University Endowment Lands

Integrated Stormwater Management Plan

Stage 1 Report

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October 14, 2016

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October 14th, 2016

Jonn Braman
Manager
University Endowment Lands
5495 Chancellor Boulevard
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Dear Jonn:

Project No: 60222155
Regarding: Integrated Stormwater Management Plan Phase 1

Please find attached our report for Phase 1 of the UEL ISMP. Please let me know when you are available to discuss this report.

Sincerely,
AECOM Canada Ltd.

Graham Walker
Project Manager
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Distribution List

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Version Log

Version #	By	Date	Description
1	Taylor Briggs	May 3, 2016	Phase 1 Report
2	Semyon Chaymann	May 31, 2016	Phase 1 Report – addressed comments from meeting on May 16th, 2016
3	Semyon Chaymann	Sept. 28, 2016	Phase 1 Report – Review and amendments

AECOM Signatures

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Executive Summary

Background and Context

An Integrated Stormwater Management Plan (ISMP) is an over-arching, long-term strategy that focuses on the protection and enhancement of a watershed's health. ISMPs combine concepts of urban planning, stormwater management and environmental management to facilitate sustainable development within a watershed.

The University Endowment Lands ("the UEL") retained AECOM to develop the UEL ISMP ("the ISMP") in line with the Metro Vancouver Integrated Liquid Waste and Resource Management Plan (ILWRMP) and the Environmental Management Act. Development of the ISMP will occur in four stages. This report summarises Stage 1 of the ISMP.

Stage 1: What do We Have?

Study Area

- The population and impervious area in the study area are likely to increase, with the development of Block F and as redevelopment occurs in Area D

Legislative Context

- The study area falls within the jurisdiction of Provincial (British Columbia) level of government that enforces legislative requirements relevant to the ISMP.
- The most significant regulatory items are the BC Environmental Management Act, and the Metro Vancouver Integrated Liquid Waste and Resource Management Plan, which are the drivers for developing the ISMPs in the region.
- It will be important to monitor changes in legislation relating to environmental management, water, and flood management to ensure that the ISMP remains compliant.
- The UEL Works and Services Bylaw was approved and implemented in 2016. The ISMP will specify the minimum standards for engineering design, including stormwater management and project execution in municipal infrastructure.
- The UEL currently lacks an Erosion and Sedimentation Control Bylaw to ensure that the engineered and natural drainage system is adequately protected during construction; and a Tree Protection Bylaw to regulate the cutting, removal and damage of trees on private property.

Land Use Planning

- The University Hill community consists of primarily single family homes in Areas A, B, and C. Area D consists of a mix of low and high-rise apartments, townhouses, mixed-use, and commercial development.
- A significant development is planned on the Block F property southeast of the existing Area D development. Other than the Block F property, the UEL Community has been built out. It is expected that there may be further densification of some properties within Area D when they are eventually redeveloped.
- Pacific Spirit Park, which contains a number of environmentally sensitive areas, is within the study area.

Hydrology

- The developed portion of the study area is made up of eight distinct catchments, most of which drain north towards English Bay through various creeks and ravines. A small portion of Block F drains south to Cut Throat Creek and is addressed through Musqueam Integrated Stormwater Management Plan.
- Climate change may cause more frequent and extreme storm or longer periods of drought than have historically occurred.

Existing Drainage System

- Within developed areas, the drainage system consists mainly of streets with curbs, gutters, catch basins and gravity storm sewers. Within the Pacific Spirit Park and University Golf course the system consists mainly of a network of ditches, creeks and culverts. A small section of the UEL (north of Chancellor Boulevard) is served by a combined sewer system, which is being separated as the sewers are replaced.
- All properties within the UEL that have been developed in the last 10 years have been required to limit discharge during a 5 year storm to a rate of 8 l/s.
- Hydraulic modelling of the existing drainage system was completed. Recommendations addressing drainage deficiencies are summarized in Table 6.4.
- The existing capital plan addresses some, but not all, of the deficiencies found during the hydraulic analysis.
- The storm sewer system is regularly inspected with CCTV, and was last inspected in 2012-2013. Sewers in poor condition have been slated for repair/replacement within the UEL 10 Year Capital Plan (2012-2021).

Hydrogeology and Soils

- Most of the study area is directly underlain by low permeability till which limits the ability of infiltration as a method of reducing storm water runoff.
- Groundwater flow in the Upper Aquifer discharges from the cliff faces along Spanish Banks resulting in mass wasting and erosion. Increasing infiltration is generally not recommended in the vicinity of these cliffs.
- Existing wells show the aquifer ground water table is located at approximately 50-95 m. below the surface depending on location; however, there is conflicting information from nearby shallow water wells showing ground water depth as high as 3.8m below surface. Also seasonal surface ponding will occur at some locations.

Environment

- Sampling in UEL creeks was completed during the development of the Integrated Stormwater Management Plan (ISMP) for the area. This sampling program was completed according to the methodology outline in the Monitoring and Adaptive Management Framework for Stormwater (Metro Vancouver 2014).
- Both fecal coliform and E. coli levels exceeded regional guidelines at the Spanish Bank Creek and Salish Creek sampling locations during the wet sampling period. Exceedances for the two bacteriological parameters during the dry period only occurred in Salish Creek. The point sources for these contaminations should be determined.
- Aluminum, copper, iron, manganese and zinc exceeded either one or both of the CCME and BC Water Quality Guidelines (maximum and/or 30-day) at the UEL watercourse water quality

sampling locations. Urban areas can have high metal concentrations primarily during wet season sampling due to roadway runoff.
- Benthic macro invertebrate scoring provided an overall rating of very poor stream condition for both sampling locations, at Spanish Bank Creek and Salish Creek.
- The MAMF guidance document's simplified water quality screening system was applied and determined that the overall water quality in the watershed was rated as satisfactory to good condition.
- Coho Salmon, Chum Salmon, and Cutthroat Trout have been observed in Spanish Bank Creek; and Coho Salmon has been observed in Salish Creek. It should be assumed that these fish species are also present in Unnamed Creek.
- The majority of Spanish Bank, Unnamed and Salish Creeks, north of Chancellor Boulevard, have retained their 30 metre riparian setback, but there are some areas where this is reduced to 15 metres or less.

Next Steps and Priorities

- Identify a vision and determine the goals for the UEL Integrated Stormwater Management Plan by hosting a Visioning Workshop with key stakeholders.
- As determined from the results of Stage 1 report, UEL could get a head start in the effort to create a more robust ISMP by following up on the key recommendations.
    - The review of current legislative context identified the need for Erosion and Sediment Control Bylaw to ensure that adequate protection of municipal drainage system is applied during any construction.
    - Implement a Tree Management Bylaw to regulate the cutting, removal, and damage of trees on private property. This bylaw would complement the Provincial and Federal regulations for the protection of riparian features and conditions that area crucial in maintaining long-term watercourse health.
    - Address cliff erosion issues along NW Marine Drive. Implementation of BMPs should be carefully evaluated along the cliff edge as increased infiltration could cause erosion due to increased pore water pressure.
    - Include roadway runoff in the water quality monitoring program. Especially in urbanized areas, where high concentration of metals is present.
    - Investigate cross connections for locations where households discharge into the environment. Noted issues include presence of washing machine detergent in the nearby watercourses.

Table of Contents

List of Figures

List of Tables

Appendices

1. Introduction

1.1 Overview

The Environmental Management Act is the primary regulatory instrument of environmental protection in British Columbia. The Act allows municipalities to develop community specific solutions to manage the environmental risks of liquid waste streams such as sanitary sewage and stormwater runoff.

Metro Vancouver has delegated the responsibility of managing environmental risks of stormwater runoff to its member municipalities. Metro Vancouver's Integrated Liquid Waste and Resource Management Plan (ILWRM) requires member municipalities to manage these risks through the development and implementation of Integrated Stormwater Management Plans for the watersheds within their jurisdiction.

An Integrated Stormwater Management Plan (ISMP) is an over-arching, long-term strategy that focuses on the protection and enhancement of watershed health. ISMPs combine concepts of urban planning, stormwater management and environmental management to facilitate sustainable development within a watershed.

The University Endowment Lands ("the UEL") retained AECOM to develop the University Endowment Lands ISMP ("the ISMP") in line with the requirements of the Metro Vancouver LWRMP and the Environmental Management Act. The ISMP relates to the UEL area that drains north into the Burrard Inlet.

1.2 Goals and Objectives

The primary, over-arching goals of the ISMP are as follows:

- Alleviate existing and/or potential drainage, erosion, and flooding concerns
- Protect and/or restore stream health including riparian and aquatic habitat
- Remediate existing and/or potential water quality issues

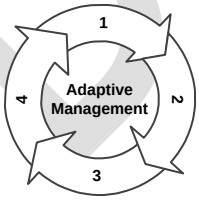
The ISMP focus is on the integration of stormwater management and land use planning. An ISMP is an integral component of a local government's land development and growth management strategy because upstream activities including land use change have downstream consequences including flood and environmental risks.

1.3 Approach

Development of the ISMP will occur in four stages, as outlined in Table 1.1, and was based on the approach outlined in Chapter 9: Developing and Implementing an ISMP in Stormwater Planning: A Guidebook for British Columbia.

Table 1.1 Summary of ISMP Approach

Stage	Question Answered	Description of tasks	Relevant ISMP Sections
1	What do we have?	Review background information and summarize existing conditions	- Study Area - Regulatory Context - Land Use - Hydrology - Stormwater System - Hydrogeology and Soils - Environment - Hydraulic Modelling and Assessment
2	What do we want?	Establish the vision for future development	- Vision and Goals
3	How do we put this into action?	Development of an implementation plan, funding and enforcement strategies	- Implementation Plan
4	How do we stay on target?	Development of a monitoring and assessment program	- Adaptive Management Plan



The ISMP contains long-term goals and objectives that have a planning horizon of up to 30 years. Predicting changes in factors such as the economy, technology, policy, land-use and public opinion over the long term horizon is challenging.

Subsequently, an Adaptive Management approach is proposed, in which the ISMP is periodically updated to ensure that it remains relevant and applicable. The adaptive process is cyclical - the last stage in the cycle focuses on monitoring, and will generate new information that should be reviewed in the first stage of the next cycle.

This report reflects the first stage of the ISMP, outlining the existing conditions and highlighting the gaps in regulation, land use planning, and infrastructure.

2. Study Area

2.1 Overview

The UEL consist of approximately 1,200 hectares of land between the City of Vancouver and the University of British Columbia. The majority of the land, approximately 920 Ha or 77%, is forested with the remaining 280 Ha, or 23%, developed for residential, commercial, and institutional land uses. The developed community within the UEL is commonly referred to as University Hill. The ISMP study area consists of University Hill and the drainage channels and streams which the stormwater infrastructure discharges to. Figure 2.1 provides an overview of the ISMP study area.

University Hill is divided into four areas:

- Area A is bordered by Chancellor Boulevard, Acadia Road, University Boulevard, and Wesbrook Mall;
- Area B is between Chancellor Boulevard and NW Marine Drive;
- Area C is between Blanca St., 6th Ave, Tasmania Crescent and College Highroad; and
- Area D is between University Boulevard, Agronomy Road, Toronto Road, and Wesbrook Mall; and includes Block F.

The Village is the UEL's centre for commercial activity located in Area D. This area includes a high density, mixed commercial and residential use development (bordered by University Boulevard, Western Parkway, Dalhousie Road and Allison Road), and the Regent College site (located on the south side of University Boulevard between Western Parkway and Wesbrook Mall). The University Hill areas are shown in Figure 2.2.

2.2 Population

The population of the UEL is estimated at 4,000 residents, and a total of 2,874 private dwellings. UEL has identified a group of properties, primarily residential rental apartments built in the 1940's and 1950's that may be redeveloped with increased density within Area 'D'. Current zoning allows for an increase in density for an estimated additional 200 units. The estimated population growth following redevelopment is approximately 304 people. Further densification of existing developments in University Hill is not expected; however, there are plans to develop a new parcel of land referred to as 'Block F'. The population of Block F following build-out of the development is estimated at 2,275. The total projected population of the UEL is approximately 6,600.

2.3 Topography

The developed portion of the study area is divided into eight main catchments, all of which discharge to English Bay via various creeks and ravines. The elevation varies from a high of approximately 100 m to a low of 10 m. The topography of the study area generally slopes northwards towards English Bay. The slope is steepest north of Chancellor Boulevard at a grade of approximately 9% and more gradual south of Chancellor Boulevard with slopes of less than 3%. There is a localized high point near the intersection of College Highroad and Wesbrook Crescent. The topography of the study area is shown in Figure 2.3.

2.4 Existing and Proposed Infrastructure

The ISMP study area contains a number of high-volume roads that serve transportation between the City of Vancouver and the University of British Columbia, including Chancellor Blvd., University Boulevard, and Wesbrook Mall. The major roads are shown in Figure 2.4.

The UEL Capital Plan outlines the planned capital improvements for the next five years, including sewer separation, storm sewer improvements, and ravine projects.

The proposed development of Block F includes new municipal water, sewer, parks, and transportation infrastructure. The proposed development consists of a 22 acre parcel of land bounded by Acadia Rd, University Boulevard, Toronto Road, and Ortona Rd. The parcel is currently zoned for multi-family residential townhouse development but if proposed rezoning is approved it may include a community center and some commercial occupancy. The development of Block F will require various improvements to the existing infrastructure as well as new infrastructure.

Translink has analyzed rapid transit options to replace or supplement the existing bus system. A rapid transit line would be built through the UEL, linking the City of Vancouver and UBC. However, the timing and route of this project is currently undetermined.

2.5 Summary

The key points relating to population, topography and infrastructure issues relevant to the ISMP are as follows:

- The population and impervious area in the study area is likely to increase, with the development of Block F and redevelopment in Area D

Figure 2.1 Study Area

Figure 2.2 University Hill Areas

Figure 2.3 Topography

Figure 2.4 Major Infrastructure

3. Regulatory Context

3.1 Overview

As an unincorporated area, the UEL does not have an elected municipal council. Instead, the provincial government is the governing body, and is administered through the Ministry of Community, Sport and Cultural Development under the University Endowment Land Act. This legislation enables the Minister to, among other things:

- levy property taxes;
- enact bylaws;
- appoint a person to administer the University Endowment Lands.

The Minister of Community, Sport and Cultural Development appoints a Manager who is responsible for the day-to-day administration of the UEL. Decisions made by the UEL Administration and staff are guided by the Official Community Plan, and the Land Use, Building and Community Administration Bylaw

The study area falls within the jurisdiction of three levels of government, from federal down to regional, and all three levels enforce legislation with which the ISMP will need to comply. The regulatory requirements of the ISMP include a variety of planning, engineering and environmental components, which is reflective of the multi-disciplinary nature of integrated stormwater management planning.

This section summarises the regulatory drivers, legal requirements, and other planning, engineering or environmental guidelines relevant to the ISMP.

3.2 Regulatory Drivers

The UEL is developing and implementing this ISMP under Metro Vancouver's Integrated Liquid Waste and Resource Management Plan (MV ILWRM) as a member body of the Greater Vancouver Sewerage & Drainage District (GVS&DD).

Table 3.1 summarizes the context of the ISMP in relation to Metro Vancouver's ILWRM and BC Environmental Management Act.

Table 3.1 Context of UEL ISMP

Government Body	Instrument	Key Points
BC Ministry of Environment	Environmental Management Act	- Protects human health and the quality of water, land and air in British Columbia - Allows municipalities to develop community-specific solutions for wastewater management under LWMPs - Authorizes and regulates LWMPs

Government Body	Instrument	Key Points
Metro Vancouver	Metro Vancouver Integrated Liquid Waste and Resource Management Plan	- Identifies liquid waste management goals and actions for wastewater infrastructure operated by Metro Vancouver - Sets specific actions for GVS&DD members regarding their management of stormwater runoff - Prescribes that GVS&DD members submit an Integrated Stormwater Management Plan for drainage areas within their jurisdiction - Goal 3, Strategy 3.4.7: "Municipalities will... Develop and implement integrated stormwater management plans at the watershed scale that integrate with land use to manage rainwater runoff"
UEL	University Endowment Lands Integrated Stormwater Management Plan	- A comprehensive, ecosystem-based approach to long-term rainwater management in line with the requirements of the Metro Vancouver ILWRM - Provide direction for future development plans by balancing land use planning; stormwater engineering; flood and erosion protection; and environmental protection

3.3 Legislative Requirements

The ISMP study area falls within the jurisdiction of three levels of government: Federal, Provincial (BC), and Regional (Metro Vancouver). All three levels of government enforce legislative requirements relevant to the ISMP, and the ISMP outcomes will need to comply with these requirements.

Table 3.2 summarizes the key purpose and requirements of legislation relevant to the ISMP.

Table 3.2 Legislative requirements of ISMP

Regulation / Policy	Key Points
Federal (Canada)	
Fisheries Act	- Protects riparian features and conditions that are crucial in maintaining long-term watercourse health
Provincial (British Columbia)	
Environmental Management Act 2004	- See Table 3.1

Regulation / Policy	Key Points
Fish Protection Act 1997	- Provides legislative authority for water managers to consider impacts on fish and fish habitat before approving new licenses, amendments to licenses or issuing approvals for work in or near streams - Focuses on four major objectives: ensuring sufficient water for fish; protecting and restoring fish habitat; improved riparian protection and enhancement; and stronger local government powers in environmental planning
Riparian Areas Regulation 2004	- Protects riparian features and conditions that are crucial in maintaining long-term watercourse health - Requires local governments to protect riparian areas against developments that border along streams, lakes, and wetlands
Sensitive Streams Designation and Licensing Regulation	- Protects water flows in streams significant to fisheries by designating them as “Sensitive Streams”, which triggers a higher level of protection from development and other stressors
Water Sustainability Act 2015	- Principal law for managing the diversion and use of provincial water resources - Specifies activities that may be conducted within a stream or a stream channel, as well as regulating dam safety and ground water protection - The Water Sustainability Act was put into force in early 2016 repealing the Water Act 1996.
Regional (Metro Vancouver)	-
Regional Growth Strategy Bylaw	- “A Bylaw to adopt a Regional Growth Strategy for the Greater Vancouver Regional District (Metro Vancouver)” - Enforces the application of the MV Regional Growth Strategy by members

Regulation / Policy	Key Points
Sewer Use Bylaw 299	- "A bylaw respecting the direct or indirect discharge of waste into any sewers and drains connected to a Sewage Facility operated by the District" - Restricts the discharge of anything but stormwater, uncontaminated water or water from the provision of municipal services such as street flushing and fire extinguishing activities into stormwater sewers
Local (UEL)	
UEL Official Community Plan	- A broad statement of objectives and policies to guide decisions on planning and land use management. - Derived from a consensus-based process to provide a framework for administrating the collective decision-making of the community from service provision to development applications and zoning regulations. - Provides policies for Green Space and Tree Management - Provides policies for densification and commercial development - Provides policies for stormwater management
Land Use, Building and Community Administration Bylaw	- A bylaw that regulates land use and building within the University Endowment Lands - Regulates utility service connections - Regulates site coverage
UEL Works and Services Bylaw	- Implemented in 2016 this bylaw provides a standardized set of guidelines for design and construction of municipal infrastructure within the UEL - Contains policies relating to stormwater runoff control

3.4 Related Policies, Strategies and Guidelines

The outcomes of the ISMP will also be influenced by non-legislative strategies, plans and engineering standards issued by the provincial and regional decision-making bodies. The non-legislative documents that are likely to influence the outcomes of the ISMP are summarized in Table 3.3.

Several land use plans also apply to the study area and the impact of these plans are discussed in Section 4.

Table 3.3 Summary of relevant non-legislative documents

Policy / Plan	Key Points
Provincial (British Columbia)	
Stormwater Guidebook	- Provides a watercourse-level, site-specific approach to stormwater management in British Columbia
Regional (Metro Vancouver)	
Regional Growth Strategy (RGS)	- Establishes land use designations and policies to support growth and enhance economic prosperity whilst maintaining the environmental qualities that contribute to the livability and sustainability of the Vancouver region. - A core goal of the RGS is to protect the environment and respond to climate change impacts. This is supported by a number of strategies which include protecting conservation and recreation lands (Strategy 3.1) and protecting and enhancing natural features and their connectivity (Strategy 3.2). To support these objectives, municipalities are requested to consider integrated stormwater management when developing municipal plans
Integrated Liquid Waste and Resource Management Plan	- See Table 3.1
Local (UEL)	
UEL 2012-2021 Capital Plan	- Identifies a number of infrastructure upgrades as well as the sewer separation strategy.

3.5 Summary

The key points relating to the regulatory context of the study area are summarized as follows:

- The study area falls within the jurisdiction of Provincial (British Columbia) level of government that enforces legislative requirements relevant to the ISMP.
- The most significant regulatory items are the BC Environmental Management Act, and the Metro Vancouver Integrated Liquid Waste and Resource Management Plan, which are the drivers for developing the ISMPs in the region.
- It will be important to monitor changes in legislation relating to environmental management, water, and flood management to ensure that the ISMP remains compliant.
- The UEL Works and Services Bylaw, which was recently implemented in 2016 specifies the minimum standards for the design and construction of municipal infrastructure.
- The UEL currently lacks an Erosion and Sedimentation Control Bylaw to ensure that adequate protection of the municipal drainage system is taken during any construction; and a Tree Protection Bylaw to regulate the cutting, removal and damage of trees on private property.

4. Land Use

4.1 Overview

Land use planning for the study area is guided by strategic plans, policies and objectives which have been developed at the regional and local administrative levels. This section describes the existing land use, zoning classes, and plans that are in place for the study area and surrounding lands.

4.2 Existing Land Use

Areas A, B, and C consists solely of single-family housing and together contain 441 lots all of which have been developed. Further sub-division of existing lots is not permitted, nor are new developments encroaching on Pacific Spirit Regional Park land. All other land uses are restricted in these areas.

Area D consists of a mix of low and high-rise apartments, townhouses, mixed-use, and commercial development.

University Golf Course is situated along University Drive between Areas C and D is approximately 60 hectares.

4.3 Land Use Planning

The ISMP study area falls within the planning jurisdiction of Metro Vancouver, the UEL, which is administered by the provincial Ministry of Community, Sport and Cultural Development and the provincial Ministry of Transportation and Infrastructure (MoTI). Metro Vancouver is responsible for land-use planning on a regional scale, with the UEL responsible for local planning and the MoTI manages the Major Road Network and serves as the subdivision approving officer.

4.3.1 Regional

Regional planning for the study area is guided by Metro Vancouver, which sets long-range goals and objectives for managing land use across the region. Metro Vancouver members are required to produce Regional Context Statements to establish how their plans and policies align with regional goals. The regional planning documents that will impact the outcomes of the ISMP are listed in Table 4.1.

Table 4.1 Summary of Regional Planning Documents

Plan	Purpose and Description	Key Points for ISMP
Regional Growth Strategy 2040	- "Looks out to 2040 and provides a framework on how to accommodate the over 1 million people and 600,000 new jobs that are expected to come to Metro Vancouver in the next 30 years" - Identifies 5 goals for the region, and strategies to meet those goals - Specifies role of member municipalities/ electoral areas in achieving roles	- Growth to be focused to Urban Centres - Existing industrial and agricultural areas to be generally protected from land use change - Existing conservation and recreation areas are to be generally maintained, and should be buffered from adjacent activities
Metro Vancouver's Regional Parks Plan (2011)	- Identifies goals for the management and improvement of regional parks, and strategies to meet those goals	- Pacific Spirit Park is located within the ISMP study area

4.3.2 Local

The ISMP will need to align with the goals of the land use plans enacted by the UEL. The plans may also be used as an instrument for implementing recommendations stemming from the ISMP. Table 4.2 summarises the local land use plans that relate to the ISMP study area, and the likely impact of those plans on the ISMP.

Table 4.2 Summary of Local Planning Documents

Plan	Scope and Purpose	Key Points
Official Community Plan	- The Official Community Plan (OCP) is a statement of objectives and policies that guide local planning decisions - It is the principal land use document for the UEL	- A broad statement of objectives and policies to guide decisions on planning and land use management.
Regional Context Statement	- Identifies how the UEL fits into the Metro Vancouver regional growth strategy	- Outlines the UEL's policies to align with the regional priorities for protecting green zones, building complete communities, achieving a compact metropolitan area, and increasing transportation choices

A significant development is planned for a parcel referred to as “Block F”. “Block F” is a 21.4 acre property adjacent to the existing Area D development. The proposed development is planned to consist of residential and commercial mixed-use development as well as not less than 3.0 acres of public park space.

Aside from Block F, the University Hill area is fully built-out. The University Golf course is restricted for development for more than 75 years. Further densification is possible in Area D when some of the existing multi-family buildings are eventually redeveloped.

4.4 Park and Natural Areas

The location of parks and natural areas within the study area are shown in Figure 4.1. Pacific Spirit Park, which is partially within the study area, is mostly a natural forest but also includes walking, cycling, equestrian trails, and public beaches. The UEL municipal stormwater system discharges to watercourses within Pacific Spirit Park. Pacific Spirit Park contains a number of environmentally sensitive areas, a few of which are within the study area.

4.5 Summary

The key points relating to the land use of the study area are summarized as follows:

- The University Hill community consists of primarily single family homes in Areas A, B, and C. Area D consists of a mix of low and high-rise apartments, townhouses, mixed-use, and commercial development.
- A significant development is planned on the Block F property southeast of the existing Area D development. Other than the Block F property, the University Hill Community has been built out. It is expected that there may be further densification of some properties within Area D when they are eventually redeveloped.
- Pacific Spirit Park, which contains a number of environmentally sensitive areas, is within the study area.

Figure 4.1 Parks

5. Hydrology

5.1 Overview

This section describes the hydrological characteristics that influence the study area. Understanding the relationship between hydrologic aspects such as rainfall intensity and duration is an important component of integrated stormwater management planning.

5.2 Climate

The study area is located within the Lower Mainland ecoregion that surrounds Metro Vancouver. The region is bounded by the Coast and Cascade Mountains to the north and east, and the Pacific Ocean to the west. The climate of the study area is typical of the inter-coastal Pacific-Northwest, with wet winters with heavy rainfall often lasting into the spring, and mild summers. The UEL rarely experiences significant snowfalls.

The Vancouver International Airport is the closest Environment Canada weather station to the study area. Average temperature and rainfall recorded at this station between 1981 and 2010 are summarized in Figure 5.1 below. The average annual precipitation is 1189 mm, with the highest average precipitation in November and lowest in July. The daily average temperature varies between 18 °C in July and 3.6 °C in December.

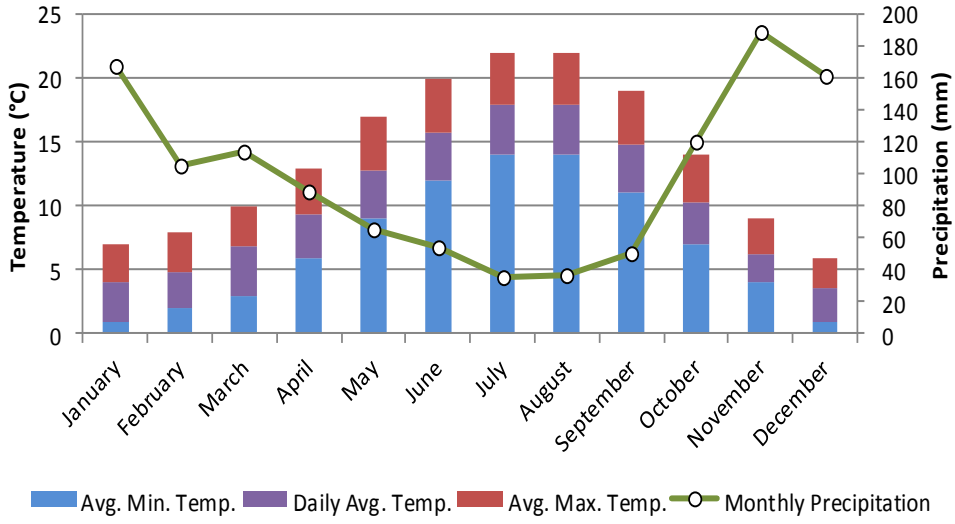


Figure 5.1 Climate of the Study Area

The UEL also references the rainfall curves developed by the City of Vancouver for use in stormwater system design and planning.

5.3 Catchments and Impervious Area

The study area is divided into eight main catchments, all of which have a unique outfall and drain northwards to English Bay via various creeks and ravines. As part of the UEL *Master Drainage Plan* completed by Urban Systems in 2007, the impervious areas were estimated using aerial photographs and construction drawings of recent homes. A range of total impervious areas was calculated, ranging from 40% to 60% for newer homes with an average of 46%. For older homes the values ranged from 29% to 44% with the average being 38%. It was estimated that as many as 40% of the homes in the UEL were not yet connected to the storm system and either discharge to on-site rock pits, the sanitary sewer, or the combined sewer. The UEL requires that property owners modify roof leaders are connected to the storm sewer system when the property undergoes significant redeveloped.

5.4 Climate Change

Climate change is likely to have an effect on the regional weather patterns, possibly causing more frequent and extreme storm events or longer periods of drought than have historically occurred. Due to the topography of the UEL, sea level rise is not expected to have a significant effect on the community, but may affect the downstream ends of the creeks and stormwater outfalls.

The City of Vancouver is currently updating their rainfall curves in consideration of climate change and the UEL may want to review these updated curves for its own stormwater planning.

5.5 Summary

The key points relating to the hydrology of the study area are summarized as follows:

- The developed portion of the study area is made up of eight distinct catchments, all of which drain north towards English bay through various creeks and ravines.
- Climate change may cause more frequent and extreme storm or longer periods of drought than have historically occurred.

Figure 5.2 Drainage Catchments

6. Stormwater System

6.1 Overview

The study area generally drains south to north through a network of roadside ditches, sewers, creeks, and ravines before discharging to English Bay. A small portion of the UEL south of Block F and University Boulevard drains south into Cut Throat and Musqueam Creeks before discharging into the Fraser River. The UEL manages a stormwater drainage system consisting of approximately 14 km of dedicated storm sewer, 4 km of combined sanitary and storm sewer, and 1 km of open drainage channels. The UEL drainage system discharges into either the Metro Vancouver sewer or natural drainage channels in Pacific Spirit Park.

Many private properties have implemented on-site stormwater BMP's to reduce the rate of stormwater flow leaving their site to meet UEL stormwater requirements. Pacific Spirit Park contains a number of open channels and wetlands. There are a number of stormwater BMP's (wetland, raingardens, swales, OGS units etc.) planned for the development at Block F. Within the existing urban developed area there are not any existing stormwater BMP's within the public realm (e.g. detention ponds or rain gardens) but the new Works and Services Bylaw makes a number of requirements with respect to managing stormwater run-off and minimum soil depths.

The study area has eight catchments, each with its own outfall.. The catchments are defined by the ground topography as well as the direction of flow in the storm sewers and combined sewers. The catchments are shown in Figure 5.2.

University Golf Course has a series of culverts, drainage lines, and open ditches that primarily discharge into the Salish Creek and Spanish Bank Creek. A portion of the golf course drains south to Cut Throat and Musqueam Creeks. A more detailed illustration of the University Golf Course drainage is attached in Appendix B.

6.2 Existing Drainage System

A review of the existing municipal stormwater drainage system upstream of the discharge points was performed to develop an understanding of the composition of the network, including size, material, conduit type and age, and identify opportunities for improvements. The review was performed using GIS information obtained from the UEL.

6.2.1 Sewers

The drainage system consists predominantly of gravity sewers up to the outfalls at the creeks. The 16 km of gravity sewer make up approximately 95% of the drainage system by length.

Table 6.1 summarizes the existing stormwater sewers according to size. For the purpose of this study all stormwater sewers greater than or equal to 525 mm in diameter were assumed to be trunk sewers.

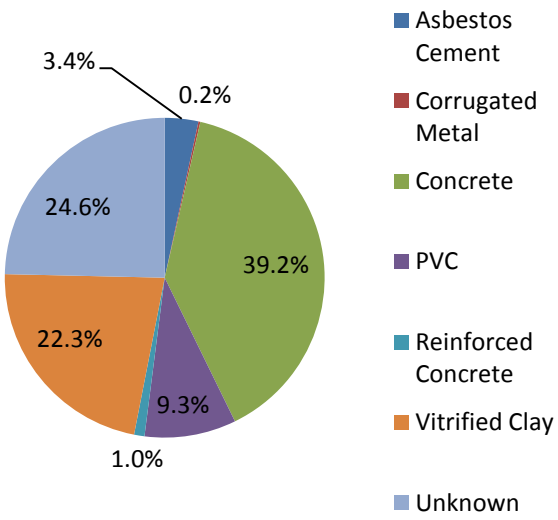
Table 6.1 Summary of Stormwater Sewer Sizes

Classification	Total Length (m)
Trunk (≥525mm)	1,198
Minor (≤525mm)	12,710
Total	13,908

Table 6.2 summarizes the construction material of the stormwater sewer network within the study area. The data shows that the most common pipe material is concrete, followed by vitrified clay; however, a significant amount (25%) of the pipe material is unknown. The storm sewers materials are shown graphically in Figure 6.2.Figure 6.2 Existing Storm Sewer Materials

Table 6.2 Summary of Stormwater Sewer Materials

Material	Length (m)
Asbestos Cement	472
Corrugated Metal	27
Concrete	5,448
PVC	1,288
Reinforced Concrete	146
Vitrified Clay	3,099
Unknown	3,427
Total	13,908



The GIS data from the City also showed that the drainage network also includes a large number of manholes and other devices. The quantity of these other drainage features is summarized in Table 6.3.

Table 6.3 Other Stormwater Features in Network

Asset Type	Quantity
Manholes	**169**
Property Connections	**181**
Catch Basins	**435**

6.2.2 Creeks and Ditches

There are 3 major creeks within the study area: Spanish Bank Creek, Salish Creek (also known as Acadia Creek), and Canyon Creek (listed from west to east). Water Quality and Benthic Sampling was performed on each of these creeks as part of this study. The sampling is discussed in Section 8.

6.3 Existing Drainage Issues

Any reported drainage issues typically occur within the open channels due to the build-up of debris, sometimes due to resident beavers within Pacific Spirit Park.

6.3.1 Combined Sewer System

The UEL has approximately 4 km of combined sewers in operation, all of which are located in Area A. The combined sewers direct stormwater into the Metro Vancouver wastewater collection system. There is an existing plan to separate all combined sewers. Separation of a significant portion of these combined sewers is planned within the UEL's current 10 year Capital Plan (2012-2021).

6.3.2 Water Quality

Water quality issues were identified during water quality sampling in the creeks that was completed as a part of this study. This issue is discussed further in Section 8.

6.4 Hydraulic Modelling and Analysis

6.4.1 Approach

The UEL has previously had hydraulic modelling of the stormwater drainage system completed as a part of previous assignments. AECOM analyzed the existing sanitary, storm, and combined sewer computer models which were originally developed by Urban Systems. As part of previous modelling projects for UEL, AECOM performed a number of checks of the accuracy of the model, including rainfall volumes, runoff mass balance, confirmation of catchment and impervious areas, sanitary flow and I&I volumes. The adjustments made to the models are summarized below:

- The modelled 5 year 30 minute storm event was adjusted for a total rainfall depth of 9.4 mm from 9.0 mm to match the 2007 Urban Systems report and Environment Canada's Atmospheric Service design storm.
- UBC sanitary flows were added to the model to match the existing system configuration and Urban Systems report.
- It was also noted that the modeled I&I volumes appeared to be a conservative estimation, but were not changed in the model.

With the adjustments noted above, the provided model was verified to be consistent with the following reports completed by Urban Systems:

- University Endowment Lands Master Drainage Plan 2007 Update, February 22, 2007
- UEL Sanitary and Storm Systems Model Generation and Capacity Analysis, December 10, 2010
- UEL Block F Development – Impact to Sanitary and Storm Infrastructure, December 8, 2010

The model was simulated using a 5-year 30-minute design storm condition to identify hydraulic constraints in the sewer network. Storm sewers running more than 100% full (Qpeak/Qfull > 1.0) were recommended for upgrade.

6.4.2 Findings

The results of the hydraulic analysis are shown in Table 6.4. The sewers referenced in Table 6.4 are show in in Figure 6.3.

All of the combined sewers in the drainage network are located in Area A. Sewer separation is currently planned to create separate sanitary and drainage networks in place of all remaining combined sewers.

Table 6.4 Hydraulic Modelling Results

Project Reference	Description	Recommendation
CMB-01	56 m of 250 mm combined sewer on Acadia Rd. between Chancellor Blvd. and Kingston Rd.	Sewer separation is planned for this area. If all drainage connections are removed from the combined sewer, no upgrades will be required to service sanitary flows. Sewer separation planned for CMB-01 to CMB05 in 2018.
CMB-02	115 m of 250 mm combined sewer on Acadia Rd. between Kingston Rd. and NW Marine Dr.	
CMB-03	91 m of 250 mm combined sewer on Acadia Rd. between Kingston Rd. and NW Marine Dr.	
CMB-04	91 m of 250 mm combined sewer on Acadia Rd. between Kingston Rd. and NW Marine Dr.	

Project Reference	Description	Recommendation
CMB-05	91 m of 300 mm combined sewer on Acadia Rd. between Kingston Rd. and NW Marine Dr.	
CMB-06	91 m of 375 mm combined sewer on Acadia Rd. between Kingston Rd. and NW Marine Dr.	
CMB-07	91 m of 375 mm combined sewer on Acadia Rd. between Kingston Rd. and NW Marine Dr.	
STM-01	42 m 250 mm dia. culvert underneath University Blvd.	Upgrade is a requirement of the proposed Block F development.
STM-02	91 m of 200 mm storm sewer on Acadia Rd. between Newton Wynd and NW Marine Dr.	Upgrade to 375 mm dia. Planned for 2018.
STM-03	91 m of 200 mm storm sewer on Acadia Rd. between Newton Wynd and NW Marine Dr.	Upgrade to 375 mm dia. Planned for 2018.
STM-04	91 m of 250 mm storm sewer on Acadia Rd. between Newton Wynd and NW Marine Dr.	Upgrade to 450 mm dia.
STM-05	91 m of 375 mm storm sewer on Acadia Rd. between Newton Wynd and NW Marine Dr.	Upgrade to 525 mm dia.
STM-06	30 m of 200 mm storm sewer between Acadia Rd. and NW Marine Dr.	Upgrade to 525 mm dia.
STM-07	65 m of 375 mm storm sewer on NW Marine Dr., east of Acadia	Upgrade to 525 mm dia.
STM-08	192 m of 375 mm storm sewer on NW Marine Dr., east of Acadia	Upgrade to 525 mm dia.
STM-09	95 m of 600 mm storm sewer on University Blvd., west of Acadia Rd.	Upgrade to 675 mm dia.
STM-10	166 m of 450 mm storm sewer on Acadia Rd., north of University Blvd.	Upgrade to 525 mm dia.
STM-11	151 m of 450 mm storm sewer on Acadia. Rd., north of McMaster Rd.	Upgrade to 600mm dia.
STM-12	154 m of 450 mm storm sewer on Acadia Rd., north of College Highroad	Upgrade to 600mm dia.
STM-13	68 m of 450 mm storm sewer on Acadia Rd., between Wycliffe Road and College Highroad	Upgrade to 600mm dia.
STM-14	120 m of 450 mm storm sewer on Acadia Rd., south of Wycliffe Rd.	Upgrade to 600mm dia.

Project Reference	Description	Recommendation
STM-15	68 m of 450 mm storm sewer on Acadia Rd., north of Wycliffe Road	Upgrade to 600mm dia.

6.5 Scheduled Capital Works

UEL's 2012-2021 Capital Plan was updated in 2015. This plan outlines the scheduled capital improvement projects for UEL's municipal infrastructure. Table 6.5 outlines the stormwater capital projects identified within the 10-year Capital Plan.

Table 6.5 10-Year Capital Plan Stormwater Projects

Project Reference Number	Description
2015-02	Construction of stormwater/sanitary sewer separation on Wesbrook Cres, north of Chancellor Blvd.
2016-02	Construction of storm sewer replacement on Wesbrook Cres. South of Chancellor Blvd.
2016-01	Construction of new storm sewer on Alison Rd between Campus Rd. and College Highroad, and on Western Parkway between College Highroad and University Blvd.
2017-02	Design and construction of storm sewer replacements on lane north of College Highroad
2018-01	Construction of sanitary/stormwater separation on Acadia Rd. north of Chancellor Blvd.
2018-02	Design and construction (reline) of storm sewer on Drummond Dr. and College Highroad
2021-01	Construction of Water, Sewer and Road replacement on Newton Wynd between Acadia Rd. and Kingston Rd.
TBC-02	Construction of storm sewer replacement on lane north of Wycliffe Rd.

6.6 Best Management Practises

Best Management Practices (BMPs), sometimes known as low impact development strategies, are tools that can be implemented to manage stormwater in order to protect natural resources such as watercourses and wetland areas. The objective of BMPs is to mimic the natural hydrologic regime within a development to provide a more sustainable way of managing stormwater. The objective is often accomplished through one or more of the following processes:

- Reducing imperviousness
- Conserving natural resources and ecosystems
- Maintaining natural drainage courses
- Reducing the use of and reliance on conventional pipe systems
- Minimizing clearing and grading of land for development (cluster housing)
- Maintaining pre-development time of concentration by strategically routing flows to maintain travel time or through the installation of detention facilities
- Infiltrating run-off into the ground
- Implementing effective public education programs to encourage property owners to use pollution prevention measures; and, maintain the on-lot hydrologically functional landscape management practises

BMPs can be utilized to aid in peak flow attenuation, volume reduction, and water quality protection. BMPs are not only beneficial for stormwater management and the environment, but they can also improve the aesthetic appeal of urban developments and contribute to a positive community sentiment.

Historically, the UEL has restricted run-off from all new development to a maximum rate of 25 l/s per hectare for a five (5) year storm. As a result, most newly developed properties limit the amount of imperviousness, have disconnected roof leaders and/or provide on-site stormwater storage. The proposed new development at Block F and all future development subject to the Works and Services Bylaw will need to meet the following criteria outlined below.

Stormwater runoff rates, volume and quality requirements are as follows:

- Reduce post-development flow (volume, shape and peak instantaneous rates) to pre-development levels for the 6-month, 24 hour and the 5-year, 24 hour precipitation events.
- Retain the 6-month, 24 hour post-development volume from impervious areas on-site and infiltrate into ground where it will not cause instability of steep slopes. If infiltration is not possible, the rate of discharge from the “flow reduction BMPs” will be equal to the calculated release rate of an infiltration system.
- Collect and treat the volume of the 24-hour precipitation event equaling 90% of the total rainfall from impervious areas with vehicular traffic with suitable BMPs.

6.7 Summary

The key points relating to the stormwater system of the study area are summarized as follows:

- The study area generally drains from south to north through a network consisting of predominantly gravity sewers and discharge to one of three creeks and eventually to English Bay
- Hydraulic modelling of the existing drainage system was completed. Recommendations addressing drainage deficiencies are summarized in Table 6.4.
- The existing 10 Year capital plan (2012-2021) addresses some, but not all, of the deficiencies found during the hydraulic analysis.

Figure 6.1 Existing Storm and Combined Sewer Infrastructure

Figure 6.2 Existing Storm Sewer Materials

Figure 6.3 Hydraulic Analysis Recommendations

7. Hydrogeology and Soils

7.1 Overview

This section summarizes the hydrogeological and geotechnical features of the UEL study area based on the review of previous reports, aerial photos, contour mapping, and Ministry of Environment (MOE) water Atlas.

7.2 Bedrock

Bedrock, which is blanketed by thick layers of till and sediments, is approximately 100m from the surface. Bedrock in the study area likely consists of tertiary sedimentary rocks including sandstone, siltstone, shale, and conglomerate.

7.3 Surficial Geology and Soils

Surficial soils are a key component of the hydrologic cycle. They form the interface between rainfall infiltration and runoff. Soil is not a homogeneous material. It is composed of various mineral and organic components that may or may not be distributed and organized into vertical and horizontal patterns. The soil components and their distribution is a function of parent geological materials, topography, climate, biology, and geologic history. An understanding of surficial soils is important to developing knowledge of the study area and its operation under a range of conditions. A review of surficial soils was undertaken to establish an understanding of the potential engineering opportunities and constraints relating to drainage and possible infiltration as it relates to stormwater BMPs.

The surficial geology units in this area have been mapped by the Geological Survey of Canada (Reference: Surficial Geology GSC Map 1486A Surficial Geology, New Westminster, BC). The main surficial soil units that occur in the study area are described below.

7.3.1 Capilano Sediments (Ca)

There is a pocket of Capilano sediments (Ca) along Spanish Bank Creek and branching westward. This layer consists of raised marine beach, spit, bar and lag veneer, poorly sorted sand and gravel up to 10 m thick mantling older sediments and containing fossil marine shell casts.

7.3.2 Capilano Sediments (Cb)

There is a pocket of Capilano sediments at the upstream end of Spanish Bank Creek running through the middle of Area C and the eastern portion of the golf course. This layer consists of raised beach medium to coarse sand 1 to 5 m thick.

7.3.3 Vashon Drift and Capilano Sediments (VCb)

The majority of the study area and nearly all of the developed area in University Hill is mapped as Vashon Drift and Capilano Sediments; including lodgement and minor flow till, lenses and interbeds of sub stratified glaciofluvial sand to gravel, and lenses and interbeds of glaciolacustrine laminated stony silt up to 25 m thick. This dense till unit has low permeability and infiltration through this unit will be very slow.

7.3.4 Pre-Vashon Deposits (PV)

Towards the north end of the study area and including a small portion of the most northern properties in University Hill are underlain with pre-Vashon deposits. This layer also lies beneath the Vashon Drift and Capilano Sediment layers. This layer consist of pre-Vashon Quadra sand fluvial channel fill and floodplain deposits including crossbedded sand containing minor silt and gravel lenses and interbeds. The lowest layer of the Quadra Sand unit consists of interbeds of sand and laminated silt which acts as an aquitard. This unit overlies another sand unit that extends from below sea level in some locations.

7.4 Stormwater Infiltration

Soil infiltration rates are generally expected to be low based on the surficial geological mapping that indicates the presence of Vashon glacial till underlying the study area. There are pocket areas with sandy fill where higher percolation rates could be expected; however, these pockets are underlain by dense till with low percolation rates. Percolation testing for the Block F development, where surficial soils generally consisted of sandy materials, yielded a percolation rate of 8.8 minutes / 25mm drop in water level.

In the context of the ISMP this means that greater runoff can be expected compared to regions with more permeable soils. Where there is low permeability of the soils, implementation of infiltration based volume reduction type best management practises may be more difficult. It is recommended to conduct percolation tests in advance of designing infiltration facilities. If infiltration is low, then other techniques for volume reduction may need to be investigated such as the implementation of surficial vegetated facilities (i.e. rain gardens) that use evapotranspiration.

7.5 Aquifers and Wells

Water that seeps through the till cap, typically percolates down through the Upper Sand unit until it reaches the Sand Silt unit, which acts as an aquitard. The perched water bearing sand unit located above the aquitard is referred to as the Upper Aquifer. The water that seeps through the aquitard flows down into the lower sand unit, which when saturated, forms the Lower Aquifer.

The Upper Aquifer is classified as low demand, moderate productivity, and moderate vulnerability. No data was available for the Lower Aquifer.

The BC Water Resources Atlas shows there are five existing wells in the study area. Well data for each well is summarized in Table 7.1. The well data shows the groundwater table to be 48 - 87 metres below the surface. Nearby shallow wells on University Blvd., west of Wesbrook Mall show the ground water elevation to be just 4 metres below the surface. This groundwater elevation is well above those reported elsewhere.

Table 7.1 Well Data

Well Number	Location	Use	Well Depth (m.)	Water Depth (m.)	Yield (GPM)
18016	Allison Rd., north of Chancellor Blvd.	Unknown	105	89	25
17995	Acadia Rd., north of Chancellor Blvd.	Observation	104	84	-
17996	Acadia Rd., south of Chancellor Blvd.	Unknown	91	48	-
56790	Dalhousie Rd., west of Western Pky.	Regent College	34	25	100
17970	College Highroad, west of Tasmania Cres.	Observation	79	68	-

7.6 Groundwater Flow and Slope Stability

Groundwater flow generally follows the topography of the low permeability layers towards the cliffs. Seepage from the Upper Aquifer results in piping at the cliff face resulting in mass wasting and erosion. Increased subsurface infiltration will likely result in increased discharge and erosion at the cliff faces. Discharge from the Lower Aquifer passes mostly through beach deposits and does not significantly impact cliff erosion. Increased infiltration into the Upper Aquifer near the cliff face is generally not recommended as a method of reducing stormwater runoff. As part of their Integrated Stormwater Management Plan, the University of British Columbia has contracted Golder Associates to estimate erosion along the NW Marine Dr. The study produced a series of maps along the UBC cliffs that show erosion and accumulation between 2010 and 2015. Based on this assessment UBC is implementing a best management practice of mandating 300 metre “No Infiltration” buffer along the cliff face of the UBC property. The UEL may consider coordination with UBC on efforts in protection of slope stability along the North West Marine Drive. The images provided by UBC are attached in Appendix C.

7.7 Contaminated Sites

There are no known contaminated sites within the University Endowments Lands.

7.8 Summary

The key points relating the hydrogeology and soil characteristics of the study area are summarized as follows:

- Most of the study area is directly underlain by low permeability till which limits the ability to count on infiltration as a method of reducing storm water runoff.

- Groundwater flow in the Upper Aquifer discharges from the cliff faces resulting in mass wasting and erosion. Increasing infiltration is generally not recommended north of Chancellor Blvd.
- Existing wells show the aquifer ground water table is located at approximately 48 - 87 metres below the surface depending on location; however, there is conflicting information from nearby shallow water wells showing ground water depth as high as 3.8 m below surface. There will also be seasonal surface ponding at some locations.

8. Environment

8.1 Overview

The study area is located in the Eastern Variant of the Very Dry Maritime Subzone of the Coastal Western Hemlock Biogeoclimatic Ecosystem Classification Zone. This climate is characterized by warm, dry summers and moist, mild winters with little snowfall.

According to the Pacific Spirit Park Society, the following species of trees can be found within Pacific Spirit Park: Cedar, Hemlock, Douglas Fir, Sitka Spruce, Vine Maple, Red Alder and Bitter Cherry. Other plant varieties found in the park include salal, salmonberry, blackberry, elderberry, ferns, mosses, lichens and mushrooms. Birds and small animals that have been found in Pacific Spirit Park include owls, bald eagles, chickadees, warblers, wrens, kinglets, woodpeckers, sea birds, Douglas Squirrels, voles, mice, coyotes, skunks and raccoons, salamanders, newts, Garter Snakes, toads and tree frogs.

As part of this ISMP, AECOM performed benthic macroinvertebrate and water quality studies for the UEL over the course of one sampling year which included sampling in both the wet and dry seasons. The objective was to collect data representative of existing conditions to be used to monitor temporal changes (both impacts and improvements) in the UEL study area, identify factors potentially impacting environmental health and to determine the overall health of the watercourses. Baseline conditions were established through sampling that included water quality and benthic macroinvertebrates during different seasons.

8.2 Stream Conditions

A site visit was conducted for the three creeks (Spanish Bank Creek, Canyon Creek, and Salish Creek) located within the study area of the UEL. The lower reaches of the three creeks were examined to determine if they could support fish passage.

The Spanish Bank Creek has the best streambed condition of the three streams and can be attributed to the daylighting of the stream in 1999 and the rehabilitation in the spring of 2014. The creek has an 800 mm diameter wood culvert with water flowing at a depth of 200 mm which runs under Northwest Marine Drive. The stream is narrow with sufficient depth to allow fish passage upstream. There was limited debris in the stream. The lower reaches of this creek are at a gentle grade. The Ministry of Environment Habitat Wizard Streams Report states that Chum Salmon, Coho Salmon, and Cutthroat Trout have been observed in the stream.

Salish Creek has a concrete culvert that crosses under Northwest Marine Drive. This is the only culvert that has baffles installed to assist the upstream passage of fish. The stream has sufficient flow for fish passage; however, the streambed is very wide in sections which limit the water depth. Debris is present throughout the lower courses of the stream. The wide streambed and significant amounts of debris is expected to present a problem for fish passage. The Spanish Bank Streamkeepers have reported observation of Coho Salmon attempting to swim up Salish Creek.

Canyon Creek has a concrete culvert that crosses under Northwest Marine Drive. The stream flow was lower than 100 mm in the culvert and would present

problems for fish passage. The stream has significant number of trees and other debris that severely block portions of the stream. The low flow and debris would make fish passage through the lower reaches of this stream very difficult. No reports of fish could be located for this stream. It should be assumed that this creek may contain the same fish species as both Salish Creek and Spanish Bank Creek.

The riparian setbacks for each of the three creeks were examined using GIS. Figure 8.1 shows the riparian setbacks for each of the creeks. The riparian area of Salish Creek is encroached upon on the west side by single family homes and to a greater extent by the Public Works Yard. There is no encroachment on Canyon Creek. Spanish Bank Creek's riparian area is encroached upon by a trail at the north-west end of the creek and by single family homes on the east side. The contour map of the area notes that there are some steep grades (46% slope) in the middle to upper reaches of the streams.

The City of Vancouver have confirmed that based on the stormwater servicing information for the properties 1600-1900 BLKS of Drummond Dr. and 4800 BLKS of Belmont and Fannin, all properties have applied for new stormwater service connections and should have service to the property frontage. However, incomplete records suggest that over time some properties have developed discharge to ground systems that may runoff to the Spanish Bank Creek ravine.

A detailed assessment of the creeks would need to be undertaken to determine the extent of fish passage for the entire length of the watercourses, to assess riparian habitat integrity, and to assess stream erosion.

The Spanish Bank Streamkeepers volunteer group is actively involved in monitoring, assessing, and safeguarding the Spanish Bank Creek, Canyon Creek, and Salish Creek. The group receives support from the Pacific Streamkeepers Federation and members are encouraged to get Streamkeeper Certification, which provides training in watercourse monitoring and assessment. The Spanish Bank Streamkeepers have provided educational opportunities for the public, including school children programs and summer camps. The Streamkeepers have also taken on investigative work in assessing water quantity variability in the Salish Creek. Together with the UEL Operations staff, the Spanish Bank Streamkeepers have discovered that, during the dry summer months, Regent College is discharging groundwater directly into the UEL storm drains after it is utilized for the building cooling system. The flow discharges into the Salish Creek at the box culvert at Acadia Circle. The Streamkeepers are eager to determine the impact of the flow from the Regent College on the ecology in the Salish Creek, and have contacted the Pacific Streamkeepers Federation to provide further guidance on the next steps.

8.3 Water Quality

Benthic macroinvertebrate and water quality sampling was performed over the course of one sampling year. The objective was to collect data representative of existing conditions to be used to monitor temporal changes (both impacts and improvements) in the UEL study area, identify factors potentially impacting environmental health and to determine the overall health of the watercourses. The water quality assessment system, when considered along with the benthic invertebrate and hydrometric indicator information, gives a holistic assessment of

stream health in watersheds at risk from urban land use and non-point source pollution.

High levels of mayflies, stoneflies, and caddisflies are indicative of a healthy stream. The majority of the benthic invertebrates collected during sampling were predominately blackflies, which are pollution tolerant, and an overall benthic invertebrate score of very poor was obtained at Spanish Bank Creek and Salish Creek.

Bacteriological analyses were based on Health Canada guidelines for recreational primary contact levels. E.coli guideline values were exceeded at Spanish Bank Creek and Salish Creek sampling locations. Both fecal coliform and E. coli levels exceeded guideline values at these two sites during the wet sampling period. Exceedances for the two bacteriological parameters during the dry period only occurred in Salish Creek. The point sources for these contaminations should be determined. Coliforms could be coming from either or both wildlife and sewage cross connections. Caffeine could be included in the sampling locations of concern. Measuring caffeine measurements in municipal water systems provides a good estimate of fecal contamination caused solely by humans.

The Monitoring and Adaptive Management Framework (MAMF) document produced by Metro Vancouver was used to identify key water quality parameters. The document's simplified water quality screening system was applied and determined that the overall water quality in the watershed was rated as satisfactory to good condition, with fecal coliform, E.coli, dissolved oxygen, conductivity, and total iron marked as 'Needs Attention' at one or more locations. The 'Needs Attention' priority indicator suggests that water quality is in non-attainment with Provincial Water Quality guidelines and it is recommended that supplemental water quality monitoring and/or adaptive management actions are taken. If concentrations of E.coli or fecal coliforms exceed guideline concentrations, the Health Authority should be contacted and informed of the findings. Sources of metals could be natural or anthropogenic. Typically, anthropogenic sources in urban water system are related to roadway runoff. A stormwater sampling program could be designed to aid in determining the source of the issue.

Further sampling should be conducted to determine potential point sources for all water quality parameters that were exceeded during the dry and wet sampling periods. Areas with high metal concentrations primarily during wet season sampling have a higher indicated of metal concentrations from roadway runoff. High levels at sites in both the dry and wet season sampling periods indicate a high probability of elevated natural levels. As part of further investigations, more parameters such as nutrients and parameters associated with roadway runoff could be added to the program to aid in the identification of point sources for water quality exceedances. It is recommended to include QA/QC water quality sampling to ensure overall quality of data collection and sample analysis of the program, such as duplicate and field and travel blanks.

The full Benthic Macroinvertebrate and Water Quality draft report is included in Appendix A. The report describes the studies conducted in 2015 in UEL watercourses including Spanish Bank Creek, Canyon Creek, Salish Creek and a wetted area along Spanish Trail in Pacific Spirit Park.

8.4 Summary

Water quality and benthic macroinvertebrate sampling was completed in 2015. The follow are the key points and recommendations resulting from the report:

- Sampling of creek water was completed during the development of the Integrated Stormwater Management Plan (ISMP). The sampling program was completed according to the methodology outline in the Monitoring and Adaptive Management Framework for Stormwater (Metro Vancouver 2014).
- Coho Salmon, Chum Salmon, and Cutthroat Trout have been observed in Spanish Bank Creek; and Coho Salmon has been observed in Salish Creek. It should be assumed that these fish species are also present in Canyon Creek.
- Benthic macro invertebrate scoring provided an overall rating of very poor stream condition for both sampling locations, at Spanish Bank Creek and Salish Creek.
- The MAMF guidance document's simplified water quality screening system was applied and determined that the overall water quality in the watershed was rated as satisfactory to good condition.
- Bacteriological analyses were based on Health Canada guidelines for recreational primary contact levels. E.coli guideline values were exceeded at Spanish Bank Creek and Salish Creek sampling locations. Both fecal coliform and E. coli levels exceeded at these two sites during the wet sampling period. Exceedances for the two bacteriological parameters during the dry period only occurred in Salish Creek. This may be a result of either or both wildlife and sanitary sewer cross connection. Caffeine sampling could be done in future water quality sampling to determine if there is fecal contamination from human waste.
- Aluminum, copper, iron, manganese and zinc exceeded either one or both of the CCME and BC Water Quality Guidelines (maximum and/or 30-day) at all the water quality sampling locations. Urban areas with high metal concentrations primarily during wet season sampling have a higher indicated of metal concentrations from roadway runoff. As part of further investigations, more parameters such as nutrients and parameters associated with roadway runoff could be added to the program to aid in the identification of point sources for water quality exceedances.
- The Metro Vancouver Monitoring and Adaptive Management Framework recommends that sampling be conducted every 5 years at a minimum. Particular attention to B-IBI ratings and water quality guideline exceedances should be utilized as overall health monitoring indicators.

Figure 8.1 Riparian Setbacks

9. Next Steps

With the conclusion of this report, Stage 1 of the four stage ISMP approach is complete. This report provides a thorough review of background information and a summary of the existing conditions. In addition to providing the context for the study, this report also highlights opportunities for improvement of UEL stormwater system. When addressing the highlighted opportunities, UEL should prioritise efforts in the following areas.

- The review of current legislative context identified the need for Erosion and Sediment Control Bylaw to ensure that adequate protection of municipal drainage system is applied during any construction. The new Works and Services Bylaw requires that all construction shall be accompanied by an Erosion and Sediment Control plan.
- Implement a Tree Management Bylaw to regulate the cutting, removal, and damage of trees on private property. This bylaw would complement the Provincial and Federal regulations for the protection of riparian features and conditions that are crucial in maintaining long-term watercourse health.
- Address cliff erosion issues along NW Marine Drive. Implementation of BMPs should be carefully evaluated along the cliff edge as increased infiltration could cause erosion due to increased pore water pressure.
- Include roadway runoff in the water quality monitoring program. Especially in urbanized areas, where high concentration of metals is present.
- Investigate cross connections for locations where households discharge into the environment. Noted issues include presence of washing machine detergent in the nearby watercourses.

In terms of developing an Integrated Stormwater Management Plan, the next steps are:

- Establish the vision for future Development (Stage 2),
- Develop an implementation plan, funding, and enforcement strategies (Stage 3),
- Develop a monitoring and assessment program (Stage 4).

Appendix A

Water Quality & Benthic Sampling
Draft Report

Appendix B

University Golf Course Drainage Map
Draft Report

Appendix C

University of British Columbia Cliff Erosion Study
Draft Report

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("Consultant") for the benefit of the client ("Client") in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

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