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Memorandum

To:	Bruce Nidle, B.Sc., R.P. Bio.	**From:**	Geneve Lau, P.Eng Russell Warren, P.Eng
Cc:	Gordon Easton	**Date:**	Revised March 17, 2015
Project #:	12-125	**File:**	12-125-04
Re:	Musqueam Block F – DFO Notification		

A hydrological analysis was completed for the proposed Block F development in the University Endowment Lands (UEL) to address the following issues related to the stormwater management plan for the site.

1. Identifying and achieving the Department of Fisheries and Oceans (DFO) Stormwater Guidelines
2. Impacts of upgrading the existing 250mm diameter culvert under University Boulevard
3. Proposed best management practices (BMPs) for onsite stormwater source control

1.0 HYDROLOGICAL ANALYSIS

1.1. BACKGROUND DATA

The base map for the area was comprised of a National Topographical System map to determine the catchment area. Peak flows were calculated using the rational method due to the fact that the catchment area was less than 10 hectares. The rational formula used was:

$$Qp = CIA/360$$

Where:

Qp is the peak rate of runoff in cubic meters per second (cms);

C is the runoff coefficient;

I is the rainfall intensity in mm/hr for a storm whose duration is equal to the time of concentration; and

A is the effective area of the drainage basin in hectares.

The catchment area of the proposed site is divided into two catchments. Catchment A consists of Phase 1 of the development and Catchment B consists of Phase 2 (Lots H, I and J) for a catchment area of 6.8 Ha and 2.0 Ha, respectively. The time of concentration (Tc) was estimated based on the Overland Method formula. The time of concentration calculated for pre-developed conditions for Catchment A and Catchment B was 49 minutes and 60 minutes, respectively. In the post development condition, the time of concentration was calculated for Catchment A and B to be 24 minutes and 20 minutes, respectively. Based on the mapping, the project area was considered forested with gravel, sand, and till soil (per Geoscience Map 2005-3, Geology of British Columbia) consistent of a hydrologic group B soil with higher infiltration rates and low to moderate runoff. Rainfall data for the 100 year 24 hour storm was obtained from Environment Canada Vancouver UBC Rainfall Intensity Duration Frequency (IDF) Data per Table 1.

The geotechnical report completed by exp Services Inc. dated July 25, 2013 states the existing site consists of fill underlain with sand to silty sand. Groundwater seepage was encountered at depths of 1.6 to 1.8m on top of till-like soils. This was interpreted as perched groundwater and may vary seasonally, but based on file information, the regional water table was expected to be below the excavation depths in the order of about 60m below grade. Percolation tests were conducted with an average reading of approximately 170 mm/hour.

Table 1: Intensity Duration Frequency Data for 100 Year Storm

Musqueam - Block F		
Storm Duration	**Rainfall**	**Rainfall Intensity**
Hrs.	**mm**	**mm/hr**
0.0833	7.6	91.2
0.1667	10.4	62.4
0.2500	12.6	50.4
0.5000	15.7	31.4
1.0000	20.6	20.6
2.0000	23.8	11.9
6.0000	44.1	7.4
12.0000	75.9	6.3
24.0000	113	4.7

The derived formula from the IDF data is depicted in the following Figure 1 used to determine the rainfall intensity (y) given a storm of duration (x) hours.

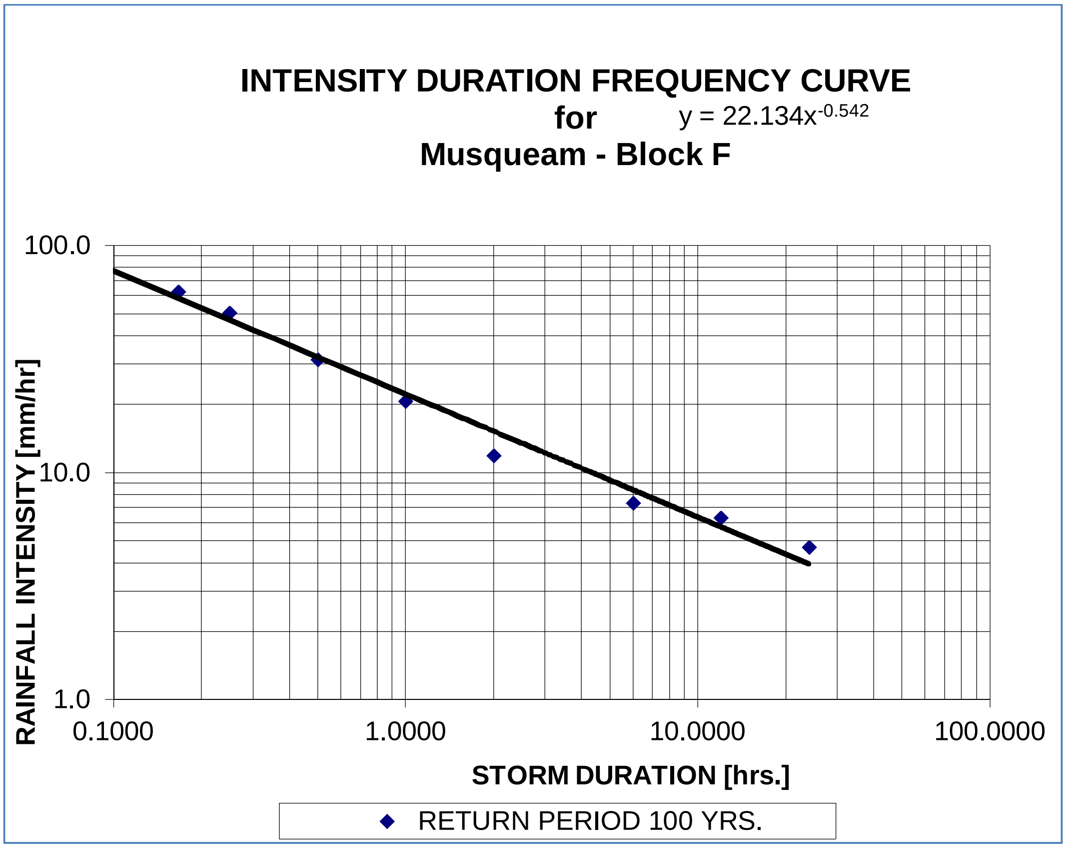

Figure 1: Intensity Duration Frequency Curve

The following characteristics have been taken into consideration: basin slope, type of vegetation, hydrologic soil group, rainfall intensity, and drainage basin area. The drainage basin/catchment area used was the whole Block F property for 22 acres or 8.8 hectares per the map shown in Figure 2 below. Block F is a high point and therefore does not have any tributary flow going into it.

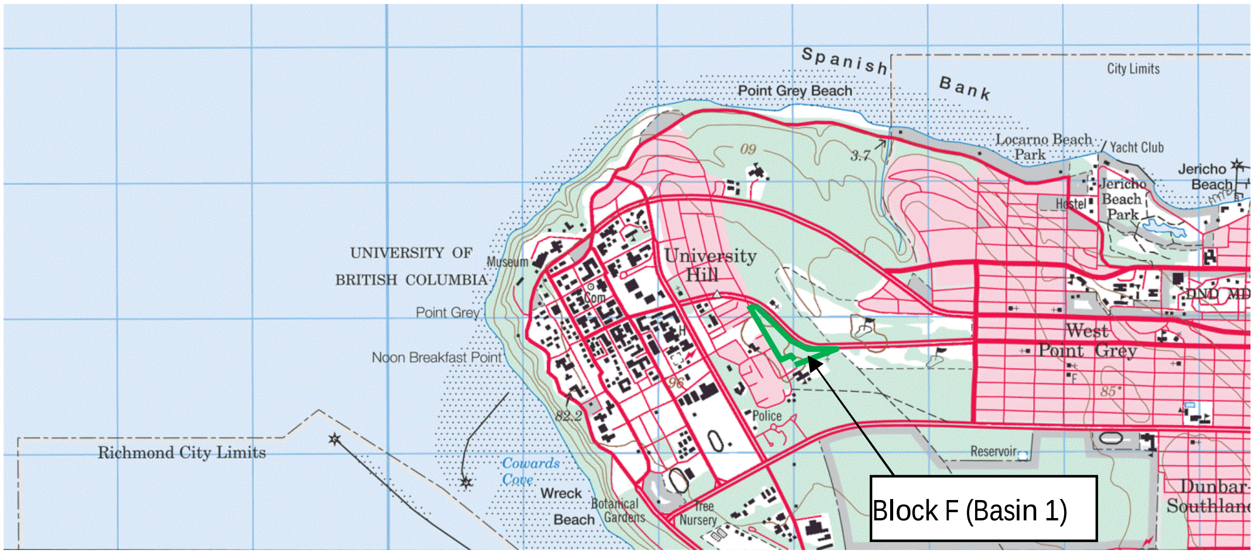

Figure 2: Block F (Basin 1) Catchment Area (National Topographical System)

A summary of the flow calculations is shown in Table 2.

Table 2: Flow Calculation Summary

Storm	Catchment	Area, A	Runoff Coefficient, C		Intensity, I *(mm/hr)*		Qp (m^3/s)	
		(ha)	C_{pre}	C_{post}	*Pre*	*Post*	*Pre*	*Post*
5 yr	*A*	6.8	0.10	0.61	15.0	21.3	0.028	0.260
5 yr	*B*	2.0	0.10	0.69	13.7	23.3	0.008	0.071
100yr	*A*	6.8	0.30	0.67	27.7	38.8	0.157	0.520
100yr	*B*	2.0	0.30	0.75	25.4	43.2	0.042	0.144

* Pre = pre-developed, Post = post-developed

1.2. DFO STORMWATER MANAGEMENT REQUIREMENTS

Table 3 illustrates the minimum stormwater criteria for the new development to achieve.

This proposed development will meet/exceed the DFO minimum standards.

Table 3: DFO Stormwater Guidelines

Objective	Target
Detention or Rate Control	Reduce post-development flows (volume, shape and peak instantaneous rates) to pre-development levels for the 6-month/24-hour, and 5-year/24-hour precipitation events.
Volume Reduction	Retain the 6-month/24-hour post-development volume from impervious areas on-site and infiltrate to ground. If infiltration is not possible, the rate-of discharge from volume reduction Best Management Practices (BMPs) will be equal to the calculated release rate of an infiltration system.
Water Quality	Collect and treat the volume of the 24-hour precipitation event equaling 90% of the total rainfall from impervious areas with suitable BMPs.

In addition to UEL's requirement to restrict the 100 year post-development runoff rate to the pre-development runoff rate, the site will meet the detention and rate control requirement from DFO for the specified storm event.

Water quality and volume reduction criteria from DFO will be in addition to the UEL's requirements. Since 6 month/24 hour rainfall data is not available for the site, as stated in the GVRD Source Control Design Guidelines, the volume reduction or capture volume quantity is equivalent to calculating 72% of the 2-year/24 hour rainfall of 56mm. For this calculation, we calculated the capture volume required within each catchment using the runoff coefficients for a 5 year event.

Catchment A

Capture Volume = (0.72 x56mm)/ (1000mm/m) x ((0.61x6.8ha) x (10,000sq. m/ha)) = 1,673 cu. m

Catchment B

Capture Volume = (0.72 x56mm)/ (1000mm/m) x ((0.69x2.0ha) x (10,000sq. m/ha)) = 556 cu. m

To achieve the capture volume required, detention ponds are proposed for infiltration of stormwater. In Catchment A, one large detention pond able to capture 900 cu. m of stormwater will be located in the area where the existing stormwater backs up south of University Boulevard in the vicinity of the undersized existing 250mm diameter culvert. A 600mm diameter culvert is proposed to replace the undersized 250mm diameter culvert to maintain the existing flow of 0.200 cms for pre-developed conditions for a 100 year storm event based on Manning's formula for the culvert capacity. From the 600mm diameter culvert, the stormwater will travel through a channel in the Pacific Spirit Regional Park, then through the golf course to eventually end up in the Salish Creek and finally the ocean. In

Catchment B, smaller detention ponds able to capture 49 cu. m of stormwater will be located near the southeast corner of the development with overflow discharge to the existing non fish-bearing ditch in the road right-of-way.

The ponds will have flow control manholes with a maximum total release rate of 0.200 cms to meet the pre-developed conditions. The remainder of the capture volume required will be achieved through infiltration and retention of the stormwater in the detention ponds. As stated in the geotechnical report, percolation rates for the site are in the order of 170 mm/hour and over a 24 hour period, the total infiltration capacity and storage capacity of the pond will meet the required capture volume. Typical sections of the detention pond and rain garden are shown below in Figure 3 and Figure 4.

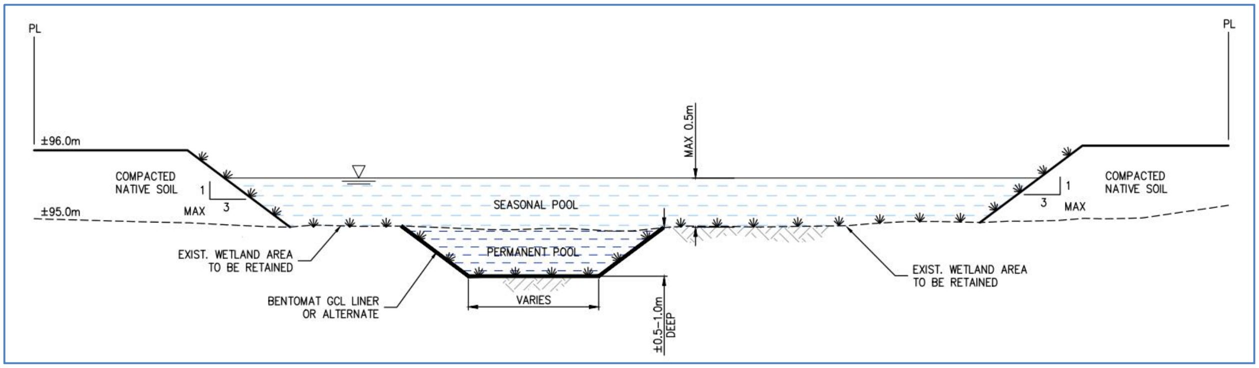

Figure 3: Detention Pond Detail

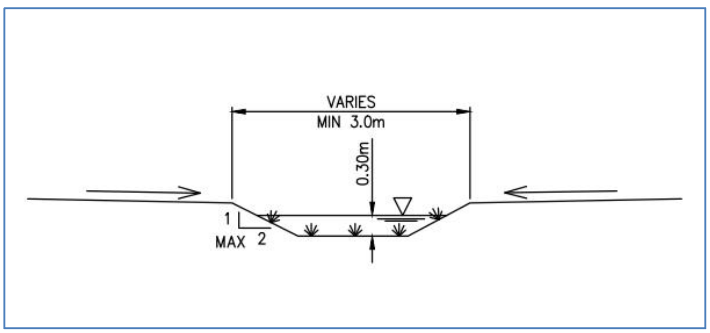

Figure 4: Bioswale Detail

1.3. REPLACING THE EXISTING CULVERT

Upsizing the existing 250mm diameter culvert to a 600mm diameter culvert under University Boulevard will reduce/prevent the flooding of the road that currently occurs during large storm events. The flooding of the road due to an undersized culvert can undermine the existing road structure eventually leading to failure. The larger culvert will also enable the existing natural flow to be carried through without blockage. Flow to the new culvert will be maintained to the existing, pre-developed levels with a flow control manhole prior to the discharge point in the detention pond and flows up to the 100 year event will be mitigated with a maximum discharge rate of 0.200 cms.

The opportunity to install a new culvert will allow for proper erosion control by incorporating riprap for inlet and outlet protection into the design per Figure 5 and 6. The inlet and outlet protection of the culvert is shown in the following details (Figures 5 and 6) where D refers to the culvert diameter. Headwalls would also be considered for scour protection.

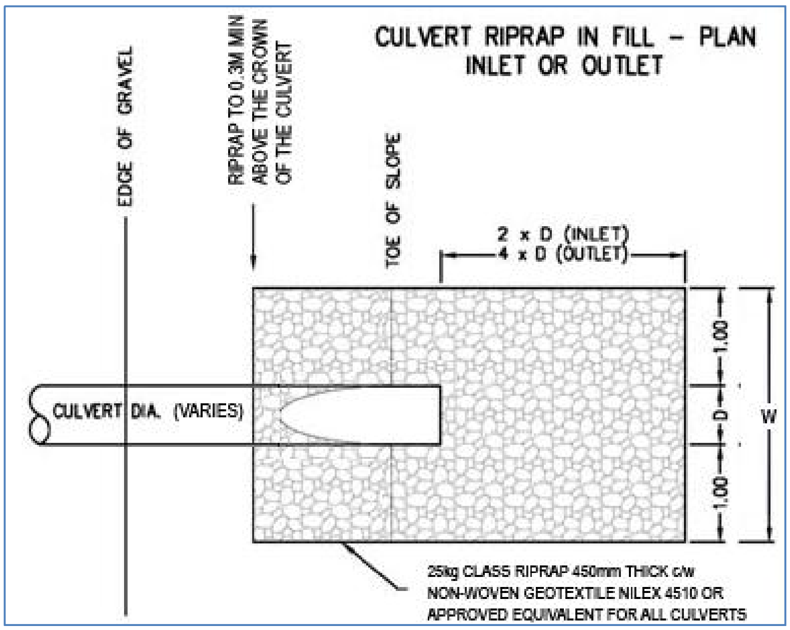

Figure 5: Inlet or Outlet Protection of Culvert – Plan View

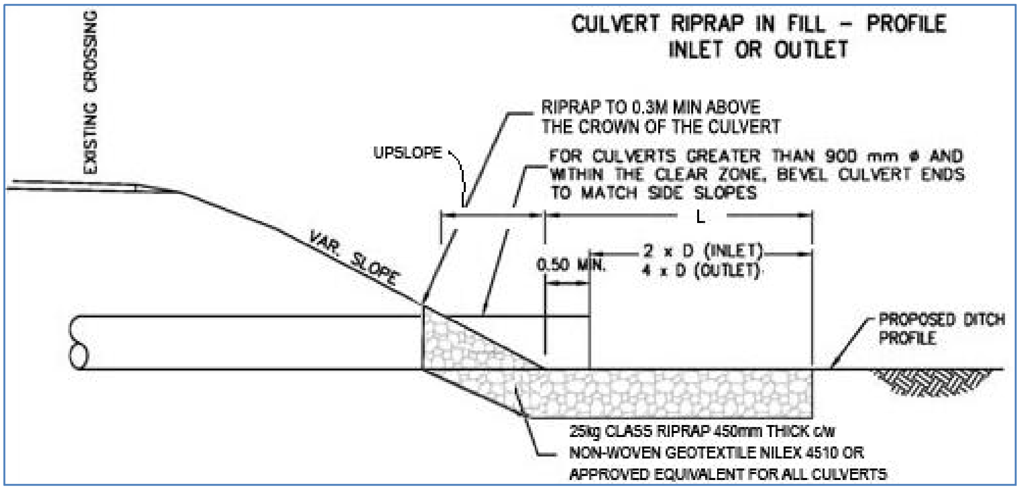

Figure 6: Inlet or Outlet Protection of Culvert – Profile View

1.4. STORMWATER BMPS

The Best Management Practices (BMP) include designing the storm conveyance system to handle the peak flows for the 1:10 year and 1:100 year design storm events, to meet and exceed the DFO Stormwater Management Guidelines, to protect life and property, and the use of BMPs that meet environmental guidelines can minimize the effects of development on the natural environment.

Potential BMPs for this site include:

- An erosion control plan to manage the quality and quantity of stormwater runoff from the site during construction. The contractor will provide temporary interceptor swales during construction to direct stormwater runoff to a number of proposed silt traps within the site. From there, runoff will be directed to a temporary stormwater detention pond before it connects to an existing discharge system.
- Reduction of impervious area where possible and maximize pervious area for a sustainable stormwater management strategy
- Stormwater source control on individual lots by utilizing absorbent landscape where possible. Absorbent landscape requires a minimum growing medium depth of 300mm and consists of trees, shrubs, grasses, soils, and surface organic matter. The pervious areas of the site should be covered with absorbent landscaping.
- Source control on roadways can include adding amended soils in the landscaped areas, adding curbs and catchbasins with trapping hoods for water quality control. The hydrocarbons on the road bind to sands/silts which settle into the catchbasin sump and the free oils rise above the trapping hood.
- Pervious pavements can be porous asphalt or concrete, concrete or plastic grid pavers, and permeable unit pavers. They allow water to drain through them to an underlying rock reservoir. On this site pervious pavement would be adequate to

capture the 6-month / 24-hour rainfall. Pervious pavements are recommended for low volume traffic and pedestrian routes but not for high traffic vehicle and pedestrian areas due to the instability of the surface.

- Rain gardens consist of a growing medium over a rock reservoir which infiltrates stormwater to the surrounding soil. The void space in the rock reservoir and the allowable exfiltration will work together to meet the capture criteria under DFO guidelines. Rain gardens would also meet the water quality treatment required.
- Detention ponds require a large footprint but they are great at pollutant removal through sedimentation, flocculation, and metabolism by aquatic plants and microorganisms.
- Oil and grit separators should be placed at the outlet pipes, sized to meet environmental water quality guidelines to treat 90% of runoff from the impervious areas.

1.5. SUMMARY

The proposed development will not exceed pre-developed flows for the 100 year storm event by providing infiltrative detention ponds and rain gardens adhering to and surpassing the minimum stormwater management guidelines by DFO for detention control, volume reduction, and water quality. Best management practices will be used for stormwater management for the proposed development at Block F.

Prepared by:	Reviewed by:
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