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Memorandum

To:	Bruce Nidle, B.Sc., R.P. Bio.	**From:**	Melissa Fahey, P.Eng., P.E.
Cc:	Gordon Easton,	**Date:**	May 17, 2013
Project #:	12-125	**File:**	12-125-04
Re:	Musqueam Block F – DFO Notification		

A hydrological analysis was completed for Block F to assess the DFO stormwater management requirements, benefits of the new (larger) culvert both on and offsite. Stormwater BMPs will also be proposed for this new development and addressed in this memo.

1.0 HYDROLOGICAL ANALYSIS

1.1. BACKGROUND DATA

The base map for the area was comprised of an NTS topographic map to determine the catchment area. Peak flows were calculated using the rational method due to the fact that the catchment area was considered small; 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 time of concentration (Tc) was estimated based on the Overland Method formula. The time of concentration calculated for predeveloped conditions was 33 minutes and for postdeveloped conditions was 9 minutes. 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.

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.

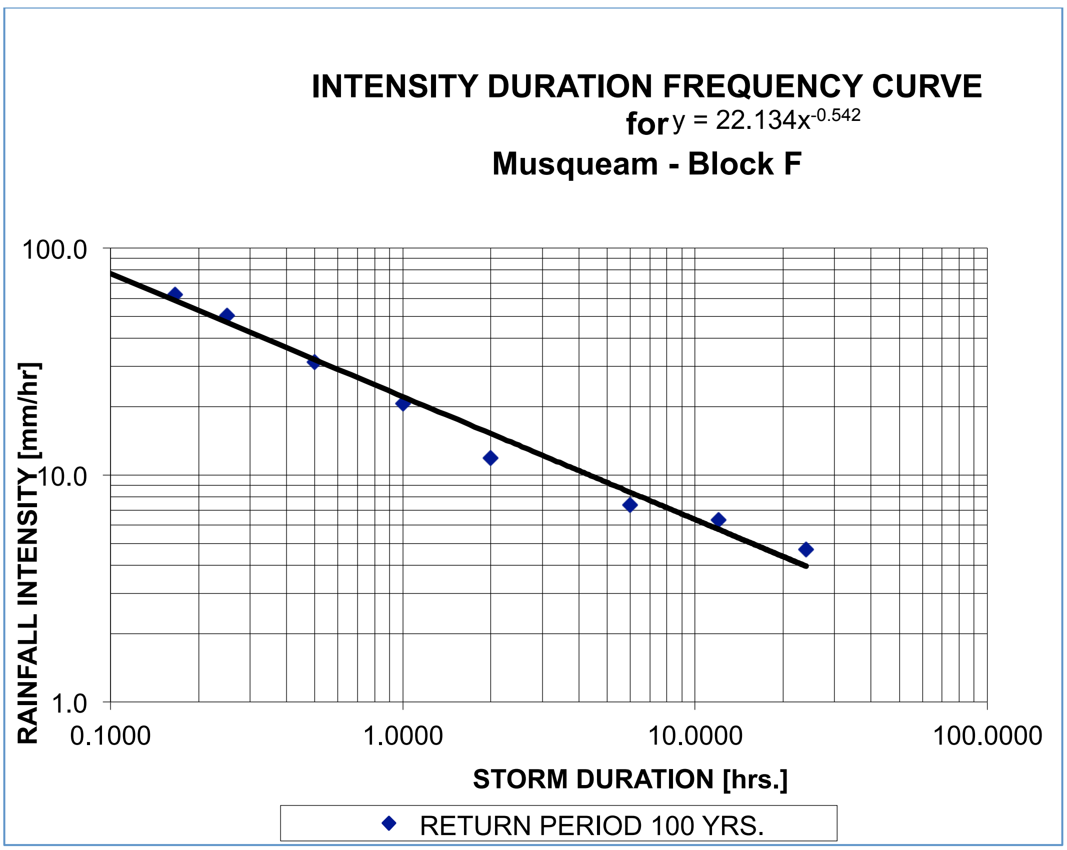


Figure 1: Intensity Duration Frequency Curve

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 NTS map shown in Figure 2 below. Block F is a high point and therefore does not have any tributary flow going into it.

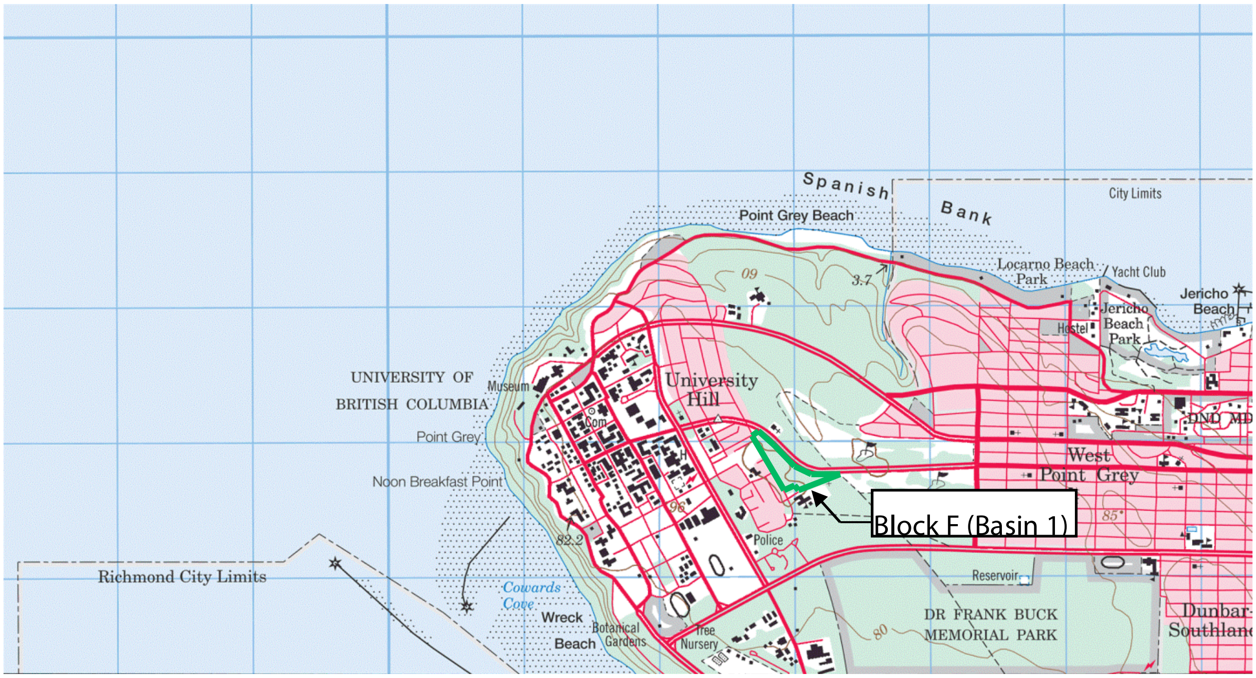


Figure 2: Block F (Basin 1) Catchment Area

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

Table 2: Flow Calculation Summary

Storm	Basin	Area, A	Runoff Coefficient, C		Intensity, I *(mm/hr)*		Qp (m^3/s)	
		(ha)	C_{pre}	C_{post}	*Pre*	*Post*	*Pre*	*Post*
10 yr	*1*	8.8	0.30	0.90	22	42	0.160	0.924
100yr	*1*	8.8	0.30	0.90	30	62	0.220	1.364

* Pre = predeveloped, Post = postdeveloped

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

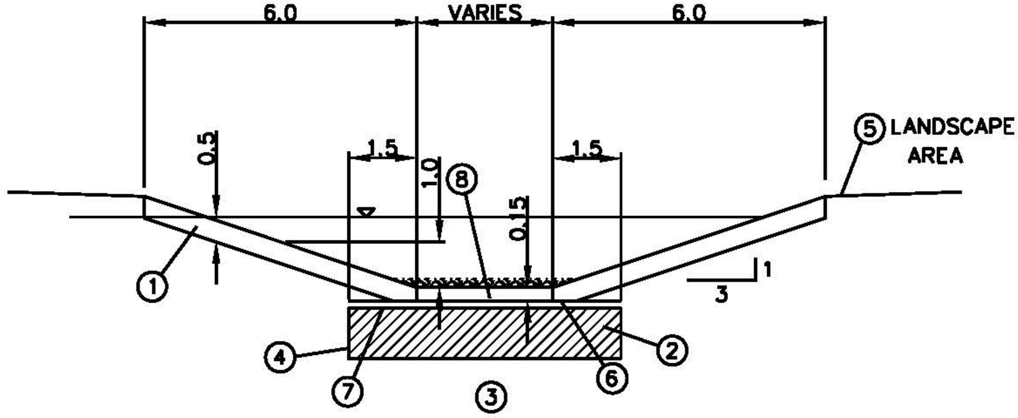
Objective	Target
Detention or Rate Control	Reduce post-development flows (volume, shape and peak instantaneous rates) to pre-development levels for the 6-month/24-hour, and 5-year/24-hour precipitation events.
Volume Reduction	Retain the 6-month/24-hour post-development volume from impervious areas on-site 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.

The most stringent of the DFO guidelines listed above are the Water Quality and Volume Reduction which the minimum requirements will be exceeded. Previously the 6-month / 24-hour rainfall had been calculated as 50% of the 2-year / 24-hour rainfall as indicated in BC Provincial Stormwater Guidebook. However, more recently the GVRD Source Control Document stated that the 6-month / 24-hour rainfall should be calculated as 72% of the 2-year / 24-hour rainfall (56mm) which is what was followed. For this calculation, it was assumed that the site would be 70% impervious.

Capture Volume = (0.72 x56mm)/(1000mm/m) x ((0.7x8.8ha) x (10,000sq. m/ha)) = 2,464 cu. m

The detention or rate control from the 100 year 24 hour storm event, which exceeds DFO minimum requirements, resulted in a detention requirement of 978 cu. m using the modified rational method per the attached excel spreadsheet. The volume requirement is exceeded with the capture volume listed previously. The capture volume will be used for the detention volume also.

To achieve the capture volume required of 2, 464 cu. m two detention ponds are proposed with infiltrative bottoms and rain gardens. One large detention pond able to capture 1, 858 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 450mm diameter culvert is proposed to replace the undersized 250mm diameter culvert to maintain the existing flow of 0.220 cms for predeveloped conditions for a 100 year storm event based on Manning's formula for the culvert capacity. A flow control manhole will control the discharge rate to the new 450mm diameter culvert under University Boulevard, not to exceed the 100 year predeveloped flow rate of 0.220 cms as mentioned previously. From the 450mm 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. A smaller detention pond able to capture 226 cu. m of stormwater will be located near the southeast corner of the development with overflow discharge planned 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 0.220 cms off the site that mimicks predeveloped conditions. The remainder of the capture volume required will be achieved through 3.5m wide rain gardens placed at various locations throughout the development. The total capture volume proposed for this development is 2, 500 cu. m which exceeds the minimum capture volume required. Typical sections of the detention pond and rain garden are shown below in Figure 3 and Figure 4.

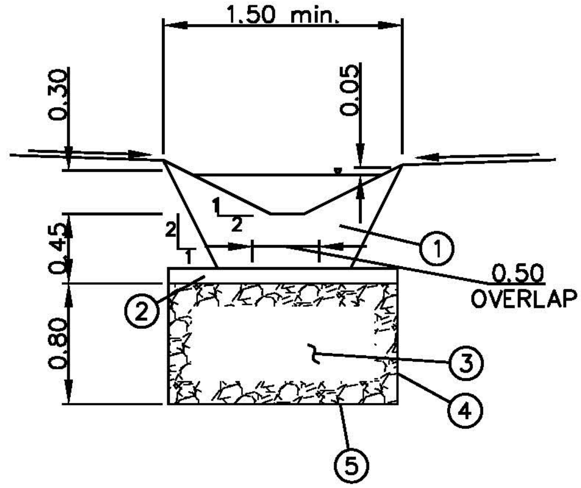


DETENTION POND SECTION DETAIL

N.T.S.

1. GROWING MEDIUM AS PER MMCD SECTION 02921 INCLUDING REQUIREMENT FOR MIN. SATURATED HYDRAULIC CONDUCTIVITY OF 2cm/hr. (MIN 450mm DEPTH)
2. 150mm MINUS CLEAN ROUND STONE POROSITY 40% (800mm DEPTH)
3. APPROVED SUBGRADE
4. WRAP DRAIN ROCK RESERVOIR WITH GEOTEXTILE (AMOCO 4545 OR EQUIVALENT) WITH 0.5m MIN OVERLAP FOR LONGITUDINAL OR TRANSVERSE JOINTS IN FABRIC
5. PROP. LANDSCAPE AREA
6. GROWING MEDIUM MIN. 150mm DEPTH AT BOTTOM OF DETENTION POND
7. 100mm DEPTH OF SAND OVER ROCK RESERVOIR
8. CLASS 25 RIP RAP AT BOTTOM OF DETENTION POND

Figure 3: Detention Pond Detail



RAIN GARDEN SECTION DETAIL

N.T.S.

(1) GROWING MEDIUM AS PER MMCD SECTION 02921 INCLUDING REQUIREMENT FOR MIN. SATURATED HYDRAULIC CONDUCTIVITY OF 2cm/hr. (MIN 450mm DEPTH)

(2) 100mm DEPTH OF SAND OVER ROCK RESERVOIR

(3) 150mm MINUS CLEAN ROUND STONE POROSITY 40% (800mm DEPTH)

(4) WRAP DRAIN ROCK RESERVOIR WITH GEOTEXTILE (AMOCO 4545 OR EQUIVALENT) WITH 0.5m MIN OVERLAP FOR LONGITUDINAL OR TRANSVERSE JOINTS IN FABRIC

(5) APPROVED SUBGRADE

Figure 4: Rain Garden Detail

1.3. REPLACING THE EXISTING CULVERT

Replacing the existing 250mm diameter culvert under University Boulevard with a larger size pipe will reduce/prevent the flooding of the road that currently occurs during large storm events. Flooding of the road can lead to undermining the integrity of the road structure eventually leading to failure, this can be avoided with a culvert replacement. The larger sized culvert will maintain existing flow and base flow downstream without increasing the existing flow.

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.

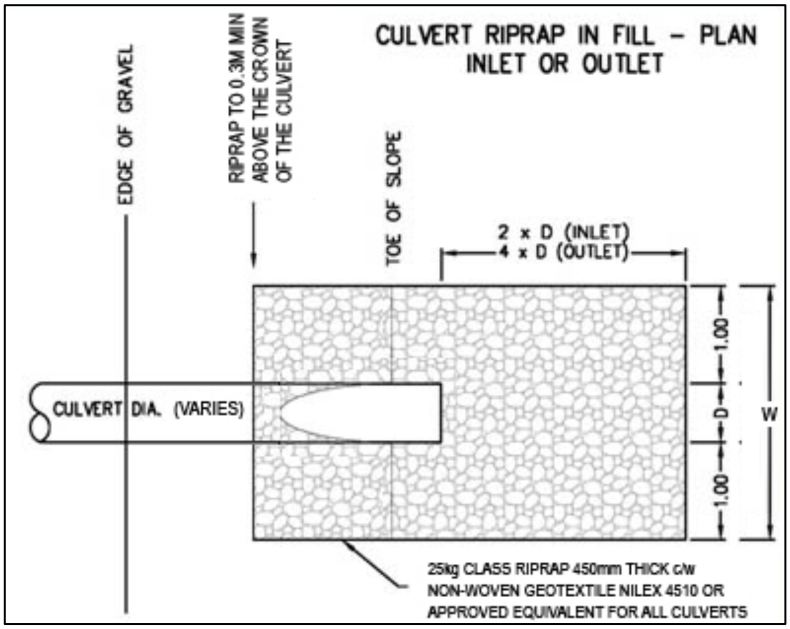


Figure 5: Inlet or Outlet Protection of Culvert – Plan View

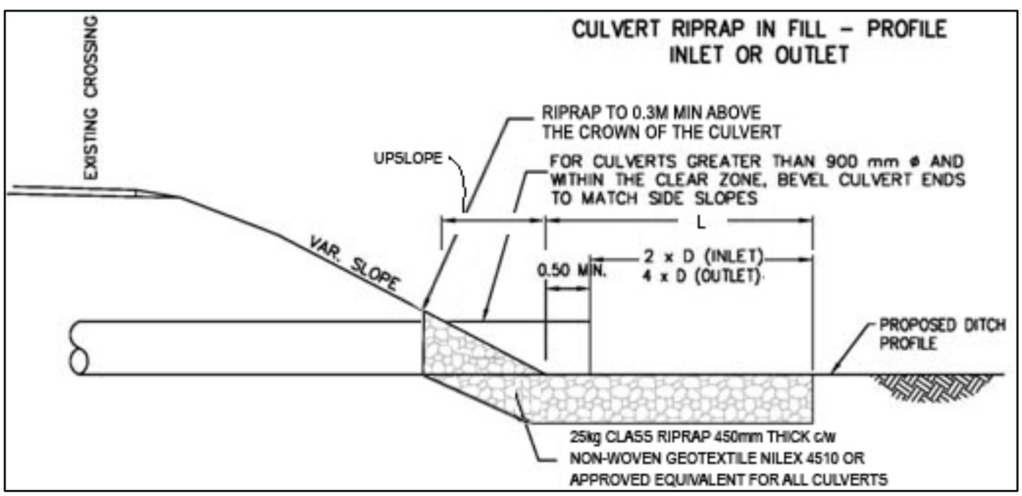


Figure 6: Inlet or Outlet Protection of Culvert – Profile View

Onsite, the larger culvert will eliminate the current backing up and ponding of water that results during a storm event onsite due to an undersized culvert. The larger culvert will also enable the existing natural flow to be carried through it without blockage.

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 use BMPs that meet environmental guidelines and minimize the effects of development on the natural environment.

BMPs proposed 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.
- Maintain or improve water quality
- Minimize impact from stormwater flow on downstream watercourses
- Reduce impervious area where possible and maximize pervious area for a sustainable stormwater management strategy
- Source control on individual lots by utilizing absorbent landscape where possible. Absorbent landscape consists of trees, shrubs, grasses, soils, and surface organic matter. The pervious areas of the site should be covered with absorbent soils.
- Source control on roadways by adding amended soil in the landscaped areas, adding curbs and catchbasins with trapping hoods for environmental control. The hydrocarbons on the road bind to sands/silts which settle into the catchbasin sump where 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 exfiltrates 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.

The proposed development will not exceed predeveloped 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:

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