UBC Vancouver Campus

Integrated Stormwater Management Plan

March 5, 2017

campus + community planning

Executive Summary

Rapid development of the UBC Vancouver campus over the last 20 years has increased the amount of stormwater runoff that the campus stormwater system has to handle. Flows have increased to the point where the existing discharge locations and some piping are under capacity. Other stormwater management-related issues, such as the erosion of the surrounding cliffs in Point Grey caused by the University's outfalls, potential flooding from large storms, and the quality of stormwater leaving campus, continue to be concerns for UBC.

The majority of the UBC Vancouver campus stormwater system is traditionally designed and constructed with large diameter concrete and plastic pipes. Opportunities exist, and are strongly supported by the University, to take a natural systems approach for stormwater handling. Measures such as green roofs, cisterns, detention facilities, bio swales, rain gardens, etc., are considered part of the solution.

Through a process of formulating and reviewing stormwater management options, Campus and Community Planning has elected to construct stormwater detention facilities and pursue aggressive stormwater management measures in order to protect the campus and adjacent lands from overland flooding and to protect campus assets. Construction of the detention facilities is planned to take place over the next 10 years and is funded through the Infrastructure Improvement Charge (IIC). Detention facilities are to be built as either underground cisterns or as daylighted storage at flood-prone areas on campus: SUB Commons, the spiral drain area, the south end of South Campus, and at the intersection of Chancellor Boulevard and Marine Drive. Other possible locations exist and should be reviewed as projects are scheduled.

The purpose of this Integrated Stormwater Management Plan (ISMP) is to consider the complete rainwater cycle and outline stormwater management tactics that aim to improve the local environment, mitigate risk, and maintain wildlife and their habitats. This ISMP also highlights the need to improve stormwater quality and reduce quantity and rate of flow to pre-development conditions (or as close as possible). Through this plan, UBC identifies stormwater management goals as follows:

- Reduce the flow of water off of the campus,
- Reduce the impacts of stormwater flows off of campus, through detention and other methods,
- Maintain or preferably enhance water quality at campus boundaries so that it meets or exceeds best practices for urbanized municipalities,
- Protect campus assets from flooding,
- Safeguard human life, and
- Incorporate the natural hydrologic cycle and natural systems approach into the long-term planning and design of the stormwater system.

UBC aims to achieve the ISMP's goals by:

- Building detention facilities with capacities to manage the 100-year storm event adjacent to the discharge locations: Chancellor/Marine Intersection, South Campus, spot locations within campus,
- Including oil/grit separators to minimize particulate matter released into the environment
- Ensuring developments minimize the stormwater that leaves the site and manage the outflow rates to lower levels in order to minimise the erosive forces on the discharges,
- Re-establishing monitoring of the discharges for quantity and quality through the installation of data recording equipment and periodic water sampling/testing, and
- Building stormwater management within the building site by calling for low-impact development practices through landscaping, infiltration (where permissible), green roofs and rainwater harvesting.

UBC will continue to address stormwater in a more integrated manner such that appropriate source-controls and low-impact development measures will be used.

1. Introduction

1.1. What is an ISMP?

Stormwater is rainwater that has fallen to the ground. An Integrated Stormwater Management Plan (ISMP) looks at the complete rainwater cycle for a watershed and outlines stormwater management tactics that also aim to improve the local environment, mitigate risk, and maintain wildlife and their habitats. An ISMP also seeks to improve stormwater quality and reduce quantity and rate of flow to pre-development conditions (or as close as possible). The integrated approach seeks to transition from a traditional practice of collection and diversion through catch basins, culverts, and pipes to an approach that incorporates natural elements and values rainwater as a resource, which is part of a greater campus movement toward regenerative community design and greater resiliency in the face of climate change.

Currently, the UBC Vancouver campus (the campus) sends storm water from the campus, across Ministry of Transportation and Infrastructure (MOTI) lands and infrastructure and Metro Vancouver lands, to the ocean. The condition of the streams and the receiving body of water, as well as the adjacent environment, is taken into consideration.

1.2. UBC's ISMP

The UBC Vancouver campus has evolved over time and so too has the treatment of stormwater on campus. Policies set out by UBC's Board of Governors currently lay out the foundation for infrastructure practices on campus, including those affecting the management of stormwater. Policy 36 requires the maintenance of the Campus Master Servicing Plans. Policy 39 encourages the use of natural systems approaches for managing stormwater within the limitations of campus hydrogeology and effects on cliff erosion. Currently, the UBC Campus Plan describes how to manage stormwater in the UBC Vancouver built environment. The increasing development of the south campus and the redevelopment of the northern academic campus have resulted in a need to review stormwater handling. In the past, studies on stormwater management at UBC have focused on either upgrading outfalls, building new ones, or managing the impact of erosion on the cliffs within Pacific Spirit Park. UBC has decided that its ISMP must be focused on variables it can control on UBC land. Therefore, this ISMP has three main objectives:

1. Reduce the flow of water off of the campus,
2. Reduce the impacts of stormwater flows off of campus, through detention and other methods and,
3. Maintain or preferably enhance water quality at campus boundaries so that it meets or exceeds best practices for urbanized municipalities.

This ISMP is intended to help address many of the stormwater-related concerns identified in the past, including cliff erosion and poor water quality at outfalls. This ISMP also ensures that planned future growth on campus will be designed to mitigate any impacts on stormwater flows and stormwater quality.

2. Background

In preparing this plan, UBC reviewed numerous studies and reports from as early as 1998 and conducted further analysis and filled technical gaps. These studies are consolidated in the plan and set the direction for future work. Key studies that inform this ISMP and its implementation can be found in Appendices 2, 3, and 4.

2.1. Existing Storm Water Policy Context

- Sustainable Development Policy #5
- Official Community Plan (OCP) (1997)
- The Comprehensive Community Plan (2000)
- Vancouver Campus Plan (2008)
- 20-Year Sustainability Strategy

2.2. Existing UBC Stormwater System

Figure 1 – Overall Map of UBC Stormwater System

There are four principal stormwater catchments on the UBC Campus:

- North,
- West,
- 16th Avenue, and
- South catchments (insert map to illustrate the boundaries of the catchment areas).

The existing drainage system comprises storm sewers serving most of the developed area of campus, some open drainage channels, three stream outfalls that discharge to adjacent lands, and one spiral vertical shaft (drain) outfall owned by the Greater Vancouver Sewerage and Drainage District. The system has been forced to develop, change, and expand over many years because of increasing new development on campus.

The four stormwater catchments that drain surface water runoff from the campus are:

- North catchment, which drains the northern half of campus (an area approximately west of Wesbrook Mall and north of Agronomy Mall); the North catchment outfall is the spiral drain,
- 16th Avenue catchment, which drains an area along 16th Avenue, near SW Marine Drive; the 16th Avenue catchment outfall is Botanical Garden Creek,

- West or Trail 7 catchment, which includes Thunderbird Park, Hawthorn Place, Totem Park Residence, and the UBC Botanical Gardens; the West catchment outfall is the stream at Trail 7,
- South catchment, which drains southern areas of campus including Acadia Park, Hampton Place, and all of South Campus; the South Catchment outfall is Booming Ground Creek.

2.3. Regulatory Environment

UBC is a unique entity in the Lower Mainland. Though not a municipality, UBC is a public/corporate entity that provides many of the services of a municipality as well as providing world-class education and research.

The UBC Vancouver campus is located in the western portion of Point Grey, adjacent to Pacific Spirit Park. There is a MOTI road corridor that encircles most of the campus and the remnants of Pacific Spirit Park, which include cliffs that encircle both the MOTI corridor and the campus (refer to map below).

Laws and regulations from the B.C. provincial and Canada's federal governments guide how the UBC stormwater system is allowed to operate, i.e. the federal *Fisheries Act* and the *Canadian Environmental Protection Act*, and the provincial *Water Act* and the *Environmental Management Act*. With such enabling legislation in place, UBC is empowered to develop supporting plans and regulations to proactively address campus stormwater runoff and stormwater quality issues through an integrated approach.

Recent changes to federal legislation have created some uncertainty as to the minimum requirements of the Provincial Water Act. The *Provincial Water Act* has generated Water Quality Guidelines, but many of the parameters of water quality are still being discussed and worked on.

UBC is required to adhere to these laws and adequately abide by them. A stormwater management program will help with compliance.

Any work associated with stormwater to be done off campus lands requires permission from the land-owner and possibly legal leases or access agreements.

On a regional basis, Metro Vancouver (acting as the Greater Vancouver Sewerage and Drainage District) has created an Integrated Liquid Waste Management and Resource Plan. This plan is applicable to Lower Mainland municipalities west of Langley. Though UBC is not a municipality and is not subject to Metro Vancouver laws (unless enacted through the B.C. *Environmental Management Act*), UBC has committed to providing a similar level of service as other municipalities.


City of Vancouver
Chancellor Boulevard
University Endowment Lands (UEL)
University Boulevard
Main Mall
Musqueam Lands
Wreck Beach
West 16th Avenue
SW Marine Drive
Fraser River
UBC Vancouver Campus Boundary
Vancouver Campus Plan Area
Neighbourhoods in VCP Area
Family Housing Neighbourhoods (excluded)
Provincial Roads
Pacific Spirit Regional Park
Provincial Ecological Reserve (not open to public)
This 24 hectare South Campus area includes the UBC Farm. No market housing to be pursued, as long as the university's housing, community development and endowment goals can be met though transferring housing density to other parts of campus. Current land uses remain until an academic plan for the area is complete and the density has been transferred.
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0 150 300m
June 2010

2.4. Current Campus Stormwater Practices

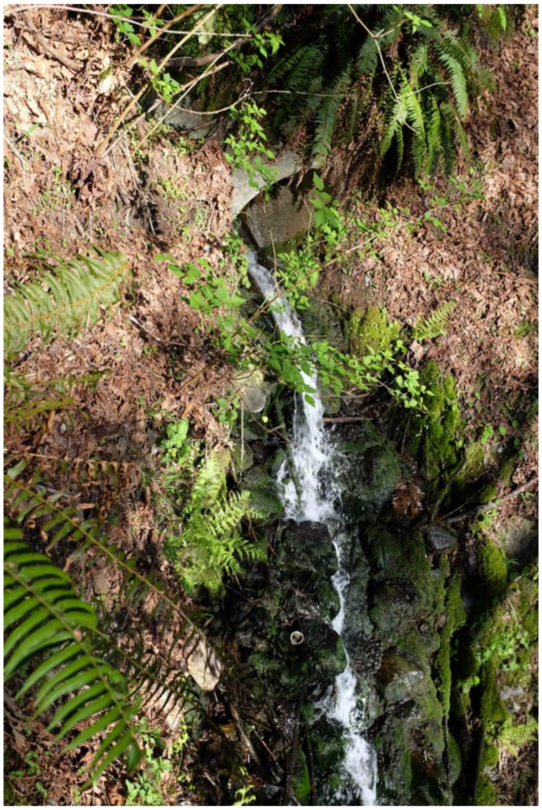
Current stormwater practices on campus differ little from most municipalities in the Lower Mainland. UBC's location and situation presents a challenge in that the discharge from the campus must pass through the land of other jurisdictions before reaching a receiving body.

Stormwater on campus is collected from the streets, walks, public open spaces, and roof leaders and sent into the storm sewer system. The catch basins in the street are fitted with sumps in order to trap the larger sediment from the street drainage. There is a sediment control program administered by Campus and Community Planning, and initiated through the development process, that ensures that construction on campus does not send excess sediment or high pH effluent to the storm sewer system. Programs with UBC's Environmental Services (Hazardous Waste Management and Storm Water Pollution Prevention) also ensure waste that discharges from UBC operations is handled correctly and hazardous materials are disposed of properly so as to not enter the environment.

Figure 2 – Cut-Away of Storm System Below the Street

The storm sewer system discharges the stormwater from five discrete locations (See Figure 1 in Section 2.2).

Figure 3 – 16th Avenue Stormwater Outfall



Outfall for the 16th Avenue catchment. Photo shows base flows during the summer.

Since the late 1970s there have been concerns about erosion of the cliffs that surround campus and that an overland flood could cause a significant washout. There has also been some concern that seeping water from the upper aquifer is moving fine sediments from the cliff face. To mitigate these concerns, the land between the Museum of Anthropology and Cecil Green was landscaped with berms to contain a significant flood. To reduce the seepage-related erosion, wells were installed on the north side of the Museum of Anthropology to drain water from the upper aquifer to the lower aquifer where it is less likely to cause concern.

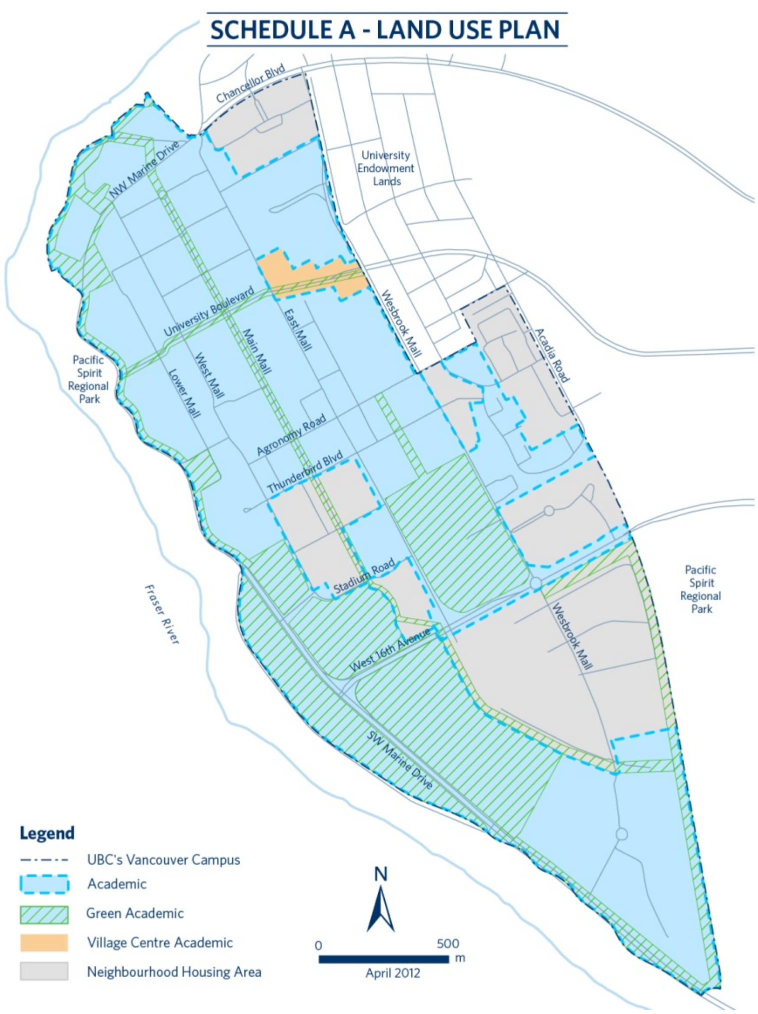
UBC has recently implemented its Vancouver Campus Plan, which includes design guidelines requiring all new projects on campus to meet Leadership in Energy and Environmental Design (LEED) Gold standards. LEED is a rating system recognized as the international mark of excellence for green building in 150 countries. The LEED point for Stormwater Management is mandatory in this system. New buildings are also required to detain the 10-year, 24-hour storm volume and discharge at the two-year, 24-hour pre-development rate. In addition, UBC's Residential Environmental Assessment Program (REAP) for residential buildings being developed on Campus requires that new buildings conform to UBC's stormwater policies.

There are limitations on the stormwater practices that can be implemented on Campus. For instance, with respect to concerns around water from the upper aquifer causing erosion of the surrounding cliffs, there is a policy in place requiring that infiltration not to be used within 300 metres of the top of the cliffs.

2.5. Changing Land Use

Both the 2010 Vancouver Campus Plan and the 2011 Land Use Plan for the UBC Vancouver Campus examine the upcoming needs of the university and how future plans for student and resident population and academic facility growth will be accommodated within the campus boundaries. The UBC Vancouver Campus Plan predicts that an additional 436,620 m^2 (gross) of floor space will be needed on campus over the next 20 years. This would bring the campus built-floor space to an expected 1,755,940 m^2 – a 33 per cent increase over 20 years. Section 4.3 Servicing of the Land Use Plan also includes consideration for some of the effects of development. Densification and increasing impervious area generate increased runoff during rainfall events and increase stormwater peak flows. Mitigating the effects of development is a primary goal of UBC ISMP effort.

Figure 4 – UBC Land Use Plan



From the UBC Vancouver Land Use Plan illustrating build out, land use, and green corridors

2.6. Evolution of the Campus

How the UBC Vancouver campus uses and designates its land has evolved far beyond its original 1930s plans. And campus evolution will continue as guided through the 2010 Vancouver Campus Plan and the 2011 Land Use Plan until 2030, at which point the current level of anticipated build-out will be complete.

Subsequently, stormwater plans are affected due to the changing amounts of planned impervious area. Using this information, model scenarios were created and studied to show what the effects will be on the stormwater system.

Land use on campus can be broken down as follows:

Land Use	Hectares
Built footprint	57
Building setback allowance	9
Roads and parking	54
Parks	11
Plazas and courtyards	4
Sports and recreation	23
Gardens	5
Corridors	8
Outdoor research space (including UBC Farm)	61
Total designated land use	**317**

It is anticipated that the outdoor research space area and other outdoor uses will maintain the same areas as are currently in use. Future development of the campus will include approximately 2,300 additional student-housing units projected to be built between 2014 and 2023. Several hectares of land will be set aside to accommodate this and other new buildings.

Development of new roads, sidewalks, and buildings will have an impact on the storm sewer system. Land use through to 2030 has been accommodated within modelling for the system. At a certain point, the amount of impervious area on campus will stabilise and redevelopment will allow for new replacement buildings to reduce their impact on the system through the implementation of stormwater control measures.

3. Objectives

Through this ISMP, UBC hopes to:

- Protect campus assets from flooding, safeguard human life, prevent overland flooding and downstream erosion across the cliffs,
- Meet or exceed existing provincial and federal policies and standards for quality and quantity,
- Protect the university's environmental values and minimise the impact of campus discharge on neighbouring watercourses,
- Improve the quality of the stormwater that leaves the campus, and
- Incorporate the natural hydrologic cycle and natural systems approach into the long-term planning and design of the stormwater system.

4. Implementation

In preparing this ISMP, a number of options for handling campus-level storm water were formulated and reviewed:

Option A: Re-build and reinforce the existing outfalls from the campus. This option was not desirable from a University perspective as it would require the construction of significant works on property not owned by the University, meaning that legal agreements and leases would need to be implemented. It would also require that significant funds be spent on lands that are not part of the campus. Given the myriad of stakeholders and interest groups, achieving consensus on the design and implementation would be slow and possibly conflict-oriented.	Not recommended
Option B: Discharge the water into new wells that would drain the stormwater into the lower aquifer. This option suggests building drainage wells. The University hired AECOM to complete a hydrogeological study of the campus and determine whether there was capacity to handle the stormwater flows by transferring them to the lower aquifer. The results indicated that there was not sufficient capacity to handle the flows. It was also determined that the introduction of oxygenated water into the aquifer could cause the oxidation of dissolved metals in the aquifer requiring more frequent maintenance of the wells. There was also concern that the introduction surface contaminated storm water into an otherwise pristine aquifer would not be an appropriately environmentally sensitive approach.	Nor recommended
Option C: Use stormwater detention to capture flooding and detain some storm events. This option is the preferred stormwater management approach for the campus.	**Recommended**

Detaining storms would slow down the release rates of smaller rain events and capture larger events in order to prevent overland flows that could cause significant erosion if allowed to flow over the cliffs. It allows the works to be completed on UBC lands without impacting other stakeholders and can be incorporated into the planning and development of the campus. Detention would require a simple installation of primary treatment for the stormwater runoff in order to minimize the amount of sediments and improve the overall water quality before leaving the campus. It will also allow for smaller storms to be detained for longer periods in order to minimize the impact that they would have on the watercourses downstream of the campus.

Due to the dense programming of the campus and the limited amount of land available, the detention approach combines the use of underground tanks with use of above-grade surfaces to help augment the overall amount of detention. There is the possibility of tanks being open basins or being constructed as ponds, but that will depend on the location and permitted land use for the area.

The report, Technical Memorandum #3 from GeoAdvice, attached as Appendix 4, provides further detail as to areas of concern around stormwater detention.

Areas of greatest concern are:

1. The area at the south end of south campus where large volumes of water can be generated by a 1-in-100-year storm. The volumes may be big enough to cause overland flooding and erode the cliffs if the overland flows reach the cliffs.

2. The intersection of Chancellor Boulevard and Marine Drive, near Trail 3, where the potential concentration of stormwater in a large event could either go down the gully or travel down Marine Drive until it goes over the cliffs and causes erosion.

3. The area around the spiral drain, which has been designed to contain some significant flooding and provides for a hardened outfall area to minimize erosion. Currently, the work will contain the latest prediction by the simulation model for a 100-year event. Development of this area of campus may require alterations to accommodate the necessary stormwater retention.

4. The area around the SUB commons plaza, which is subject to flooding in the 1-in-100-year event. There is some risk that the building drains could be affected. The stormwater retention in this area would provide protection against overland flows.

Water Re-use / Harvesting

Stormwater from campus can be collected and used for irrigation, toilet flushing, emergency fire protection, or other purposes. Limitations around how to re-use water and how the stormwater system operates pose challenges to a water re-use/harvesting approach.

Proposed detention tanks are to be located near the periphery of the campus and must remain empty most of the time in order be able to receive the stormwater that would otherwise cause a flood. If water is to be re-used, then storage tanks must also be built, or the detention tanks must be built larger than currently conceived, to include a retention/storage component. The proposed locations of the detention tanks will necessitate the construction of pipes and pumps to move the stormwater appropriately.

Vancouver Coastal Health requires that any water to be re-used by humans or for spray irrigation must be treated to potable water standards. Drip irrigation does not require the same level of treatment.

Currently, the implementation of systems to reuse stormwater for irrigation or human use costs more than the bulk water bought from the regional provider. The campus is estimated to spend approximately $300,000 annually on irrigation, which is approximately 300,000 m^3 of water. To build storage for 10 per cent of the University's needs would amount to $9,000,000 for tanks and additional funds for piping and pumps to deliver water to its intended location. The payback period would be too long to justify such a project. For smaller areas, reuse of water may be appropriate. The challenge remains that at the time of greatest water need there is not much rain to be used.

4.1. Implementation Recommendations

This ISMP for the UBC Vancouver campus includes the following recommended implementation components:

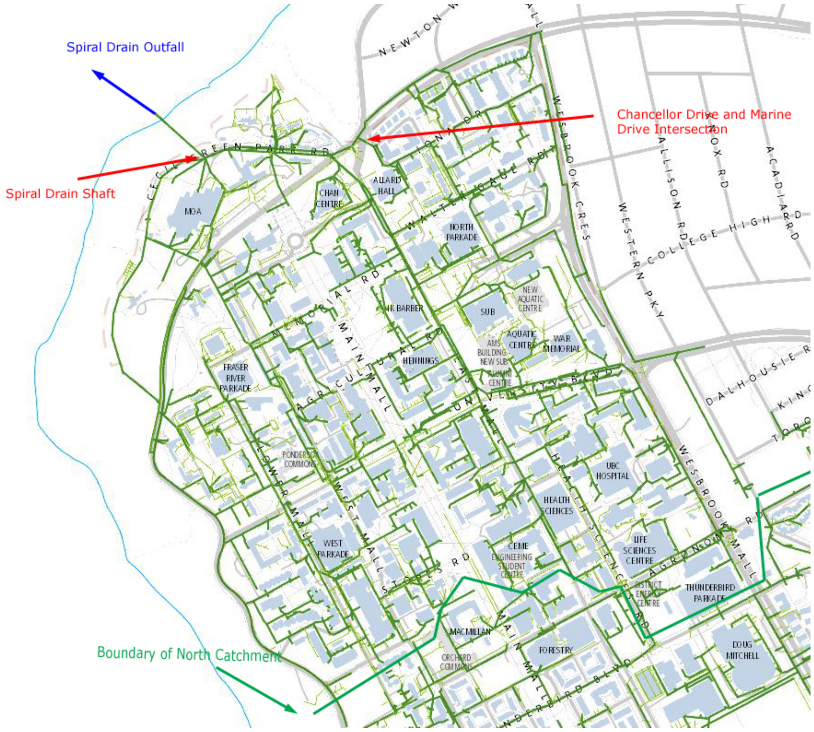
- Low-impact development practices (e.g reduced footprints, less hard surfaces)
- Landscaping and public realm approaches (e.g. thicker topsoil, less paving, xeriscaping)
- Infiltration facilities (located 300 m from the cliffs, e.g. bioswales, French drains, rain gardens, etc.)
- Green roofs or blue roofs
- Rainwater reuse

Implementation of the ISMP will occur over the next 15 to 20 years, based on the development of the campus and the provision of funding through development fees and other sources. Stormwater management projects will be subject to UBC's development process and will be presented for public input. In April 2014, designs for the detention for the area around the Student Union Building (SUB) began in conjunction with public realm development for this area. The detention tanks for the other areas of identified flooding (South Campus, Chancellor Drive, and the spiral drain) will be assessed as development continues and Infrastructure Improvement Charge (IIC) funding becomes available.

North Catchment

The North catchment, which includes the majority of the campus north of 16^{th} Avenue, receives stormwater and is drained by the spiral drain located adjacent to the Museum of Anthropology. The spiral drain is the last structure of its kind in North America. It has been extensively studied and its capacity is well understood having been modeled to have a maximum discharge rate of 3.6 m^3/s. This area has the location of the largest erosion events that have impacted the campus over the past 75 years.

Figure 5 – UBC North Catchment



Following a significant erosion event in 1995 the land around the spiral drain was shaped to provide approximately 4,000 m^3 of detention. A spillway was also constructed to create a defined and reinforced location for the water to be discharged in the event of an overflow while minimizing erosion of the cliffs during such an event.

Discharge from the spiral drain outlet structure is essentially limited to approximately 3.6 m^3/s and is sent directly to the ocean via an outlet structure located at the mouth of English Bay.

Development projects in the academic portion of the campus are not contributing greatly to the total impervious area on the North Campus because most of the developments are brownfield redevelopment of existing sites.

The stormwater model identifies that under a 10-year return storm, there will be small areas with light surface flooding, in keeping with typical municipal practice. In the 100-year return storm, the model predicts significant surface flooding at key points on campus:

- Adjacent to the spiral drain
- South Campus near Wesbrook Mall and Marine Drive
- The intersection of Chancellor Drive and Marine Drive
- The SUB commons

The primary concern is with the protection of UBC building assets and ensuring that UBC's stormwater runoff has minimal effect on the land adjacent to the campus, especially the cliffs in Pacific Spirit Park.

Piping in areas of the North catchment is now undersized for the total quantity of water that must be moved. Storms larger than the 1-in-10-year event will likely cause the drains to back up into the street. The spiral drain is also limited by its capacity and water will back up in the piping upstream from it.

Key areas of focus for mitigation include:

- The area adjacent to University Boulevard and East Mall. Extensive flooding is predicted at this location due to it being the low point for the sewer system in this area of campus. The discharge does make its way to the spiral drain, but the current pipes are undersized to carry the full flow. This area is of particular concern due to its proximity to the UBC Library Rare Book collection in I K. Barber library, the bookstore, and the coolers in the basement of the Biological Sciences complex.
- The intersection of Chancellor Boulevard and NW Marine Drive. This area will see significant flooding resulting in this flow of water travelling down Marine Drive and over the cliffs, or through the Spanish Banks Beaches.
- The low point adjacent to the Museum of Anthropology, around the spiral drain. This low point has been landscaped with berms to contain a 70-year storm event based on an earlier study. A more recent study indicates that the storage volume provided is adequate for a 100-year storm event. Excess stormwater in this area will leave through the existing spillway adjacent to the Cecil Green Park Coach House. This area has been reinforced with plantings that would minimize erosion, but erosion and flooding damage could still ensue.

Other areas are also expected to experience minor flooding in the 100-year storm event.

The spiral drain was built in 1938. It is a concrete lined shaft that descends approximately 60 m below ground level. It has a spiral water chase that allows the water to flow down without the impact consequences of a vertical drop. The structure is currently owned and maintained by Metro Vancouver (Greater Vancouver Sewer and Drainage District). Assessments should be conducted at regular intervals to ensure that the structure is in good condition and to keep up maintenance and maximize the drain's service life. Replacement of the drain would be a complicated and expensive project. A long-term plan will need to be developed to maintain and eventually replace it. It currently sets the capacity rates for discharge for the north campus. The theoretical limit of the campus discharge rate under a 100-year storm is in excess of both the observed and calculated limits of the drain.

Figure 6 – Spiral Drain Shaft Near the Museum of Anthropology

4.2. Mitigation Recommendations

Protecting against future flooding will be done through the intended detention tanks to be built at key locations. To protect against the 1-in-100-year event, large tanks, approximately 1,600 m^3 in volume need to be built adjacent to the SUB near East Mall and upstream of the spiral drain, adjacent to the Rose Garden or the Allard Building. A 1,000 m^3 storage tank will need to be built near the intersection of Chancellor Boulevard and Marine Drive. A risk assessment will also need to be completed to establish the prioritization of smaller detention tanks.

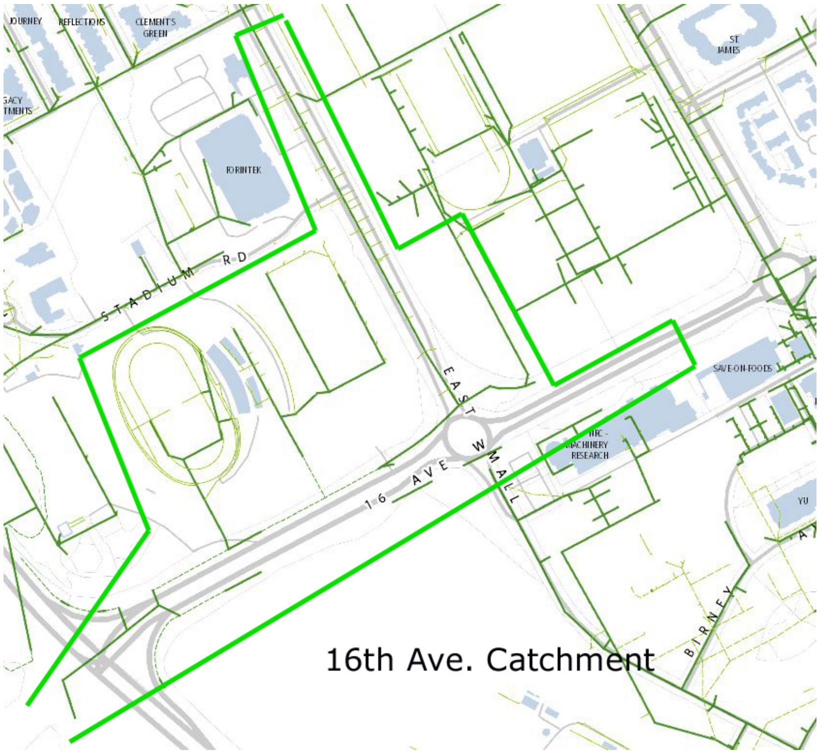
The existing landscaping provides adequate protection for the area around the spiral drain.

The proposed redevelopment of the Acadia Housing area will allow for stormwater controls to be incorporated into the design of that neighbourhood.

16th Avenue Catchment

The 16th Avenue catchment collects the stormwater from Main Mall, south of Agronomy Road, 16th Avenue, west of Wesbrook Mall, a portion of the sports fields (including Thunderbird Stadium) and the Botanical Gardens. The primary discharge point is a seasonal creek located at the cliffs, within Pacific Spirit Park. Some of the drainage from the Botanical Gardens discharges through an adjacent creek.

Figure 7 – 16th Avenue Catchment

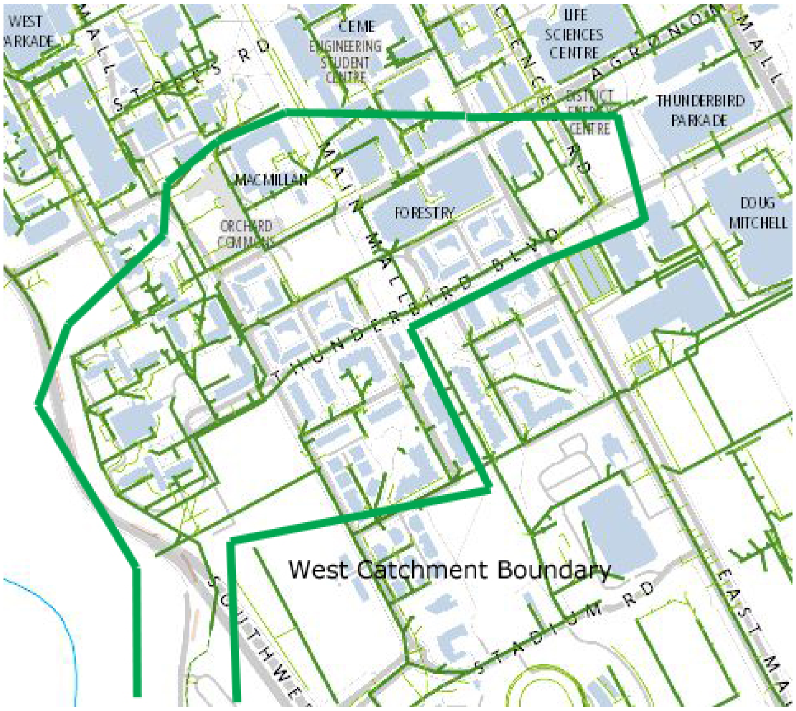


The creek in the Botanical Gardens has recently seen flooding events, but the source of the problem is unclear. The event may have been an outlier, a plugged culvert, or flows that are beyond the current design.

The areas of concern include some flooding of the sports fields but in smaller quantities. A risk analysis will be performed to determine whether there is enough potential damage to warrant mitigation. Given the study's predicted stormwater flood volumes, this is not likely.

There are few long-term consequences to this area at full build-out because there is little change anticipated to the area in terms of stormwater collection. Continued source-point controls will be important for any new development.

Figure 8 – West Catchment



Stormwater drainage for this area is via a creek that runs along the Trail 7 access to the beach. The creek runs adjacent to the stairs to Wreck Beach and is very steep, descending to a number of pools that cascade down to the beach. Base flows appear to be the primary erosive force. A very large event would possibly cause some additional bank erosion, but it is unlikely the till layer would be eroded greatly by larger flows. The sedimentary layers would see the majority of erosion.

This area is well drained and only presents minor flooding (15 m^3 in 24 hours) in a 200-year event.

Given the minor risks, no work is planned for this area.

Few changes are anticipated in terms of the development within this catchment resulting in a stable system for the stormwater catchment.

South Campus

The South Campus catchment drains most of the area south of 16th Avenue, as well as a portion of the Athletic Department's fields and the Hampton and Acadia neighbourhoods. The South Campus drainage system is relatively complex with a portion of the residential component draining into a detention facility in Nobel Park before being released into the UBC storm system. Storm drainage is collected into a single pipe that leaves the campus boundary and discharges to the ditch that runs along the east side of the MOTI Marine Drive corridor. The ditch has a culvert that crosses the driving lanes of the road and discharges the water into Booming Ground Creek. In the event of higher storm flows, approximately 20 per cent of the flows will discharge into an unnamed creek to the north of Booming Ground Creek.

Figure 9 – South Campus Catchment

Booming Ground Creek has a lot of seasonal variation resulting in erosion mainly from base flows. There is some riparian habitat along the creek, but there has been no definite indication of a salmonid population, though there have been some anecdotal reports of trout.

The model predicts that at the built-out phase of this neighbourhood there will be minor flooding at Wesbrook Mall and Marine Drive in a 10-year event. The 100-year event would generate significant flooding at this intersection as well as adjacent to the east side of TRIUMF. The ditches along Marine Drive are predicted to handle the flows, but the culvert that crosses the road is the limiting infrastructure and has potential for back-ups. This infrastructure is owned and operated by MOTI.

In order to minimize the risk of overland flows crossing Marine Drive and running uncontrolled over the cliff face, it is recommended that detention be built adjacent to Wesbrook Mall and Marine Drive. A detention facility may need to be sized in such a way that the release rate for a larger storm is limited to the culvert limit. The tank will need to detain 2,500 to 3,000 m^3 of water, while limiting the release rate to approximately 1.2 m^3/s.

The continuing development of the TRIUMF site will allow for the incorporation of some stormwater control measures in order to upsize some of the piping and provide some detention for the area.

The Acadia residential area is also predicted to have some flooding during a significant event. This area is scheduled to be redeveloped and measures can be put into place at that time.

4.3. Stormwater Quality

Stormwater can seep into the ground, pond on the ground's surface, or travel over land into catch basins and stormwater pipes and/or streams. As this water comes into to contact with different materials, it can transport contaminants or absorb them.

The majority of UBC's stormwater is runoff from the streets and sidewalks. The roads provide the majority of contaminants. These include sediments from road wear as well as from nearby construction sites. Metals and metal dust come from the passage of vehicle traffic and there is also the potential for hydrocarbons to be mixed with the stormwater, coming from asphalt and some vehicles.

Results of stormwater contaminant testing indicated the presence of sediment and metals, including lead, zinc, iron, manganese, and others in trace amounts. No detectable levels of hydrocarbons were found at the various test points in part due to low vehicle traffic on campus and the absence of fresh paving.

There have been occasions where the quality of the water entering the storm system was not appropriate for discharge. Unauthorized discharges have been the two most significant causes of water quality problems for the stormwater system.

In response, UBC has given the RMS Environmental Services group the responsibility of tracking and monitoring the use and disposal of products used in campus operations. They are tasked with ensuring that water discharges are directed to the correct disposal method. In order to manage construction sediment, the University has created a program administered by Campus and Community Planning that requires new developments on campus to create sediment control programs that include wheel well washes, filters on catch basins, and sediment removal prior to discharge. Monitoring and testing is also required as part of the permitting for sediment control. The site inspector for the campus regularly visits sites and notes to the contractors and the project managers any concerns with regards to discharge form the sites.

Currently, UBC is operating the stormwater system much the same way as any other Lower Mainland municipality. The introduction of detention tanks to handle the campus system's storm discharge allows for all the water on campus to be controlled in a manner that minimizes deleterious effects on

UBC's neighbours. Detention tanks will also allow for the introduction of oil/grit separators upstream of the tanks. The separators will provide a primary level of treatment to remove sediment and metals from the discharge and will also reduce how often staff will need to enter the confined space to clean out silt and sediment from the large tanks. The separators would have the greatest effect on the more frequent, low rainfall storms. Larger events would overwhelm the interceptors, so an overflow would be required during significant events.

Future stormwater management planning should investigate strategic interventions that will contribute to regenerative design on campus, which identifies how a natural systems approach to achieve pre-development conditions that reduce the long term need for "grey infrastructure" through integrated storm water management practices which also helps to improve water quality before entering into receiving bodies.

As the campus develops, there may be opportunity for faculty and students to identify innovative water quality, stormwater control, or green building projects that would incorporate well into the concept of managing and improving the stormwater on campus. The Living Lab concept will allow more experimental projects to move forward and the Sustainability Street project is an early example of what is possible.

4.4. Climate Change

According to the International Panel on Climate Change human actions are influencing climate patterns and impacts associated with climate change, particularly with stormwater, are posing risks for human and natural systems. Currently, there are at least seven climate models that predict a variety of effects and they are increasingly being refined. For example, in 2000 Metro Vancouver completed a study that predicted that the year's rainfall would increase by 10 to 30 feet with little increase in the summer (Taylor, 2000). Similarly, a 2007 study predicted a four to 14 per cent increase for that winter and 14 to 33 per cent decreases in rainfall for that summer, with the annual average change being an increase of one to five per cent over the next 50 years.

The most recent report from the Pacific Climate Impacts Consortium (Georgia Basin, Projected Climate Change, Extremes, and Historical Analysis, June 2012 – Murdock, Sobie, Ecklund (UVic) and PCIC) is predicting a six per cent increase in annual rainfall with five to 15 per cent reductions in summer rainfall and increases of winter rainfall of up to 16 per cent over the next 50 years.

> *"In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality"*
>
> *(Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/ar5_wgII_spm_en.pdf)*

Forecasts suggest that the 10-year storm will become more frequent, requiring adaptation to a more intense 10-year storm by 2050.

Because this is a gradual change in environment and the infrastructure that drains the campus is replaced over time, there is ample opportunity to reassess capacity as we approach the mid-century mark. Existing stormwater infrastructure on campus is adequate for current 10-year events and for some rainfall levels beyond that, except for areas that have been identified for detention tanks. Resizing pipe for 100-year events will be based on risk analyses of the consequence of flooding for certain areas.

4.5. Stormwater Monitoring

In the past UBC has monitored the discharges from the campus through programs that were, unfortunately, inconsistently and irregularly run.

Quantity and quality of the discharge are two key elements to monitoring. In order to measure the quantity of water leaving the campus, weirs must be established that have a known profile. This will allow the quantity of water passing over the weir to be measured by the height of the water above the weir notch. Data from the weirs can be collected continuously and stored for future use in calibrating the model and ensuring that the predicted situations are lining up with reality.

Water quality measures a number of different factors, some of which can be measured continuously using electronic instruments, while other contaminants must be collected and tested individually using an analytic laboratory.

Flow-volume monitoring is beneficial in that it provides the ability to verify that models are reasonable approximations of conditions on campus. Continuous monitoring of some water quality factors provides information about when an event occurs. If the data is transmitted live, it gives instant alarms so that the source of an event can be identified and the situation stopped.

Grab samples provide general, seasonal information on the nature of contaminants in the water. It is not currently a regulatory requirement and it is unknown which contaminants UBC will be required to monitor. We recommend sampling for the contaminants that are currently identified in the draft Water Act regulations. Once draft regulations are formalized, requirements for monitoring will be clear.

Flow volumes can also be monitored intermittently in order to collect data during a particular rainy season to ensure that the model is well calibrated.

The University currently plans to re-establish stormwater monitoring with electronic monitoring equipment. The weirs for measurement will need to be re-established in some of the catchments with more permanent installations. Data to be collected includes: flow volume, temperature, pH, turbidity and conductivity. These parameters can be used to identify events in which stormwater meets the Water Act requirements and to track them to their source.

Seasonal sampling of stormwater will, under this plan, also occur in summer and winter in order to characterize each contaminant in the water. Through seasonal sampling, a base line can be established to help determine other measures that may be needed for maintaining stream health.

4.6. Stormwater Management Practices for Development

UBC has made the Stormwater Quality and Quantity credit a requirement for achieving LEED Gold for buildings on campus. Infrastructure planning has also been asking that developments detain the 10-year storm on site with the discharge operating at the two-year flow rate. For sites that were previously developed, the request included a 50 per cent reduction in flows from the previous state.

The LEED Gold requirement helps UBC ensure that buildings on campus are sustainably constructed and provide low long-term operating costs. There is an opportunity to relieve UBC developments from the 10-year storm detention if the large facilities are upgraded to include for development detention volumes. This would require an increase in the size of the tanks by approximately 50 per cent. It may also require that smaller facilities be built within the catchments to moderate the flows.

Stormwater management tools that are available at the larger public realm scale are detailed in Appendix 1. Newer tools should also be brought forward for consideration. Buildings on campus should include aggressive stormwater management strategies in order to meet or exceed the LEED and REAP requirements.

5. Summary

Funding for the stormwater management program will be generated primarily from IIC funds resulting from development. This plan sets forward a conceptual change from a flows-and-pipes approach to an integrated management approach. Presented here is a concept that addresses storm water with multiple strategies at the building, site, and catchment scales. A key intervention is to address large storm events through retention and detention facilities. UBC has the option to build large, underground storage tanks or a retention pond at the southern wedge of the south campus identified as UBC Building Operations Support Area in Map 2-1 in the UBC Vancouver Campus Plan. Once the retention facilities reach capacity, stormwater is released at rates that minimize the erosion on the streams that travel through Metro Vancouver and MOTI lands.

Figure 10 – Detention Tank Concept

Facilities will be built as opportunities arise and funding permits. It is recommended that the first of three tank systems be built at the new plaza and East Mall, on the west side of the new SUB. Planned redevelopment of the plaza offers an opportunity for establishing the tank. An opportunity for building a second tank system comes with the development of a proposed roundabout at the intersection of Chancellor and Marine Drive. The third tank would be built at the south end of Wesbrook Mall, near Marine Drive. The current containment at the spiral drain is adequate, but future detention may become necessary at a later date.

The detention facilities have been envisioned as underground tanks, but other options are available if future projects allow for dry ponds, larger stormwater pipes, etc. The projects will be brought forward through the UBC development processes prior to construction.

Figure 11 – Sample of a Dry Pond

Appendices

Appendix A: UBC Staff – Technical Appendices (2013)

Best Management Practices for Stormwater Systems

This document is based on reports about the UBC Vancouver Campus stormwater system and the Infraguide reports on best management practices for Canadian Utilities.

Principal drivers for the stormwater system at UBC have been the prevention of flooding and minimization of cliffs erosion in Pacific Spirit Park. In the past, UBC has completed works on and off campus to improve the effects of stormwater discharge from the campus on adjacent properties. Significant effort was made to minimize the erosive effects that the campus discharges contribute to. A 2010 erosion survey that reviewed a five-year period indicated that current erosion levels are acceptable, but increases in flows would likely accelerate some erosion.

Integrated Stormwater Management (ISM) is a B.C.-led practice intended to manage runoff in a manner that protects the natural and built environments. ISM principles are:

- Stormwater is to be protected as a resource
- Design is not just for a worst-case scenario but also shows understanding of the average and minimal events as well
- Base flows of a watershed must be maintained
- Planning must be completed for all levels (watershed/sub-watershed/neighbourhood/building site)

Integrated planning for stormwater looks at impacts from development and mitigates them at the source. Stormwater systems can no longer function solely on the basis of providing fast conveyance of the water. Land use planning, as well as environmental science are to be used to support the goals of the plan.

ISM planning also provides for adaptive management with the best available knowledge to be used to produce the best available designs. The system must be monitored with respect to predicted outcomes and elements may require alteration if the predictions are not met.

The financial viability of an ISMP must be based on life-cycle costing. Deficiencies and flaws are to be corrected before the system is fully turned over to the owner. Funding must be available for appropriate operations and maintenance. Additionally, the life-cycle replacement of the system must be accounted for in system funding.

Planning

Stormwater mitigation should be applied to sites that change the total impervious area (TIA) by more than 10 per cent. A site's geology influences the design, plans, and implementation of such mitigation. This is particularly true for the UBC Vancouver campus.

Recommended system design captures and stores small events, returning some or all of the water to the ground. Medium sized events should be detained. Outlier events, such as 100-year or 200-year storms, are to be conveyed overland.

It should be noted that during construction, a site should be rigorously controlled for its quantity and quality of discharged water.

The UBC Vancouver campus does not have a single watershed but four small watersheds that service the area. Each of the watersheds has neighbourhoods and individual sites that can be planned to regulate stormwater in a way that achieves the University's goals.

On-Site Controls

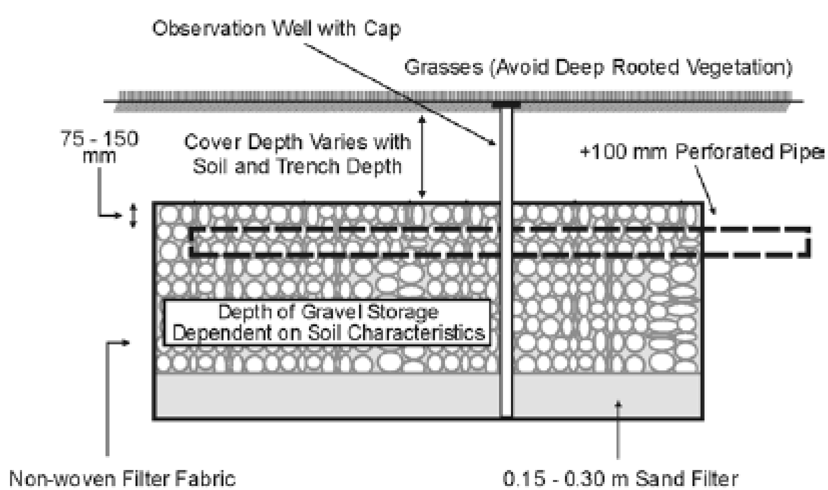
Beginning with the smallest catchment, a building site, there are a number of best management practices (BMPs) that mitigate the generation of stormwater. The list of BMPs below includes all of those in the Infraguide series, but due to UBC's concern with shallow groundwater recharge some are not appropriate for this environment.

1. Controlled lot grading ensures lot grades are less than two per cent except within 2 m of the building. This practice allows more runoff to be absorbed by the ground. This is an option for properties that are further from the cliffs.

2. Surface ponding in parking lots allow for some flooding of parking lots as a detainment tool.

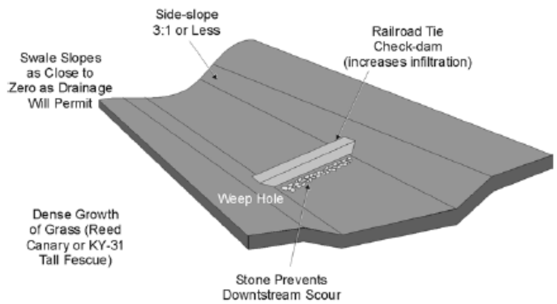
3. Roof top ponding uses a roof as a detainment option. A subset of this could be a green roof.

4. Infiltration systems provide a number of systems available to percolate water into the ground. This is not an option that can be used extensively on campus.



5. Super pipe storage uses an oversized pipe to act as a detention vessel, which could be a useful tool on campus.

6. Grassed swales slow the flow of water and allow for some contaminants to be removed. There is some percolation from these structures and they do require some area to be built in.



(b) Source: Scheuler (2000)

7. Filter strips are planted segments that surface runoff flows through. There is some removal of contaminants and some slowing of flows.

8. Buffer strips are used where surface runoff directly enters the water body

9. Oil/Grit separators are structures of varying size that remove larger sediments from the stormwater flow as well as removing oils and volatile compounds.

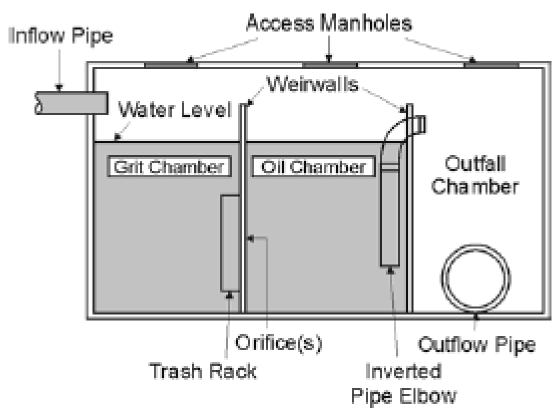


Figure 3–6: Three-chamber oil/grit separator
Source: Jaska (2000).

10. Porous pavement includes pavers or concrete systems that allow for the percolation of water into the ground.

Due to concerns about erosion at the cliffs being caused by increasing the flow of water through the shallow soil strata underneath the campus, the various methods of infiltration should be avoided.

System Controls

Once stormwater has entered the drainage system, it will make its way to the discharge point. There are a number of options available to affect how these flows are sent to the receiving water body.

Current BMP is to handle runoff and capture stormwater at 50 per cent of the two-year, 24-hour storm. Flow is to be controlled to this rate but released at the pre-development rate. Water quality enhancement measures will be designed to treat the six-month storm. Minor storms are considered to be either the five-year or 10-year storm, while the major storm is designed for the 100-year return storm.

Only a few of the BMP measures are available to UBC because most deal with creek enhancement and rehabilitation or deal with infiltration of stormwater into the ground. Measures not available to the University are: storm corridors, channel modificaiton, bank protection, infiltration basins, sand filters, pervious pipe, and pervious catch basins.a

Measures applicable to UBC include:

- Ditches designed to store some flows and provide some treatment.
- Swales to slow flows. They do not provide much storage.
- Inline/Offline storage of stormwater through the use of oversize tanks and pipes while it is being released at a slower rate than the rate of collection. This will likely be a principal tool for UBC's ISMP.
- Real-tme control, which refers to an active SCADA (supervisory control and data acquisition) system that would allow pumps and valves to dynamically respond to demand in real time. SCADA systems are expensive and require monitoring and expertise.
- Wet ponds, which are often large ponds that provide some storage and are wet year round.
- Dry ponds – a pure storage installation, similar to offline storage.
- Creating constructed wetlands that provides stormwater storage, treatment, and infiltration. Constructed wetlands demand significant land area.
- High rate treatment for water quality.
- Screening (through mechanical screens) to remove large particles from the water.
- Oil/Grit separators to remove sediments, oils, and volatile compounds from stormwater. These should be examined for use close to large concentrations of vehicles.

The primary objective of planning to manage stormwater on campus is to detain flows, creating a release rate that does not overly burden the creeks and outfall structures that do not belong to UBC. An additional concern is minimizing the infiltration of water into the shallow soil layer below campus in order to reduce erosion of the cliff faces.

UBC has already implemented some work using best management practices. The University uses ditches and swales to control some stormwater discharge. As part of the development of the southern portion of the campus, a large detention tank has been constructed that detains the 100-year storm event from the residential component of the southern catchment. New requirements have also been made of new projects to detain the 10-year storm and release it at the two-year pre-development rate.

Primary tools that should be used include large volume storage tanks, installing larger pipes where appropriate, and ditches and swales for areas where the discharge is not as critical. Possible use of oil/grit separators should be explored in conjunction with the storage tanks to minimize the amount of contaminants that are discharged to the adjacent water bodies.

Volume Reduction Tools

The amount of stormwater that reaches the stormwater system can also be reduced. As noted above, infiltration is a form of volume reduction. For both the development sites and the larger systems, there are practices that can reduce stormwater discharge.

Absorbent Landscaping

For all new landscaping works and existing landscaped or grassed areas, the installation of a minimum of 450 millimetres of absorbent topsoil would provide a significant amount of water absorption.

Rainwater Re-use

It is also possible to use stormwater for irrigation or non-potable uses, however, regulatory requirements must be met to do so. Different levels of water treatment are required for depending on how the water will be used. This is a strategy that requires a review for cost-effectiveness.

Stormwater Quality at UBC

Regulatory Environment

The regulatory environment for monitoring the quality of stormwater is in currently in flux. At present, most concerns are handled through Provincial guidelines.

No legislation currently exists that deals directly with stormwater management for municipalities. Rather, there are several legal documents that have varying degrees of relevance for different areas of stormwater management:

1. The *Fisheries Act* is enforced by the Department of Fisheries and Oceans (DFO) and allows the federal government to regulate what is discharged to a water body that contains fish and to regulate the human effects on lands adjacent to fish-bearing water bodies. This is the strongest legislation that can come to bear on a stormwater discharge. The act does not allow for any unpermitted deleterious substance to be released to a fish-bearing stream or a body of water that feeds a fish-bearing area.

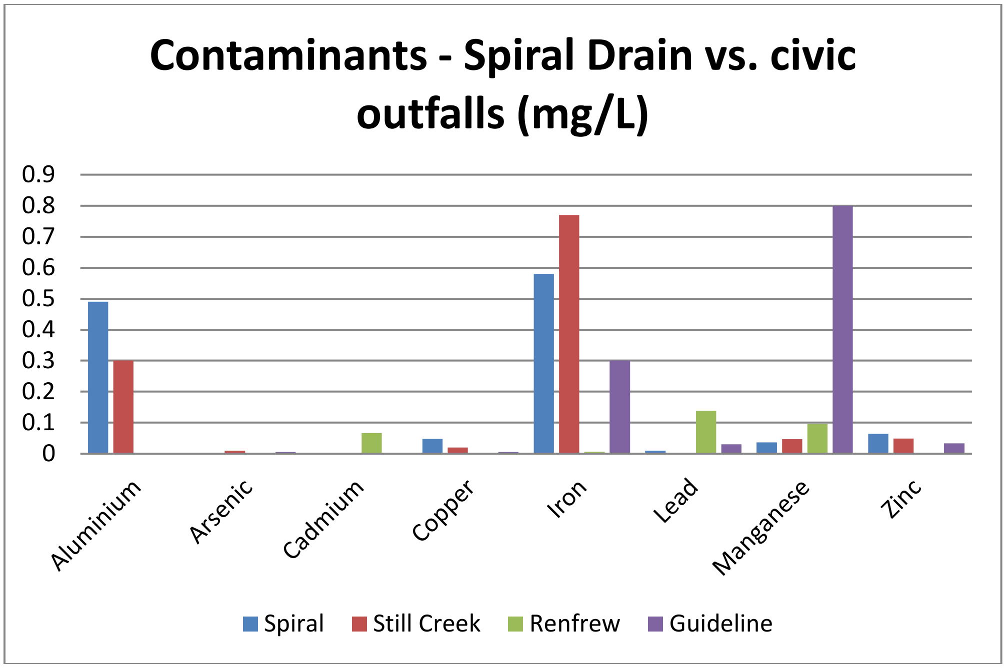
2. The *Canadian Environmental Protection Act* regulates the disposal of waste including ocean dumping and is more focused on solid waste disposal than stormwater discharge.

3. The *Water Act* is a Provincial act that prohibits polluting water bodies within the province. It is enforceable for the UBC Vancouver campus. New legislation is being drafted with a greater emphasis on water protection. Current *Water Act* concerns are around the protection of drinking water sources and minimizing the chances of drought. The last update to the review process has indicated that the review is at stage three of four, drafting the new law.

4. From this work, the Province is creating guidelines for individual contaminants. But they are not legal limits at this time. These are being compiled into the BC Water Quality Guidelines for which there is an approved 2006 document and a new revision is currently in draft.

5. The *Environmental Management Act* is provincial legislation that regulates direct discharges to streams from industrial and municipal sources. The *Environmental Management Act* requires planning for air quality controls, flooding controls, water resource planning, and solid waste management.

Metro Vancouver has created the Integrated Liquid Waste and Resource Management Plan (ILWRMP) to provide a cohesive legal framework for bylaws and system planning. Metro Vancouver's member municipalities are using this as a framework for their ISMPs. This document is primarily concerned with sanitary waste, but does address stormwater issues. Though the University is not a municipality, it has committed to the creation of an ISMP that addresses the key goals of the ILWRMP.



Typical contaminants from the Spiral Drain (1999-2009)

UBC's stormwater discharges resemble those of Lower Mainland municipalities. The chart above notes the metals levels in UBC's outfalls and compares them to stormwater found in the Still Creek and Renfrew stormwater systems. (Proposed provincial guidelines are also shown above for reference.)

The vast majority of contaminants of concern in an urbanized setting are metals, oils, and greases that are introduced into the environment by vehicle traffic..The sediments that collect on the roads include the vehicle contaminants as well as soil and grit from the local environment. Rain events then wash these contaminants into the storm system and eventually to the ocean. The worst contaminant event is the first heavy rainfall after a protracted dry period. In this event, a build-up of material is washed into the storm system over a relatively short time. Once this first flush occurs, the levels of contaminants moderate over the rainy season.

Current Practices

In the Lower Mainland, stormwater quality is complicated by the naturally occurring groundwater, which does not meet selected water quality guidelines (e.g. for dissolved iron). Because this water also enters the storm system, meeting for many municipalities is difficult.

The Lower Mainland is heavily urbanized and the nature of stormwater is greatly influenced by contaminants delivered via road drainage. Such contaminants are particularly difficult to deal with because they are not from a single point. Discussion is under way about requiring manufacturers of wear-and-tear vehicle parts to use components that do not contain as many dangerous metals, but there is no imminent progress on this issue. Few Lower Mainland municipalities have regular sampling programs for their stormwater discharge. Only combined sewer overflows in Vancouver are regularly monitored by Metro Vancouver and results are reported via the Vancouver Coastal Health Authority.

Municipalities have been proactive on point sources of contaminants, i.e. businesses and construction sites. UBC has also been very active with the creation of the Environmental Health and Safety Office to monitor the environmentally related activities (particularly waste disposal) of academic buildings and campus operations, as well as establishing a construction sediment management program that is implemented during the development process.

The University has run a number of stormwater sampling programs in different locations, at different times, measuring different parameters. Some of this sampling has identified practices that needed to be changed, but these are relatively rare occurrences. As seen in the chart above, the quality of the discharged stormwater is generally good. The Environmental Health and Safety Office has been successful in addressing these concerns with the occupants of the facilities involved.

Results from the tests indicate that the quality of stormwater from the campus is little different than the stormwater quality from the adjacent municipalities. Iron content in the water is naturally present and there is little oil and grease in the discharge. The source of the majority of the contaminants is vehicle traffic and sediment from construction and natural sources.

Water Quality – Moving Forward

In the past, water quality parameters have been measured at a variety of locations, some within, but many outside of the campus boundary. The University's current approach is to deal with stormwater management issues on site (within the campus boundary).

The ISMP will need to identify a location for each of the discharge points where the stormwater leaves campus lands. These locations should be close to the boundary and be reasonably easy to access.

UBC Vancouver has two programs in place to ensure that the harmful substances are not released into the stormwater system. The first program, operating through the Environmental Health and Safety Office, monitors all internal campus operations to ensure that waste from operations is disposed of properly, which includes ensuring that waste is not discharged to the stormwater system unless allowed to by regulations. The second program, run by Campus and Community Planning Construction Sediment Control, requires that developments on campus minimize the amount of dust and grit deposited on the roads and into the sewers. Typically, excavations have wheel-well washes to reduce dust and dirt dragged onto the street. Filters are also installed on the storm drain catch basins in order to reduce the amount of silt that might enter the sewer.

Where space allows, swales and rain gardens can be used to provide some bio-filtration of stormwater prior to it entering the stormwater system.

The installation of grit/oily water separators is recommended upstream of any large detention tanks in order to make future maintenance simpler and allow for easier disposal of the contaminants from road runoff.

A stormwater quality monitoring program will be developed as part of the implementation plan for UBC's ISMP. The program will involve the regular sampling of the outfalls to determine the nature and quantities of the components of the stormwater.

Future Considerations

With the applicable legislation and regulations currently in flux, it is recommended that water quality efforts be reviewed every five years to ensure that UBC's program conforms to the requirements set in place by the Provincent.

Appendix B – Reference Reports

1. Aecom – UBC Hydrogeologic Stormwater Management Strategy (2013)
    - Reviews potential for using wells as a key component of UBC's ISMP

2. GeoAdvice – Phase 1 – Model Update and Calibration of the University of BC Stormwater Collection System (2013)
    - Updates UBC's stormwater model for use in determining standards necessary for UBC to meet its stormwater management objectives

3. GeoAdvice – Phase 2 - UBC's Stormwater Detention and System Optimization Analysis (2013)
    - Foundation for UBC's ISMP – setting Stormwater Criteria