University Endowment Lands

Integrated Stormwater Management Plan
Stage 3 Report

Prepared by:

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Project Number:

60222155

Date:

May 19, 2017

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May 19, 2017

Jonn Braman
Manager
University Endowment Lands
5495 Chancellor Boulevard
Vancouver, BC V6T 1E3

Dear Jonn:

Project No: 60222155
Regarding: Integrated Stormwater Management Plan Stage 3

Please find attached our DRAFT report for Stage 3 of the UEL ISMP. Please let me know when you are available to discuss this report.

Sincerely,
AECOM Canada Ltd.

Graham Walker
Project Manager
Graham.walker2@aecom.com

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AECOM Signatures

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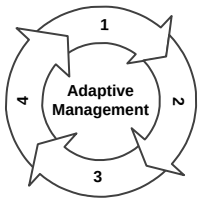
1. Introduction

The UEL has retained AECOM Canada Inc. to develop an Integrated Stormwater Management Plan (ISMP) in line with the requirements of Metro Vancouver's Integrated Liquid Waste and Resource Management Plan (ILWRMP) and British Columbia's Environmental Management Act. The development of the ISMP is separated into four stages and is based on the approach outlined in Chapter 9: Developing and Implementing an ISMP in Stormwater Planning: A Guidebook for British Columbia.



The ISMP contains long-term goals and objectives that have a planning horizon of up to 30 years. Changes in factors such as the economy, technology, policy, land-use and public opinion over the long term horizon can be addressed through an Adaptive Management approach in which the ISMP is periodically updated to ensure that it remains relevant and applicable. The adaptive process is iterative - 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.

Table 1: Summary of the 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

1.1 Stormwater Management Vision and Goals

In Stage 2 of the Integrated Stormwater Management Plan, the UEL and the key stakeholders (Metro Vancouver, City of Vancouver, Spanish Bank Streamkeepers, the University Golf Course, and the University of British Columbia), established five (5) goals to guide stormwater management for the UEL:

Goal 1: The UEL community is engaged in stormwater management.

Goal 2: Healthy streams and a natural environment are a part of the UEL.

Goal 3: Stormwater infrastructure provides an adequate level of service, while protecting life and property.

Goal 4: The UEL provides guidelines and a regulatory framework for stormwater management.

Goal 5: Stormwater management at UEL adapts to change.

These goals were established to achieve the vision of "*A stormwater management plan that protects the natural and built environment through enhancement of natural watercourses, and provides opportunities for collaboration and engagement with the community and residents on stormwater issues*".

This Implementation Plan document identifies opportunities to develop planning, environmental and engineering controls that would allow the UEL achieve its vision and goals. Where applicable, this plan identifies potential capital and maintenance costs.

2. Stormwater Management Plan Action Items

The following action items were identified and are proposed in order for the UEL to meet the goals and vision set out during the stormwater visioning process.

1. Promote stormwater management awareness and engagement opportunities (**Goal 1**).
2. Continue with the combined sewer separation strategy in Area B (**Goals 2 and 3**).
3. Manage the quantity of road runoff (**Goal 2**).
4. Treat stormwater runoff from the roadways and upgrade stormwater treatment at the UEL Works Yard (**Goal 2**).
5. Identify stormwater infrastructure that is poorly located for maintenance and develop plans for management or replacement (i.e. the 300mm diameter storm sewer in Pacific Spirit Park east of Acadia Road) (**Goals 3 and 5**).
6. Continue to upgrade system capacity and renew aging infrastructure in a proactive manner through the capital planning process (**Goal 3**).
7. Develop mitigation measures to address slope stability in Area B (**Goal 3**).
8. Integrate stormwater asset maintenance with work order management using a GIS-centric system (**Goals 2, 3, and 5**).
9. Develop Erosion and Sediment Control requirements (**Goals 2 and 4**).
10. Limit the rate of stormwater runoff from private properties (**Goals 2, 3, and 4**).

In addition to the above listed action items, Appendix A of this report provides Best Management Practices (BMPs) for stormwater management on single-family residential lots to help support Action Item #10.

The following section of this report provides details regarding the action items outlined above.

Action Item #1: Promote stormwater management awareness and engagement opportunities

One of the goals of the UEL ISMP is to increase awareness of stormwater management and stormwater related issues at the UEL (**Goal 1**). This can be achieved through support of education and community engagement efforts within the UEL that focus on stormwater management. The Spanish Bank Streamkeepers currently provide community engagement and volunteer opportunities. The UEL should promote such Streamkeepers activities and collaborate on stream related projects where possible.

To increase public awareness of stormwater issues, the UEL should:

- Promote and encourage support for Streamkeepers activities and volunteer opportunities on the UEL's website and newsletter.
- Provide a link to the Streamkeepers webpage on the "Links" page of the UEL website.
- Future ISMP iterations should identify opportunities for collaboration on stormwater management with the University Golf Course and Pacific Spirit Park Society.

To increase capacity of understanding and sharing of knowledge of stormwater management, the UEL should:

- Retain all stormwater related reports and results of studies on record.
- Allow key stakeholders to submit studies, reports, and other stormwater related findings and retain copies on record.
- Strive to achieve an easily accessible repository of stormwater information.
- Allow access to stormwater related studies, reports, and findings to key stakeholders.
- Work towards creating an Environmental page or tab on the UEL website that provides access to the above mentioned reports, studies, and findings.

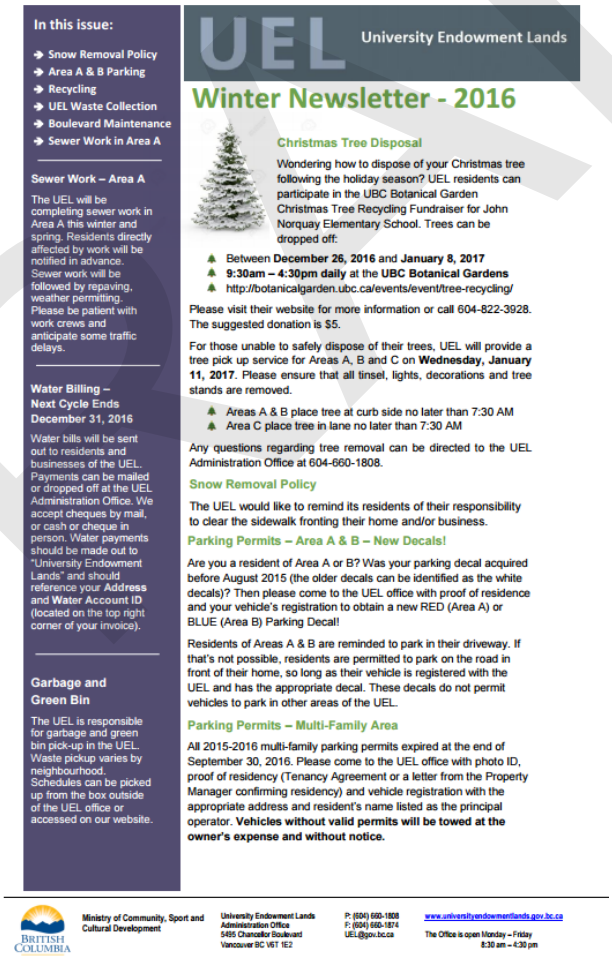
Cost

There is no capital cost associated with this Action Item. The Streamkeepers are a volunteer organization. The support of the Streamkeepers' activities does not go beyond the regular UEL commitment and cost (staff time) of maintaining content on the website and generating the newsletter.

Implementation Considerations

In order to better liaise with the Streamkeepers, the UEL should have a Stormwater Champion who would act as a point of contact. A Stormwater Champion should be a UEL staff member who is directly involved in stormwater projects at the UEL.

Figure 1: In-stream Chum salmon incubation at Spanish Bank Creek, Spanish Bank Streamkeepers January 2017



In this issue:

- Snow Removal Policy
- Area A & B Parking
- Recycling
- UEL Waste Collection
- Boulevard Maintenance
- Sewer Work in Area A

Sewer Work – Area A

The UEL will be completing sewer work in Area A this winter and spring. Residents directly affected by work will be notified in advance. Sewer work will be followed by repaving, weather permitting. Please be patient with work crews and anticipate some traffic delays.

Water Billing – Next Cycle Ends December 31, 2016

Water bills will be sent out to residents and businesses of the UEL. Payments can be mailed or dropped off at the UEL Administration Office. We accept cheques by mail, or cash or cheque in person. Water payments should be made out to "University Endowment Lands" and should reference your **Address** and **Water** Account ID (located on the top right corner of your invoice).

Garbage and Green Bin

The UEL is responsible for garbage and green bin pick-up in the UEL. Waste pickup varies by neighbourhood. Schedules can be picked up from the box outside of the UEL office or accessed on our website.

UEL University Endowment Lands

Winter Newsletter - 2016

Christmas Tree Disposal

Wondering how to dispose of your Christmas tree following the holiday season? UEL residents can participate in the UBC Botanical Garden Christmas Tree Recycling Fundraiser for John Norquay Elementary School. Trees can be dropped off:

- Between **December 26, 2016** and **January 8, 2017**
- **9:30am – 4:30pm daily** at the **UBC Botanical Gardens**
- http://botanicalgarden.ubc.ca/events/event/tree-recycling/

Please visit their website for more information or call 604-822-3928. The suggested donation is $5.

For those unable to safely dispose of their trees, UEL will provide a tree pick up service for Areas A, B and C on **Wednesday, January 11, 2017**. Please ensure that all tinsel, lights, decorations and tree stands are removed.

- Areas A & B place tree at curb side no later than 7:30 AM
- Area C place tree in lane no later than 7:30 AM

Any questions regarding tree removal can be directed to the UEL Administration Office at 604-660-1808.

Snow Removal Policy

The UEL would like to remind its residents of their responsibility to clear the sidewalk fronting their home and/or business.

Parking Permits – Area A & B – New Decals!

Are you a resident of Area A or B? Was your parking decal acquired before August 2015 (the older decals can be identified as the white decals)? Then please come to the UEL office with proof of residence and your vehicle's registration to obtain a new RED (Area A) or BLUE (Area B) Parking Decal!

Residents of Areas A & B are reminded to park in their driveway. If that's not possible, residents are permitted to park on the road in front of their home, so long as their vehicle is registered with the UEL and has the appropriate decal. These decals do not permit vehicles to park in other areas of the UEL.

Parking Permits – Multi-Family Area

All 2015-2016 multi-family parking permits expired at the end of September 30, 2016. Please come to the UEL office with photo ID, proof of residency (Tenancy Agreement or a letter from the Property Manager confirming residency) and vehicle registration with the appropriate address and resident's name listed as the principal operator. **Vehicles without valid permits will be towed at the owner's expense and without notice.**

BRITISH COLUMBIA

Ministry of Community, Sport and Cultural Development

University Endowment Lands Administration Office
5495 Chancellor Boulevard
Vancouver BC V6T 1E2

P: (604) 660-1808
P: (604) 660-1874
UEL@gov.bc.ca

www.universityendowmentlands.gov.bc.ca

The Office is open Monday – Friday
8:30 am – 4:30 pm

Figure 2: University Endowment Lands Newsletter, December 2016

Action Item #2: UEL continues to implement its combined sewer separation strategy

Combined sewers convey wastewater (e.g. from toilet flushing) along with stormwater runoff in one single pipe. This combined flow is then conveyed to Metro Vancouver's Iona Wastewater Treatment Plant. During large storms, the capacity of the combined sewer system and/or Wastewater Treatment Plant may be exceeded, resulting in combined sewage overflowing into large receiving bodies (i.e. combined sewer overflows into English Bay and the Fraser River) with the potential for sewage backing up into basements in low lying areas if there isn't a properly operating backflow device. To reduce the risk of combined sewer overflows and basement flooding, municipalities within Metro Vancouver that have combined sewers are working towards replacing them with separate storm and sanitary sewers.

Another benefit to replacing combined sewers with separate storm and sanitary sewers is that stormwater runoff can then follow its natural drainage pathways and contribute to local streams. However, due to increased imperviousness of the watershed, the natural flow regime of the stormwater runoff is altered and stormwater BMPs should be considered in conjunction with sewer separation to manage the quantity and quality of stormwater runoff before it is conveyed to local streams.

The UEL is currently in the implementation phase of the separation of its remaining 4 km of existing combined sewers within Area B. This sewer separation strategy falls in line with the goals identified in the UEL ISMP visioning consultations; namely: to maintain healthy streams and a natural environment; and to protect property (**Goal 2 and Goal 3**). One of the objectives of the combined sewer separation strategy is to eliminate stormwater from entering Metro Vancouver's wastewater system by providing dedicated sanitary and storm sewers. The following table presents the timelines of projects identified as part of the Area B storm/sanitary sewer separation strategy as identified in the Capital Plan 2015 Update.

Table 2: Combined and Storm Sewer Capital Projects for Area B - 2015 Update

Project No	Asset Class	Project Type	Project Description	Location	Project Cost	Status
2014-04	Combined	Planning / Design	Design of Combined sewer separation on Wesbrook Cres (N/ Chancellor)	Wesbrook Cres (Area B)	$25,000	Complete
2014-17	Combined	Planning / Design	Design of Combined sewer separation on Acadia Rd (N/ Chancellor Blvd)	Acadia Rd (Area B)	$30,000	Complete
2014-18	Combined	Planning / Design	Area B Combined Sewer Separation Strategy	Area B	$8,000	Complete
2014-25	Various	Planning / Design	Design of Water, Sewer and Road replacement on Newton Wynd (W/ Acadia Rd)	Newton Wynd (Area B)	$25,000	Complete
2015-02	Various	Construction	Construction of stormwater/sanitary sewer separation on Wesbrook Cres (N/ Chancellor)	Wesbrook Cres (Area B)	$352,331	Complete
2018-01	Combined	Construction	Construction of Sanitary / Stormwater sewer separation on Acadia Rd (N/ Chancellor Blvd)	Acadia Rd (Area B)	$682,666	-
2019-03	Storm	Construction	Design and Construction of Storm sewer on Western Cres and Kingston Rd (B/W Chancellor Blvd and Acadia Rd)	Western Cres, Kingston Rd (Area B)	$346,500	-

Project No	Asset Class	Project Type	Project Description	Location	Project Cost	Status
2020-03	Combined	Construction	Design and Construction of Sanitary / Stormwater sewer separation on Chancellor Blvd (bet. Western Cres and Acadia Rd)	Chancellor Blvd (Area B)	$303,600	-

Cost

A portion of the total capital costs associated with the combined sewer separation strategy have been included as part of the 10-year Capital Plan. Table 2 provides cost estimates for proposed sewer separation in Area B. By scheduling the sewer separation projects at the end of a combined sewer's life (i.e. when the pipe needs to be replaced in any case due to anticipated failure), the actual cost of sewer separation can be minimized.

Implementation Considerations

Because of the increase in "hard surfaces" (or imperviousness) at the UEL in comparison to pre-developed conditions, the stormwater that is returned to the creeks after combined sewer separation shall meet the quantity and quality recommendations set by Canada's Department of Fisheries and Oceans (DFO). This creates an opportunity for the UEL to implement stormwater BMPs such as rain gardens in the areas of newly separated sewers to showcase that the UEL is well aware of the implications of increased imperviousness on the neighbouring fish bearing creeks. Any BMPs implemented in Area B may need to be designed without infiltration (e.g. through the use of filter fabrics) due to slope stability concerns (see Action Item #8).

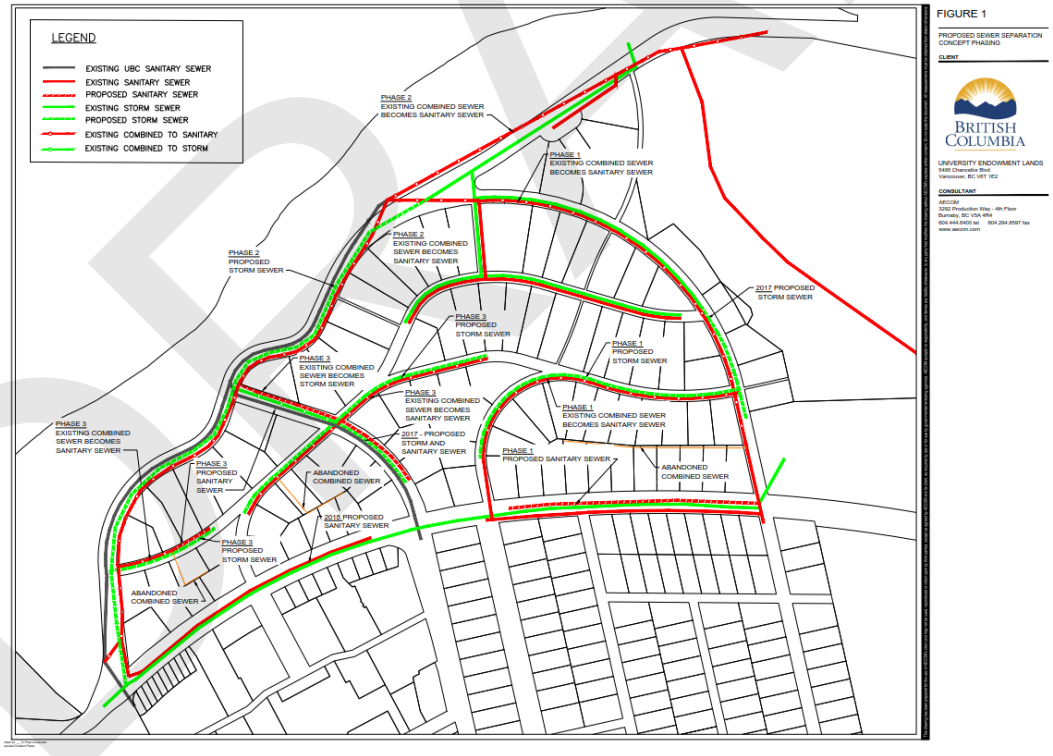


Figure 3: Existing Combined Sewers in Area B

Action Item #3: Manage the quantity of road runoff

Managing the quantity of water that is discharged to the fish-bearing creeks within the UEL was identified as an important step in achieving healthy streams (**Goal 2**). Increases in the amount of hard surfaces (e.g. roadways, roofs etc.) will alter the natural water cycle by increasing the amount of runoff during storms and decreasing the amount of rainfall that soaks into the ground. This can cause an increase in stream erosion and a decrease in stream base flows, which can have a detrimental effect on a stream's ability to support aquatic life.

Currently there are provincial and federal stormwater discharge criteria for controlling the runoff from urbanised areas to limit the impact on natural receiving waterbodies. Metro Vancouver's Stormwater Source Control Design Guidelines document provides a detailed summary of the provincial and federal stormwater criteria and makes recommendations on how to achieve these criteria. The guidelines present a number of source controls, such as rain gardens, which can be used either in roadways or on private property to achieve the stormwater discharge criteria. Not only do rain gardens reduce the volume of stormwater runoff from roadways, but they can also help replenish aquifers, increase summer base flows in creeks, remove some contaminants from the road runoff, be implemented in conjunction with traffic calming features (bump-outs), and provide a visually pleasing landscaped feature.

The UEL should consider implementing curbside rain gardens (see Figure 4) within its roadways, particularly in conjunction with infrastructure renewal projects. As outlined in Metro Vancouver's Stormwater Source Control Design Guidelines, for every 30 square metres of roadway, at least 1 metre of rain garden should be installed to mitigate the negative impacts on stormwater runoff.

Cost

The cost for a rain garden is approximately $250 per square metre. If the UEL were to install 1 square metre of rain garden for every square metre of roadway (127,000 m^2) then then the total cost of rain gardens to mitigate the UEL's entire roadway system is approximately $1 million. For a "standard block" of roadway (100 metre long by 8 metres wide) then the cost would be approximately $7,000 (in addition to the standard curbing etc.). This does not include Provincial roads such as Chancellor Boulevard that traverse the UEL.

Implementation Considerations

Implementation of BMPs on NW Marine Drive, University Boulevard and Chancellor Boulevard would have to be coordinated with the BC Ministry of Transportation and Infrastructure (MoTI). Rain gardens within Area B may need to be designed to not include infiltration (e.g. use filter cloth) due to slope stability concerns (see Action Item #8).

Figure 4: Example of Curbside Rain Garden in Residential Area of City of Spokane, Washington, USA

Action Item #4: Treat stormwater runoff from the roadways and upgrade stormwater treatment at the UEL Works Yard

Arterial roadways and maintenance works yards can be significant sources of pollutants such as metals, sediments, chlorides and hydrocarbons. Water quality monitoring that was conducted in Stage 1 of the ISMP showed high concentration of metals that typically come from motor vehicles. Further investigation to identify sources of metal pollution was recommended by the water quality report.

The arterial roadways within the UEL are part of the provincial road network. So any effort to treat the runoff from these roadways would need to be in done in conjunction with the MoTI. Action Item #3 recommends the implementation of rain gardens within the remaining roads at the UEL. This would help address water quality issues associated with these roadways. Further water quality testing will be recommended in Stage 4, particularly at the UEL's maintenance yard. Currently, the UEL works yard employs a stormwater chamber to collect the sediments running off the maintenance (Figure 5). Based on the results of further water quality testing, the UEL can decide whether it should upgrade its stormwater treatment system to mitigate the potential pollution from the works yard activities. This could provide a good opportunity for the UEL to showcase its commitment to maintaining healthy streams and a natural environment (**Goal 2**).

A possible upgrade of the current treatment system is installation of an Oil/Grit Separator (OGS). The OGS units are commonly used in municipalities and other industries to remove hydrocarbons, litter, and large sediments from stormwater runoff. Many pollutants, such as metals, tend to adhere to sediments; so by removing sediments, one will likely remove other pollutants as well. Stormwater treatment technologies such as membrane filters and bioretention facilities can remove finer sediments and other substances such as phosphorous, but these technologies tend to cost more and are therefore only used where more rigorous treatment is required.

Sediment and associated pollutants can be removed from the stormwater system through best operational practices such as regular catch basin cleaning and street sweeping. Catch basins should be inspected and/or cleaned at least once per year and street sweeping should be done twice per year (more often on arterial roadways). Increases in winter sanding and salt use may require an increase in frequency of catch basin cleaning and street sweeping practices.

Cost

Advanced OGS units such as the Stormceptor STC models that remove particles from 20 to 2000 microns in size, free oil, heavy metals and sediments, range in cost from $11,000 to $90,000, depending on the size of the unit (range from 1.2m to 2.4m in diameter). Conventional Oil/Water Separators and Oil Interceptors (e.g. API style or Coalescing Plate style) range from $2,000 to $20,000 but require a larger footprint and a sump. The prices listed above are estimated unit costs only and do not include detailed design, shipment of materials, and installation.

Implementation Considerations

OGS installations on arterials (e.g. NW Marine Drive, Chancellor Blvd or University Boulevard) need to be done in consultation with the MoTI who own and operate these roadways.

Figure 5: UEL Works Yard Sediment Chamber

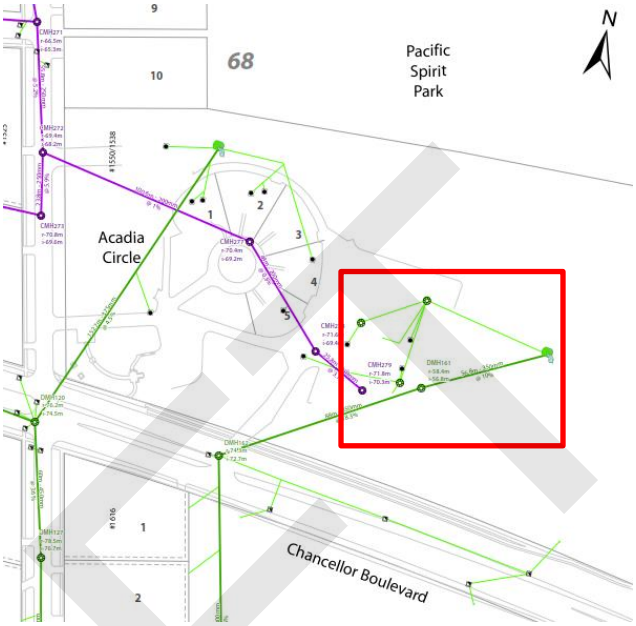


Figure 7: Location of the UEL Works Yard and associated stormwater system on Chancellor Boulevard.

Figure 6: Stormceptor STC by Imbrium Systems

Action Item #5: Identify stormwater infrastructure that is poorly located for maintenance and develop plans for management or replacement (i.e. the 300mm diameter storm sewer in Pacific Spirit Park east of Acadia Road).

A naturalised area located east of the properties on the eastern side of Acadia Road north of College High Road, contains 280m of a 300mm diameter storm sewer that collects storm flow from the adjacent properties (as shown on Figure 8). The challenge for the UEL is associated with access and responsibility for the maintenance and renewal of this storm sewer as it is located within a vegetated area with limited vehicle access. This action item aligns with UEL's **Goal 3** of the stormwater vision.

As the houses on the east side of Acadia Road are redeveloped they should be connected to the 450mm diameter storm sewer on Acadia Road to permit the eventual decommissioning of the 300 mm diameter storm sewer in Pacific Spirit Park. This would increase the total flow in the 450mm diameter storm sewer. However, based on the preliminary hydraulic modelling results identified in Stage 1 of this ISMP, and recommendations that stem from those results, the UEL should upgrade 300m of the existing 450mm diameter storm sewer on Acadia Road south of Chancellor Boulevard to 600mm diameter storm sewer when the sewer is renewed. As the houses are reconnected to the 450mm diameter storm sewer (or newly upgraded 600mm diameter storm sewer) on Acadia Rd., UEL can disconnect these properties from the 300mm diameter storm sewer that runs parallel to Pacific Spirit Park. This presents UEL with an opportunity to decommission the 300mm diameter storm sewer in the right-of-way and 70m of a 300mm diameter storm sewer that connects it to Acadia Road. However, further investigation and a management plan are required to address the existing ditch at the back of the properties on the east side of Acadia Road to mitigate any flooding potential and opportunity to daylight the existing buried storm system.

Cost

Capital cost of upgrading the storm sewer along Acadia Road between College Highroad and Chancellor from 450mm to 600mm diameter main is approximately $400,000. If it is decided that the 300 mm diameter storm sewer is to be decommissioned, the pipe should be capped at Chancellor Boulevard, manholes should be filled with gravel and risers/lids removed. The approximate cost of decommissioning the 550m of the 300mm diameter storm sewer is $15,000.

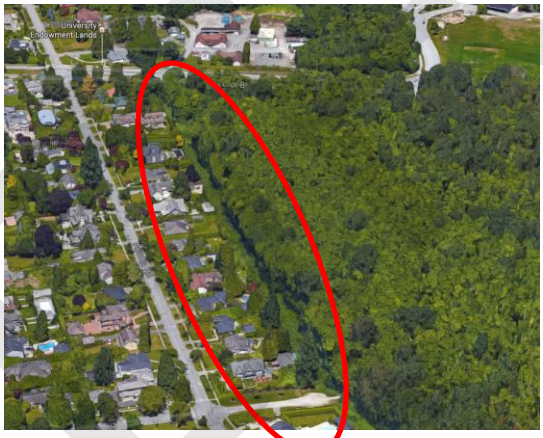


Figure 8: Location of Existing 300mm Storm Sewer behind Acadia Road

Figure 9: Existing 300mm Storm Sewer behind Acadia Road

Action Item #6: Continue to upgrade system capacity and renew aging infrastructure in a proactive manner through the capital planning process

One of the goals articulated by the UEL was to maintain stormwater infrastructure in order to provide an adequate level of service and protect life and property (**Goal 3**). The UEL's 10-Year Capital Plan, as described in the Phase 1 Report of the UEL's Integrated Stormwater Management Plan, recommended a number of sewer upgrades to address insufficient capacity and/or structural failures.

As part of the capital plan development, AECOM conducted a hydraulic modelling analysis by simulating the impact of a 5-year 30-minute design storm conditions to assess the constraints in the sewer network. The most urgent pipe upgrades were included within the 2012 – 2021, 10 year capital plan but future capital plans will need to consider the remaining capacity issues. It should be noted that as steps are taken to reduce the amount of stormwater in the existing system through sewer separation, by limiting the runoff from individual properties and controlling runoff from roadways then the need to increase the capacity of the existing combined/storm systems is reduced.

Table 3: 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.

In summary, it is recommended that the UEL:

- Continue to implement its 10 year capital plan; and
- Continue to use the hydraulic model to review the capacity of its combined/stormwater system before any infrastructure upgrades are finalised and any development is approved. Confirm that upgrades and development are in conjunction with future capital planning efforts.

Cost

The capital costs associated with the stormwater projects outlined above in Table 3 have been included as part of the 10-year Capital Plan. Since the UEL already has a stormwater model, periodic reviews and updates are minimal in cost.

Implementation Considerations

As the UEL upgrades its storm sewer system or changes the allowable discharge per property, the hydraulic model needs to be updated accordingly.

Action Item #7: Develop mitigation measures to address slope stability in Area B

A recent study for UBC by Golder Associates on erosion along the UBC cliffs highlights continuing concern with slope stability along NW Marine Drive and within Salish (Acadia) Creek. From previous project experience and consultation with a senior hydrogeologist at AECOM it has been noted that increased infiltration of water in close proximity to the cliffs may increase erosion potential and slope instability. With high potential for erosion along the cliff face, it is best to take the precautionary approach and to only allow infiltration facilities if a geotechnical and hydrogeological assessments are completed in advance.

The UEL should retain a consultant to delineate areas requiring geotechnical/hydrogeological assessment prior to implementation of infiltration facilities and areas to exclude infiltration as a means of stormwater management. Potential scope of work required to conduct this study would include a review and assessment of available background information and data, field inspections and assessment by a qualified hydrogeologist and a geotechnical engineer, development of the conceptual model, and preparation of Geographic Information System (GIS) maps to present the results.

Cost

The estimated cost of retaining a consultant to delineate areas of no infiltration is $45,000. This includes assessments by a professional hydrogeologist and geotechnical engineer, and design and preparation of technical maps by a GIS professional.

Implementation Considerations

The UEL is collaborating in a multi-agency working group aimed at addressing slope stability concerns in this area. Without timely mitigation measures, Metro Vancouver parkland, UBC sanitary sewer, MoTI road, UEL storm sewer and private property upslope are at risk. The UBC Integrated Stormwater Management Plan and the UBC Cliff Erosion Study are two primary documents that provide recommendations to UBC regarding maintaining slope stability and further prevention of cliff erosion.

Figure 10: Salish (Acadia) Creek Riparian Setback, UEL ISMP Stage 1 Report, 2016

Action Item #8: Integrate stormwater asset maintenance with work order management using a GIS-centric system

A GIS-centric asset management means that the stormwater asset records are fully integrated with GIS mapping and all stormwater asset records can be accessed and updated using map locations. Stormwater infrastructure maintenance activities play an integral part in keeping sidewalks, roads and properties safe from flooding, maintaining slope stability, ensuring that stormwater assets are functioning as designed and protecting natural streams. Developing an asset management system for easy tracking of asset maintenance and related work order management activities will help the UEL reach the envisioned goals of protecting life and property while providing an adequate level of service. A GIS-centric, integrated, system could contain asset information such as year of installation, condition assessments, maintenance records, and remaining expected service life. This consolidated information could then be used to develop future capital plans.

Cost

Integration of asset maintenance plans with the work order management processes in a GIS-centric system for stormwater infrastructure has an approximate cost of $42,000. However, additional savings are envisioned if the UEL should undertake similar integration of water and sanitary sewer infrastructure in addition to stormwater. An approximate cost to integrate water, sanitary and storm infrastructure is $90,000. The above mentioned estimate includes the cost of labour to migrate asset inventory data into a GIS-centric system and link to a future Computerized Maintenance Management System (CMMS). The estimated cost above does not account for the GIS license and CMMS license costs.

Implementation Considerations

The UEL has made good progress in digitizing most of the storm sewer infrastructure and already has a good inventory in its GIS program. This will cut down on the time required to migrate asset data.

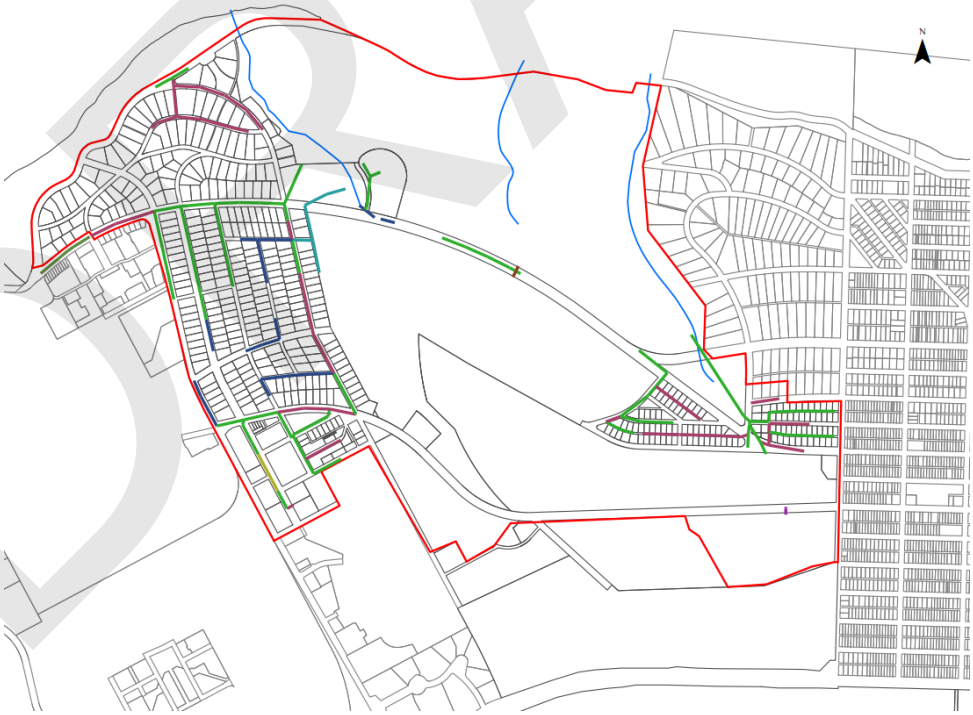


Figure 11: UEL storm sewer infrastructure colour coded based on type of material; available in GIS format

Action Item #9: Develop Erosion and Sediment Control requirements

The UEL Works and Services By-law Schedule B Section 1.20 stipulates that "an Erosion and Sediment Control (ESC) plan that has the objective of preventing deleterious substances from entering the storm system during construction must be submitted to and approved by the UEL in advance of any works". While the requirement of the ESC plan developed by a Qualified ESC Professional is a good practice, the Works and Services By-law does not provide any detailed guidelines on what is required to be included in the ESC plan. In addition the UEL Works and Services By-law only applies to works by developers within the public right-of-way. Therefore it does not apply to construction works on private property (i.e. new house construction).

AECOM recommends that the UEL adopts ESC plan requirements that are at least in line with the ESC plan requirements of the adjacent municipalities (Figure 14). The ESC Plan requirements would help the UEL achieve **Goals 2, 3,** and **4.** The ESC Plan requirements must extend to private property development, and construction on public streets and roadways. The requirement of an ESC plan for single lot development and construction on public streets must be stipulated within the UEL's By-laws such as the Works and Services By-law and Land Use and Building By-law.

An ESC Plan shall include, but not be limited to, the following:

- A phased construction schedule that limits the extent of tree and vegetation removal and soil disturbance to the immediate areas of site construction.
- Details showing site access and measures in place to address soil tracking.
- Plans to control and treat TSS and pH in runoff water from the construction site.
- Plans to prevent clogging of any nearby rainfall capture facilities (e.g. rain gardens) and their underlying soils.
- Protection of any identified rainwater infiltration areas to prevent disturbance and compaction.
- Location(s) of discharge to the UEL's storm system, and the environment.
- A program to remove debris from UEL property.
- Storm sewer catch basin and drain inlet protection.
- Sampling and analysis to demonstrate compliance with the Bylaw.

The ESC requirements should work in tandem with the Works and Services By-law by specifying standards for meeting maximum discharge of 25mg/L of suspended sediment above background levels under dry weather conditions and 75mg/L under wet conditions.

ESC Plans should outline provisions for implementing Erosion and Sediment Control BMPs such as:

> **For Erosion:** Mulch, Polyethylene Sheeting, Check Dams, Straw Wattles, and Slope Texturing/Tracking.
>
> **For Sediment Control:** Fencing, Stabilization of Construction Access (wheel wash), sediment barriers, filter socks/tubes/berms, stormwater treatment system (Stormtec Filtration systems).

Cost

The estimated costs are associated with development of standards and ESC requirements, and UEL staff time requirement for By-law amendments, permit reviews and construction inspections. The estimated cost is $10,000 - $20,000 for consulting support for the initial development and by-law amendments. UEL staff time will be required in the development of the bylaw, for permit review and construction inspection.

Figure 12: Catch Basin Donut, BMP Supplies

Figure 13: Silt Fence and Posts, BMP Supplies

BULLETIN 2002-003-EV **March 1, 2017**
EROSION AND SEDIMENT CONTROL LARGE LOT DEVELOPMENTS (1,000M² OR MORE) **(Revised)**

EROSION AND SEDIMENT CONTROL (ESC) MONITORING CRITERIA

Applicable Bylaw	Sewer and Watercourse Bylaw No. 8093 (the Bylaw)
pH Requirements	Discharge water to have a pH of 6.0-9.0
Turbidity Requirements	Discharge water Total Suspended Solids (TSS) not to exceed 75mg/L.
Environmental Monitoring	Must be completed by a Qualified Person (QP). Acceptable designations include Applied Science Technologist (ASc.T), Environmental Professional in Training (EPt) or EP, BC Certified Erosion and Sediment Control Lead (CESCL) or equivalent, Engineer in Training (EIT), Professional Engineer (P. Eng), and Biologist in Training (BIT) or higher.
Monitoring Frequency	Dry Season (May-Sept): Bi-weekly Wet Season (Oct-Apr): Weekly Additional monitoring is required within 24 hours of a significant rainfall event (SRE) (>25 mm in 24 hrs). Additional monitoring is not required if the SREs are within 48 hours of each other. Discharge water sampling can cease once the Site is connected to the City sewer system or with written approval from Environmental Protection. Monitoring of best management practices should continue for the duration of the project. Monitoring frequency can be modified upon agreement in writing between the City Inspector and the Contractor or QP.
Sampling Parameters	Samples will be submitted for laboratory analysis of TSS if field testing results exceed the Trigger Value of 45 nephelometric turbidity units (NTU)** The Environmental Monitor may be permitted to submit a Site specific calibration curve to the City if analytical results are consistently below 75 mg/L. If the field measurements exceed 45 NTU or if the pH is less than 6.0 or greater than 9.0, the Contractor **must cease discharge** until appropriate remedial measures have been undertaken.
Report Submission	Templated report submitted within 48 hours of the monitoring event for Sites which are out of compliance. Templated report submitted within 7 days of the monitoring event for Sites which are in compliance. If laboratory analysis is required, the analytical results must be submitted within 7 calendar days. Reports are to be submitted to: environmentalprotection@vancouver.ca
Site Maintenance	No sediment-laden water from the work site shall be pumped out or otherwise discharged directly to a storm sewer system, water course, or other drainage system in such a manner as to bypass the sediment control system. Deficiencies identified by the Environmental Monitor are to be resolved as soon as practically possible.
Removal/Alterations of Treatment Works	No changes to the water treatment system are to be made without the City's Environmental Protection approval. A written request must be approved by Environmental Protection. A Site inspection may be required prior to approval.

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Figure 14: ESC Plan Monitoring Criteria – City of Vancouver

Action Item #10: Controlling runoff from private properties

In order to limit the loading on the storm sewer system, the UEL historically required all new single family dwellings to limit the runoff from their site to 3 litres per second. As the average home is approximately 0.12 hectares in size, this requirement translates to a discharge limit of 25 litres per second per hectare. Fisheries and Oceans Canada, along with Metro Vancouver, recommend limiting runoff from individual properties to 4 litres per second per hectare in order to protect downstream receiving waters. The additional benefit of further limiting the discharge from individual properties is that it reduces the need to upgrade the UEL's stormwater system for capacity reasons.

The UEL's new Works and Services By-law is in accordance with the new runoff limits outline above. It is not clear if the UEL is applying these new limits to all new single-family dwelling developments in the UEL.

Various options available to developers for limiting the stormwater runoff from their site are described in Section 3 of this report and examples of each proposed BMP are provided in Appendix A. It should be noted that stormwater management on new development in Area B will need to consider the outcome of Action Item #7 above.

Cost

The only cost will be UEL staff time in communicating and enforcing the new requirements to developers.

Implementation Considerations

If the UEL is already applying the new allowable stormwater discharge limits from individual properties then the stormwater model will need to be updated accordingly, which could result in a reduction in required stormwater upgrades based solely on capacity. The sewer upgrades within this 10 year capital plan will not be affected as most of those are based on condition and/or sewer separation.

3. Stormwater Best Management Practices (BMPs)

This section provides information specific to six (6) stormwater BMPs (absorbent landscaping, rain gardens, infiltration swale, infiltration trench, pervious pavement, and green roofs) that may help homeowners meet the 6-months/24-hour storm event on-site retention (which is approximately 4.0 L/s per hectare of allowable runoff) as prescribed by Metro Vancouver's Source Control Guidelines. Appendix A provides conceptual drawings of each BMP along with rough size estimates, maintenance practices and requirements for a typical single-family residential lot at University Endowment Lands. The BMPs were chosen for evaluation based on design information available through Metro Vancouver's Stormwater Source Control Design Guidelines and previous AECOM experience. These six BMPs provide a range of options based on complexity of design and construction.

Absorbent Landscaping

Natural landscape surfaces have an inherent ability to soak up, store, and slowly release rainfall. Depending on the soil type and location, the ability of the natural landscape to perform the retention and filtration of rain water may differ. Percolation testing for the Block F development in Area D yielded a percolation rate of 8.8 minutes / 25mm drop in water level. However, further area specific soil infiltration tests can be done to determine the natural infiltration rate, which may change the design requirements for stormwater BMPs. Absorbent landscaping can consist of natural forest land, existing trees, and undisturbed soil. It is recommended to conserve as much of the natural environment as possible in order to have areas that inherently act as natural rainwater filtration and attenuation features. The capacity of the absorbent landscaping is designed to infiltrate the rainfall that falls on it and may infiltrate runoff from limited upstream impervious area. The ratio of impervious area to absorbent landscape area is designed to be maximum 2:1. As a BMP, absorbent landscape can include the disconnection of rooftop leaders from the storm sewer and directing the rainfall from all impervious areas onto the absorbent landscape.

Infiltration Rain Garden

Rain gardens are an extension of an absorbent landscape solution. However, the rock trench and overflow outlet features allows the rain garden to reduce the footprint area required to capture desired rainfall amount. The maximum design ratio of impervious area to rain garden footprint within a single family lot is 50:1 and for a local roadway is 30:1. In addition to the bioretention and filtration functions, rain gardens are also aesthetically pleasing. The surface vegetation must reflect the soil moisture conditions but mostly consists of shrubs and grasses. Rain gardens are beneficial for volume reduction as well as water treatment. The soil layer and vegetation serve as natural filtration devices and the deeper rock layer adds a temporary storage layer due to the rock void space (approximately 35% of rock volume).

Pervious Pavement

Pervious paving is a surface layer which allows rainfall to percolate into the under layer where the rainfall is stored and either filters into the subgrade or discharged via a sub drain. The pervious pavement may consist of porous asphalt or concrete with greater void space for percolation; concrete grid pavers that support the load and large void space with pervious material; or pavers with gapped joins that allow water to pass between the pavers. Pervious paving is not suitable for extensive treatment of stormwater due to the absence of deep soil and vegetated layer. The maximum design ratio of impervious area to pervious pavement footprint is 2:1.

Infiltration Swale

An infiltration swale system is a combination of an absorbent landscaping with a deeper rock trench. The grassed swale is designed to collect the surface runoff from adjacent impervious areas and retain the flow behind a weir. With a design of a rock trench below the grass layer, the infiltration swale is allowing the water to infiltrate slowly into the soil. This combination allows for stormwater volume reduction, flow attenuation, as well as some treatment as the water percolates through the soil layer. Similar to the rain

garden, the maximum design ratio of impervious area to swale footprint is 50:1 for single family lots. However, the footprint of a swale tends to be larger than a rain garden due to a minimum side slope of 3:1. The side slope allows for easier maintenance of the grassed swale.

Infiltration Trench

An infiltration trench provides an opportunity for runoff from impermeable surfaces to soak away into the ground. Most commonly, infiltration trenches are used for management of roof runoff. For water that comes off other surfaces, especially vehicle accessible surfaces, pre-treatment to the infiltration trench is required as it does not provide any water quality treatment options. A typical pre-treatment to an infiltration trench is composed of a rain garden. Installation of infiltration trenches in soils with infiltration rates as low as 0.06mm/hr is possible with a use of an overflow feature, however, installation of infiltration trenches in poor soil conditions is ill advised. Infiltration trenches also require more maintenance and have a poor performance history across the Lower Mainland, B.C.

Green Roof

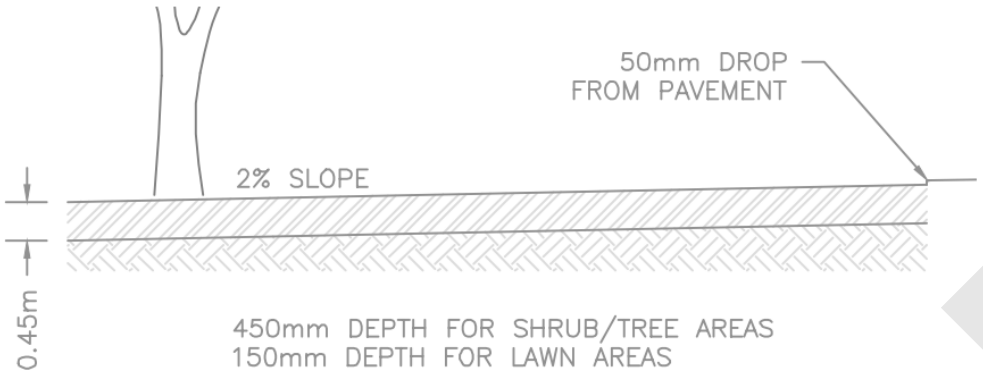
Green roof allows for support of living vegetation, which allows for natural attenuation of stormwater runoff and water treatment. An impermeable membrane protects the building from damage due to water and vegetation. The thickness of the soil layer may vary based on the design and rainfall capture targets. Green rooves that support grassed vegetation require a soil layer of 300mm. For a green roof that supports trees a soil layer greater than 300mm thickness is required. Green roofs are suitable for many industrial, commercial, and institutional buildings that have extensive and relatively flat roofs. Rooftops with slopes greater than 20 degree angles may require additional engineering considerations. Green roofs have benefits beyond stormwater management such as insulation, reduced heat island effect and protection of rooftop membrane from external damage. The additional benefits of green roofs are not considered in the evaluation of this BMP in this report.

4. Next Steps

This report identified actionable items that will help the UEL achieve its Integrated Stormwater Management Plan vision and goals. The next step is to develop a monitoring and assessment program that will allow the UEL to track its progress and stay on target of achieving its vision.

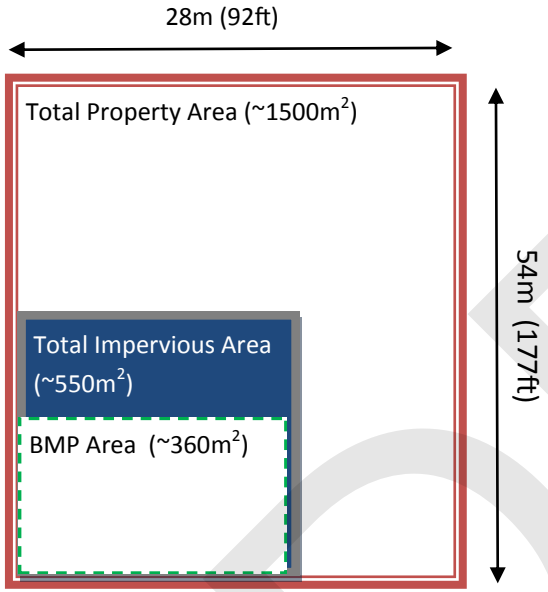
Appendix A

Stormwater Best Management Practices for a Typical Single Family Residential Lot



Conceptual Cross Sectional Drawing of Absorbent Landscaping

Above: Example of absorbent landscaping
Photo Credit: GoogleEarth



General Notes:

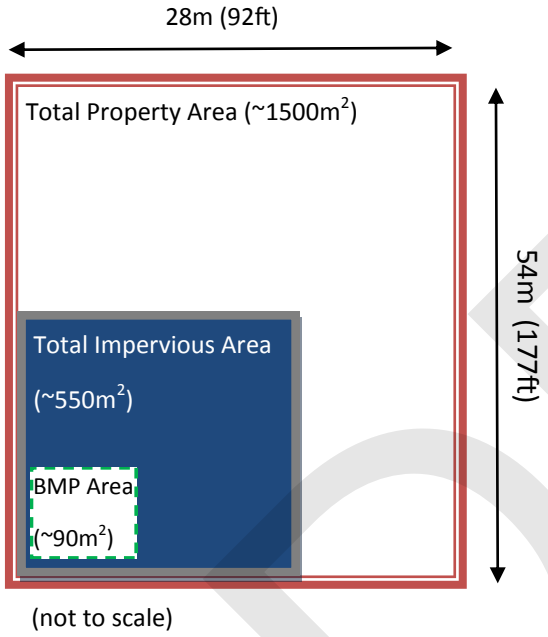
1. Design on-site drainage from impervious areas to absorbent landscape areas (Max Ratio of Impervious Area to Pervious Area allowed is 2:1).
2. Ensure adequate depth of media for stormwater needs—150mm depth for lawns and 450mm for trees/shrubs
3. Ensure presence of organic content at 8% for lawns and 15% for tree and planting beds.

Maintenance:

1. Routine upkeep as part of regular yard maintenance.
2. Provide protection from sediment deposition onto the landscaped areas
3. Do not use fertilizers or pesticides of any kind.
4. Pruning and mulching are recommended on annual basis.

University Endowment Lands Integrated Stormwater Management Plan	Stormwater BMPs for a Typical Single-Family Residential Lot **Absorbent Landscape**	Project 6022155 Date March 2017	AECOM BRITISH COLUMBIA

Above: Example of on-site stormwater rain garden
Photo Credit: designbuzz.com



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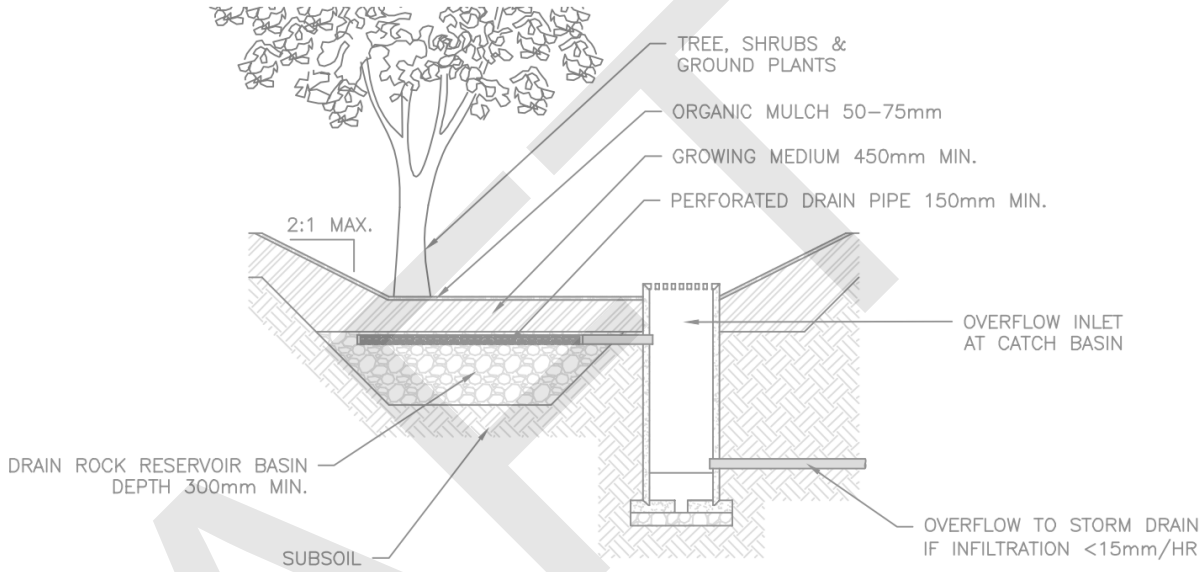


Conceptual Cross Sectional Drawing of Rain Garden

General Notes:

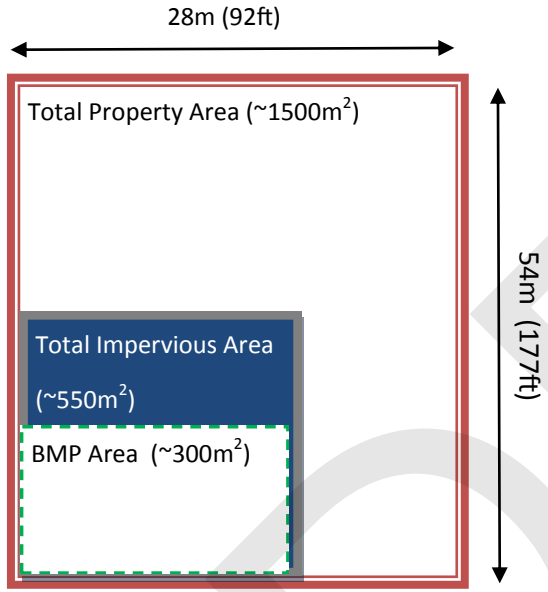
1. On-site stormwater rain gardens should be located 3 meters from the house and 12 meters from steep slope.
2. Design rain gardens to drain within 48 hours to reduce risk of standing water and mosquito breeding.
3. Max Ratio of Impervious Area to Pervious Area allowed is 50:1 for single-family residential lots

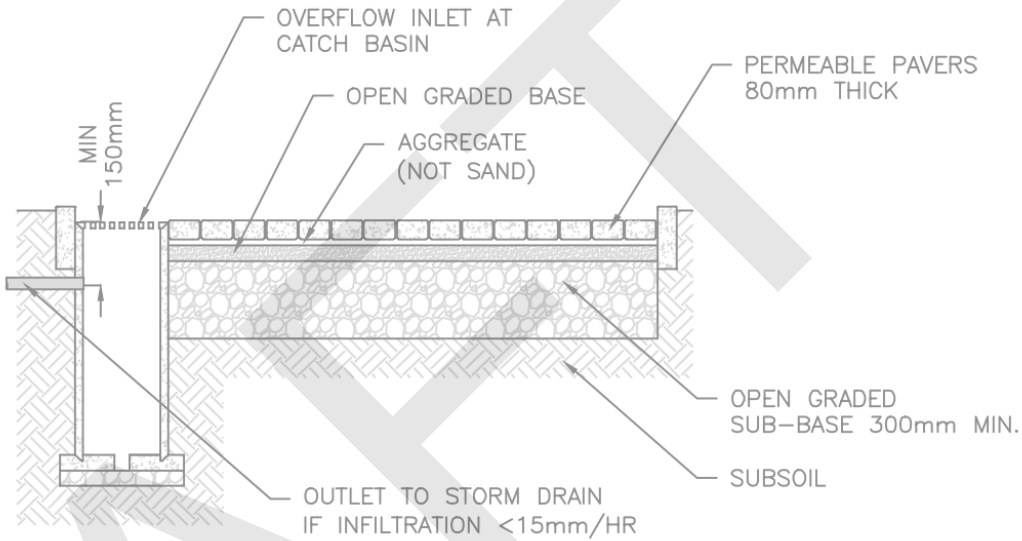
Maintenance:

1. Routine upkeep as part of regular yard maintenance.
2. Weeding and irrigation is essential until recommended rain garden plants have been established (use native and drought tolerant plants as prescribed in Schedule C of the Works and Services Bylaw).
3. Do not use fertilizers or pesticides of any kind.

University Endowment Lands Integrated Stormwater Management Plan	Stormwater BMPs for a Typical Single-Family Residential Lot **Rain Garden**	Project 6022155 Date March 2017	AECOM BRITISH COLUMBIA

Above: Example of on-site pervious paving
Photo Credit: mnrhardscaping.ca





Conceptual Cross Sectional Drawing of Pervious Pavement

General Notes:

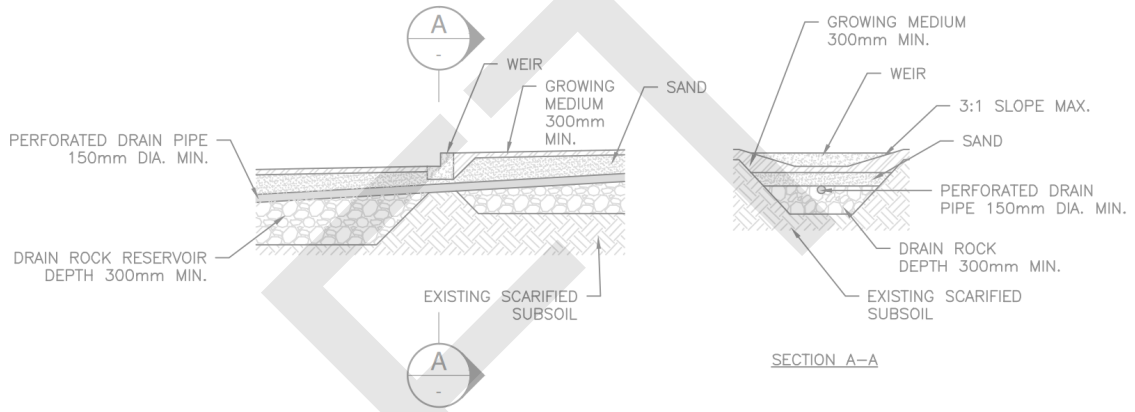
1. Direct on-site drainage from impervious areas to pervious pavement areas (Max Ratio of Impervious Area to Pervious Area allowed is 2:1).
2. Plant vegetation in between or around pavers.
3. Do not use pervious pavement BMP in areas with high sediment loads that can clog porous areas.

Maintenance:

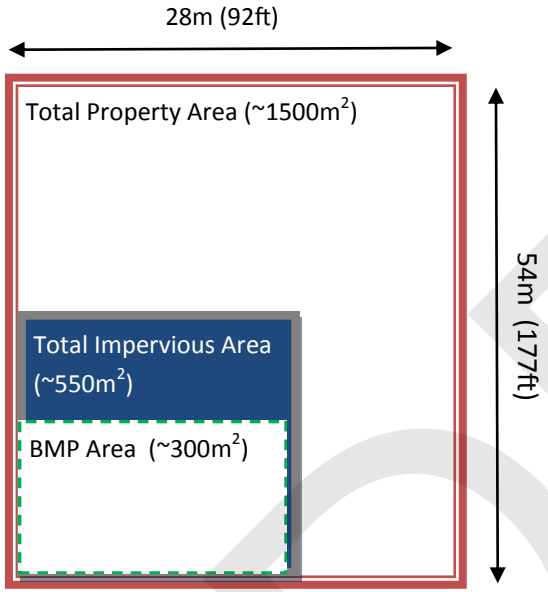
1. Keep impervious areas draining to pervious pavement free of sediment to prevent clogging.
2. Perform annual sweeping and vacuuming to maintain permeability.
3. Remove weeds and invasive plants from in-between pavers.

University Endowment Lands Integrated Stormwater Management Plan	Stormwater BMPs for a Typical Single-Family Residential Lot **Pervious Pavement**	Project 6022155 Date March 2017	AECOM BRITISH COLUMBIA

Above: Example of bioswale/ infiltration swale
Photo Credit: NRCS, US Department of Agriculture



Conceptual Cross Sectional Drawing of Infiltration Swale



General Notes:

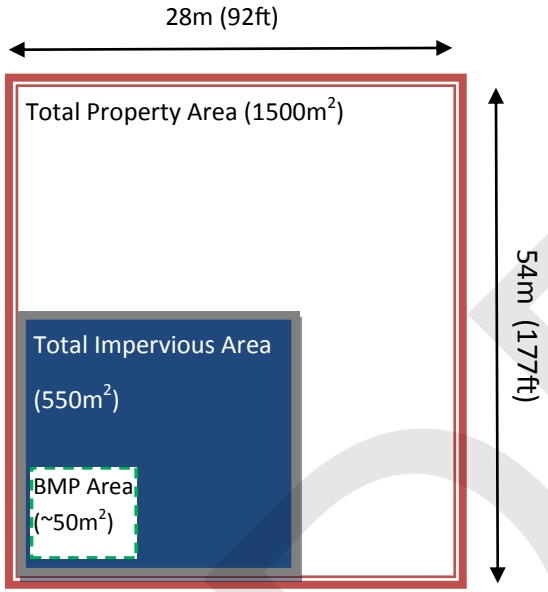
1. Slope swales at a minimum of 2% from beginning to end to convey water
2. Direct on-site drainage from impervious areas to pervious pavement areas (Max Ratio of Impervious Area to Pervious Area allowed varies between 20:1 and 50:1 depending on impervious surface type).
3. Plant native or drought tolerant vegetation.
4. Do no allow heavy machinery into the swale to prevent soil compaction

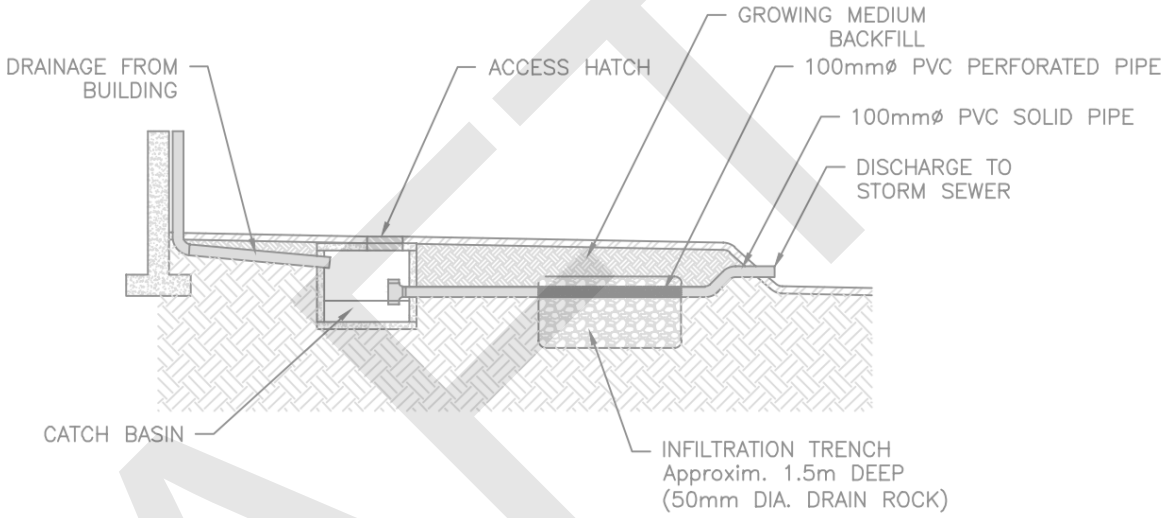
Maintenance:

1. Protect swale from erosion potential before the plants in the swale are well established.
2. Perform mowing in spring and fall (to 3 inches), weed control, vegetating bare areas, clearing debris and accumulated sediment.

University Endowment Lands Integrated Stormwater Management Plan	Stormwater BMPs for a Typical Single-Family Residential Lot **Infiltration Swale**	Project 6022155 Date March 2017	AECOM BRITISH COLUMBIA

Above: Example of on-site pervious paving
Photo Credit: SuDs Wales, Sustainable Drainage Systems





Conceptual Cross Sectional Drawing of Infiltration Trench

General Notes:

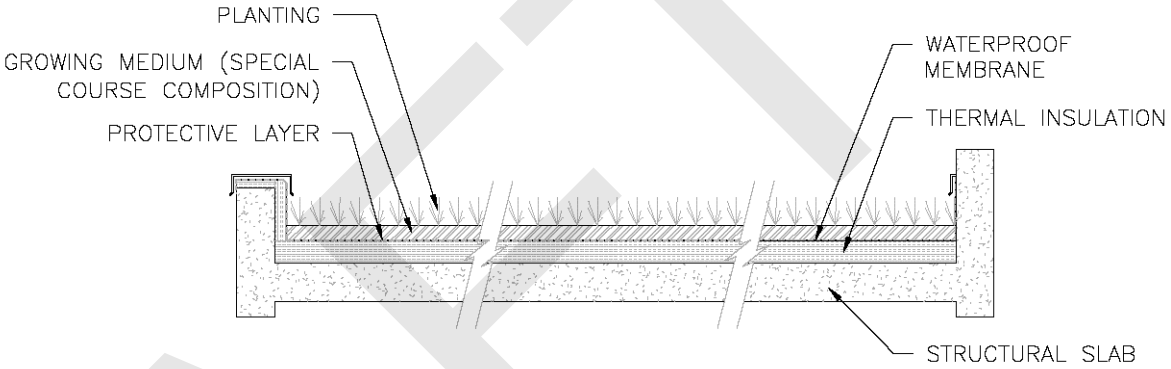
1. All infiltration structures must be professionally designed and constructed. There is a high risk of failure for improperly sited, designed, or maintained infiltration trench.
2. Maximum impervious/pervious surface area ratio is 50:1 for single-family lots
3. Do not build infiltration trench in area with high sediment input.
4. Design the infiltration trench to drain within 72 hours.

Maintenance:

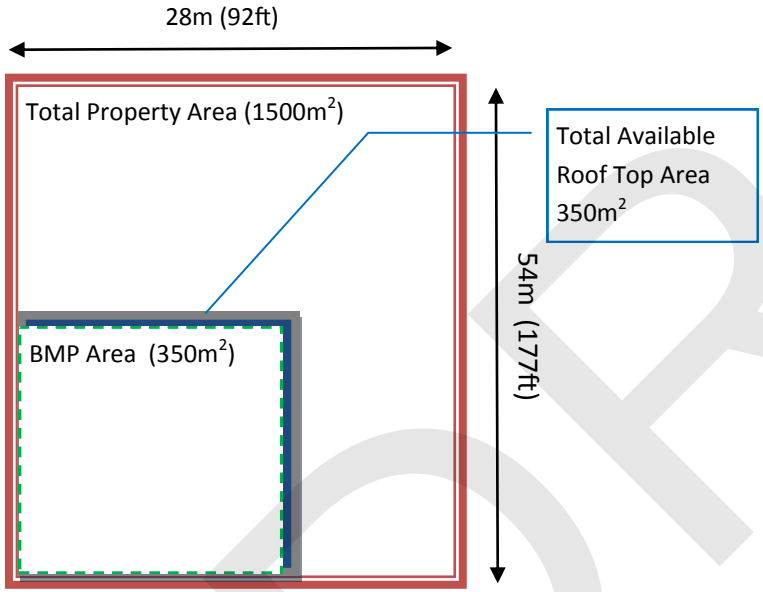
1. Specific inspection and maintenance schedule is required.
2. Inspect during and after a major precipitation event in the first year. Inspect twice per year in consequent years.
3. Remove garbage and plant debris on a regular basis.
4. If the infiltration structure appears clogged, consult a professional immediately for repair requirements.

University Endowment Lands Integrated Stormwater Management Plan	Stormwater BMPs for a Typical Single-Family Residential Lot **Infiltration Trench**	Project 6022155 Date March 2017	AECOM BRITISH COLUMBIA

Above: Example of green roof
Photo Credit: Vancouver Convention Centre



Conceptual Cross Sectional Drawing of Green Roof



General Notes:

1. Summer rainfall retention—70-90% ; Winter rainfall retention—25-40%
2. Identify and select growing medium/material and loading capacity to suit climate.
3. Rooftop slope should not exceed 20%

Maintenance:

1. Maintenance depends on the type of plants, growing medium and climate/ weather conditions.
2. Irrigate as required to establish the vegetation.
3. Perform regular inspections for damage, roots penetrating the waterproof membrane, debris, invasive species, and weeds

University Endowment Lands Integrated Stormwater Management Plan	Stormwater BMPs for a Typical Single-Family Residential Lot **Green Roof**	Project 6022155 Date March 2017	AECOM BRITISH COLUMBIA