Reducing stormwater runoff and infrastructure damage through Low Impact Development techniques

Final Report

Nova Scotia Environment Climate Change Adaptation Fund

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Ecology Action Centre

NOVA SCOTIA

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Executive Summary

Changes in the amounts and intensity of precipitation associated with climate change in conjunction with problems associated with aging infrastructure and an ever expanding area of impervious surfaces (roads, roofs, parking lots) in most cities make managing stormwater a critical issue. Key stakeholders including: developers, planners, homeowners, municipal councillors, need access to information on how to implement BMPs for managing stormwater.

This project involves a partnership between the Ecology Action Centre, HRM, Halifax Water and Insurance Bureau of Canada, to select a site and prepare a restoration plan for a stormwater management demonstration project in HRM targeting planners, developers, municipal officials and other stakeholders. During phase I of the project, we worked with partners to research innovative stormwater Best Management Practices (BMPs) and policy options, create and update a stormwater management blog, identify potential stormwater demonstration sites and build province-wide capacity around stormwater management by convening a workshop for local and regional stormwater experts. The project resulted in:

1) a review of stormwater best management practices;
2) a review of stormwater management policies;
3) a stormwater management blog;
4) stormwater retrofit plans for 2 sties; and
5) a practitioners workshop

The 'Applied Stormwater Management' workshop was held on February 20-21 at Dalhousie University attracted 48 participants and featured presentations by regional and national stormwater experts. A stormwater management blog (www.stormwatercentral.ca) was also created to raise regional education and awareness around stormwater issues and innovative practices to reduce volume and improve quality of stormwater runoff. Over 30 posts have been written for the blog, including 5 original videos, and the blog has garnered over 1900 hits to date.

This project will continue throughout the Spring and Summer of 2012 (Phase II) with the development of stormwater demonstration sites at the University Avenue Fire Station and the George Dixon Community Centre. The demonstration sites will increase capacity of Nova Scotians to identify and implement site appropriate stormwater Best Management Practises that will encourage on-site retention and infiltration of stormwater and reduce infrastructure damage and flooding.

The stormwater workshop and blog have been extremely successful tools to raise awareness about the issues associated with urban stormwater runoff and best management practices to improve stormwater management for new and existing developments. The construction of two stormwater demonstration sites in HRM, the first in Nova Scotia, will become valuable long-term education tools and allow a wide audience to learn about innovative stormwater management techniques and see them being applied. Documenting the retrofit process and sharing what we have learned on our blog will allow for regional information sharing and will encourage others outside of HRM to implement Low Impact Development techniques to reduce flooding, infrastructure damage and degradation of water quality regionally.

Introduction

Environment Canada climate change models predict that HRM will see a 12% increase in precipitation and an increase in rainfall intensity within the next 80 years (HRM 2007). The impacts of more severe and more frequent storm events are felt primarily in urban landscapes where the high area of impervious surface cover (roofs, roads, parking lots) prevents water from being retained in the ground. In urbanized areas like many parts of HRM and other cities and towns in Nova Scotia, water instead moves quickly over the hardened urban landscape, collecting contaminants along the way, and flows directly into the drainage system which can lead to combined sewage overflow, infrastructure damage from flooding, erosion and degradation of water quality. The purpose of this project was to raise awareness on issues associated with stormwater and innovative Low Impact Development techniques that can be applied to new and existing developments in urban areas. There are currently no demonstration sites in HRM where the public or development community can go to learn about techniques, and see them applied – although there are a number of new developments (Canada Games Aquactic and Recreation Centre, Dartmouth Crossing) that do showcase some water conservation and stormwater management techniques.

This project has helped to fill an information gap about best practices in stormwater management by laying the groundwork for two stormwater demonstration sites to improve capacity of developers, the planning community and the general public to identify and implement site appropriate stormwater management techniques that will reduce infrastructure damage and flooding associated with increased precipitation amounts and intensity. The stormwater management demonstration sites will showcase innovative techniques to reduce infrastructure problems caused by flooding and heavy rainfall.

Project Team

The Ecology Action Centre (EAC) has worked towards sustainability for Nova Scotia's communities and environment for 40 years with a reputation of offering well–researched, cost-effective, solutions to environmental challenges facing Nova Scotia's communities. The EAC is a vital provincial voice on climate change issues in Nova Scotia. The EAC has been involved in many research and capacity building projects, both with community partners and in collaboration with government and academic institutions. We have considerable expertise in climate change adaptation research and education. Community engagement for climate change adaptation is a strong component of our coastal, water, energy, forestry, and food security initiatives. The project was led by Ashley Sprague, EAC's Restoration Coordinator.

A project advisory committee was established to help guide Phase I and Phase II of the project. Committee members include:

- Richard McLellan (HRM – Energy and Environment). Energy and Environment is the organizational lead for Environmental Sustainability at HRM.
- John Sheppard and Patricia Isnor (Halifax Water). Halifax Water is responsible for municipal water, wastewater and stormwater infrastructure in HRM.
- Leah Sanford and Amanda Dean (Insurance Bureau of Canada Atlantic). IBC is the national industry association representing Canada's private home, car and business insurers. IBC is well

aware of the costly effects of severe weather events, and are actively engaged in developing, promoting and implementing adaption measures for homeowners and municipalities.

Project Deliverables

The contractor completed the following tasks:

October:

- Review stormwater BMPs for new and existing developments
- Conversations with HRM, Halifax Water, IBC regarding retrofit site selection
- Form advisory committee

November:

- Launch stormwater management blog (www.stormwatercentral.ca)
- Circulate blog link to contacts
- Develop blog posts and videos through interviews, field trips
- Identify and visit potential stormwater demonstration sites (Citadel High School, George Dixon Community Centre, Adventure Earth Centre, Brunswick St Firehall, Duffus St Firehall, University Avenue Firehall)
- Identify three top stormwater demonstration candidate sites (George Dixon Centre, Duffus St. Firehall, University Avenue Firehall)
- Begin preparations for 'Applied Stormwater Management' workshop

December:

- Circulate workshop 'Save a Date' to stormwater contacts
- Organize workshop logistics
- Prepare background and resource material
- Contact workshop presenters

January:

- Finalize workshop plans
- Prepare stormwater scenario exercise
- Prepare Best Management Practices handout for workshop
- Work with Dalhousie School of Sustainability Students

February:

- Held 1 ½ day workshop in Halifax
- Held workshops in Digby and Saint John (funding provided by BoFEP)
- Hold discussions regarding building maintenance/operations of potential demonstration sites
- Research municipal stormwater management policy options

March:

- Create site retrofit assessment videos from field trip for blog
- Work with project partners to create site plan
- Source contractors and landscape architect
- Prepare and distribute final workshop report

Workshop Overview

A 1 ½ day workshop on stormwater management issues and solutions was held at Dalhousie University of February 20-21 (See Appendix I - Workshop Invitation). Fourty-four participants attended the workshop including municipal planners, engineers, provincial government representatives, consultants and environmental organizations (See Appendix II – Workshop Participants). The workshop included presentations and an interactive stormwater scenario exercise designed to increase capacity of workshop participants to identify and implement stormwater Best Management Practices (BMPs) to reduce infrastructure damage, flooding and impacts to marine and freshwater systems.

A half day field trip was offered on the morning of February 21st to discuss appropriate BMPs and retrofit options for our top three candidate stormwater demonstration sites – George Dixon Community Centre, University Avenue Fire Station and Duffus Street Fire Station. Guided by leading Canadian stormwater expert, Dr. Jiri Marsalek, the field trip identified site-specific bioretention and water harvesting solutions to reduce stormwater runoff volume and rate and improve stormwater quality. This was a unique and interactive learning opportunity for participants and provided valuable ideas that were incorporated into our demonstration site design plans.

The morning portion of the workshop included presentations on issues associated with stormwater runoff and changing weather patterns, followed by presentations on innovative stormwater management practices which included examples of projects that have incorporated Low Impact Development in Canada and beyond (See Appendix III - Workshop Agenda). All workshop presentations are available on-line at www.ecologyaction.ca/content/coastal/publications. Presentations included:

- John Sheppard, Director, Environmental Services - Halifax Water - “Introduction to Stormwater Management in Halifax Regional Municipality”
- Bill Adams, Vice President – Insurance Bureau of Canada Atlantic - “The Costs and Impacts of Storm Events on Homeowners and Municipalities”
- Paul Morgan, Senior Planner - Halifax Regional Municipality – “Halifax Regional Municipality: Stormwater Policy and Initiatives”
- Jeff Pinhey, Engineer - ABLE Engineering - “Reducing Runoff, Restoring Recharge”
- Jiri Marsalek, Emeritus Scientist, Water Science and Technology Directorate - Environment Canada, Burlington, Ontario - “50 Years of Municipal Stormwater Management and Still Learning”

The workshop participants took part in a stormwater scenario exercise during the afternoon. The purpose of this exercise was to allow participants to practice selecting appropriate BMPs to improve stormwater management on an individual property and neighbourhood scale. The participants were divided into four groups and assigned to work on one of two different scenarios. The participants were encouraged to identify opportunities to reduce the velocity, volume and pollutant load of runoff on their site by reducing impervious surface area, selecting tools to allow water to infiltrate into the ground and promoting water capture and reuse. Each group was given a large map of their site, smaller additional site photos, a write-up describing the site and various water issues being impacting the area, a table describing of stormwater BMPs and tracing paper (all stormwater scenario materials are included in Appendix IV).

The groups each had 45 minutes to work through the exercise and select appropriate BMPs that could be implemented on their site. A handout describing several stormwater BMPs was provided to each group (Appendix V).The groups drew their designs on the site map using tracing paper and then reported their design plans back to the larger group. A large group discussion, facilitated by Dr. Jiri Marsalek, was then held to compare results and explore alternative solutions. This presented an excellent opportunity for participants to learn from each other's experience as well as receive feedback on their design plans from a national stormwater expert.

The workshop ended with an hour for participants to view display booths showcasing various rainwater harvesting and stormwater management treatment technologies. Booths were displayed from the following Halifax-based companies:

- Grun-Sol Technologies (rainwater harvesting, gray and black water recycling)
- Soleno (Stormwater collection, storage, treatment)
- Shaw Group (Stormwater treatment)
- EMCO Ltd (Stormwater treatment)

The Ecology Action Centre was able to leverage funding from the Climate Change Adaptation Fund to hold two additional stormwater management workshops. Funding was received from the Bay of Fundy Ecosystem Partnership (BoFEP) to host one-day 'Stormwater and Wastewater Management' workshops in Digby (Feb. 22) and Saint John, New Brunswick (Feb 23). The workshop in Digby had 23 participants representing the Town of Digby, Town of Shelburne, Town of Middleton, Town of Annapolis Royal, Town of Yarmouth, Municipality of West Hants, Municipality of Digby, Yarmouth/Argyle/Barrington Planning District as well as local environmental organizations Tusket River Environmental Protection Association (TREPA) and Clean Annapolis River Association (CARP). The Saint John workshop attracted 45 participants representing many town and municipal officials, provincial government, consultants and environmental organizations from across New Brunswick.

Workshop Content

Key Points on Issues Associated with Stormwater Management:
Summary from John Sheppard (Halifax Water) and Bill Adams (IBC) presentations

- We are experiencing more intense and frequent precipitation events due to climate change

- Nova Scotia's coast and water resources (including residential, municipal, and industrial infrastructure) are increasingly vulnerable to extreme weather impacts.
- Development and land use patterns (increased impervious surface area coverage) are changing peak volume, speed and quality of runoff.
- Old development patterns led to encroachment and loss of natural water filtering/storage systems (floodplain and wetlands). These systems capture and gradually release runoff.
- Impacts include flooding, erosion, degradation of receiving water bodies, higher costs, risks to human health and safety, prevention of groundwater recharge.
- Impacts of thermal water pollution needs to be considered
- Older areas of Halifax and Dartmouth (pre-1960's) are treated by combined sewer systems
- Stormwater entering wastewater systems is a serious operational and maintenance issue that leads to sewage overflows, basement backups, washout of treatment processes
- Halifax Water leads investigation and assessment to increase compliance
- Old infrastructure/past standards do not meet reality of today's weather
- Inadequate investment to upgrade infrastructure.
- National municipal water supply, wastewater and stormwater system deficit stands at $31 billion for existing infrastructure, with new needs estimated at almost $57 billion ($88 billion total)
- Several different regulators are involved. Nova Scotia Environment regulates freshwater environments, Department of Fisheries and Oceans regulates marine environment
- Across Canada, extreme weather has replaced fire as the highest cost of insurance payouts. Water related damage (mostly basement flooding and sewage backups caused by increasingly intense and unpredictable precipitation) costs the insurance industry 1.2 billion dollars annually in insurance payouts.
- These costs are rising quickly. In Atlantic Canada, home insurance claims resulting from water damage, increased by 143% between 2005 and 2009**.**
- Consumer awareness is an issue. Do people know what their policy covers?
- Adaptation is local. Individuals can make a difference.

Key Points on HRM Stormwater Policy and Initiatives:
Summary from Paul Morgan (HRM) presentation

- HRM Regional Plan requires watershed studies prior to secondary planning strategies for new communities
- Watershed studies will:
    - recommend water quality objectives for key watercourses
    - determine assimilative capacity and areas suitable/not suitable for development
    - recommend stormwater management measures, regulatory controls
    - recommend water quality monitoring plan
- Example was given of Bedford West Secondary Planning Strategy which includes 3 components: Environmental Protection, Municipal Services and Land Use. Stormwater management plans fall under Environmental Protection, along with preservation of Environmentally Significant Areas and watercourse setbacks and tree replanting program

- Stormwater Management Functional Plan is required by Regional Plan – objective is to determine appropriate measures to improve quality of stormwater into natural receiving waters and reduce peak discharges
- A stormwater management and lot-grading by-law is being prepared for approval by HRM

Key Points on Innovative Stormwater Management Approaches:
Summary from Jeff Pinhey (ABLE Engineering) and Jiri Marsalek (Environment Canada) presentations

Key Concepts:

- Watersheds include land (forests, fields, urban/rural developed areas), not just streams, rivers and lakes. Any activity on land will impact how runoff through the environment and contaminants enter the water from many sources.
- Innovative stormwater management approaches aim to keep it simple. Look for opportunities for multiple gains and simple approaches rather than a giant solution. Favour passive, low energy solutions.
- Our biggest gains come from mimicking natural functions, i.e. working with gravity (grading, sloping) of land using, natural drainage paths and land features that already slow water or retain water (wetlands, floodplains). Allow ecology of the land to determine what development should take place (theory of ecological determinism)
- Investigation and assessment
- Pre-development conditions determines how we should develop
- Stormwater management solutions are site specific
- Geology matters. Consider soil type, bedrock depth when selecting appropriate BMPs.

Key Approaches:

- Stormwater management starts with good planning
- Reducing runoff volume commonly looks for opportunities to increase infiltration, increase storage and slow peak flows. (I.e., Slow it, spread it, sink it)
- Enhancing runoff quality commonly uses settling, filtration, vegetation measures, or a combination of practices where possible.
- Runoff can be viewed as either a resource (chronic events can be source of water to reuse)or hazard (catastrophic, intense rainfall events lead to flooding)
- Sites should be designed to have same pre and post peak flow and volume of runoff for the chronic storms
- 3 tiers of stormwater management - on-site, neighborhood level and watershed level
- On-site measures attempt to:
    - reduce directly connected impervious areas,
    - divert runoff from impervious to pervious
    - increase water storage and reuse.
- Neighbourhood measures attempt to:
    - Reduce impervious surfaces, avoid curb & gutter street design

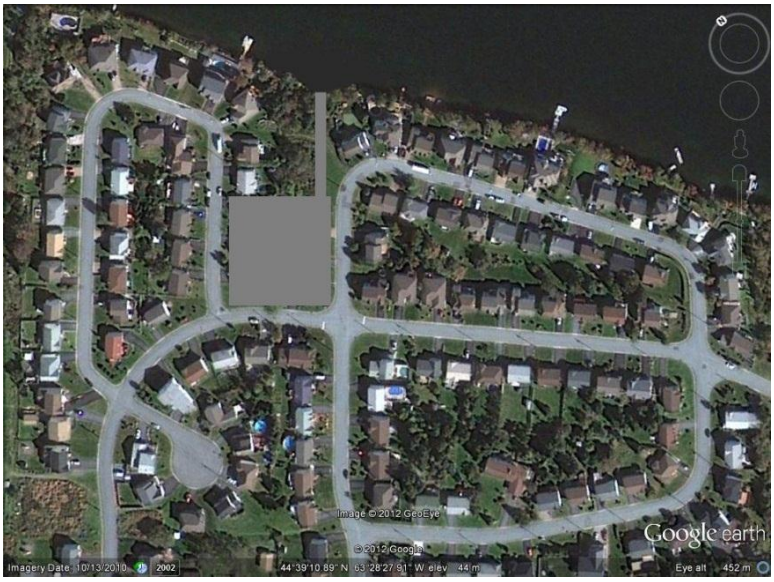
        - Compact stormwater treatment devices
        - Stormwater ponds and wetlands
        - Parking lots with pervious pavement
        - Source controls (street sweeping, reduce road salting, contaminants retention, restoration of contaminated areas)
- Watershed measures attempt to:
        - Establish riparian buffer zones
        - Provide passive or active treatment for all stormwater
        - Designate and maintain temporal flood waters storage areas
        - Maintain natural stream channels
- Policy (non-structural) measures are an important component
- To sustain benefits, monitoring and maintenance are needed
- Education and incentives
- Importance of watershed planning – cumulative impacts

Considerations:

- Water Balance over different timescales
- Green field developments (GFD) vs. retrofit developments GFD have space for SW BMPs and costs covered by new homeowners. Retrofits have more space and financial constraints. Focus depends on rate of municipal growth. GFD important in areas that are growing, retrofits important in areas that are shrinking.
- Residential features need to be dovetailed with education and consideration of practicality (climatic conditions, expense)
- Seasonal changes of rain events

Stormwater Scenario Exercise Summary

Scenario One: Cattail Lake



Site Description:

- Suburban lakeside development with many new homes, a school and a community centre recently constructed
- Untreated stormwater enters into the lake
- Algal blooms have been occurring over the past several years
- The large parking lot frequently floods
- A recently introduced 'Stormwater Surcharge' has motivated homeowners to reduce imperviousness and runoff in the neighbourhood

Options presented by groups to improve stormwater management on-site:

To reduce runoff leaving homes/streets:

- Plant trees on front lawns
- Reduce driveway imperviousness by using pervious materials or narrowing width
- Remove or create cuts in curbs to allow runoff from road to enter bioswales
- Vegetative island in centre of cul-de-sac and street intersections. Regrade so runoff flows to centre area
- Encourage homeowners to install of rainbarrels and raingardens
- Green roof and rainwater harvesting system for school or community centre
- Disconnect downspouts and direct runoff toward infiltration trench

To reduce parking lot flooding:

- Use permeable pavement on large parking lot, or reduce size of parking lot
- Create underground storage beneath parking lot

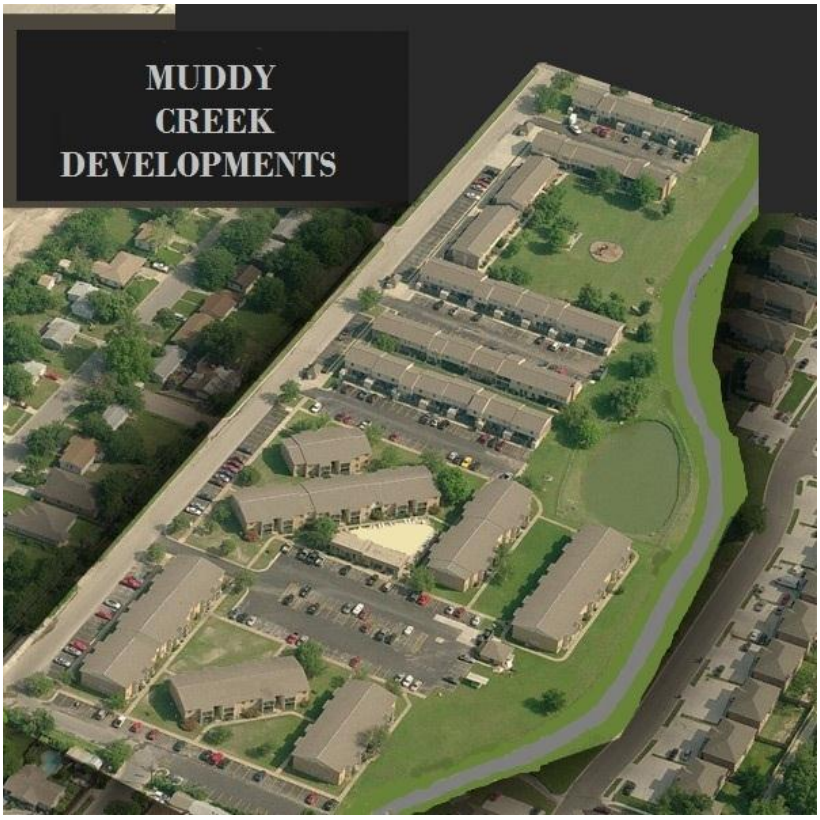
To improve water quality in lake:

- Engineered wetland between parking lot and lake
- Storm septor at outfall to treat stormwater
- Install hypolimnion aerator to improve oxygen flow
- Native species planted along shoreline

Non-structural BMPs:

- Homeowner education program to encourage use of native plants, riparian zone planting, organic fertilizers, reduce pet waste
- School outreach program
- Use phased approach beginning with education (phase I), consultation with others and work in common areas, ie. Wetland for parking lot runoff (phase II), engage residents around entire lake and encourage more individual actions (phase III)

Scenario Two: Muddy Creek Developments



Site Description:

- Muddy Creek Developments consists of rows of apartments and townhouses with ample parking, landscaped green space, paved bike trail and interest to plant a community garden
- Unfiltered stormwater enters the small pond and growing algal blooms are a concern for residence
- Water has been collecting between the rows of apartments and a few homes are experiencing basement flooding following heavy rain events

Options presented by groups to improve stormwater management on site:

To reduce flooding on site:

- Lot grading away from building and toward pond to reduce basement flooding
- Runoff from roof drains collected in Z-boxes
- Daylight downspouts
- Install french drains
- Use rainbarrels to collect rooftop runoff
- Reduce parking surface area and add swales or bioretention area in the middle of the lot, or remove curb and create a bioswale along edge of parking lot
- Undulate surface of parking lot

To improve water quality of pond:

- Plant vegetation along shore of pond (create riparian buffer) to increase nutrient uptake, improve habitat
- Add stormwater septor/ oil grit separator to treat runoff and ensure proper maintainance

Other non-structural BMPs:

- Create community association to manage, maintain systems and create policies to reduce pesticides and pet waste

Workshop Assessment

The workshops provided an excellent opportunity to bring people from various backgrounds together to network, talk about issues, share information and knowledge and discuss what is needed to improve stormwater management in HRM. Information presented was relevant and needed by the planning community, and speakers were excellent. Bringing in a national expert to present, facilitate the scenario exercise and lead the field trip was a key factor in making this workshop a success. Positive feedback was received from the organizers, presenters and participants (Appendix VI – Workshop Evaluation).

Stormwater Demonstration Site Selection Process

In November, 2011, preliminary assessments of several HRM owned buildings on the Halifax Peninsula were conducted to determine retrofit potential. Factors considered in the initial site visits were building location (proximity to homeowners, accessibility, and visibility for passer-bys), area of impervious surface cover, area of green space that could be available for landscaping features, rooftop runoff collection (presence of downspouts and eavestroughs), potential water issues on-site (flooding, wet areas) and presence of existing stormwater management techniques implemented on-site. Eight sites were visited in during our initial scoping, including the Adventure Earth Centre, Citadel Community Centre, George Dixon Community Centre, Duffus Street Fire Station, University Avenue Fire Station, West Street Fire Station and Devonshire Family Court and the Saint Mary's Boat Club.

In consultation with our project partners we narrowed down our initial list of sites and selected the following top three demonstration candidate sites:

- University Avenue Fire Station
- Duffus Street Fire Station
- George Dixon Community Centre

A further assessment of our three candidate sites was conducted during our 'Applied Stormwater Management' workshop fieldtrip with Dr. Jiri Marsalek. The field trip provided options for reducing the volume of runoff leaving each site and provided ideas that informed the development of a basic retrofit design plan. A detailed site description and summary of Dr. Marsalek's comments are included below. Following our field trip, additional information was gathered through conversations with HRM Building Maintenance Service and other stakeholders to identify willingness to participate in the project, discuss

current water issues on the property, opportunities for water reuse and explain preliminary design plans to improve stormwater management on site.

From these conversations and based on advice of Dr. Jiri Marsalek, the project committee decided that the best opportunities to demonstrate a range of BMPs exist on two sites – the George Dixon Community Centre and the University Avenue Fire Station. Plans for the George Dixon Community Centre include a rain garden and other landscape based approaches to improve stormwater management, and the more urbanized University Avenue Fire Station will showcase tools for water storage and improving permeability of the site's compacted gravel parking lot. The diversity of these two sites will allow us to highlight a range of tools that will be transferrable to different locations and building types, will allow a wider audience to view the BMPs and will lead to the creation of not one, but two, stormwater demonstration sites for HRM! Basic site descriptions and design plans for the George Dixon Community Centre and the University Avenue Fire Station are included below.

Candidate Demonstration Site Descriptions

Site: George Dixon Community Centre
2502 Brunswick Street
Contact: Claudette Levy, Area Coordinator, HRM (490-4560)

Site description:

This community centre is located in Halifax's North End. The building has a gymnasium, pottery room, rental spaces and offices. The community is connected to the building and there is high walking traffic through the park in the summer months. In winter months, an area of the hill near the basketball courts is used for sliding.

This is a large site with significant area coverage of both pervious (lawn and small planted garden) and impervious (paved paths, parking lot, rooftop, water park) areas. The steeply sloping and terraced grounds contain 4-5 distinct levels that contain a basketball court, playground and small water park. There are plans to create raised vegetable gardens this summer in partnership with the Nova Scotia Sea School. There is interest in collecting rainwater for irrigation purposes.

The community centre building has a large flat roof. Runoff is collected on the roof and enters into the building through internal spouts. The building has no eavestroughs or downspouts. The large parking lot is curbed and has one catchbasin. Several asphalt pathways exist on the site and the site is serviced by combined sewer systems.

Claudette Levy is excited to be part of our stormwater retrofit project and feels it would be a great initiative that the community would support and learn from. Her only concern is regarding additional site maintenance.

Water issues on site:

- There have been issues with the roof leaking above the gymnasium.
- Runoff is currently funneled toward the paved pathway leading from the lower parking lot to the main entrance of the building. This leads to a problem with ice covering the path in the winter.

Comments from site assessment with Dr. Jiri Marsalek:

- Theoretical annual runoff could be 20,000 m^3
- Work with the terracing theme that already exists. Additional terraces could be added.
- Terracing and steep slopes may indicate presence of rock or bedrock (soil infiltration opportunities may be limited)
- Options to enhance soil storage of water exist
- Opportunities for several water features (pond, fountain) exist, but may need treatment if used for recreational purposes (wading pool)
- Paved paths that run through the path will contribute to generation of runoff. Could be reduced by discharging runoff onto neighbouring pervious surfaces (ie. crowning) so water quickly leaves path.
- Could use weir rings on rooftop inlets to slow inflow of water and increase evaporation
- Add trees and shrubs to increase evapotranspiration and rainfall interception

Preliminary Retrofit Design Plan:

Two main stormwater BMPs will be demonstrated at the George Dixon Community Centre including **bioretention (rain garden) and water capture and storage**. We have engaged a landscape architect,

Cary Vollick of Vollick McKee, and engineer Jeff Pinhey, ABLE Engineering, to help develop a design plan for this site. The design plan will identify:

- the most suitable location for a native plant *rain garden* to demonstrate bioretention
- opportunities to capture and store rooftop runoff for reuse on site for irrigation purposes
- options to reduce the runoff volume funnelling onto the paved pathway leading from the building's main entrance to the Brunswick Street parking lot. This may include trenching the side of the path to create small *bioswales*, crowing the pavement to slow and divert runoff off the path or replacing the asphalt surface with *porous pavement or permeable pavers* (interlocking concrete blocks).

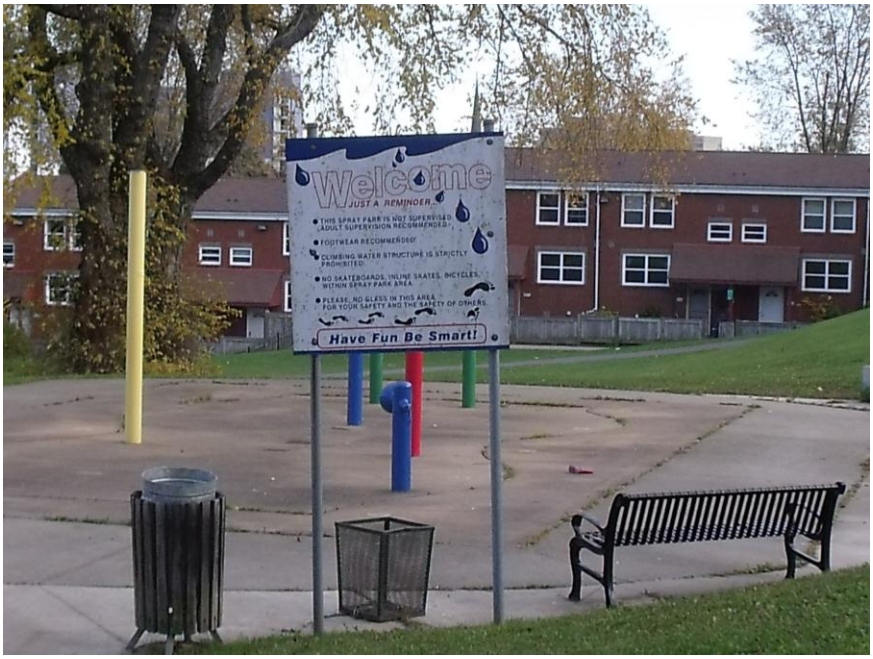
The landscape architecture design plan will likely include more BMPs than we are able to implement this summer, however, the plan will provide excellent guidance for future work that could be done to improve stormwater management on this site. The design plans will be featured on our stormwater blog.

Interpretive panels showing **downspout disconnection, water capture and reuse and permeable pavement** will be showcased on site as an education and awareness tool.

Additional site photos:

Site grading

Parking lot



Existing water park

Site: University Avenue Firehall
5988 University Avenue
Contact: Chris Mitt – Transportation and Public Works, responsible for all fire stations. 490-5564

Photo: www.halifax.ca/fire/images/station_2.jpg

Site description:
This centrally located fire hall is located adjacent to Dalhousie University and the IWK Health Centre. The area is highly urbanized with limited pervious cover. The large building is surrounded by paved sidewalks, roads and has a gravel parking lot. Raised garden beds exist around one side of the building.

Runoff is collected from the large roof into several downspouts which are connected to the building's internal piping. Opportunities exist to disconnect the downspouts and allow for water infiltration or storage.

The land is graded toward the building on one side. This may lead to flooding or water damage (unconfirmed). There is one stormwater inlet at the low point of the sloping side the building.
The gravel parking lot at the back of the building may be larger than necessary as there only appears to be two rows of parking. Downsizing the parking lot could provide additional space for water infiltration or storage opportunities.

The area has high foot traffic and could be a highly visible location for a demonstration site. The site resembles a house, so retrofitting this location may showcase BMPS that are applicable for homeowners and developers. The area is serviced by combined sewer systems.

Chris Mitts is very interested in greening initiatives for the fire stations. Upgrades to the parking lot are being considered for this summer, and permeable pavement could be an option. The building is a heritage site, which means any changes to the exterior of the building would need to be approval.

Water Issues on Site:
There is concern that snow plows push gravel into the storm drain causing it to clog in the winter.

Comments from site assessment with Dr. Jiri Marsalek:

- Site is approximately 1000m2, and is nearly 100% impervious
- Theoretical annual rainfall runoff~1000m^3
- Solutions are somewhat limited on such small parcel or land, perhaps could explore collaboration with neighbouring IWK garden (directly across the road) ie. Add water feature/fountain, irrigation for garden
- Concrete at front of building is necessary for firetrucks, but runoff could be intercepted using a grated drainage channel. This would divert runoff to either side of the building
- Could increase storage on sloping side of building (ie. Large planter box –box could have two levels one for vegetation (evapotranspiration) and one for storage and reuse). Water from storage would slowly be released to reduce peak flow discharge
- Imperviousness of parking lot could be improved

Preliminary retrofit design plan:

The two main stormwater BMPs that will be demonstrated on the University Avenue Fire Station are **water capture and storage** and **permeable pavement**. The eight downspouts around the building will be disconnected and directed toward a large cistern or stormwater planter on the east side of the building. A stormwater planter would have two levels, as described above. The top level would be planted with vegetation and the bottom level would provide water storage. The captured water would be available for reuse on site (washing fire trucks and irrigation). Discussions have also been held with Ian Williams (Plant Maintenance, IWK) who is interested in reuse captured water for irrigation of the Newman Garden in front of the maternity ward. We will consult with Mr. Williams as this project moves forward.

The imperviousness of the compacted gravel driveway will also be improved. The parking lot will likely be paved with regular asphalt, but will include a strip of permeable pavement (porous asphalt) along one side. There will be a clear stone base under the permeable area with a perforated PVC pipe leading to catch basin in the corner of the lot. Water that infiltrates through the pavement will have a chance to soak into the ground before being picked up by the perforated pipe. The parking lot would be graded to allow runoff to flow toward the permeable area. We will also consider reducing the size of the parking lot to provide more green space for a potential bioretention area (swale or rain garden) that would use native plants.

Interpretive panels showing **downspout disconnection, water capture and reuse and permeable pavement** will be showcased on site as an education and awareness tool.

Additional site photos:

The large gravel parking lot will be redesigned

Land sloping toward building. A cistern/planter box will be installed here.

Site: Duffus Street Fire Station
5830 Duffus Street

Site description:
This firehall is located beside a school in a residential area of Halifax. Halifax Water has a water tower near the site. There is a considerable amount of lawn space and including some landscaped gardens exist at the front of the building. There is a large amount of impervious area including concrete pathways and a parking area (parking lane). Back of building is mostly paved.

The firehall has a large flat roof. Runoff is collected on the roof and enters into the building through internal spouts. There are no eavestroughs or downspouts. This area is serviced by combined sewer systems.

Comments from site assessment with Dr. Jiri Marsalek:
-Site is an example of poor stormwater management planning. (Angular lot with excessively large driveway)
- Gardens, increased vegetation and bioretention areas could be added to slow runoff and beautify grounds
- Firefighter monument could be highlighted and enhanced with more vegetation
- Replace access driveway with more pervious surface. Could also be sloped to bring more runoff toward newly created pervious areas
- Add weir rings on rooftop inlets to slow inflow and keep layer of water on roof surface for evaporation

Additional site photos:

Large impervious area (with monument)

Stormwater Management Blog

Our stormwater management blog (www.stormwatercentral.ca) went online in November, 2011, and has since had 30 posts and over 1,900 views. The purpose of the blog was to raise awareness of issues associated with stormwater in a changing climate and showcase a range of tools to reduce runoff volume, velocity and pollutant load. The blog has been an excellent tool to highlight various innovative tools that have already been applied to developments the in HRM region and elsewhere. The researcher was able to visit several sites with developers and project engineers and learn about the techniques that have been implemented. Each site was then described on the blog including:

- Dartmouth Crossing (retention ponds)
- Canada Games Centre on Lacewood Drive (detention ponds)
- Prospect Community Centre (bioswales)
- Dalhousie University (porous asphalt)
- First Lake (Contaminant/Sediment Control (CSC) Filter System)
- Russell Lake (Continuous Deflection Separators)

Five original videos have also been produced for our blog:

- Grey Water Recycling
- Managing Stormwater Quality in Urban Lakes
- Retrofit Assessment: University Avenue Fire Station
- Retrofit Assessment: Duffus Street Fire Station
- Retrofit Assessment: George Dixon Community Centre

Blog stats show that people are finding the blog through directly linking to the site, through facebook links and through google searches of keywords such as 'porous pavement', 'urban bioswale', 'continuous deflection separators' and 'stormwater infiltration'. The geographic audience for the blog is wide ranging with nearly 1100 visits from Canada, close to 500 from United States and the rest from other countries around the world (as of March 19, 2012). Our most popular post to date was 'Bioswales' written on Dec 10th, followed closely by our original 10 question Stormwater Management Quiz posted on January 4th.

The blog will continue throughout Phase II of the project to document the development of our demonstration sites from start to finish.

Stormwater Policy Options for HRM

Research was conducted to determine some leading stormwater policy tools that have been implemented in other areas across Canada and the United States. The general purpose of the policies is to reduce stormwater runoff rates and volume in order to limit associated impacts such as flooding, infrastructure and property damage, erosion, sediment transport, decrease in groundwater recharge, degradation of aquatic habitats and combined storm sewer overflows. Several policies exist that try to maintain pre-development hydrologic conditions by regulating the quality and quantity of runoff that can leave a site post-development. Other policies require developers to implement Low Impact Development techniques for new developments and re-developments, while others encourage a homeowners to reduce runoff by creating stormwater charges for property owners based on the impervious surface area. Examples of specific stormwater policies that could be implemented in Halifax Regional Municipality are described below. This policy review will be shared with Richard MacLellan, Director HRM's Department of Energy and Environment and Paul Morgan, Senior Planner, who is drafting the Stormwater Management Functional Plan for HRM.

Low-Impact Development Bylaw – State of Massachusetts
http://www.mass.gov/envir/smart_growth_toolkit/bylaws/LID-Bylaw.pdf

The purpose of this bylaw is to provide guidance for planning of new and re-development projects and to regulate post-development stormwater runoff quality and quantity. The bylaw includes site planning guidelines encourages the application of both structural and non-structural Best Management Practices. The LID bylaw states:

- *Require that new development, redevelopment and all land conversion activities **maintain the natural hydrologic characteristics of the land** in order to reduce flooding, stream bank erosion, siltation, nonpoint source pollution, property damage, and to maintain the integrity of stream channels and aquatic habitats;*

- *Encourage the use of LID practices such as reducing impervious cover and the **preservation of greenspace and other natural areas**, to the maximum extent practicable; Coordinate site design plans, which include greenspace,*

- *All stormwater runoff generated from land development and land use conversion activities **shall not discharge untreated stormwater runoff** directly to a wetland, local water body, municipal drainage system, or abutting property, without adequate treatment.*

- ***Annual groundwater recharge rates shall be maintained**, by promoting infiltration and recharge through the use of structural and non-structural methods. At a minimum, annual recharge from the post development site shall equal the annual recharge from pre-development site conditions.*

- *Structural best management practices (BMPs) must be designed to remove [80%] of the average annual post development total suspended solids (TSS) and [40%] for total phosphorus [TP], and [30%] for total nitrogen (TN). It is presumed that a BMP complies with this performance goal if it is:*
    a) Sized to capture the prescribed water quality volume;
    b) Designed according to the specifi c performance criteria outlined in the [Massachusetts Stormwater Management Manual or an approved local equivalent];
    c) Constructed properly; and
    d) Maintained regularly.

Land Use Planning Measures - State of Washington
http://www.ecy.wa.gov/programs/wq/stormwater/municipal/LID/LIDjointMTGmaterials081210.pdf

In 2010, the Department of Ecology proposed requirements and timelines to update development codes to incorporate Low Impact Development through zoning and subdivision code changes. Land use planning measures to reduce stormwater runoff include reduced road width, retention of native vegetation in new developments, clustering and impervious surface area limits.

Developers may also be subjected to a graduated menu of required stormwater management technologies that change according to the amount of impervious surface area for a proposed project. Developments with > 2,000 ft^2 are subject to a list of mandatory LID measures including rain gardens, green roofs, permeable pavement, etc. Developers are required to select techniques from the list to meet performance standards based on maintaining pre-development runoff characteristics.

Green Roof ByLaw, Toronto, Ontario:
http://www.toronto.ca/legdocs/municode/1184_492.pdf

Toronto is the first City in North America to have a bylaw to require and govern the construction of green roofs on new developments. It was adopted by Toronto City Council in May 2009 under the City of Toronto Act. The bylaw applies to new building permit applications for residential, commercial and institutional developments.

The green roof coverage requirement is graduated and ranges from 20-60 per cent of available roof space, depending on the size of the building. Available roof space is the total roof area minus areas designated for renewable energy, private terraces and residential outdoor amenity space. Residential buildings less than 6 storeys or 20m in height are exempt from being required to have a green roof.

Gross Floor Area (Size of Building)	Coverage of Available Roof Space (Size of Green Roof)
2,000 - 4,999 m^2	20%
5,000-9,999 m^2	30%
10,000-14,999 m^2	40%
15,000-19,999 m^2	50%
20,000 m^2 or greater	60%

Source: www.toronto.ca/greenroofs/overview.htm

Rainfall Capture, Chilliwack, British Columbia:
http://www.chilliwack.com/main/attachments/files/658/Surface_Water_Management.pdf

- *Capture the first 30mm of rainfall per day and return it to the natural hydrologic pathways by promoting infiltration, evapo-transpiration and reuse. Where the permeability of local soils prohibits effective infiltration, alternative source controls may be required to meet the City's performance targets (capturing rainwater for reuse – greywater and/or irrigation, applying green roofs to residential, commercial buildings and parkades)*

Protection and Management of Rainwater Bylaw - District of Metchosin, British Columbia:
https://metchosin.civicweb.net/Documents/DocumentDisplay.aspx?ID=276

- Post-development quantity of runoff: *The quantity of rainwater leaving the site after development shall be equal to or less than the quanity of rain water leaving the site before development, to the maximum extent possible to achieve the following performance targets:*

  *a. Impervious surfaces shall be **designed to drain at least 90% of the rainwater runoff volumes** entering the lot for any storm event to natural hydrologic pathways at the site within the same lot (ie through infiltration and other source controls) such that not more than 10% of the total rain water runoff volume crosses any lot line at post-development*
  b. The rate of pre-development rainwater runoff from the lot shall be maintained at all times to ensure stream flow rates do not exceed those rates corresponding with the Mean Annual Flood, and that this maximum rate will occur not more than once per year

- *where the onsite retention and infiltration of rain water is not possible, development shall require detention that:*

  a. Prevents an increased rate of flow leaving a site during a range of storm events
  b. Ensures the rain water runoff from the lot if less than 10% of the rain water received on the lot
  provides enough storage capacity to capture the rain water runoff from the mean annual rainfall , and releasing the stored runoff at the pre-development rate of infiltration

Stormwater Credit Policy –City of Kitchener, Ontario
http://www.kitchener.ca/en/livinginkitchener/Stormwater_Credit_Policy.asp

This program, approved in March 2012 by Kitchener city council, offers incentives to property owners who reduce quantity and improve quality of stormwater runoff leaving their properties. In 2011, the City of Kitchener altered the funding approach of its stormwater program, moving it from the tax base to a user-pay system. The rate is based on the amount of impervious area on each property and creates sustainable funding for the City's stormwater management program.
The stormwater credit policy will offer incentives to property owners who actively decrease the volume of stormwater and pollution coming off their properties and will come into effect Oct. 1, 2012.

Private property owners are encouraged to reduce total volume and pollutant load of stormwater runoff through already existing or proposed stormwater facilities or through best management practices.

- *Non-residential and multi-residential property owners who pay the stormwater rate are eligible to apply for up to 45 per cent credit. Three components will be considered: flood prevention, pollution reduction and educational programs. Residential property owners can also apply for up to 45 per cent credit, based on the volume of stormwater diverted from the municipal stormwater system from their property.*

Dalhousie University Student Project

This project has allowed us to partner with six *Environmental Problem Solving II: The Campus as a Living Laboratory* students at Dalhousie University. The group of students selected a stormwater management project submitted by the Ecology Action Centre and have been supervised by Ashley Sprague. The student project is titled 'Best Stormwater Management Designs using Bio-retention Retrofits at Dalhousie University' and the group is creating retrofit design plans for two sites on campus – the Grad House and the Dunn parking lot. The students will present a range of options for each site with associated cost estimates for each option. The overall goal of the project is to develop designs through the use of bio-retention and other BMPs to help Dalhousie become a leader in stormwater management retrofits and act as a role model for other HRM properties. The designs will feature BMPs that are transferable to other properties (homeowners and larger buildings). The site design plans will be completed by April 3rd and the students will be posting their plans and site descriptions on the Stormwater Central blog.

Next Steps

This stormwater management project is now moving into phase II which will run from April 1- Sept 30, 2012 and is being funded by Halifax Water, HRM and Insurance Bureau of Canada to. Phase II focuses on completing retrofit work on the George Dixon Community Centre and University Avenue Fire Station stormwater demonstration sites. Additional work will now be done with landscape architect Cary Vollick and engineer Jeff Pinhey, to develop a detailed design plan for each site. A public event will be organized to celebrate the launch of Nova Scotia's first stormwater management demonstration sites. Media, public, project partners and others will be invited to this event will be held to the launch. Site tours will be planned for various stakeholder groups.

The Stormwater Central blog will continue to serve as a valuable education tool. The construction of the demonstration sites will be documented to provide a chronological timeline of developments, ideas, photos, and how-to videos. This will create a community sharing platform where people can share their innovative solutions to stormwater management.

This project is timely as HRM is beginning to develop a stormwater management functional plan as part of its regional planning process. Their approach will seek to identify areas where expensive seaward and wastewater infrastructure improvements are required and others where natural infiltration can be improved by use of techniques such as BMPs. As other municipalities prepare their Integrated Community Sustainability Plans before 2014, they will also benefit from access to information, resources, and demonstration sites around stormwater management. The policy findings and other resource materials generated from this project will be shared with HRM and made available for other municipalities.

Appendix I: Applied Stormwater Management Workshop Invitation

January 13, 2012

This letter is to invite you to 'Applied Stormwater Management Workshop', a 1 ½ day, interactive workshop focused on managing impacts of stormwater in urban landscapes. This workshop will take place on February 20th-21st at Dalhousie University. Hosted by the Ecology Action Centre, Halifax Regional Municipality (HRM) Environment and Energy Office, Halifax Water and Insurance Bureau of Canada (IBC), the workshops are designed to increase capacity of workshop participants to identify and implement stormwater Best Management Practices (BMPs) to reduce infrastructure damage, flooding and impacts to marine and freshwater systems. Interactive presentations will be given by local and national experts with extensive knowledge and practical experience with stormwater management.

This one day workshop will provide information, resources and opportunities to discuss topics such as:

- Impacts of stormwater including flooding, infrastructure damage and reduction of water quality
- Stormwater policy, regulations and initiatives in Nova Scotia and elsewhere in Canada
- Innovative stormwater BMPs for existing and new developments
- Site assessment methodology to guide on-site BMP implementation

A half day field trip will also be offered to discuss appropriate BMPs and retrofit options for a range of sites in HRM. Guided by a leading Canadian stormwater expert, the field trip will identify site-specific bioretention and water harvesting solutions to reduce stormwater runoff volume and rate. This will be present a unique, interactive learning opportunity for participants.

The Ecology Action Centre has worked towards sustainability for Nova Scotia's communities and environment for 40 years with a reputation of offering well–researched, cost-effective, solutions to environmental challenges facing Nova Scotia's communities. Energy and Environment is the organizational lead for Environmental Sustainability at HRM. Halifax Water is responsible for municipal water, wastewater and stormwater infrastructure in HRM. IBC is the national industry association representing Canada's private home, car and business insurers. IBC is well aware of the costly effects of severe weather events, and are actively engaged in developing, promoting and implementing adaption measures for homeowners and municipalities. The funding to develop this workshop and resource material comes from the Nova Scotia Environment's Climate Change Adaptation Fund.

The workshop will be held at Dalhousie University on February 20th. The field trip will take place on the morning or February 21st. Register online at **www.ecologyaction.ca/stormwaterworkshop** by February 3 if you are interested in this opportunity as enrollment is limited. There is a $30 registration fee for participants which will include snacks, lunch, resource material and field trip expenses.

Please contact Ashley Sprague with any questions.

Sincerely,

Ashley Sprague
Restoration Coordinator, Ecology Action Centre
(coastaloutreach@ecologyaction.ca)
902-442-5046

Jennifer Graham
Coastal Coordinator, Ecology Action Centre

Appendix II: Workshop Participants

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Appendix III: Applied Stormwater Management Workshop Agenda

Room307 Student Union Building, Dalhousie University
February 20th, 2012

Time	Activity	Presenter
8:30	Welcome and overview of day	Ashley Sprague, EAC
9:00	Introduction to Stormwater Management in HRM	John Sheppard, Halifax Water
9:30	Costs and Impacts of Storm Events to Homeowners and Municipalities	Bill Adams, IBC
10:00	Summary and Discussion	Jennifer Graham, EAC
10:15	Break	
10:30	Stormwater policy and initiatives in HRM	Paul Morgan, HRM
11:00	Innovative stormwater management: Examples in HRM	Jeff Pinhey, ABLE Engineering
11:30	Municipal Stormwater Management and Low Impact Development	Jiri Marsalek, Environment Canada
12:15	Lunch	
1:15	Stormwater Scenario Exercise: Introduction	Ashley Sprague, EAC
1:45	Stormwater Scenario Exercise: Group Work	All participants
2:30	Break	
2:45	Stormwater Scenario Exercise: Presentations and Facilitated Discussion	Jiri Marsalek, Environment Canada
3:30	Wrap Up, Evaluations	
4:00	Visit Display Booths	
5:00	End	

Tuesday, Feb 21: Field Trip

8:45 - Meet outside of DAL Student Union Building
9:00-12:00 – Guided field trip to assess potential stormwater retrofit sites

Ecology Action Centre
HALIFAX REGIONAL MUNICIPALITY
NOVA SCOTIA
IBC | BAC Insurance Bureau of Canada / Bureau d'assurance du Canada
Halifax Water Halifax Regional Water Commission

Appendix IV: Stormwater Scenario Exercise

Why a Stormwater Scenario Exercise*?*
The participants at this workshop represent many different types of expertise and experience about stormwater management. To maximize the opportunity to learn from each other, we will be spending some time today working in groups on stormwater scenario exercises.

We are using a scenario exercise format because it allows participants to apply the concepts presented in today's workshop, as well as their own expertise to hypothetical (yet realistic) urban stormwater management situations.

The purpose of this exercise is to practice selecting appropriate Best Management Practices (BMPs) to improve stormwater management on an individual property and neighbourhood scale. Try to identify opportunities to reduce the velocity, volume and pollutant load of runoff on your site by reducing impervious surface area, selecting tools to allow water to infiltrate into the ground and capturing and reusing rainwater.

How the activity works
Each group will work on one of two stormwater scenarios. Your scenario, along with a description of stormwater BMPs, are included in the workshop kit. The groups will work together to answer specific questions and prepare to report back to the larger group. Each group will find more photos of their site, flip chart paper and markers to help prepare to report back to the larger group. There will be a facilitated large group discussion after the small group session, to compare results and explore alternative solutions.

Getting started
- Introduce yourselves to each other. Find out about the background each member brings to the group.
- Read through your group's stormwater management scenario. Ask each other or the facilitators for clarification as needed.
- Lay the clear sheet provided on top of your site map and use a marker to draw changes to your site and selected BMPs.
- Assign a note taker to record highlights from the discussion for reporting back to the larger group.
- Figure out who will present your results to the larger group.

Answer these questions, keeping in mind the particular condition of your site, as well as the need to incorporate essential stormwater management concepts:

1. What are the opportunities and challenges for improving stormwater management on your site?
2. What are the on-site retrofit locations opportunities on your site? (rooftops, parking lots, underground, streets, parks, etc.)
3. What BMPs are the most appropriate to improve stormwater management on your site? Use a minimum of 3 different tools.
4. What additional benefits will your retrofit design plan create? (i.e., habitat, aesthetic value, water reuse, etc.)

5. What maintenance considerations apply to your design plan?

During the large group discussion you will have **5 minutes** to:

- Introduce your scenario
- Describe the on-site retrofit location opportunities on your site
- Present the various BMPs you have chosen to implement in your scenario
- Explain your reasoning behind the citing of various BMPs and how they will function to reduce velocity, volume and pollutant load of stormwater runoff.

Other tips

- It's your site! Feel free to add relevant information about existing land use, water use, habitat value, and human activities on the property. Also, you can make assumptions about your site if you feel the scenario is incomplete. For example: the size of stormwater outflows, drainage area, presence of bedrock.
- You can use additional BMPs that are not listed in the handout (i.e., tree planting, daylighting, education and awareness tools such as brochures for homeowners).
- If helpful, use sketches or additional drawings to explain your design plan when presenting back to the large group
- If time remains, feel free to discuss costs of your design plan based on your experience

Stormwater Scenario 1: Muddy Creek Apartment Development

Site Description:
Muddy Creek Developments is a spacious housing complex located only 20 km outside of the urban centre of Waterville, Nova Scotia. Land use has changed quickly in this area with several new housing developments, a school, community centre, and a shopping mall constructed in the past eight years. Only 10 years ago, the area was primarily forest with some land developed for agricultural purposes.

Muddy Creek Developments offers a range apartments, townhouses and condominiums at affordable prices. Ample parking space exists for residents and their guests. Rooftop rainwater is collected into downspouts which drain onto the site. The beautifully landscaped grounds consist of large grassed areas, a small water park and playground for kids, and a pond where you can relax and watch the resident ducks swim. A paved bike trail runs adjacent to the Development. Several youth in the area have recently decided to plant a community garden.

Stormwater Runoff Concerns:
The developer has recently started receiving complaints from tenants who are concerned about the health of the pond. Over the past two summers, the usually clear water has become covered with algal blooms. Families are no longer able to enjoy this space and the beloved ducks did not return to the pond this Spring. Storm drains collect runoff from the roofs and parking lots of the site, which drain into the pond unfiltered via one stormwater outlet. Wet areas have started to develop in between the rows of apartments and a few homeowners are also experiencing basement flooding following heavy rain events.

Additional Site information:
Soil type: Well-draining loam (60% sand, 30% silt, 10% clay)
Depth of water table: 4 m

Scenario #2: Cattail Lake

Site Description:
Development is rapidly growing around this suburban lake. The lake is very popular for recreation purposes, with canoeing, kayaking, swimming, fishing and bird watching all taking place during the spring and summer months. A large parking lot and paved road was built to provide public access to the lake. Many new homes, a school and a community centre have been constructed in the past 15 years.

Many of the lakefront homes have removed a high percentage of the existing vegetation in order to have an unobstructed view of the lake. The use of cosmetic pesticides is common practice for many homeowners. Untreated stormwater from the developments drains into the lake unfiltered via 10 different stormwater outlets.

Stormwater Runoff Concerns:
In the past 12 years, users of the lake have reported algal blooms and eutrophication, and for the past 5 years the local beach has had to be closed on days following heavy rain events. A local residents committee was formed to raise awareness about the health of the lake. The committee began testing the lake's water quality and found high levels of phosphorous.

The site slopes toward a depression where the parking lot was constructed to provide public access to the lake. Several large pools of water form in this area following heavy rain events and accelerated shoreline erosion has been reported in this area.

The municipality has recently introduced a 'Stormwater Surcharge' and rates are based on the area of impervious surfaces in a neighbourhood. The rates can be greatly reduced if the neighbourhood can demonstrate a reduction in runoff volume through of on-site retention and reuse or a reduction of impervious surface area.

In order to address these growing concerns, a community meeting was held and several homeowners committed to making changes on their individual properties. Residents also agreed to look for opportunities to help reduce the amount and pollutant load of runoff entering the lake in shared, public areas of the neighbourhood.

Additional Site information:
Soil type: Well-draining loam (60% sand, 30% silt, 10% clay)
Depth of water table: 4 m

Appendix V: Stormwater Retrofit Best Management Practices Handout

BMP	Description	Location possibilities	Pollutant Removal	Other benefits	Other Considerations
Detention (Dry) Ponds	- stores runoff after a rain event for some minimum amount of time (ex. 24 hours) - dry between rain events	- watershed or neighbourhood scale -existing ponds -roadway culverts -below outfalls -large parking lots	-fair removal of particulates -poor removal of soluble pollutants	-flood and erosion protection of downstream channel -groundwater recharge	-best used with other BMPs such as wetland or wet pond. -can be designed with pool at inlet and/or outlet -can be used with slopes up to 15% -most soil types appropriate -impermeable liner may be needed in sandy soils
Retention (Wet) Ponds	-permanent pool of standing water that temporarily holds stormwater - runoff from each new storm displaces water from previous storm	- watershed or neighbourhood scale -existing ponds -below outfalls -large parking lots	-moderate to high removal rate of all stormwater pollutants -both settling and biological uptake (i.e., algae) occur	-aesthetic value (community acceptance) -groundwater recharge	-need sufficient drainage area to maintain permanent pool -can be used with slopes up to 15% -most soil types appropriate
Constructed Wetlands	-shallow depressions that received stormwater inputs for treatment - runoff from each new storm displaces water from previous storm	- watershed or neighbourhood scale -existing ponds -roadway culverts -below outfalls -large parking lots -conveyance	- moderate to high removal of all stormwater pollutants -range of physical (settling), biological, chemical and microbial processes	-replicate natural wetland ecosystems -habitat value -aesthetic value (community acceptance)	-potential to take up a lot of space (not suitable for all urban areas) -need sufficient drainage area to maintain permanent pool -can be used with slopes up to 15% -most soil types appropriate

Filtration	-captures and temporarily stores runoff -runoff passed through an engineered filter media, collected in an underdrain and returned to storm drain system	-neighbourhood/ individual property -small parking lots -small, highly impervious sites	- moderate particulate pollutant removal -low soluble nutrient removal -mainly physical treatment (filtering, settling, straining)	-good for areas with limited space (use little surface land)	-several filter variations including surface sand filters, underground sand filters, organic media filters, multi-chamber treatment train - can have two chambers, one for settling and one serves as filter bed (i.e., sand) - Other engineered filtering systems exist (CDS separators, etc)
Infiltration (i.e., infiltration trenches, basins)	-shallow impoundment designed to capture and temporarily store runoff before infiltrating into soil -runoff initially passes through other treatment (i.e., swale) then is stored in rock filled chamber with no outlet before infiltrating into the ground	-neighbourhood/ individual property -small parking lots	-high pollutant removal -most pollutants trapped by soils	-increase groundwater recharge -reduce runoff volumes to prevent CSOs (runoff does not enter storm drain system)	-perforated pipe or other proprietary materials can be used instead of stone to increase storage capacity -effectively used in narrow, linear areas along property boundaries -soil requirements can limit applicability -bottom of basin must be completely flat to ensure infiltration throughout
Swales (bioswales, dry swales, grassed swales)	-linear vegetated open channel to slow and treat runoff -vegetation slows runoff allowing sedimentation -do not have underground rock-filled chamber, but may require fabricated soil bed to improve filtration	-neighbourhood/ individual property -small parking lots -individual streets	-moderate pollutant removal through settling, filtering, infiltration and plant uptake	-groundwater recharge	-improvement over conventional roadside ditch -most require widening, or deepening existing open channel -can be used for conveyance, or with other BMPs (i.e., rain garden) - best on slopes < 4% - not well suited for highly impervious soil types

Rain Garden	-small landscaped depressions that capture, filter and infiltrate rooftop runoff -sand/soil mix planted with grasses, shrubs, plants	-neighbourhood/ individual property -small parking lots -rooftop runoff	--moderate pollutant removal through settling, filtering, infiltration and plant uptake	-recharge groundwater -personal stewardship and increased watershed awareness -habitat value -aesthetic value	-allows at least 30% more water to infiltrate into the ground than conventional lawn (UWEO, 2002) -need proper maintenance -should be minimum of 10 ft. away from house to prevent basement flooding -well drained soils work best
Green Roofs	-layer of vegetation and soil installed on conventional roof designed to store and treat runoff	-neighbourhood/ individual property -commercial, industrial and residential buildings -rooftop runoff	-moderate removal of nitrogen and phosphorous due to soil microbial processes and plant uptake	-increased thermal insulation and energy efficiency - increased acoustic insulation -increased durability and lifespan compared to conventional roofs -habitat value	- extensive green roofs have < six inches of growing medium and usually have moss/grass cover (lower maintenance and cost) -intensive green roofs have > 6 inches of substrate and can support wide range of plants - flat roofs most common, but can be installed on 30% sloping roofs with special strapping -structural analysis of roof required to meet weight bearing requirements
Rain Barrel	-stormwater collection device to capture, store and reuse runoff from rooftop downspouts	-neighbourhood/ individual property -small parking lots -rooftop runoff	-low -designed for capture, not treatment	-water conservation through reuse (i.e., irrigation, car washing, etc.)	-should be drained and disconnected in winter months
Cisterns	- capture rooftop runoff from non-residential sites in aboveground or underground storage tanks	-neighbourhood/ individual property -small parking lots -rooftop runoff	- low -designed for capture, not for treatment	-water conservation through reuse (i.e., irrigation, grey water, etc.)	-generally much larger than rain barrels (typical capacity of over 40,000 L)
Stormwater Planters	-confined planters that store runoff and/or	-neighbourhood/ individual property	-low-moderate removal of nitrogen and phosphorous	-aesthetic landscaping feature	- infiltration planters allow runoff to pass through the planter and

	infiltrate runoff through soil bed -generally receive runoff from rooftop downspouts	-small parking lots -rooftop runoff	due to soil microbial processes and plant uptake	-useful in highly urban areas	into natural soil bed -filter boxes does not allow infiltration into natural soil bed -treat small drainage area
Permeable Pavers	-porous or semi-porous material used on driveways, parking lots and walkways to reduce and treat runoff -runoff infiltrates into soil or gravel bed	-neighbourhood/ individual property -small parking lots -rooftop runoff	-moderate pollutant removal	-groundwater recharge - aesthetic value	-can be porous asphalt or interlocking concrete blocks -maintenance required to ensure pores are not clogged
French Drains (Dry Wells)	-shallow underground trench with perforated pipe along bottom -runoff from rooftop leaders are directed to trench via swale or downspout	-neighbourhood/ individual property -small parking lots -rooftop runoff	-moderate removal of particles and soluble nutrients		-small drainage area -limited opportunities in very high density neighbourhoods -do not function in winter months - minimum of 10 ft. from house to prevent basement flooding - -regular maintenance required

Appendix VI: Workshop Evaluation Form Summary

Question	Response
Overall, how satisfied were you with this workshop?	very satisfied - 10 satisfied – 14 neutral -2
The content of this workshop was:	Too advanced for your knowledge - 1 (comment: a good thing!) just right for your knowledge - 23 too basic for your knowledge -2
The information presented was:	extremely useful -14 somewhat useful -12
The stormwater scenario exercise was:	extremely useful -12 somewhat useful -13 not useful - 1
How satisfied were you with the opportunity for discussion?	very satisfied - 5 satisfied -18 neutral – 2 dissatisfied - 1
What did you like most about the workshop?	-practical examples - Jiri Marsalek's presentation and input into scenario exercise -Jeff Pinhey presentation -presentations (variety of topics covered) -good cross section of people, experience -diverse group in attendance -interactive, opportunity to work together -scenario (hands on consideration of applying techniques) -excellent learning environment
What did you like least?	-more time for Jiri Marsalek's talk (questions) -would have liked smaller groups for scenario exercise -parking availability -wanted more on new developments vs. retrofits -more time to mingle -would like to hear a contractors perspective -presentations were informative, but could be more in-depth