERNAL PIPE CONFIGURATION MAY VARY
DEPENDING UPON OUTLET LOCATION.

filterra®

THIS PRODUCT MAY BE PROTECTED BY ONE OR MORE OF THE FOLLOWING U.S. PATENTS: 6,277,274; 6,569,321; 7,625,485; 7,425,261; 7,833,412; RELATED FOREIGN PATENTS.

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www.ContechES.com
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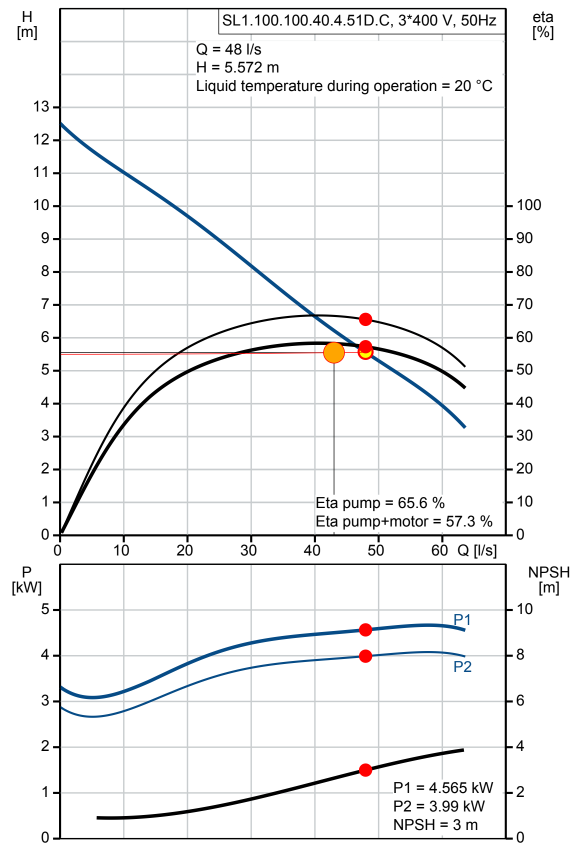
FILTERRA OFFLINE (FT) CONFIGURATION DETAIL

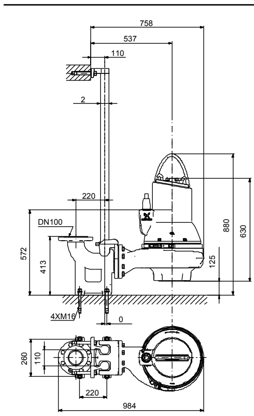
I:\COMMON\CAD\TREATMENT\54 FILTERRA\40 STANDARD DRAWINGS\FT - OFFLINE\LAYOUT DETAILS\DWG\FILTERRA STANDARD OFFLINE CONFIG DTL.DWG 11/1/2017 11:31 AM

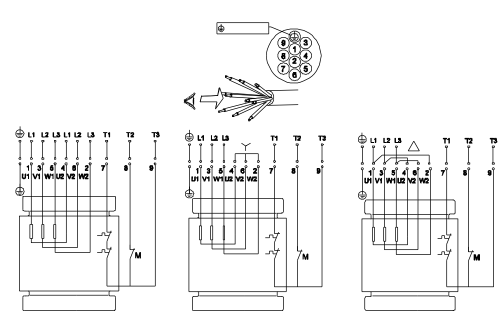
Company name:
Created by:
Phone:

Date: 25/02/2018

Description	Value
General information:	
Product name:	SL1.100.100.40.4.51D.C
Product No:	98624701
EAN number:	5711498435490
Technical:	
Actual calculated flow:	48 l/s
Max flow:	63.6 l/s
Resulting head of the pump:	5.572 m
Head max:	12 m
Type of impeller:	S-TUBE
Maximum particle size:	100 mm
Primary shaft seal:	SIC/SIC
Secondary shaft seal:	CARBON/CERAMICS
Approvals on nameplate:	CE, EN12050-1
Curve tolerance:	ISO9906:2012 3B2
Cooling jacket:	without cooling jacket
Materials:	
Pump housing:	Cast iron (EN-GJL-250)
	EN-GJL-250
Impeller:	Cast iron (EN-GJL-250)
	EN-GJL-250
Motor:	EN-GJL-250
Installation:	
Maximum ambient temperature:	40 °C
Flange standard:	DIN
Pump inlet:	150
Pump outlet:	100
Pressure rating:	PN 10
Maximum installation depth:	20 m
Inst dry/wet:	SUBMERGED
Installation:	Vertical
Frame range:	C
Liquid:	
Pumped liquid:	Water
Maximum liquid temperature:	40 °C
Liquid temperature during operation:	20 °C
Density:	1000 kg/m³
Kinematic viscosity:	1 mm2/s
Electrical data:	
Power input - P1:	4.8 kW
Rated power - P2:	4 kW
Mains frequency:	50 Hz
Rated voltage:	3 x 380-415 V
Voltage tolerance:	+10/-10 %
Max starts per. hour:	20
Rated current:	10.1-10.1 A
Requested voltage:	400 V
Rated current at this voltage:	10.1 A
Starting current:	65 A
Cos phi - power factor:	0.72
Cos phi - p.f. at 3/4 load:	0.63
Cos phi - p.f. at 1/2 load:	0.50
Rated speed:	1464 rpm
Motor efficiency at full load:	87.4 %





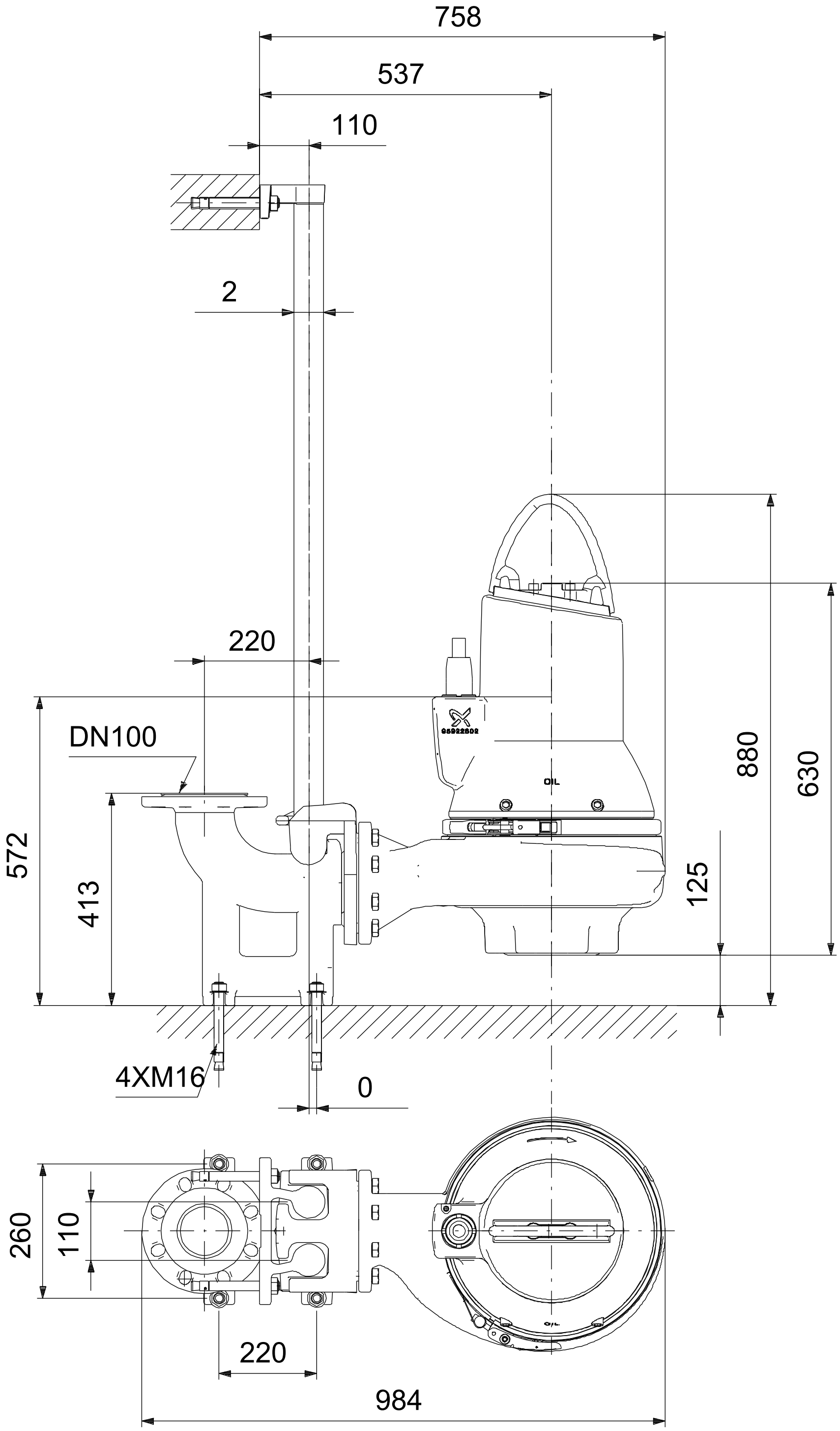


GRUNDFOS

Company name:
Created by:
Phone:

Date: 25/02/2018

98624701 SL1.100.100.40.4.51D.C 50 Hz



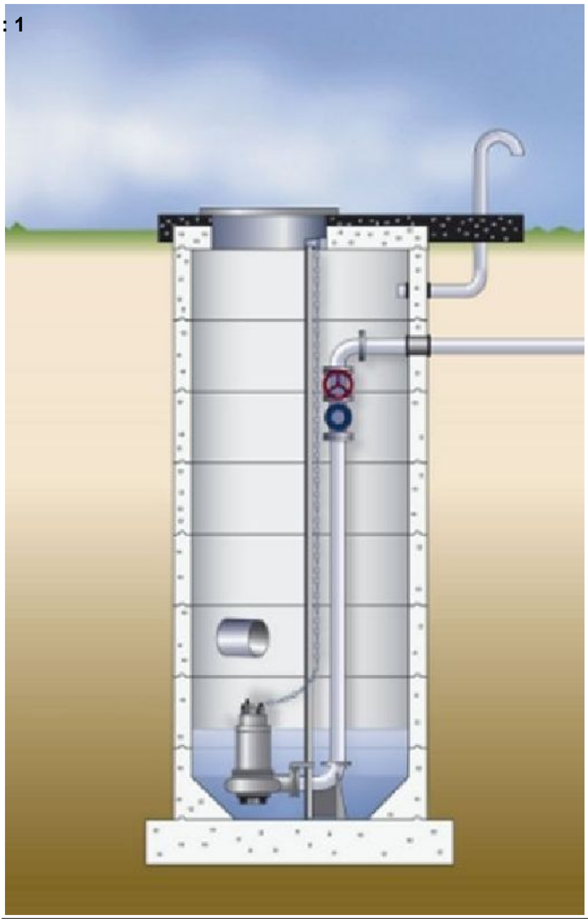
Note! All units are in [mm] unless others are stated.
Disclaimer: This simplified dimensional drawing does not show all details.

GRUNDFOS

Company name:
Created by:
Phone:

Date: 25/02/2018

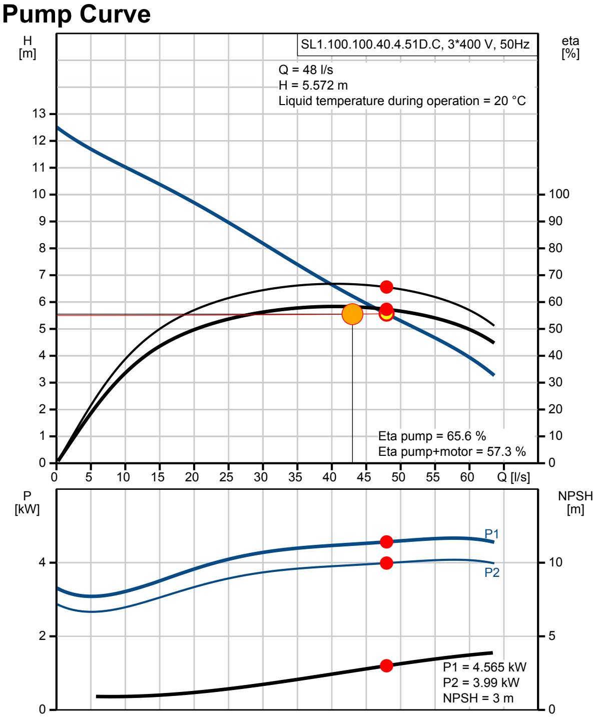
Installation and Input



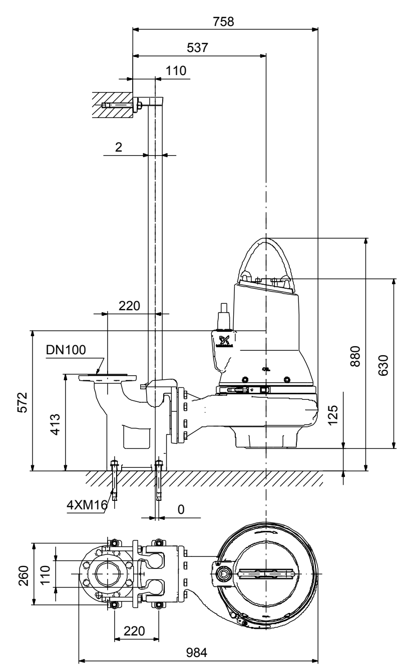
Sizing Results

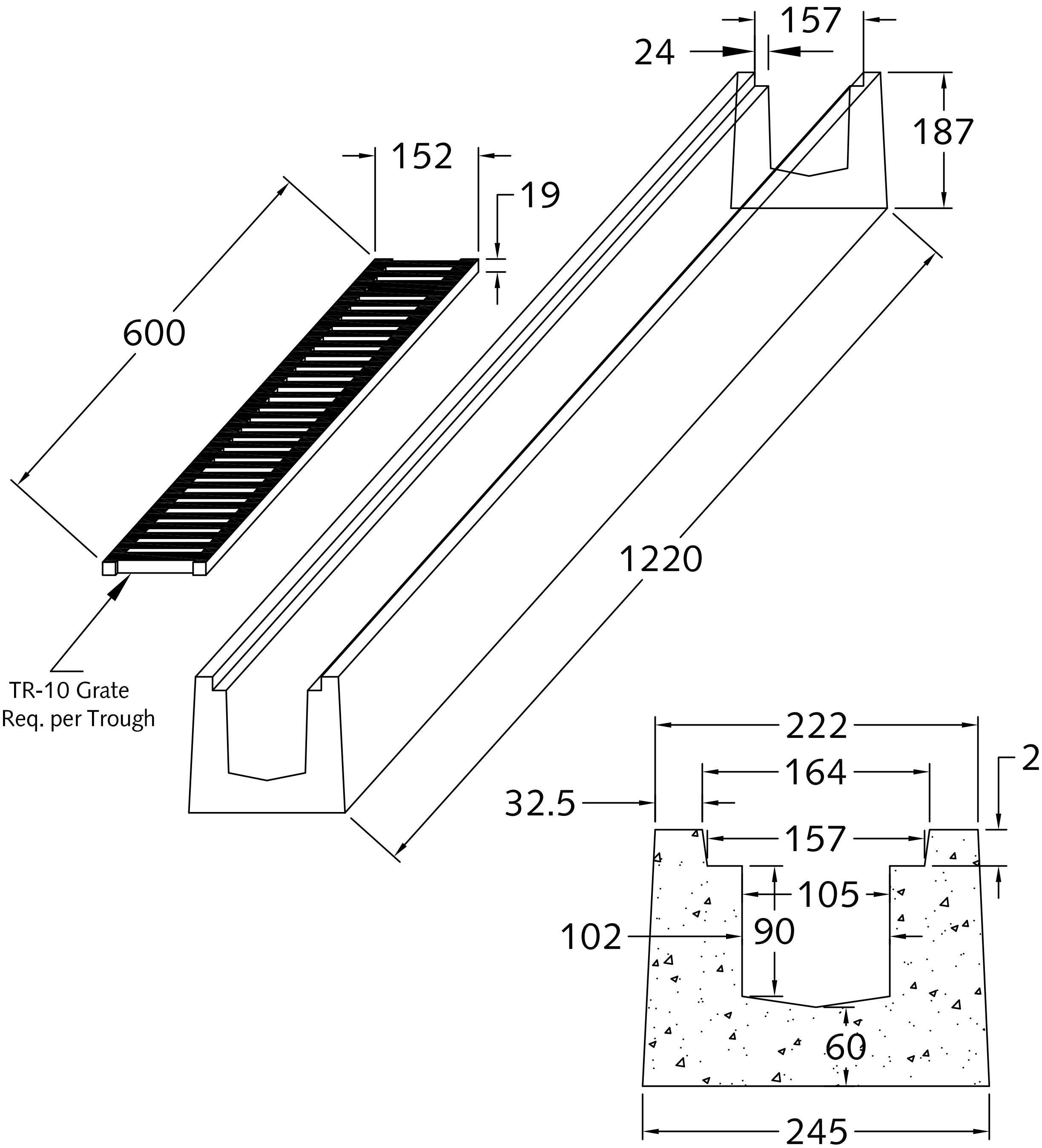
Product number:	98624701
Type:	SL1.100.100.40.4.51D.C
Flow:	48 l/s (154815)
H total:	5.572 m (+0%)
Power P1:	4.565 kW
Power P2 required in the duty point:	3.99 kW
Max starts per hour:	20
NPSH required:	2.997 m
Eta pump:	65.6 %
Eta motor:	87.4 %
Eta total:	57.3 %
Best eta pump:	66.7 % =Eta in best efficiency point
Best eta pump+motor:	58.3 % =Eta in best efficiency point
Nom. Motor Speed:	1464 rpm
Energy consumption:	4094 kWh/Year
Price + energy costs:	On request /10Years
Phase:	3
Voltage:	380-415
Frequency:	50 Hz
Current (rated):	10.1-10.1 A
Type of impeller:	S-TUBE
Size, pump outlet:	100
Pressure stage, pipe connection:	PN 10
Maximum installation depth:	20 m
starting method:	star/delta
Max starts per hour:	20
Enclosure class (IEC 34-5):	IP68
Insulation class (IEC 85):	H
Ex-protection:	no
Net weigth:	150 kg
Max. particle size:	100 mm

Pump Curve



Dimensional Drawing



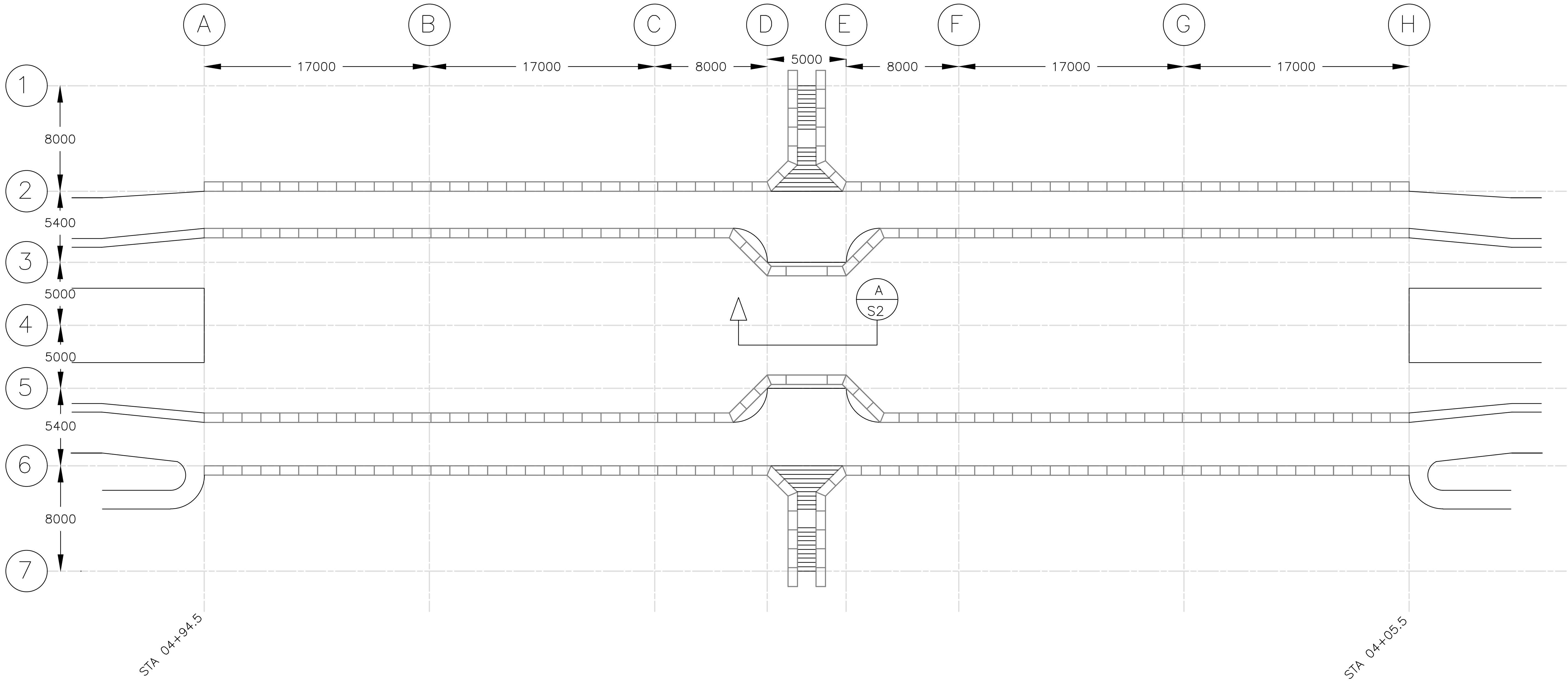


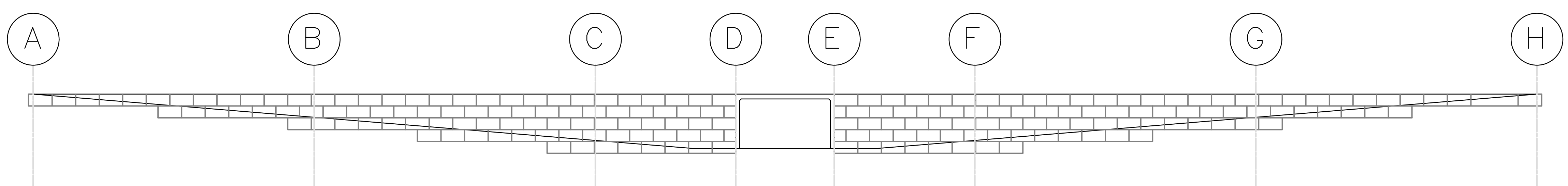
Section View
N.T.S.

Notes:
1. Trough drains supplied in 1.22m lengths as shown.
2. Drains designed to accept TR-10 cast iron grates.
3. Troughs can be set end to end, 'butt' style.
4. TR-10 grates are for residential, non-HS-20 loading only.
5. Weight : 86 kgs.
6. Min. concrete strength: 27.5MPa.

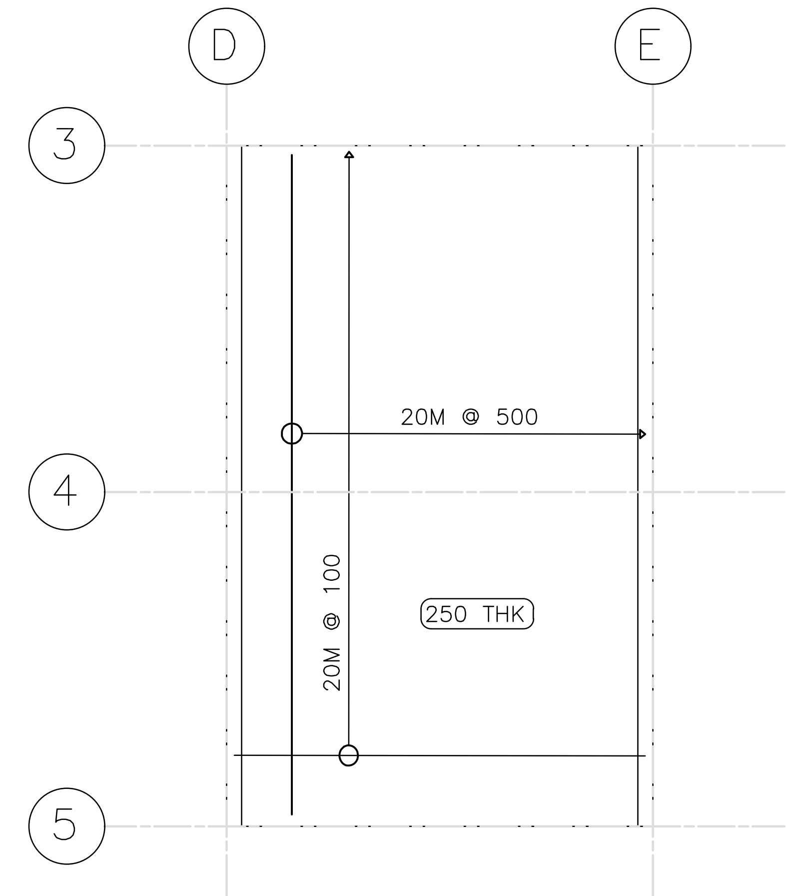
THE Langley CONCRETE GROUP The LANGLEY CONCRETE Group of Companies	**DESCRIPTION:** 150x1200mm Drain Trough www.langleyconcretegroup.com	**DRAWN BY:** JAO **SCALE:** 1:10 **DATE:** Mar/16/2010	**ORIGIN:** CHWK **DRAWING NO:** DT-1.1

LANGLEY (604)533-1656 VICTORIA (250) 478-9581 CHILLIWACK 1-800-667-9600

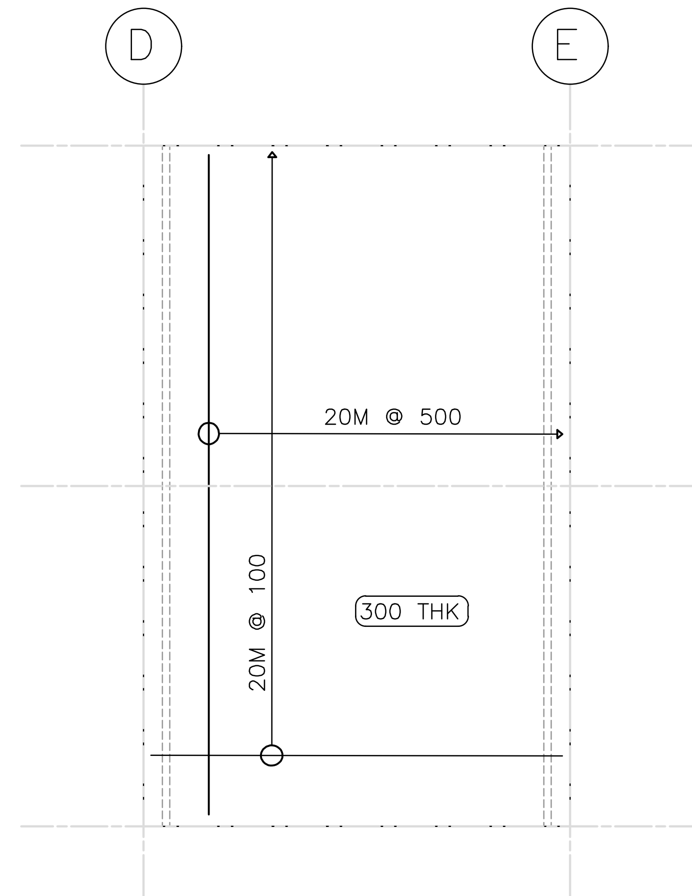




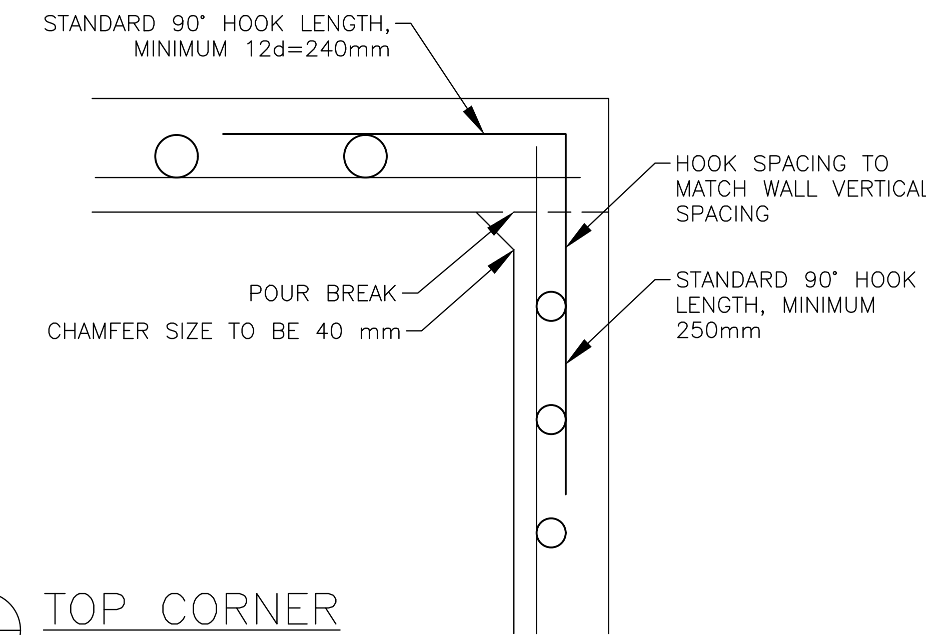
UNDERPASS – BASE PLAN		
UNIVERSITY OF BRITISH COLUMBIA	DESIGNED BY BK	DRAWN BY DA
	CHECKED BY BK	DATE 23/11/2017
CHANCELLOR BLVD DREDESIGN	UNITS MM	SHEET S1
	SCALE 1:666	



B FOUNDATION PLAN – NTS

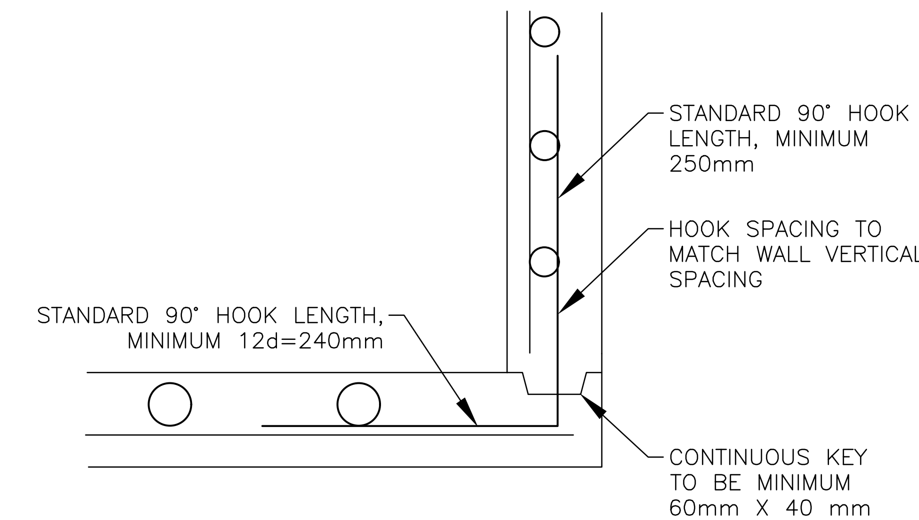


C ROOF SLAB PLAN – NTS



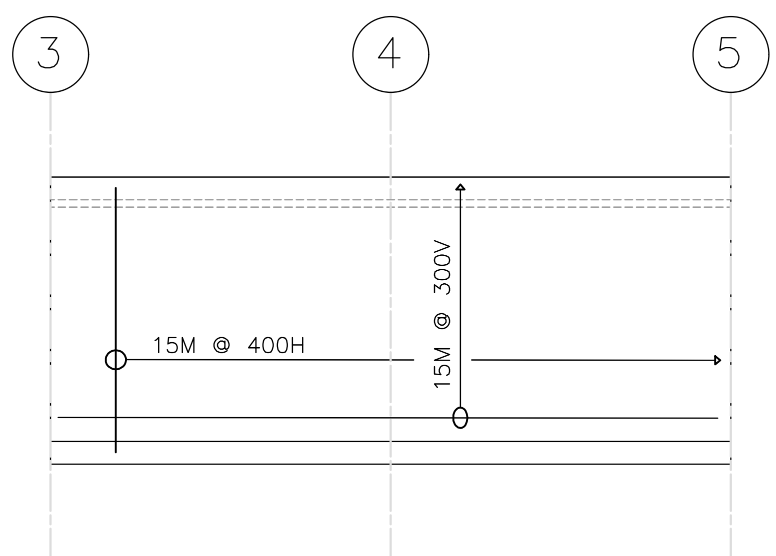
1 TOP CORNER DETAIL

NTS

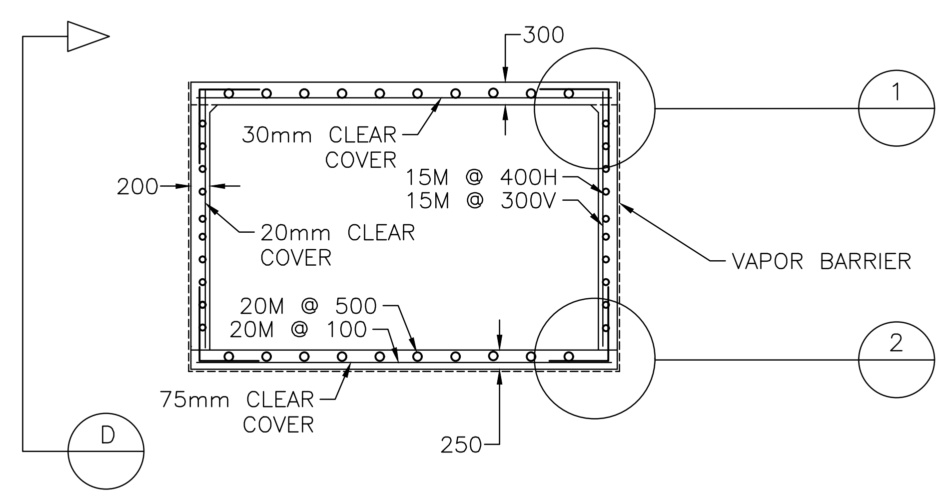


2 BOTTOM CORNER DETAIL

NTS

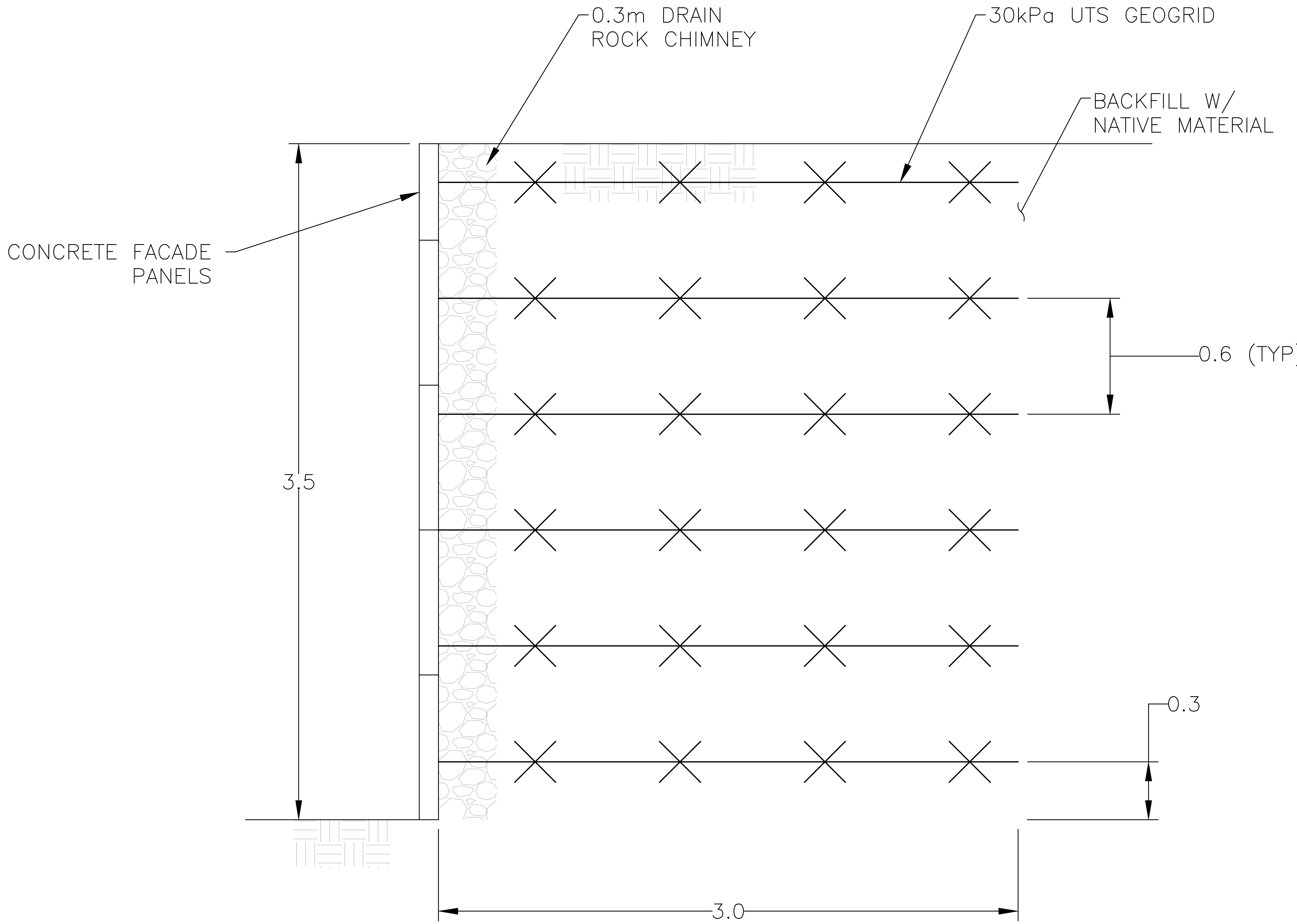


D SIDE ELEVATION – NTS



A UNDERPASS CROSS SECTION – NTS

UNDERPASS – STRUCTURAL DETAILS		
UNIVERSITY OF BRITISH COLUMBIA	DESIGNED BY BK	DRAWN BY DA
	CHECKED BY BK	DATE 23/11/2017
CHANCELLOR BLVD DREDESIGN	UNITS MM	SHEET S2
	SCALE 1:NTS	



RETAINING WALL SECTION		
UNIVERSITY OF BRITISH COLUMBIA	DESIGNED BY AK	DRAWN BY AK
	CHECKED BY DA	DATE 21/02/2018
CHANCELLOR BLVD DREDESIGN	UNITS M	SHEET S3
	SCALE 1:25	