LOW IMPACT DEVELOPMENT (LID) DEMONSTRATION PROJECT

5.1 INTRODUCTION

As discussed previously, The City of Ottawa and CLC have agreed to pursue phased stormwater management demonstration projects for the former CFB Rockcliffe using LID Best Management Practices (BMPs). An integral component of this process is the City of Ottawa and CLC's desire to advance the Rockcliffe CDP as a demonstration (or pilot) project for Low Impact Development (LID).

- CLC`s Goal – is for the Former CFB Rockcliffe development to be a model community for LID.
- City of Ottawa`s Goal – is to implement LID as part of development, monitor, gain experience, answer key questions and build capacity in a phased and controlled setting with a willing partner

The phased stormwater management demonstration project for the Former CFB Rockcliffe site using Low Impact Development Best Management Practices (BMPs) will be integrated with conventional piped stormwater infrastructure and stormwater management ponds.

Rigorous scientific research, evaluating the range of stormwater management treatment strategies, has produced overwhelming evidence that pipe and pond stormwater treatment strategies alone do not meet general water quality objectives (FTL, 2010) and are resulting in longer periods of elevated flow and exacerbated erosion issues, thermal enrichment of surface water bodies and increased pollutant loadings to receivers.

As such it is necessary that stormwater management treatment strategies begin by maximizing pervious surfaces and increasing infiltration and groundwater recharge through a combination of lot-level (source), conveyance and end-of-pipe stormwater management controls.

5.2 LID DEMONSTRATION PROJECT PURPOSE

The purpose of the demonstration projects is to implement, monitor, and evaluate alternative stormwater management systems based upon the principles of Low Impact Development (LID). LID design approaches utilize small scale, distributed, landscaped based controls which are intended to mimic natural watershed systems whereby rainwater is infiltrated, evaporated and reused with the goal of protecting aquatic and terrestrial systems, habitats and functions through the preservation of the site natural hydrology.

5.3 PROCESS

A work program was developed in consultation with the City of Ottawa in order to provide direction for potential LID controls to be implemented in parallel with the storm servicing presented in the Master Servicing Study (MSS) prepared by IBI (2015) - under separate cover.

A SWM Working Group has been formed and will consist of key members of the City of Ottawa administration, Canada Lands Company staff, and consultants engaged by Canada Lands Company.

Section 2.1 and describes the purpose of the SWM Working Group and Section 5.23 details the topics covered and comments received through the process. The following sections are the result of the aforementioned process and includes where possible the comments and requests of the SWM Working Group.

5.4 CHAPTER PURPOSE

The purpose of this chapter is to provide:

- The purpose of the LID demonstration project
- The LID demonstration project process
- An introduction to Low Impact Development
- Introduce and summarize LID lot-level, & conveyance controls options
- An outline of the phasing and timing of proposed LID implementation
- An outline of the LID demonstration project scope
- An assessment of the suitability of LID controls by land-use
- A description of the proposed LID techniques for future consideration
- A description of the proposed LIDs for implementation as part of Phase 1A
- Describe specific SWM related projects proposed as part of the re-development of the Former CFB Rockcliffe site
- An assessment of the post-development LIDs through modelling simulations
- Outline the proposed approach for 'scaled' stormwater infrastructure construction in concert with the proposed development phasing.
- Design guidance and approvals considerations
- Assumption protocols and monitoring requirements
- Construction sequencing and erosion and sediment control procedures
- Provide policy recommendations to City of Ottawa staff for consideration
- Summarize the SWM Working Groups meetings and comments

5.5 INTRODUCTION TO LID

LID is comprised of a suite of landscape-based, decentralized, micro-control Best Management Practices (BMPs). There are many definitions that have been developed in an attempt to define Low Impact Development, with the most widely accepted definition being that used by the United States Environmental Protection Agency (EPA, 2007):

Low Impact Development (LID) is a stormwater management strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution. LID comprises a set of site design approaches and small scale stormwater practices that promote the use of natural systems for infiltration, evapotranspiration, and reuse of rainwater. These practices can effectively remove nutrients, pathogens and metals from stormwater, and they reduce the volume and intensity of stormwater flows.

LID techniques mimic natural systems as rain travels from the roof to the stream by applying a series of practices across the entire subwatershed, development area, and or site before discharge to receiving water body. Real-world LID designs typically incorporate a series of LID BMPs in a 'treatment train' approach to provide integrated treatment of runoff from any and all sites.

The general approach is for a holistic strategy which utilizes the 'treatment train' approach which integrates with the broader landscape features and functions. The selected LIDs utilize infiltration practices to protect and enhance groundwater recharge, maintain hydrologic connection to watercourses, protect aquatic and terrestrial habitats, minimize erosion and maintain the existing conditions water balance.

Bioswales within a parking lot, Mississauga, ON

LID practices are considered at the earliest stage of site design, are installed during construction and sustained in the future as a component of the stormwater infrastructure system. Each LID practice incrementally reduces the volume of stormwater on its way to the receiver. In doing so, LID practices are applied to meet stormwater management targets for water quality, erosion and water balance (infiltration) objectives.

The Ministry of the Environment 2003 Stormwater Management Planning and Design (SWMPD) Manual contains guidance for stormwater management facilities that employ infiltration including lot level and conveyance controls. More specifically and in relation to the soils within the Former CFB Rockcliffe, the 2003 SWMPD manual Section 4.2 and Table 4.1 provides guidance that relates to "physical constraints which could limit the use of lot level, conveyance...", but does not in any way indicate that area soil with lower relative infiltration rates be excluded from infiltration practices. The infiltration rate of soils will have an obvious effect on the drawdown-time of the facility between events and therefore should be sized accordingly based on design guidance from sources such as the Low Impact Development Stormwater Management Planning and Design Guide Version 1.0 (TRCA/CVC - 2010) or others. As such, soil infiltration capacity guidance in the SWMPD manual should not be interpreted as a prohibition but as a caution that controls relying primarily on infiltration may not be as effective as they could be on soils with higher relative rate of infiltration.

Based on the in-situ soil testing as detailed in Section 3.5.2, it is anticipated that the soils tested at the Former CFB Rockcliffe will have a field saturated hydraulic conductivity below 15mm/hr and therefore will require the installation of a underdrain per the TRCA/CVC LID Stormwater Planning and Design Guide (2010). As such it the LID infiltration based lot-level and conveyance controls shall be designed as partial infiltration systems, where the volume to be infiltrated shall be the volume stored below the underdrain pipe.

LID practices, together with traditional BMP's can be applied to achieve an overall stormwater management system which provides better performance, is more cost effective, has lower maintenance burdens, and is more protective during extreme storms than conventional stormwater practices alone. The underlying concept is that each LID and traditional practice within the treatment train provides successive storage, attenuation and water quality benefits.

Furthermore, LID lot-level and conveyance practices may be beneficial in order to meet objectives beyond the field of stormwater management such as community sustainability objectives, energy/water conservation, reduction and reuse of materials, ozone protection, reduction of the effects of 'Urban Heat Island', aesthetic improvements and neighborhood revitalization.

5.6 SUMMARY OF LID LOT-LEVEL CONTROLS

LID lot-level (also known as source) controls are physical measures that detain runoff, encourage the infiltration of water into the ground and reduce runoff volumes. These systems are integrated into the design of private residential, commercial/retail and industrial developments, institutions, municipal lands such as parks, municipal buildings and even the municipal rights-of-way (ROW).

The suitability of LID lot-level controls (discussed in detail in Section 5.9) is generally evaluated based on criteria which include:

- Predominant soil types
- Primary land-uses
- Available area (assumed lot coverage)
- Implementation considerations
- Past and current consultations with stakeholders

Lot-level controls can include techniques such as green roofs, permeable pavement, soakaway pits, trenches and chambers, bioretention, rainwater harvesting (cisterns), downspout disconnections/ redirections, soil amendments, and tree clusters.

Green Roofs

Green rooftops, also known as “living roofs” or “eco-roofs,” consist of a thin layer of vegetation and growing medium installed on top of conventional flat (large commercial roofs). Green roofs are touted for their multiple benefits to cities, as they improve energy efficiency, reduce heat island effects, and create urban green space for passive recreation, aesthetics and habitat. To a water resources manager, they are attractive for their water quality, water balance, and geomorphic benefits. Hydrologically speaking, the green rooftop acts like a lawn or meadow by storing rainwater in the growing medium and ponding areas. Excess rainfall enters underdrain and overflows points and is conveyed in a typical building drainage system and onto the next LID BMP in the treatment train. After the storm, stored water is transpired by the plants or evaporates.

Green rooftops are particularly useful in developments with a high percentage of lot coverage sites where space for ground level BMPs is limited.

High-rise Green Roof Portland, OR

Permeable Pavement

Permeable pavements, an alternative to traditional impervious pavement, can be used for low traffic surfaces such as parking lots, driveways, access roads, plazas, and walkways. Permeable paving techniques include:

- Permeable Interlocking Concrete Pavers (PICP)
- Plastic lattice or grid systems (grass pavers)
- Porous asphalt and concrete.

Commercial Permeable Interlocking Pavers - Mississauga, ON

With all permeable pavements, the resulting surface voids allow stormwater to filter through the pavement into an underlying stone reservoir. Water then infiltrates into the underlying soils or enters an underdrain system. These systems provide an aesthetic alternative to traditional paving and can be used anywhere a traditionally paved system might have been installed.

Soakaway Pits, Trenches and Chambers

Soakaways, infiltration trenches and infiltration chambers are specific techniques within an overarching group of subsurface infiltration practices.

Soakaways and infiltration trenches are rectangular or circular excavations lined with geotextile fabric and filled with clean granular stone or other void forming material that receive runoff from a perforated pipe inlet and allow it to infiltrate into the native soil. They typically service individual lots and receive only 'clean' runoff (i.e. roof runoff). Soakways are well suited to sites where available space for infiltration is limited.

Infiltration Chamber installed below asphalt surface – Cheltenham, ON

Infiltration chambers include a range of proprietary manufactured modular structures installed underground, typically under parking or landscaped areas that create large void spaces for temporary storage of stormwater runoff and allow it to infiltrate into the underlying native soil. Most structures typically have open bottoms, perforated side walls and optional underlying granular stone reservoirs. They can be installed individually or in series in trench or bed configurations.

Bioretention

Bioretention, also known as 'rain gardens' captures, temporarily stores, and treats stormwater runoff by passing it through an engineered filter media. The primary component of a bioretention practice is the filter media bed, composed of a mixture of sand, soil, and organic material as filtering medium.

Bioretention can be applied in most soils or topography, since underdrains which collect and return filtered water to the surface or sub-surface system may be used when full infiltration into native soils is not feasible. Snow storage can be provided by bioretention, especially those located adjacent to parking lots and roadways. Plant material must be salt-tolerant, perennial, and tolerant of periodic inundation.

Bioretention is often popular in developments with a higher urban design standard as it can meet local landscaping requirements and provide improved site aesthetics.

Residential Bioretention (rain garden) Edmonton

Urban Bioretention (rain garden), Minnesota

Rainwater Harvesting (cisterns)

Rainwater harvesting (RWH) is the practice of intercepting, diverting and storing rainfall in an above or below-ground storage tank for future use. The captured rainwater is then pumped into the building where it can be used for non-potable water uses such as to serve toilets, to be used in building cooling processes or for outdoor irrigation applications such as underground sprinkler systems for landscaped elements. This capture and re-use of rainwater can, in turn, significantly reduce stormwater runoff volumes and pollutant loads.

Urban Cistern (Employment Building) – St.Paul, Minnesota

Downspout Disconnections/ Redirections

Downspout disconnection involves directing flow from downspouts to a pervious area. This prevents stormwater from directly entering the drainage system or flowing across a "connected" impervious surface such as a parking lot. Downspout disconnections are typically used in combination with other LID lot-level controls, but can be used as standalone techniques if appropriate quantities of pervious area are present.

Soil Amendments

Compost amendments are tilled or mixed into existing soils thereby enhancing or restoring soil properties by reversing the loss of organic matter and compaction. They also are used to make Hydrologic Group C and D soils suitable for on-site stormwater BMPs such as downspout disconnection, filter strips, and grass channels. Soil amendments benefits include increased infiltration, stormwater storage in the soil matrix, survival rate of new plantings, root growth and stabilization against erosion, improved overall plant health and decreased need for irrigation and fertilization of landscaping. Amended soils are suitable for any pervious area where soils have been or will be compacted by the grading and construction process.

While soil amendments will never be used solely to meet stormwater management objectives they are effective in reducing the overall runoff volume, will contribute to a lower peak discharge, and can help reduce the size of total runoff storage needed.

Park Soil Amendments - Kitchener, ON

Tree Conservation

Tree conservation at development sites should be given priority as a technique to maintain a natural hydrologic regime. Mature forest canopy, reduces stormwater runoff volume and peak flow and improve water quality, generate organic soils, absorb greenhouse gases, create wildlife habitat, and provide shading to mitigate temperature increases at development sites.

Tree Conservation accompanied by A Soakaway Pit Design - Hamilton, ON

5.7 SUMMARY OF LID CONVEYANCE CONTROLS

LID conveyance controls are linear stormwater transport systems that are generally located within the road right-of-way (ROW) of private and public roads or parking lots where they encourage infiltration of water into the ground, improve water quality and reduce runoff.

The suitability of LID conveyance controls depends on many environmental and planning considerations, including soil conditions, ROW size and characteristics, and implementation considerations. Section 5.9 and Table 23 discuss suitability considerations in detail.

LID conveyance controls can include techniques such as, vegetated and grass swales, bioswales or biofilters, subsurface perforated pipe systems and permeable pavements.

Vegetated and Enhanced Swales

Vegetated and enhanced swales have long been used for conveyance, particularly as roadway drainage. More recently, their benefits as a stormwater best management practice have been recognized.

Vegetated & enhanced swales are closer in hydrologic properties to natural zero order channels than drainage systems composed of curb and gutter, inlets, and pipes. Grass channels allow infiltration, discharge at a lower rate, and reduce pollutant loads.

Swales are most frequently applied for drainage alongside roads, highways, and parking lots however they are also well suited for use in conjunction with drive-lanes and rooftop drainage as well as within pervious surfaces, such as parks and landscaped areas.

Vegetated Swale – Seattle, WA

Bioswales or Biofilters

Bioswales and biofilters are essentially bioretention cells that are configured as a linear channel. The bioswale is a soil filter system that temporarily stores and then filters the desired water quality volume. Bioswales are similar to bioretention areas in that they rely on the same engineered media bed placed below the channel invert. Runoff volume which cannot fully infiltrate into the native soils is directed to an underdrain, which conveys treated runoff back to the conveyance system further downstream. The underdrain system consists of a perforated pipe within a gravel layer placed below the engineered media bed. Bioswales may appear as simple grass channels with the same shape and turf cover, while others may have more elaborate landscaping. Bioswales can be planted with turf grass, tall meadow grasses, decorative herbaceous cover, or trees.

Bioswales - Mississauga, ON

Biofilters are a bioswale variant, which is designed to prevent infiltration and instead focuses on the treatment of runoff by the media bed through filtration.

Although not categorically a bioswale, roadside bioretention facilities (or rain gardens) can be located with the municipal ROW to accept, treat and convey road runoff. An example of a proposed bioretention facility (rain garden) to be constructed along Sunnyside Avenue within the City of Ottawa is depicted below.

Artist Rendition of a Proposed Bioretention - Ottawa, ON

Perforated Pipe Systems

Subsurface perforated pipe systems are essentially a variant/combination of a French drain type Soakaway pit and a conventional storm sewer system. These systems provide efficient conveyance, while encouraging infiltration and groundwater recharge. Perforated pipe systems are linear perforated pipes surrounded by gravel and wrapped in filter cloth, designed to encourage infiltration, thereby reducing runoff volumes, improving water quality and providing a water balance benefit.

Subsurface perforated pipe systems have been constructed throughout Ontario (including in Ottawa) to treat road runoff and can be used at commercial and industrial sites. These systems can be sized to convey any size storm as they are only limited by the pipe dimension and slope.

Perforated Pipe - Mississauga, ON

Permeable Pavement

Although disused previously as a lot –level control, permeable pavements can also be integrated into the municipal ROW as:

- Part of the pavement surface itself,
- Sidewalks and or multi-use pathways, and/ or
- Lay-by parking areas

Within the Municipal ROW, recommended permeable pavements can include:

- Permeable Interlocking Concrete Pavers (PICP)
- Porous asphalt and concrete.

Permeable Interlocking Pavement Lay-by - Mississauga, ON

Porous Asphalt Roadway – Philadelphia, PA

5.8 PHASING & TIMING

The overall servicing of the Former CFB Rockcliffe CDP site is anticipated to be completed in four (4) phases (Figure 34) specifically:

- Phase 1A – 2015-2016
- Phase 1B – 2017-2018
- Phase 2 – 2019-2024
- Phase3 – 2024 (depending on market analysis)

Corresponding development areas and the respective development units of each servicing phase are detailed in the Table below.

Phasing (1-3) Characteristics

	Area (ha)	Units
Phase 1	37.5	920
Phase 1A - West of Codd's	16.0	171
Phase 1B - East of Codd's	25.8	749
Phase 2	35.6	1,715
Phase 3	34.7	2,590
Total	150	5,225

As discussed in Section 4.3, in general, stormwater servicing is anticipated to follow the above noted phasing, with some minor exceptions where servicing beyond the limits of the respective phases is required. This is generally limited to the conventional stormwater management system – storm sewers and end-of-pipe ponds. Additional detail in regards to the storm sewer system is included within the MSS (IBI, 2015) under separate cover.

The LID Pilot/Demonstration project is proposed to follow the anticipated development phasing. Phase 1A of the stormwater management demonstration project using LID is proposed to generally encompass the area west of Codd's Road (Phase 1A: 2015-2016). Additional detail is provided in the subsequent section.

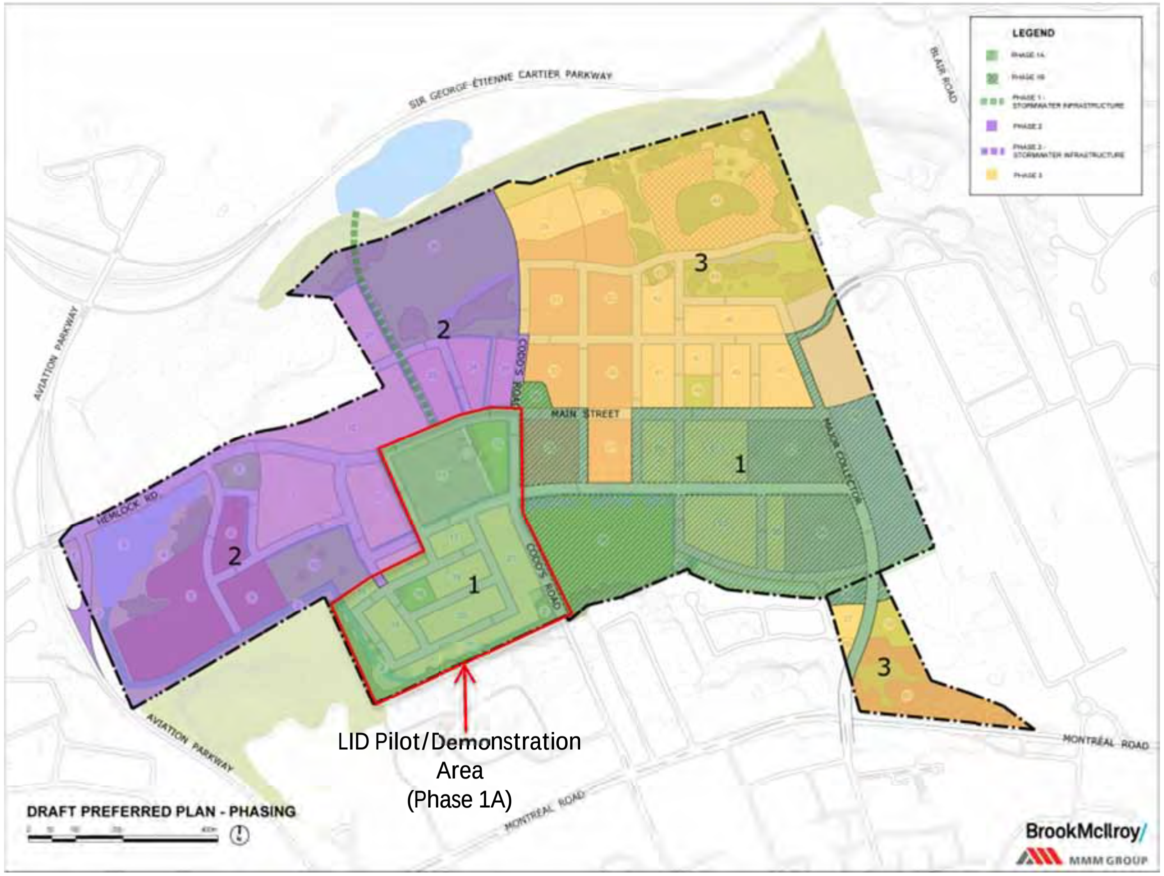


Figure 34: Development Phasing Plan & LID Pilot/ Demonstration Area (Phase 1A)

5.9 LID PILOT/ DEMONSTRATION PROJECT SCOPE

The LID Pilot/Demonstration project is proposed to follow the anticipated development phasing.

Phase 1A of the stormwater management demonstration project using LID is proposed to generally encompass the area west of Codd's Road (Phase 1A: 2015-2016) and will service primarily a Low-rise Residential land-use, parkland and the municipal ROW (Figure 34). Proposed LID techniques are detailed in subsequent sections.

Phase 1A of the LID stormwater management demonstration project has the following characteristics (see Figure 2 and Figure 34 for block numbers and demonstration project limits respectively):

- The area of the LID Pilot/ Demonstration project is 11.6 hectares
- 920 units of low-rise residential (1-4 stories) with anticipated lot coverage of 50-60%.
- Six (6) local roadways (20m ROW) and two (2) sections of minor arterial roadway (26m ROW); a portion of Codd's Road and Via Venus Private.
- Two (2) parks (blocks 18 and 22)
- A school (block 14)

5.10 SUITABILITY OF LID CONTROLS BY LAND-USE

The suitability of LID controls has been evaluated in the context of the Former CFB Rockcliffe site based on criteria which includes:

- Predominant soil types
- Primary land-uses
- Available area (assumed lot coverage)

Land-use suitability also considers general implementation considerations and suitability based on previous consultations with the development community, various Ontario municipalities including past consultation with the City of Ottawa, past project experience and consultation with the SWM Working Group including:

- Implementation cost,
- Types of expected infrastructure to accompany site development,
- Anticipated site specific uses,
- Anticipated lot-level of runoff and
- General City of Ottawa policy considerations.

Table 23 summarizes the suitability of each LID lot-level and conveyance control in relation to the aforementioned criteria for each proposed land-use of the Former CFB Rockcliffe CDP.

LID controls evaluated as either highly suitable or suitable are recommended for further consideration as part of the LID Demonstration Project phases 1A-3.

LID controls evaluated as having poor suitability or not having applicability in relation to the specific land-use will not be carried forward for further consideration.

Table 23: Low Impact Development (LID) Suitability Matrix by Land-Use

		Former CFB Rockcliffe CDP Proposed Land-uses						
		Low & Medium Rise Residential	Low and Medium Rise Mixed-Use	High-Rise Mixed-Use	High Rise Employment	Schools & Parks	Natural Areas	Municipal ROW
	Assumed Lot Coverage*	50-60%	80-100%	75-80%	80-100%	10-30%	0%	n/a
LID Type								
Lot- Level Controls	Green Roofs	□	□	□□	□□	n/a	n/a	n/a
	Bioretention	□□	□□	□	□	□□□	n/a	□□□
	Rainwater Harvesting	□	□	□□□	□	n/a	n/a	n/a
	Soakaways, Trenches & Chambers	□□□	□□□	□	□□	□□□	n/a	n/a
	Downspout Disconnection	□□□	□□□	□□□	□	n/a	n/a	n/a
	Soil Amendments	□□□	□□□	□□□	□□□	□□□	□	n/a
	Permeable Pavements	□□	□□	□□□	□□□	□□	n/a	See Conveyance Controls
	Infiltration Basins	n/a	n/a	n/a	n/a	□□□	□□□	n/a
Conveyance Controls	Vegetated/ Grass Swales	n/a	n/a	n/a	n/a	□	□□□	□□
	Bioswales/Biofilters	n/a	n/a	□□	□□	□□	□	□□□
	Perforated Pipes	n/a	n/a	□	□	□	□	□□
	Permeable Pavements	n/a	n/a	□□□	□□□	□□	n/a	□□□

* Assumed lot coverage indicates percentage of development with hard surface land cover

□ □ □ = Highly Suitable, □ □ = Suitable, □ = Poor Suitability, n/a = Not Applicable

Site Specific Impacts Screening Process

In the context of the Former CFB Rockcliffe site it is recommended that at the detailed design stage the site specific impacts (groundwater & water quality) be assessed per the following two (2) approaches. The impacts should be evaluated hierarchically by first examining the site as a whole in regards to ultimate intended land-use, followed by the identification and assessment of the individual internal drainage areas in regards to the sources of runoff and the anticipated quality or characteristics of the generated runoff.

Step 1– Site Specific Land-use Assessment

Process - Examine the subject development site focusing on specific land-uses to identify activities classified as potential "hot spots" or 'high-risk".

High risk activities uses are defined as those with the potential for high levels of contamination such as hydrocarbons, metals, organic and inorganic compounds, and chlorides (i.e. Gas Stations, Oil Change Centres etc). At this scale of study, it is impossible to predict the ultimate site specific use / activities of the individual to be developed sites; however, the concept of high-risk or contamination hot spots can be used to screen and identify all or portions of each site where LIDs should be discouraged. However high risk land uses do not preclude the use of those LID techniques that utilize filtration, evapotranspiration (ET) or re-use as the primary processes. Additionally, the infiltration of rainwater not directly impacted by the respective high risk site use/activity such as rainwater emanating from rooftops or directly falling on permeable surfaces is generally considered relatively 'clean' and should not be excluded from infiltration

Step 2– Sources and Quality of Runoff

Process - Examine the subject development site in regard to the anticipated sources of runoff from the individual internal drainage areas.

Table 24 separates infiltration sources into four (4) categories depending on the water quality, and the suitability for infiltration. Classifying LID infiltration measures based on the source of stormwater provides a reasonable and scientifically-based approach to designate areas of infiltration or no infiltration within the context of the ultimate intended land-use of the Former CFB Rockcliffe Site.

Table 24: Screening Framework for Sources of Runoff, Typical Characteristics & Opportunities for Treatment and Use

Source		Runoff Characteristics	Opportunities	Principles for Environmental Protection
1	Foundation drains, slab underdrains, road and parking lot sub-drains	Relatively clean, cool water	Suitable for direct infiltration or discharge to receiving watercourse	Should not be directed to stormwater management facility that is tributary to road/parking lot runoff.
2	Roof drains, roof terrace area drains, overflow from green roof areas	Moderately clean water, contaminants may include asphalt granules, leaves and organic fallout from airborne pollutants, potentially warm water	Infiltration with minor pre-treatment through vegetated filter (lawn, grassed swale, bioretention). Recycling through collection in central cistern and reuse as irrigation supply or grey water supply for internal building systems (toilet flushing etc)	Where possible, should not be directed to end-of-pipe facilities in order to capitalize on potential for reuse and infiltration however, flow moderation (quantity control) prior to discharge into the receiving watercourse is required.
3	Road, sidewalk and parking lot surfaces	Typically warm. Potential for high contamination with hydrocarbons, metals, grit/sediment and chlorides.	Infiltration only after pre-treatment. Attenuation & treatment in a basin, wet pond, wetland or hybrid facility. Recycling for irrigation purposes after treatment in pond, wetland or hybrid facility	Runoff should be pre-treated using vegetated, granular or hydrodynamic techniques i.e. oil grit separator prior to infiltration or re-use. Water quality should be tested prior to use for irrigation purposes.
4	High Risk Site uses Gas station, auto-repair facilities, outdoor storage, industrial sites	Potential for high levels of contamination - hydrocarbons, metals, organic and inorganic compounds, sediments and chlorides	Attenuation and treatment in wet pond, wetland or hybrid facility. Potential requirement for pre-treatment (oil/grit separator). Infiltration and recycling alternatives are not permitted.	Runoff from these sources should not be infiltrated or used for irrigation. Spill containment/mitigation devices recommended contingent on size of storage facilities.

5.11 OVERVIEW OF PROPOSED LIDS FOR IMPLEMENTATION

This section and Figure 34-A provides additional detail in regards to the recommended LID Lot-level and LID Conveyance Controls as well as specific projects for further consideration as part of the Phased LID Demonstration Project Phase 1A- 3. Refer to Table 23.

Low/Medium Rise Residential and Mixed-Use

For low and medium rise residential land-uses (Figure 2) potential LIDs for consideration include:

a) Downspout disconnection/ redirection will direct roof runoff to front yard subsurface soakaways/chambers for detention and infiltration. For low and medium rise mixed-use land-use, the use of subsurface chambers beneath landscaped or hard-surface elements (i.e. driveways) should be anticipated. The potential to include rear yard infiltration facilities where year yard catch basins are proposed may also be considered at the detailed design stage.

b) All green space (grassed and vegetated) include soil amendments in conformance with the:
- Implementation Guide for the Pinecrest Creek/ Westboro SWM Guidelines: Development Requiring a Building Permit Only (Draft, 2013) and
- Preserving and Restoring Healthy Soil: Best Management for Urban Construction (Sustainable Technologies Evaluation Program – STEP, June 2012, Version 1.0)

Other potential LID controls for consideration may include the use of bioretention areas to replace conventional landscape areas and or the use of permeable pavements driveways in place of conventional impermeable surfaces.

High-Rise Mixed-Use

For high-rise mixed-use land-uses (Figure 2) potential LIDs for consideration include:

a) Downspout disconnection be utilized to harvest roof water and direct it to sub-surface cisterns (i.e. rain water harvesting) in accordance with the 2006 amendments to the Ontario Building Code (OBC) which permits the use of collected rain water to supplement indoor, non-potable uses i.e. toilet flushing, vehicles washing etc. in addition to outdoor irrigation of landscaping.

b) All green space (grassed and vegetated) include soil amendments in conformance with the:
- Implementation Guide for the Pinecrest Creek/ Westboro SWM Guidelines: Development Requiring a Building Permit Only (Draft, 2013) and
- Preserving and Restoring Healthy Soil: Best Management for Urban Construction (Sustainable Technologies Evaluation Program – STEP, June 2012, Version 1.0)

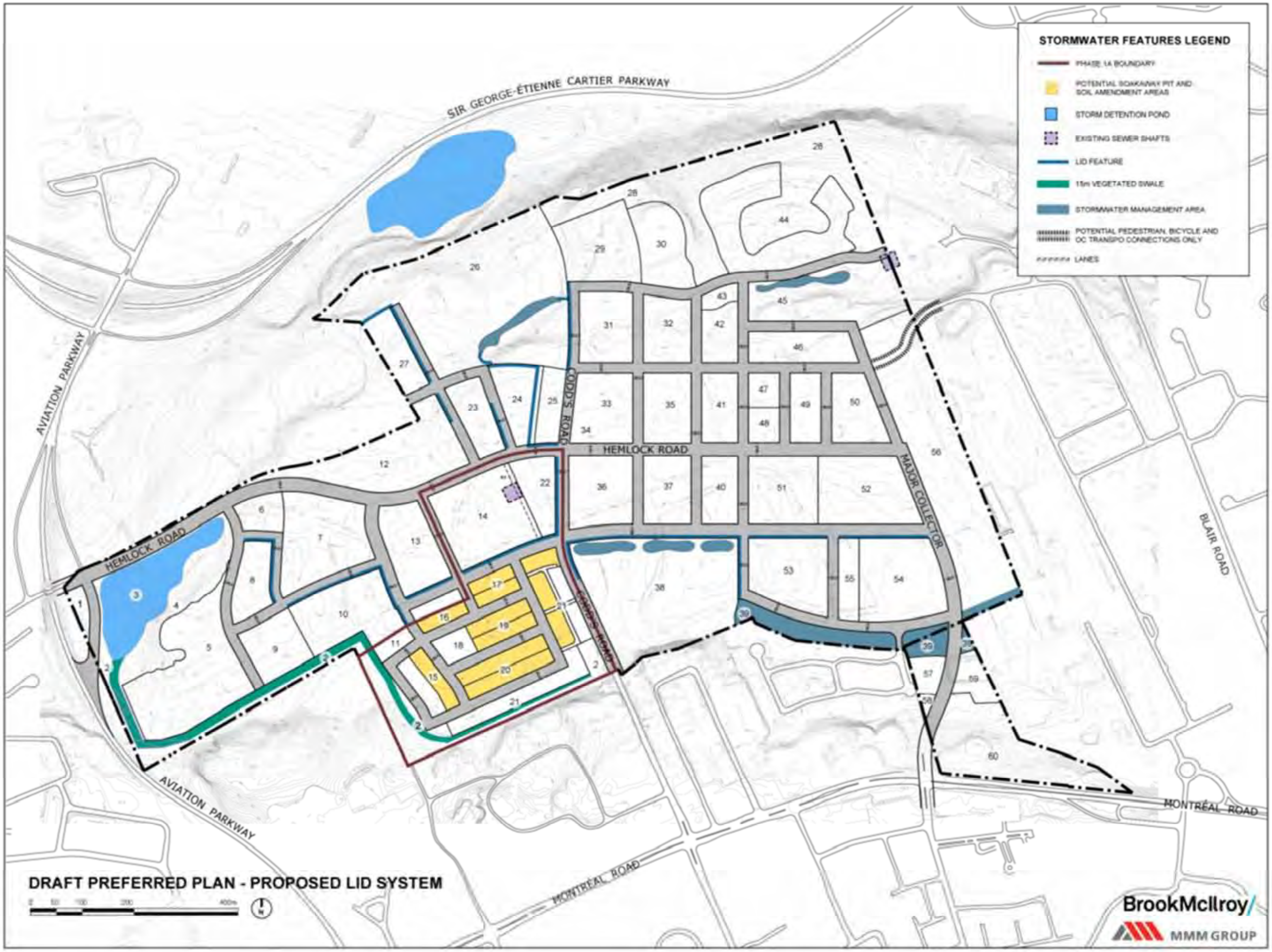


Figure 34-A: Overall SWM Locations including Recommended LID Lot-level and LID Conveyance Controls

c) Permeable pavements be utilized for all surface parking features in place of conventional impermeable surfaces. It is anticipated that the high-rise mixed-use land-use may include the provision for substantial parking areas.

Other potential LID controls for consideration may include the use of green roof in place of conventional flat roofing systems and or the use of bioswales within parking lot as vegetated landscape features in place of islands for selected high-value development blocks.

High Rise Employment

For high-rise employment land-uses (Figure 2) potential LIDs for consideration include:

a) Permeable pavements are utilized for all surface parking features in place of conventional impermeable surfaces.

b) All green space (grassed and vegetated) include soil amendments in conformance with the:
- Implementation Guide for the Pinecrest Creek/ Westboro SWM Guidelines: Development Requiring a Building Permit Only (Draft, 2013) and
- Preserving and Restoring Healthy Soil: Best Management for Urban Construction (Sustainable Technologies Evaluation Program – STEP, June 2012, Version 1.0)

Other potential LID controls for consideration may include the use of green roof in place of conventional flat roofing systems, the use of bioswales within parking lot as vegetated landscape features in place of islands and or the use of subsurface chambers beneath hard-surface elements. Note rainwater harvesting has not been recommended due to anticipated lack of demand for reclaimed rainwater in the employment land-use. Should a substantial demand be substantiated, this recommendation may be reconsidered.

Schools & Parks

For school and park land-uses (Figure 2) potential LIDs for consideration include:

a) Bioretention facilities (rain gardens) are incorporated in place of planned conventional landscape areas/ gardens as gateway features and outside active use areas.

b) All green space (grassed and vegetated) include soil amendments in conformance with the:
- Implementation Guide for the Pinecrest Creek/ Westboro SWM Guidelines: Development Requiring a Building Permit Only (Draft, 2013) and
- Preserving and Restoring Healthy Soil: Best Management for Urban Construction (Sustainable Technologies Evaluation Program – STEP, June 2012, Version 1.0)

c) Infiltration capabilities be included as part of all Dry Pond features (Park Dry Pond, Eastern Dry Pond and Central Dry Pond) proposed as part of the MSS (IBI, 2015) through the use of engineered soils/ media and the use of perforated underdrains.

The Park Dry pond with infiltration capabilities shall be located, to the maximum extent feasible, outside the boundaries of active use areas and shall ensure that active uses are not impacted or limited. It is acknowledged that an explicit approval from the City of Ottawa Parks department is required prior to implementation.

The Eastern and Central Dry Pond with Infiltration capabilities be located within passive use park land-uses to preserve hydrologic connection and function of exiting important tree grouping and off-site natural areas (as discussed in the subsequent section).

Through the use of engineered soils/ media and the use of perforated underdrains, the infiltrating Dry Ponds are recommended to attenuate small-event hydrology (i.e. frequent low intensity rainfall) and shall ensure hydroperiods and time or inundation does not impact existing vegetation communities or habitats. It is acknowledged that an explicit approval from the City of Ottawa Parks department is required prior to implementation.

Other potential LID controls for consideration may include the use of permeable pavements and bioswales within planned parking lot areas servicing park facilities.

Natural Areas

To preserves the hydrologic functions and support of identified significant vegetation communities, off site UNAs and on-site natural areas (Figure 2) potential LIDs for consideration include:

a) Central and Eastern Dry Ponds be located within the natural area of Block 26 and Block 45 respectively to preserve hydrologic connection and function of existing important vegetation communities (North of Hemlock Private on both sides of Hurley Crescent and North of Arcturus Private, east of Burma Road) as well as off-site natural areas (the Airbase Woods, and the NRC Woods North).

   It is intended that the Eastern and Central Dry Pond with infiltration capabilities will replicate the existing hydrologic function to attenuate flows and reduce downstream erosion. The infiltrating Dry Ponds are recommended to be designed such that it attenuates small-event hydrology (i.e. frequent low intensity rainfall) and shall ensure hydroperiods and time of inundation does not impact existing vegetation communities or habitats.

b) Vegetated grass/ Enhanced swales which utilize native vegetation and planting be established in Block 2 such that they encourage infiltration, reduce stormwater runoff and act to minimize ‘clean’ sources of runoff from external areas from entering the conventional stormwater management system to the greatest extend possible (pipes and ponds). The vegetated swales shall be located such that they complement and enhance existing and planned buffers to natural features, vegetation and sensitive neighboring communities.

Municipal ROW

Within the municipal ROW potential LIDs for consideration, in conformance with the proposed road-cross sections, include:

a) Bioretention (Rain Garden) be recommended within boulevard bump-out areas at each terminus of on-street curb-less parking

b) Permeable interlocking concrete pavers be recommended within lay-by parking areas, subject to further review by the City of Ottawa at the detailed design stage.

c) Bioswales be recommended within the designated stormwater management features of the boulevard area to accept road runoff and boulevard drainage

d) Permeable interlocking concrete pavers and porous asphalt be recommended for sidewalk and Multi-use pathways where feasible in accordance with the City of Ottawa policies and the Accessibilities for Ontarians with Disabilities Act (AODA) and subject to further review by the City of Ottawa at the detailed design stage. Note the location may be limited to specific ROW cross-section only.

Figure 35 to Figure 39 illustrates the five (5) proposed road cross-sections (Section 1A, 1B, 2, 3A and 3B) with their respective location within the Former CFB Rockcliffe site.

Table 25 summarizes the potential LIDs for consideration within the five (5) proposed road cross-sections (Section 1A, 1B, 2, 3A and 3B).

Figure 40 to Figure 44 illustrates the potential LIDs for consideration within the five (5) proposed road cross-sections (Section 1A, 1B, 2, 3A and 3B) with relevant examples.

It is important to note that linear infrastructure (ROW including sidewalks and multi-use pathways) comprises a significant total area of any proposed development. With consideration for its associated high impervious levels, linear infrastructure assets, when converted to impervious surfaces, can have a significant effect on SWM control (water quality, flooding, erosion and water balance) with a minimal increase or in many cases a total life cycle costs reduction when impervious surfaces and the maintenance of related conventional SWM practices are considered. For addition detail in regards to Life Cycle costs comparisons for LIDs (permeable pavements and others) and conventional SWM, the STEP (TRCA) Assessment of Life Cycle Costs for Low Impact Development Stormwater Management Practices (2013) can be consulted.

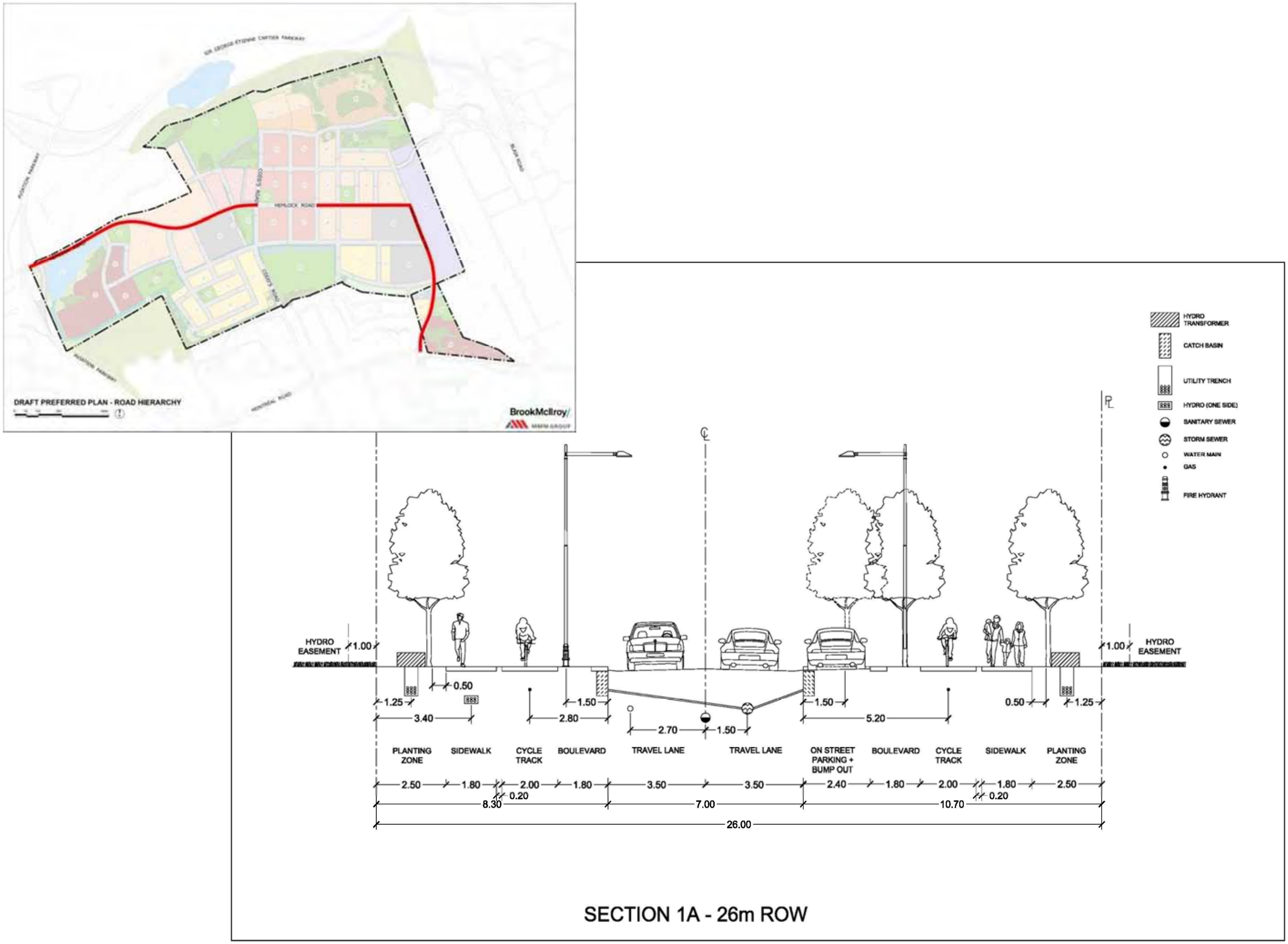


Figure 35: Section 1A, Major Collector (26 m) - See Figure 40

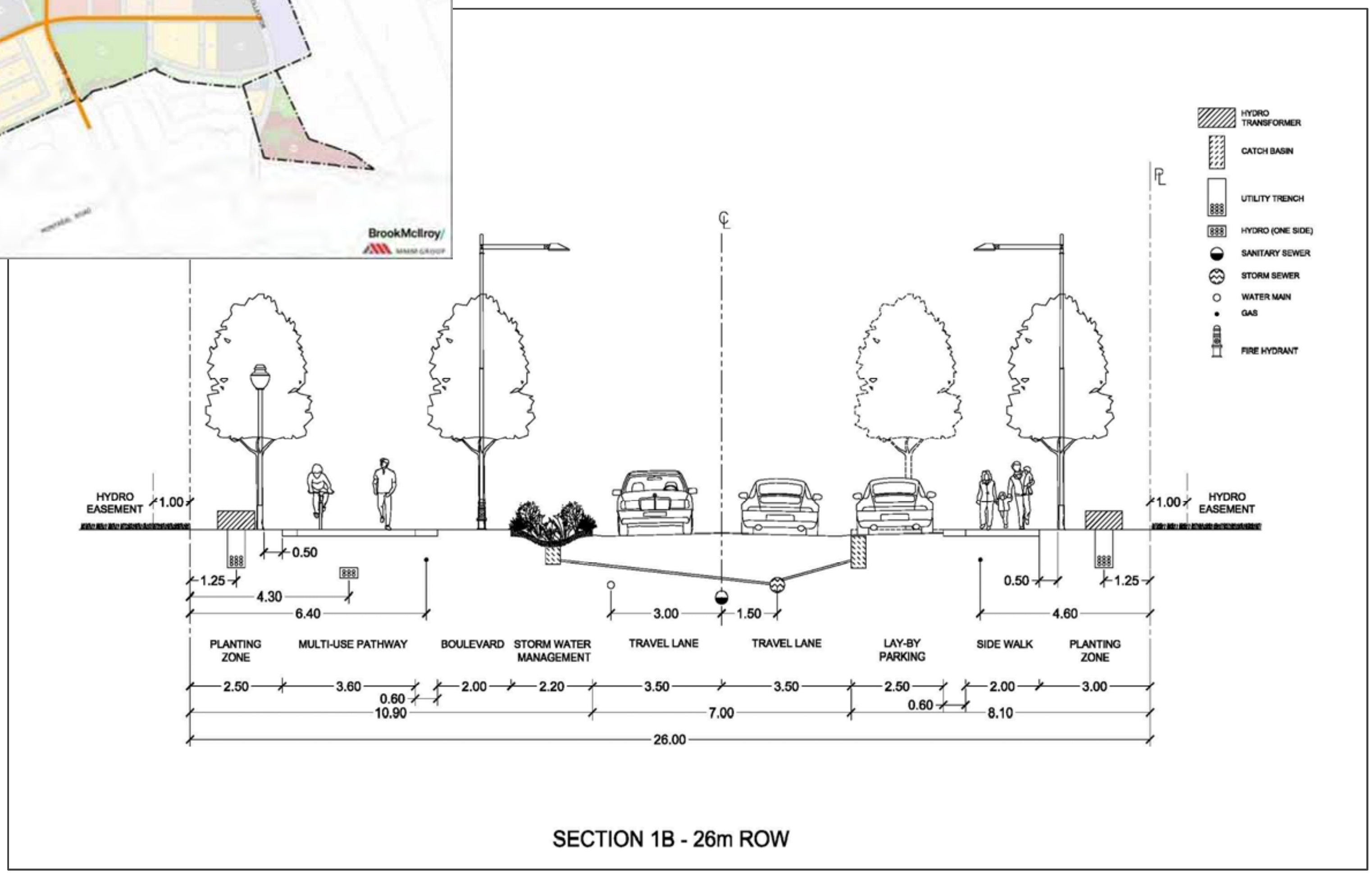
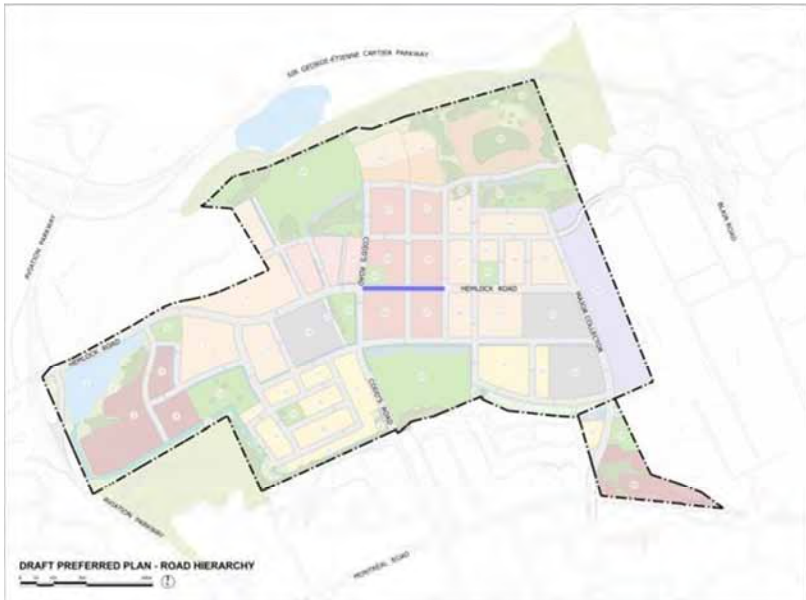


Figure 36: Section 1B, Collector (26 m) - See Figure 41



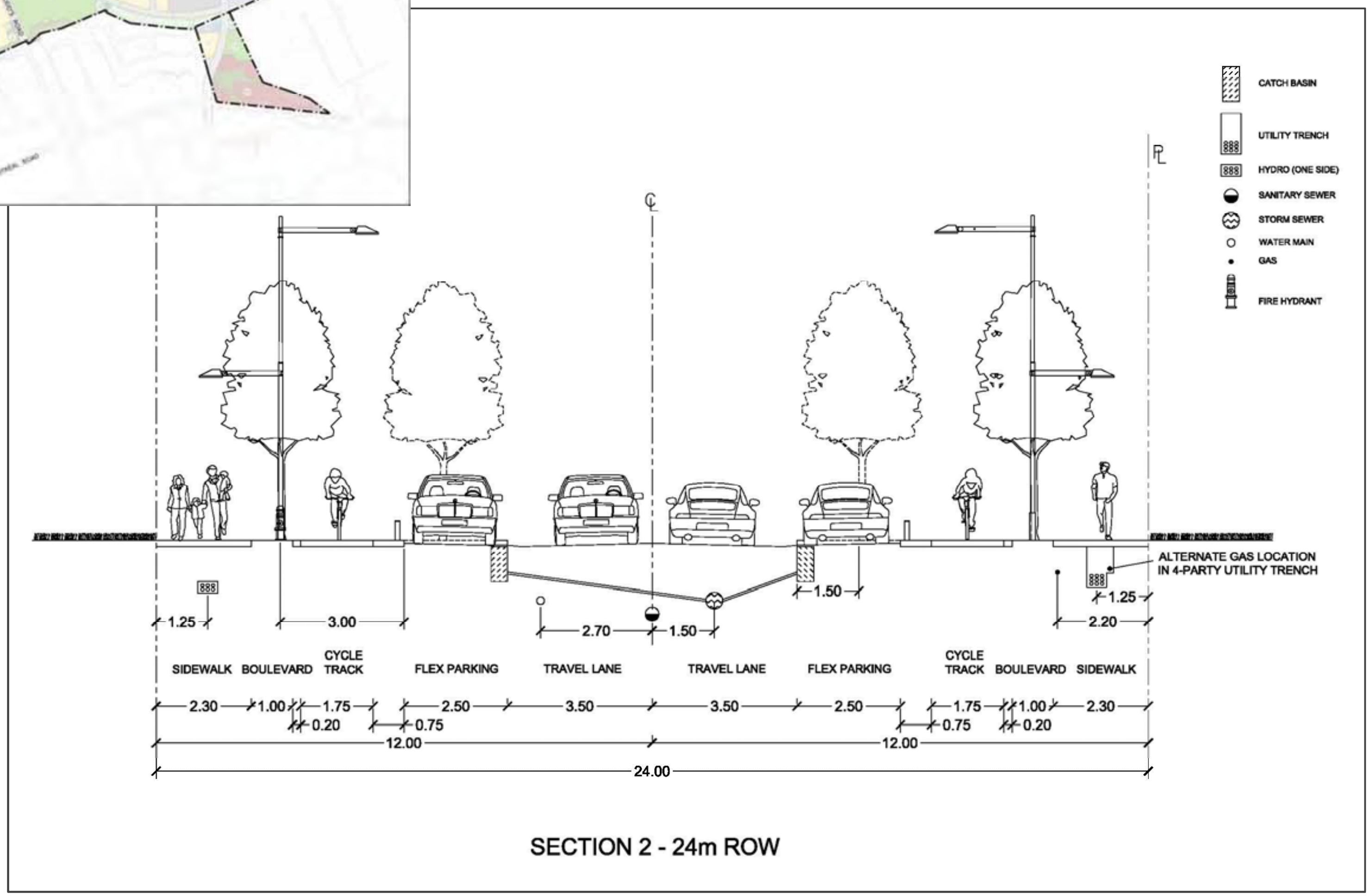


Figure 37: Section 2, Hemlock Core Street (24 m) - See Figure 42

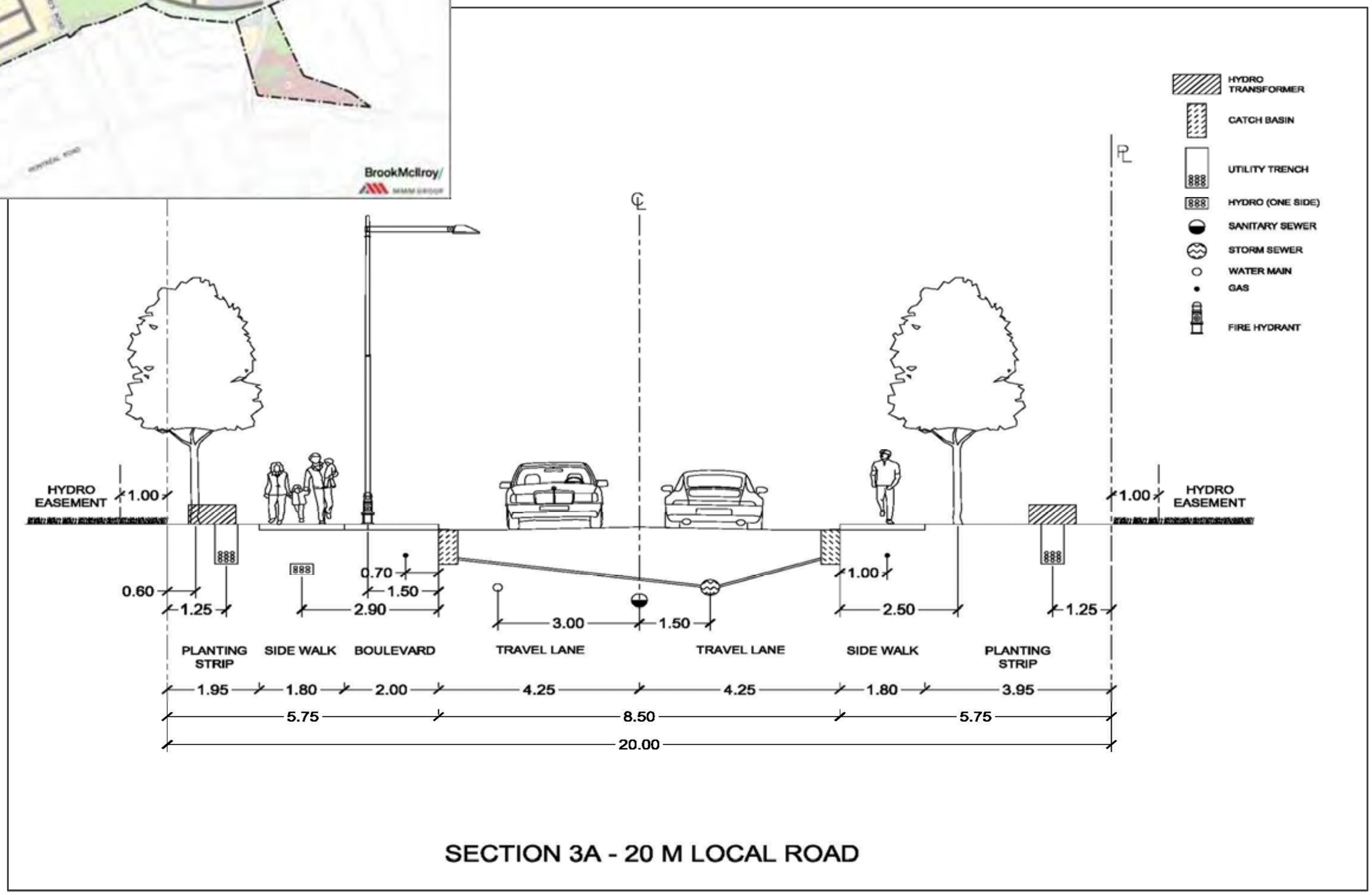


Figure 38: Section 3A, Local Road (20 m) - See Figure 43

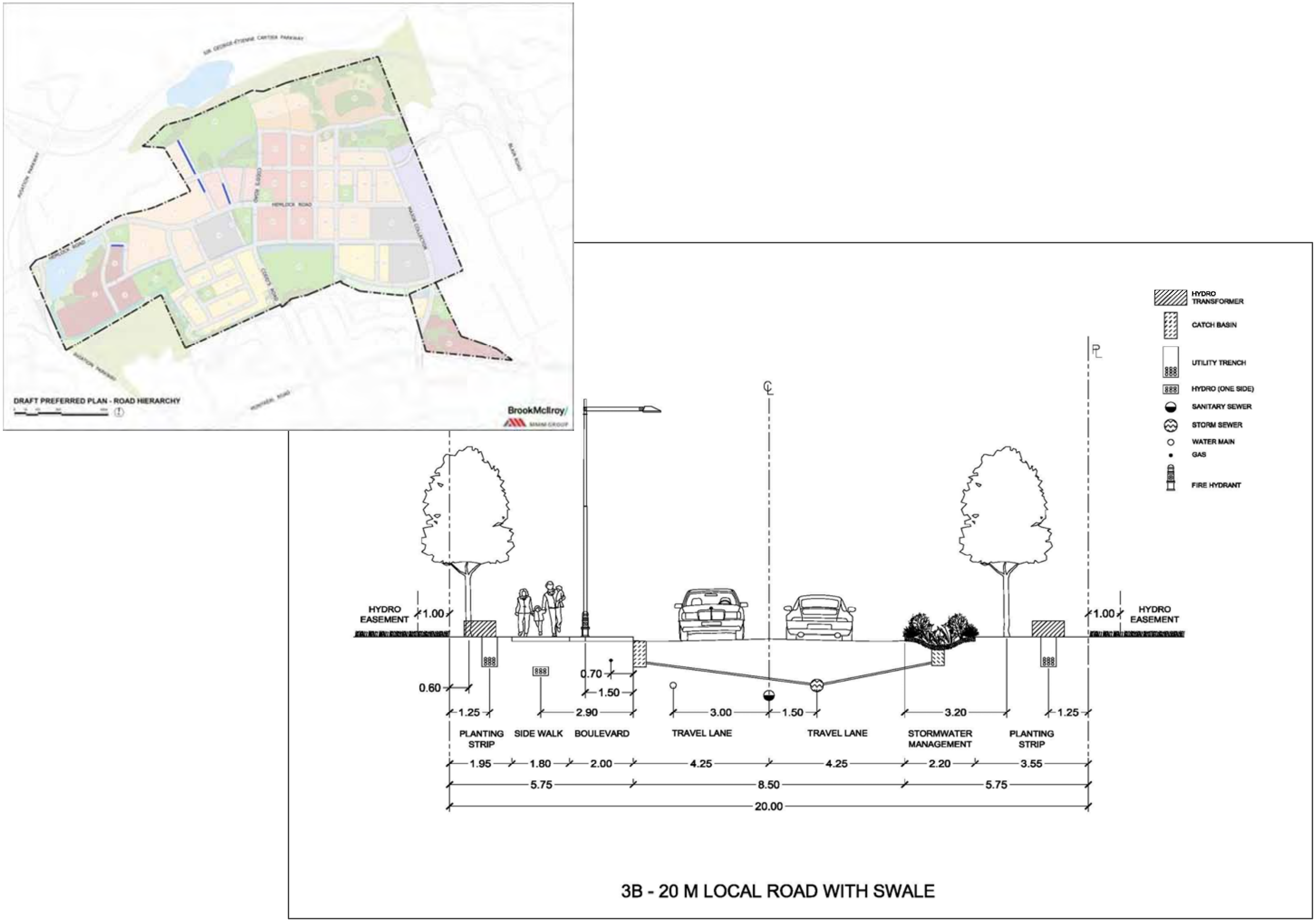
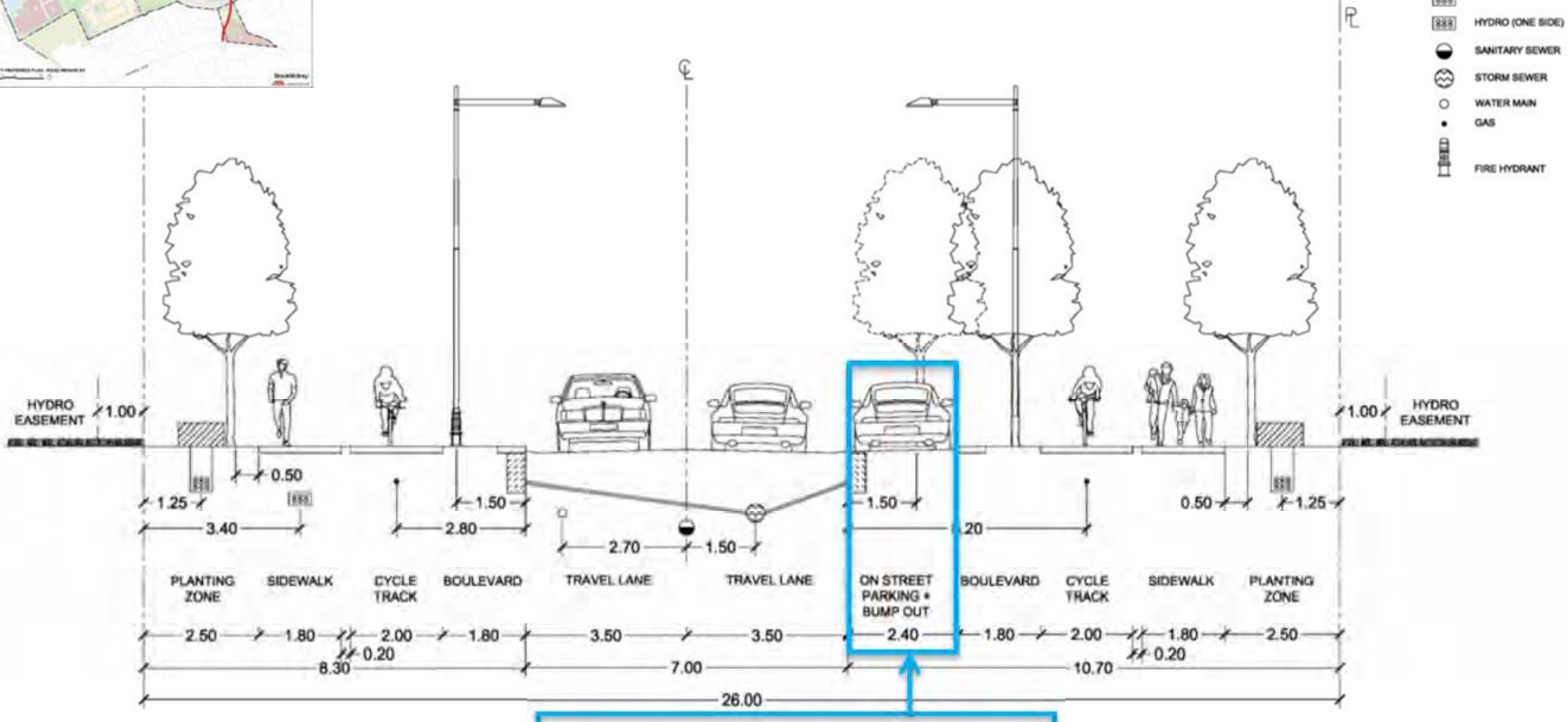


Figure 39: Section 3B, Local Road (20 m) - See Figure 44

Table 25 – Recommended LID within Proposed Road Cross-Sections according to ROW Features

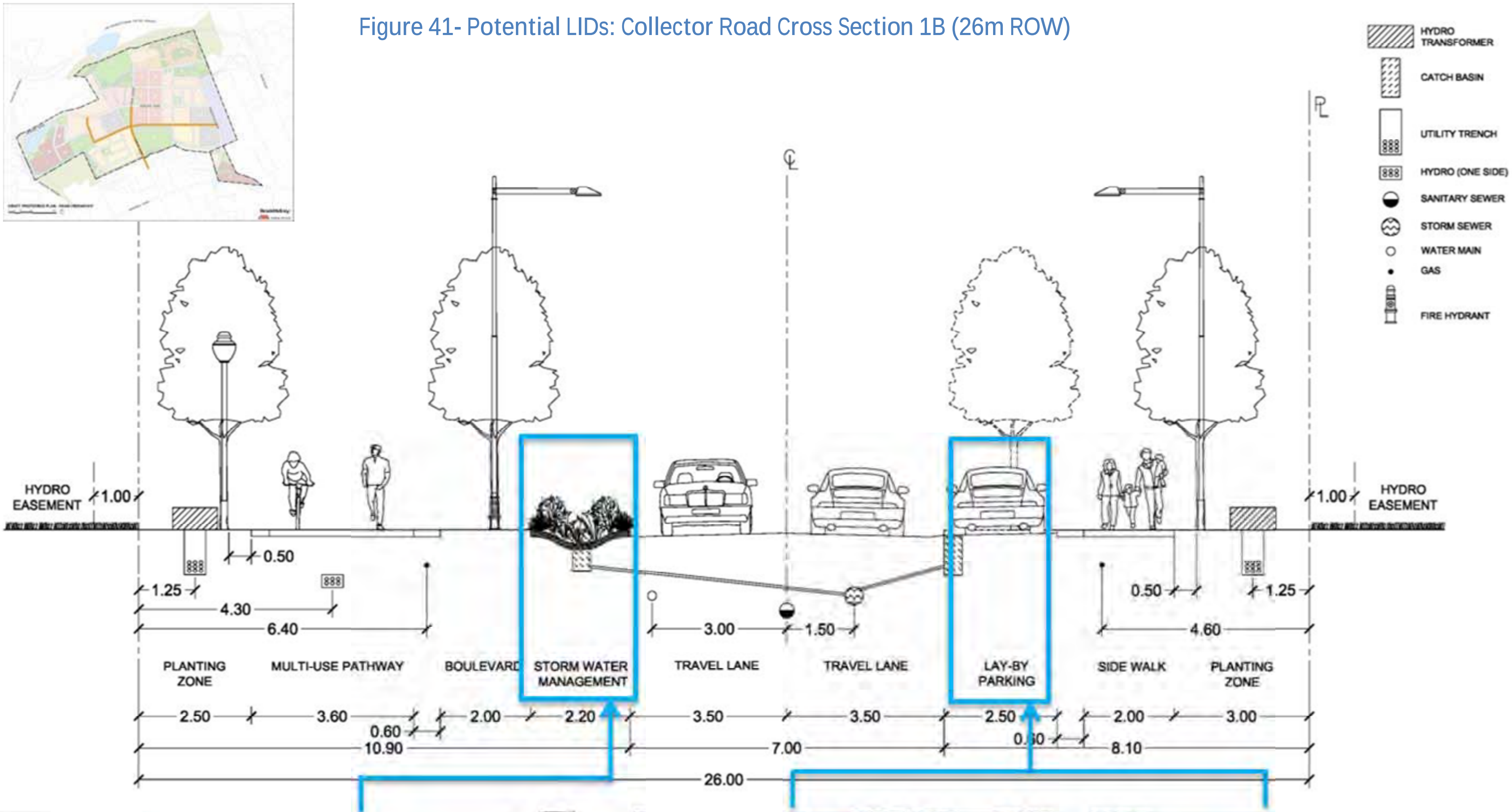
ROW Feature	Curb-less on Street Parking & bump-out	Parking Lay-by†	Designated SWM Area (Boulevard)	Sidewalks & Multi-use Pathways†
Road X-Section Type	Recommended LID Type			
Section 1A – Major Collector (26m ROW) (Figures 35 & 40)	Bioretention (Rain Garden) within boulevard bump-out areas at each terminus of on-street curb-less parking	-	-	Permeable interlocking concrete pavers and porous asphalt
Section 1B – Collector (26m ROW) (Figures 36 & 41)	-	Permeable interlocking concrete pavers within lay-by parking areas.	Bioswales within boulevard area to accept road runoff and boulevard drainage	-
Section 2 – Core Street (24 ROW) (Figure 37 & 42)	Bioretention (Rain Garden) within boulevard bump-out areas at each terminus of on-street curb-less parking	-	-	-
Section 3A – Local Road (20m ROW) (Figure 38 & 43)	-	-	-	Permeable interlocking concrete pavers and porous asphalt
Section 3B – Local Road with Swale (20m ROW) (Figure 39 & 44)	-	-	Bioswales within boulevard area to accept road runoff and boulevard drainage	Permeable interlocking concrete pavers and porous asphalt
† Subject to further review by the City of Ottawa at the detailed design stage.				

Figure 40 - Potential LIDs: Major Collector Road Cross Section 1A (26m ROW)



Illustrative examples of Bioretention (Rain Garden) within boulevard bump-out areas at each terminus of on-street curbless parking

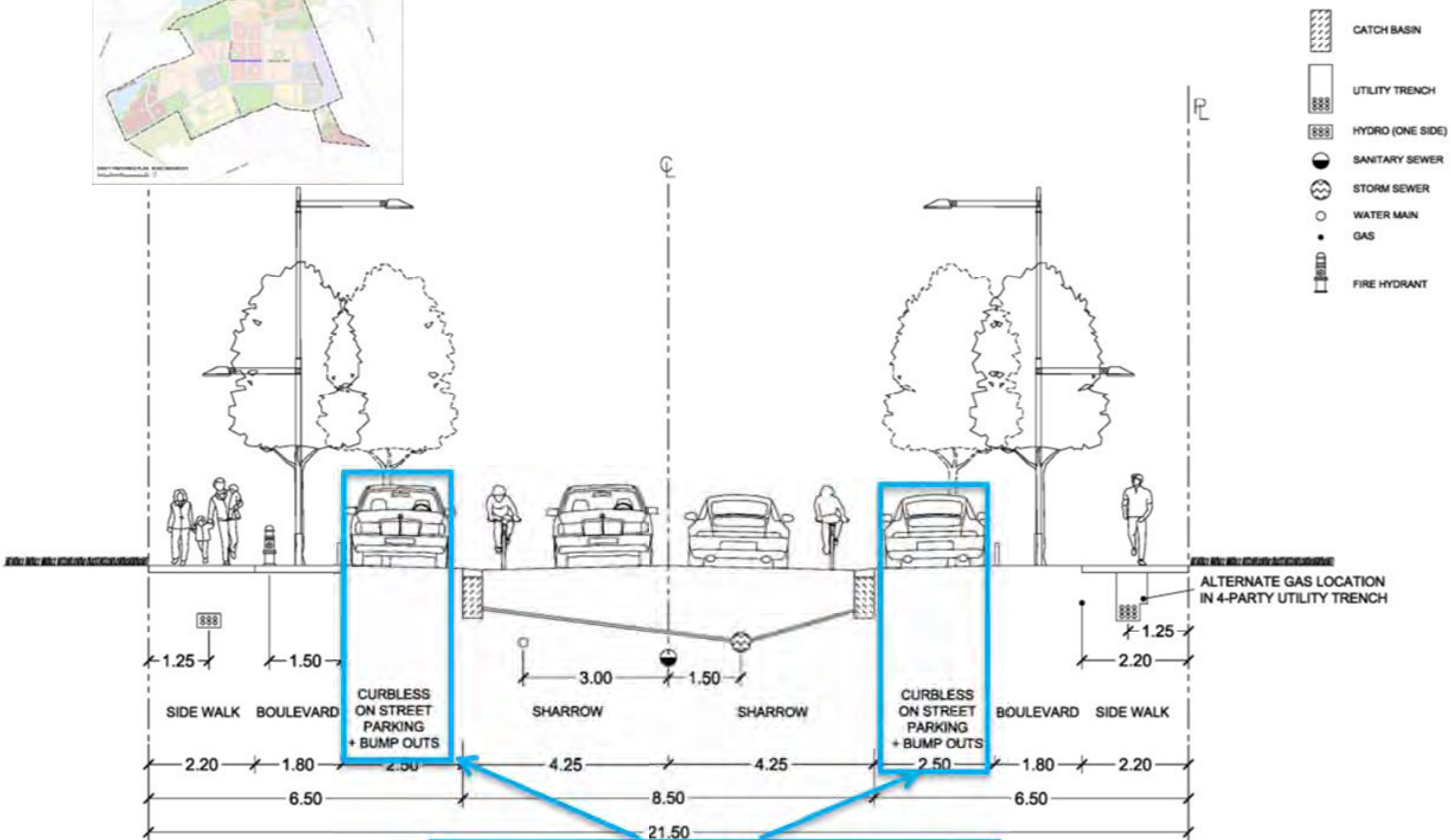
Figure 41- Potential LIDs: Collector Road Cross Section 1B (26m ROW)



Illustrative examples of Bioswale (high density residential)

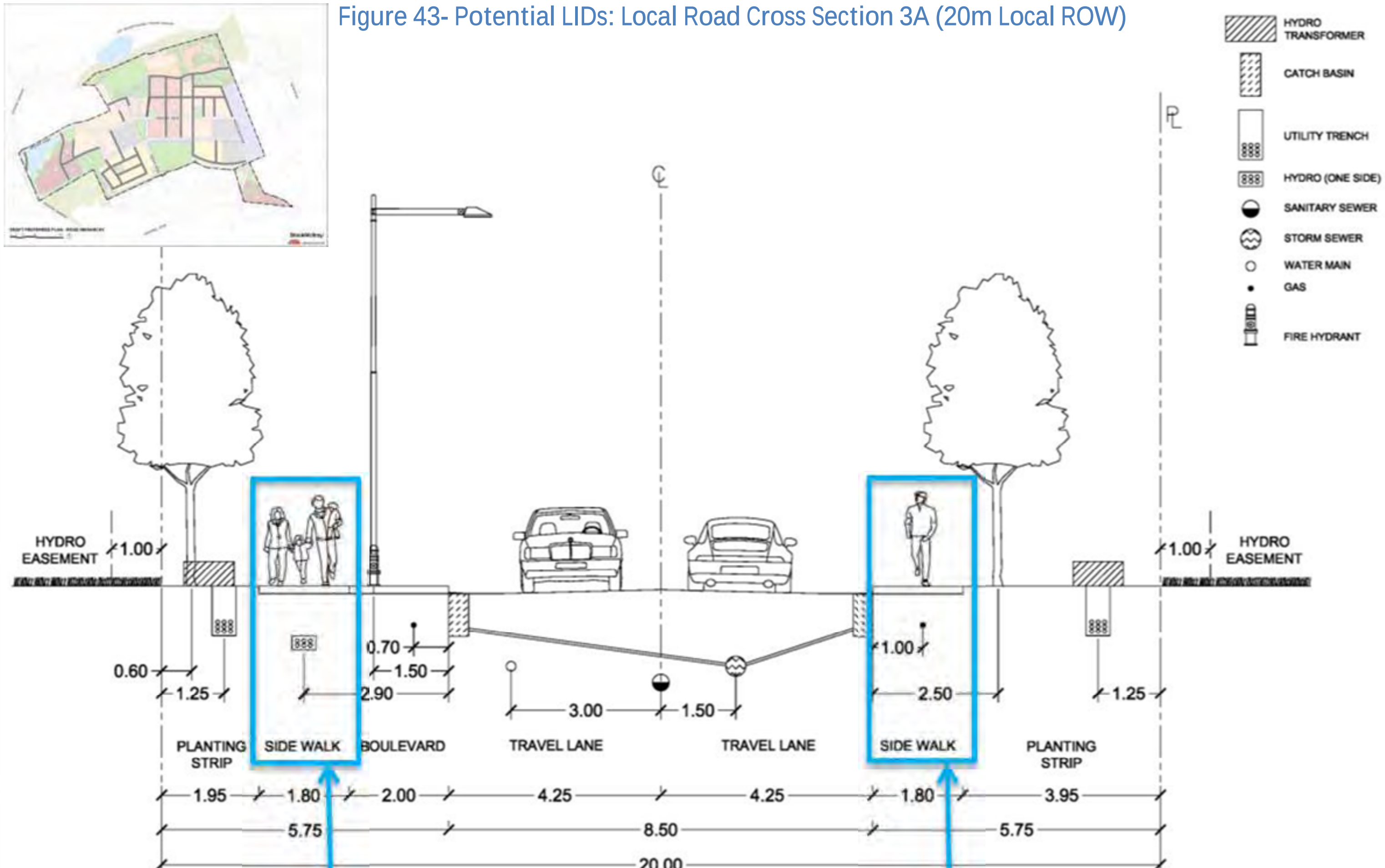
Illustrative examples of Permeable Pavement Lay-bys

Figure 42- Potential LIDs: Core Street Road Cross Section 2 (24m ROW)



Illustrative examples of Bioretention (Rain Garden) within boulevard bump-out areas at each terminus of on-street curbless parking

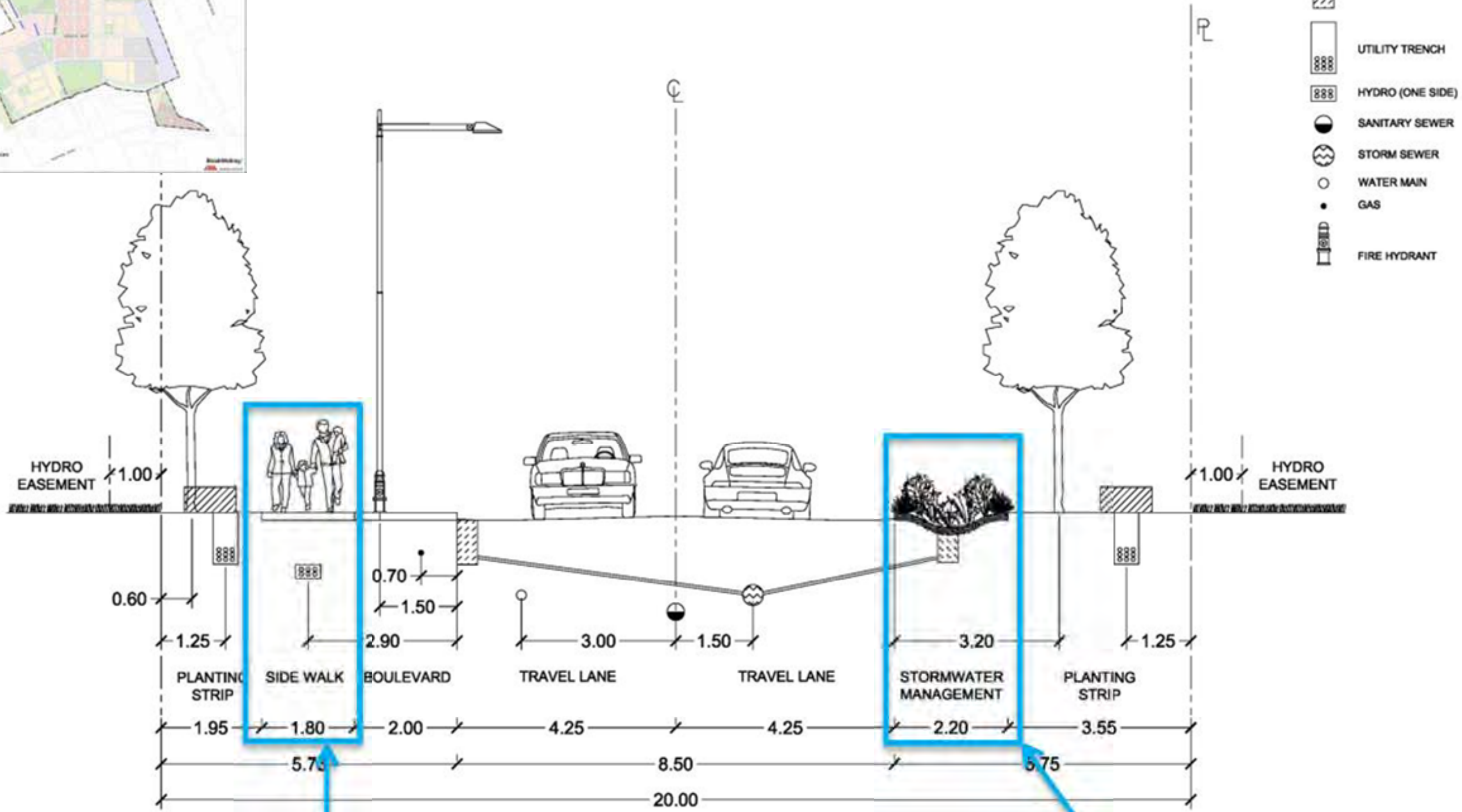
Figure 43- Potential LIDs: Local Road Cross Section 3A (20m Local ROW)



Illustrative examples of PICP sidewalk

Illustrative examples of porous concrete sidewalk

Figure 44- Potential LIDs: Local Road Cross Section 3B (20m Local ROW)



Illustrative examples of PICP sidewalk

Illustrative examples of Bioswale (low density Residential)

5.12 LID PILOT/ DEMONSTRATION PROJECT – PHASE 1A

Phase 1A of the Stormwater Management Pilot/ Demonstration project using LID is proposed to generally encompass Phase 1A (2015) and will service primarily a Low-rise Residential land-use, parkland and the municipal ROW (Figures 2 and 34). The LID Pilot / Demonstration project Phase 1A is proposed to incorporate the following. Figure 45 provides the locations of LIDs and Table 26 provides the characteristics.

Summary of LID Implementation

Per Figure 45, the following summarizes the implementation of LIDs in Phase 1A.

Soakaways

- Total Area of Development Blocks (11, 15-17, 19-21) = 5.51 ha
- Total Area of Development Blocks Containing Potential Soakaway Pits = 3.5 ha
- Percentage of Development Area Containing Potential Soakaway Pits = 64%
- Percentage of Total Phase 1A Site Area Containing Potential Soakaway Pits = 22%

Table 26- Phase 1A Post Development Characteristics and LID Controlled Areas

Phase 1A	Areas (ha)	TIMP (%)	Impervious Area	Imp. Area Controlled with LIDs (Figure 45)	
				Lot-level Control (Soakaways & Soil Amendments)	Conveyance Controls (Bioswales)
Parks	1.3	35	0.45	0.45ha Soil Amend.	
School	2.5	40	1.0	1.0ha Soil Amend.	
Greenspace	1.13	10	0.11	0.11ha Soil Amend.	
Residential Blocks (11, 15-17, 19-21)	5.51	75*	4.13	4.13ha Soakaways 4.13ha Soil Amend. (note: Both LIDs applied to control imp. area but has not been double counted)	
Enhanced Swale	0.32	10	0.03		
Bioswale	0.21	10	0.02		
Roads	5.0	90	4.5		0.2
TOTAL	16	-	10.25	5.70	0.2
TOTAL %	100%	39%†	64%	56%	4%

* Assumed TIMP based on ultimate conditions including roof area, driveways, patios, decks, sheds etc.
† Weighted imperviousness = sum [Future land-use area (ha) per block x Future land-use area TIMP (%)] / total developable area (ha)

Enhanced Swale

- Total Area of Development Blocks backing onto Enh. Swale = 2.01 ha
- Total Area of Development Area draining to Enh. Swale (60%) = 1.2ha
- Percentage of Total Phase 1A Site Area draining to Enh. Swale = 21%

Bioswales

- Total Area of Roadway Containing Bioswales = 0.2ha
- Percentage of Roadway Draining to Bioswale = 4% Percentage of Total Phase 1A Site Area draining Bioswale =1.2%

Soil Amendments

- Total Area of Development Blocks (11, 15-17, 19-21) = 5.51
- Total Area of Development Blocks Containing Soil Amendments = 5.51 ha
- Percentage of Development Area Containing Soil Amendments = 100%
- Percentage of Total Phase 1A Site Area Containing Soil Amendments = 34%

LID Pilot Project #1- Phase 1A Candidate Development Blocks for Soakaway Pits

- Phase 1A Boundary
- Potential Soakaway Pit Location (Front or Back Yards)
- Enhanced Swale
- Bioswale in Road Right-of-Way
- Residential Block
- School
- Park/Parkette

Total Phase 1A Area = 16.0 ha
Parks, School & Nat. Areas= 3.6 ha
LIDs: Enhanced Swale & Bioswale = 0.32 ha
Total Area of Development Blocks = 5.51 ha

SOAKAWAYS
Total Area of Blocks with Soakaways = 3.5 ha
% of Dev. Blocks with Soakaways = 64%
% of Phase 1A with Soakaways = 22%

ENHANCED SWALE
Total Area of Blocks with E. Swale = 1.2 ha
% of Dev. Blocks cont. to E. Swale = 21%
% of Phase 1A cont. to E. Swale = 7.5%

BIOSWALE
Total Road Area with Biowale = 0.2 ha
% of Total Road cont. to Biowale = 4%
% of Phase 1A cont. to E. Swale = 1.2%

SOIL AMENDMENTS (S.A.)
Total Area of Blocks with S.A. = 5.51 ha
% of Dev. Blocks with S.A. = 100%
% of Phase 1A with S.A. = 34%

Figure 45

Subsurface soakaway/ chambers

Downspout disconnections are proposed to direct roof runoff to front yard (and or rear yard where catch basins are proposed in the conventional SWM design) subsurface soakaways/chambers for detention and infiltration. Soakaway locations as indicated on Figure 45 were selected based on type of proposed building/ structure, access points from roadways (i.e. driveways, laneways), as well as forecasted utility conflicts. Locations which have the ability to drain to the proposed enhanced swale feature (Southwest Channel) were not proposed for soakaway pit implementation.

The proposed facility is recommended to include the following attributes:

- Constructed of 40-50mm Ø clear stone wrapped in a geotextile. Where space is adequate aggregate sizing can be reduced to 20mm Ø, however where limitations in available area are encountered (infrastructure/ servicing conflicts exist such as transformer box locations etc.) arched chambers or other high void forming products may be used.
- Located a minimum of 3m from the proposed building foundation. Note: building setbacks in Area A (LID Pilot Area Phase 1A) have been adjusted to permit the minimum 3m setback from soakaway locations to the building foundation. Refer to Former CFB Rockcliffe Community Design Plan Planning Rational (March 31, 2015):
    i. Page 19 Table 3-2: *R4 Subzone AA and BB Zone Provisions*
    ii. Page 30 Figure 3-2: Zoning Schedule
- Inclusion of a cleanout/ observation port located at the property line
- Provision of an overflow to the municipal storm sewer and an emergency overland overflow route in the form of a downspout relief and splash pad.
- Provision for water level monitoring ports

A typical detail specific to the Former CFB Rockcliffe site is provided as Figure 46.

Soil Amendments

All green spaces (grassed and vegetated) are proposed to include soil amendments in conformance with the:

- Implementation Guide for the Pinecrest Creek/ Westboro SWM Guidelines: Development Requiring a Building Permit Only (Draft, 2013).
- Preserving and Restoring Healthy Soil: Best Management for Urban Construction (Sustainable Technologies Evaluation Program – STEP, June 2012, Version 1.0)

Figure 47 and Figure 48 presents draft details developed for the City of Ottawa for the Pinecrest Creek/ Westboro SWM Guidelines: Development Requiring a Building Permit Only (June 21, 2014) and is illustrative of a typical topsoil amendment strategy for: a) On-site Soil Amendment and b) Import and Replacement.

Features of the soil amendment strategy include:

- Provision of a minimum depth of 0.30m (300mm) of amended topsoil over all landscaped areas in the post construction condition
- Amended topsoil to consist of organic content of 8-15% by weight, or 30-40% by volume

- Direction of downspouts/ roof drainage to landscaped area to minimize runoff
- Front and rear yard grading should be limited to a maximum of 2%, if possible while still meeting the surrounding existing grades.
- Decompaction of all sub-soils to 100mm depth prior to placement of amended soils. No decompaction within 3m of building foundations or within tree protection areas.
- Amendment materials must be obtained from accredited vendors who comply with:
- The Guidelines for the Production and Use of Aerobic Compost in Ontario (2004), Ministry of the Environment (OMOE)

- Guidelines for Compost Quality (2005), Canadian Council of Ministers of the Environment (CCME)

Southwest Channel – Enhanced Swale

As detailed previously, to encouraging infiltration, reducing stormwater runoff and to minimize 'clean' sources of runoff from external areas to the south from entering the conventional stormwater management system (pipes and ponds), an enhanced swale is proposed for integration within the Southwest Channel of Block 2 (See Figure 2.0). An example of an enhanced swale is illustrated below.

Enhanced Swale - Minneapolis, Minnesota

The enhanced swale is recommended to include the following attributes:

- Amendment of the subsurface soil profile below the swale invert to encourage infiltration using a typical biomedia as specified in Figure 49
- Where required to ensure rapid drawdown or where soils are not capable of infiltrating stored runoff within 24-48 hours, the use of perforated underdrains will be required. Underdrains are anticipated based on site soils.
- Where the longitudinal slope of the swale is such that excessive erosion may occur or may limit infiltration potential, internal check-dams may be incorporated. From the MSS (IBI, 2015) the longitudinal slopes ranges from 0.5 to 1.7%.
- Vegetation should be selected that is non-invasive, and where feasible native and should complement and enhance the adjacent vegetation communities with consideration for localized habitat requirements.
- The conveyance capacity of 2.9cms during the 100 year event at the downstream end per the MSS (IBI, 2015) must be maintained in the design of the enhanced swale. Enhanced swale design must consider the ultimate surface roughness parameters of mature vegetation in hydraulic analysis and design.

A typical detail specific to the Former CFB Rockcliffe site is provided as Figure 49.

Bioswales within the Boulevard Area

To accept road runoff and boulevard drainage per the proposed road cross-Section 1B (26m ROW), (Figure 36 and Figure 41), it is proposed that bioswales be incorporated into the municipal ROW.

Bioswale locations and inclusion within specific cross-sections were based upon the following:

- The efficient placement of LID bioswale facilities in relation to proposed sub-surface infrastructure in order to minimize potential conflicts including but not limited to sanitary sewers, hydro, gas, telecommunications and water mains. Consultation with the relevant utility companies was undertaken as part of the development of the proposed road cross-sections which included LIDs.
- Focus on run-off prevention. Placement of bioswales adjacent to areas of high imperviousness to minimize runoff generated.
- Placement of bioswale treatment closest to contaminant source for improved water quality. Bioswales were placed adjacent to the roadway, sidewalk and cycling facilities (impervious surfaces) anticipated to generate the highest contaminant loads.
- Improved aesthetics and streetscape of the roadway, sidewalk and cycling facility network to improve community spaces.
- Location of bioswales on roadways anticipated to have minimal crossing from driveways and access roads in order to minimize the 'fracturing' of the feature into multiple smaller units.
- Size of the adjacent lot frontage and available area for bioswales.

The bioswale is recommended to include the following attributes:

- Inlets to be constructed using either:
  - Open-back side inlet catch basins or
  - Cast iron side inlet curb inserts
- Planting profile to consist of a typical biomedia as specified in Figure 50.
- A 20mm Ø clear stone gavel storage layer to be provided with a perforated pipe underdrain system connected to a free draining outlet (i.e. the municipal storm sewer), wrapped in a geotextile.
- Surface ponding depth to be limited to maximum of 300mm.
- Where additional storage is required, orifice control may be included.
- Perennial vegetation should be selected that is non-invasive and salt tolerant. Vegetation should be capable of surviving periods of both inundation and prolonged drought.
- Provision for a minimum thickness of 50mm of shredded hardwood mulch
- Provision for an overflow system when surface ponding depth is exceeded.

A typical bioswale detail specific to the Former CFB Rockcliffe site is provided as Figure 50.

Permeable Pavement within Lay-by Parking Areas

Where lay-by parking areas are proposed as part of Section 1B (26m ROW), the use of permeable interlocking concrete pavers is recommended. Note: the use of permeable interlocking concrete pavers parking lay-bys is subject to further review by the City of Ottawa at the detailed design stage, however it remains an option for implementation, but was not included in the modelling exercises.

The permeable pavement is recommended to include the following attributes:

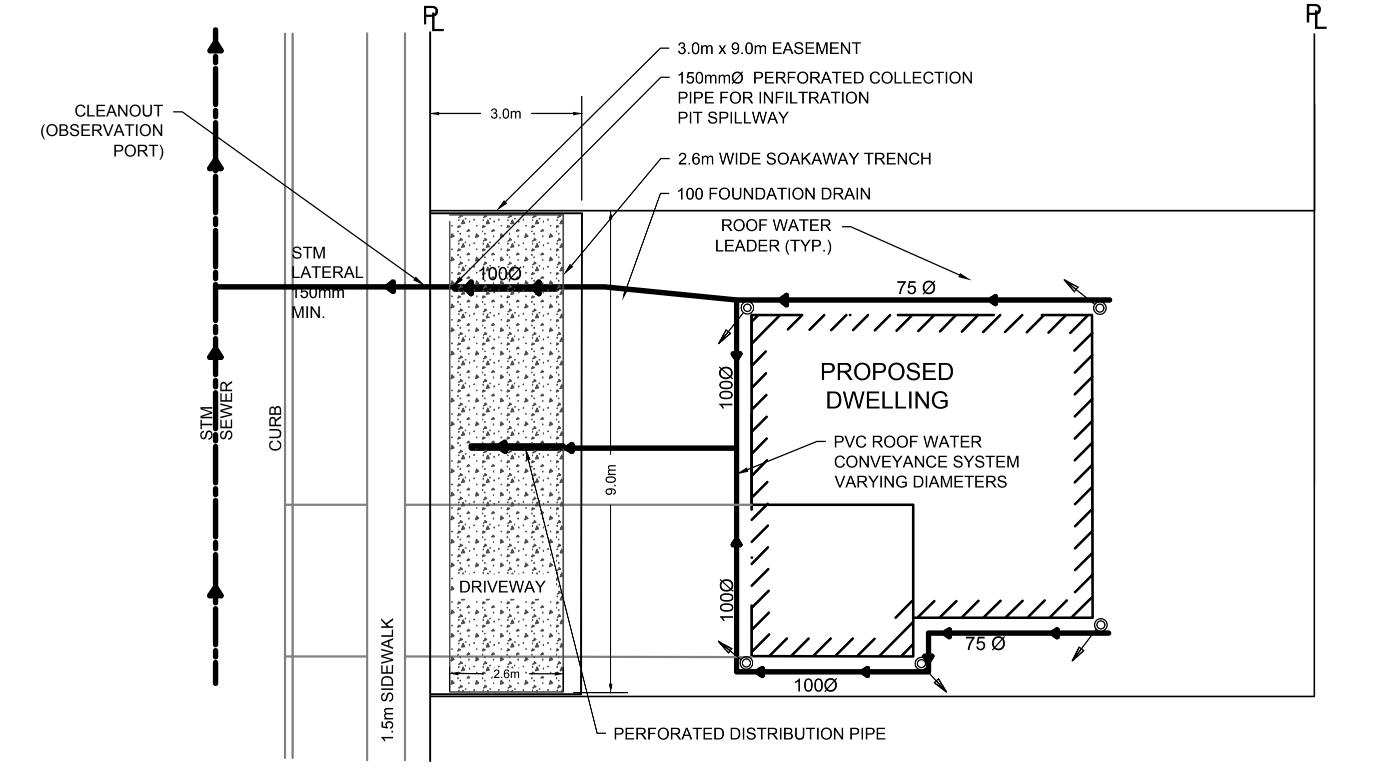
- Aggregate and paver cross-sections shall be based on structural analysis of soil bearing capacities, anticipated vehicle loads and design life requirements.
- Aggregates and jointing materials used in the construction of permeable pavements shall be free draining, clean, have zero plasticity and contain no material below the No. 200 sieve size. Crushed stone shall be 90% fractured face, L.A. Abrasion to ASTM C131, a minimum CBR of 805 per ASTM D 1883 and should be washed and have no visible fines present
- Design and material specification shall conform to:
    - the TRCA/CVC LID Stormwater Planning and Design Guide,
    - the Permeable Interlocking Concrete Pavements guide (ICPI, 3rd Edition) and
    - the North American Permeable Interlocking Concrete Pavement Standard (ASCE, Pending).

- Provision of a perforated a perforated pipe underdrain system connected to a free draining outlet (i.e. the municipal storm sewer) shall be included to prevent prolonged soil saturation and or standing water in the aggregate layers longer than 24-48 hours.

An example permeable interlocking concrete pavement detail is provided as Figure 51 as reference only. Site specific analysis and design must be completed.

Other LIDs

Other potential LID controls for consideration may include the use of bioretention areas to replace conventional landscape areas in parks and schools and or the use of permeable pavements driveways in place of conventional impermeable surfaces (i.e. driveways). These additional LIDs are not recommended as primary controls for the purposes of the LID Demonstration Project - Phase 1A but remain as an option for future consideration.



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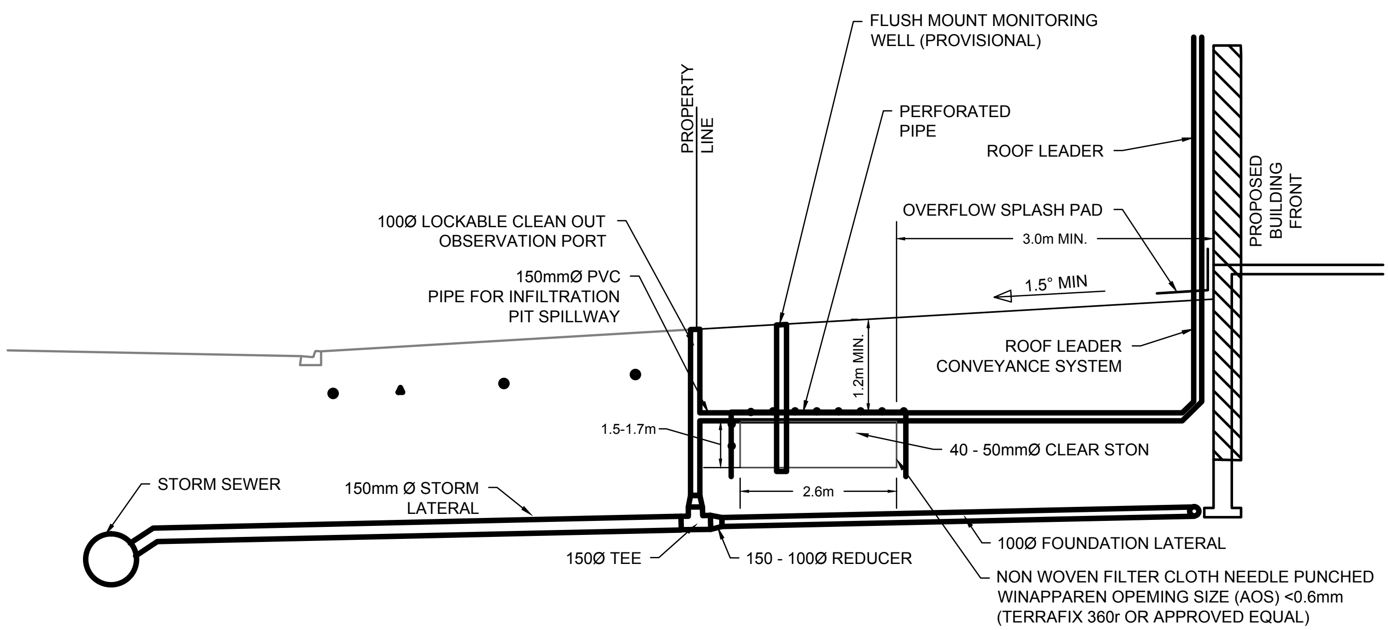


N.T.S

Aquafor Beech Limited

TYPICAL SINGLE LOT FRONT YARD INFILTRATION PIT DETAIL

STANDARD DETAIL

APPROVED	DWG No.
REVISION No.	Figure 46
DATE	

On-Site Soil Amendment - Default Ratio 3:1

Figure 47

Materials

- Amend existing site topsoil using 3:1 ratio by volume (3 parts existing topsoil, 1 part amendment material)
- Amendment Material: organic matter primarily leaf, yard and bark waste compost of 20-30% by dry weight as determined by Loss-on-Ignition (LOI) and a pH of 6.0 to 8.0
- No uncomposted manure or other organic materials, sphagnum peat or organic amendments that contain sphagnum peat

Placement and Amendments

1. Remove existing topsoil and preserve on-site.
2. Decompact native subsoil at depth of 100-200mm. Decompaction using a perpendicular pattern (See Detail No.1) ensuring full site coverage. No decompaction within tree protection areas (See Detail No.2) or within 3m of building foundations (See Detail No.3).
3. Amend existing site topsoil to meet post construction soil amendment requirements using 3:1 ratio by volume (topsoil : amendment material).
4. Two (2) methods for amending the existing soils in place are acceptable:

   Method No.1 - Layer and Incorporate (Detail No.4)

   i. Apply 100mm of existing site topsoil followed by 50mm of amendment material and incorporate/mix amended material.
   ii. Lightly roll or smooth using the back of the machinery bucket.
   iii. Repeat i. and ii.
   iv. Adjust layer quantities to ensure a settled amended topsoil depth of 300m and compliance with site grading. Placement should account for 10% settlement.

   Method No.2 - Mechanical or Bucket Mix

   i. Successively add, mix and pile one (1) unit of amendment material with three (3) unit of existing site topsoil.
   ii. Thoroughly mix.
   iii. Repeat i. and ii to ensure thorough mixing until required volume is achieved.
   iv. Place 150mm of amended topsoil, lightly roll or smooth using the back of the machinery bucket.
   v. Repeat iv.
   vi. Adjust layer quantities to ensure a settled amended topsoil depth of 300m and compliance with site grading.

   Amended topsoil should be wetted after application, allowed to settle for a minimum of one (1) week and grades adjusted as required prior to installation of turf.

-IMPORTANT-

Documentation Requirements

As part of verification, the owners shall produce delivery tickets, receipts and specifications detailing the delivery address, quantities and product description and sources for verification by City inspectors. Delivery address is to be listed and must correspond to the property/site being inspected. Site without proper documentation may be subject to additional verification procedures including laboratory testing at the expense of the owner.

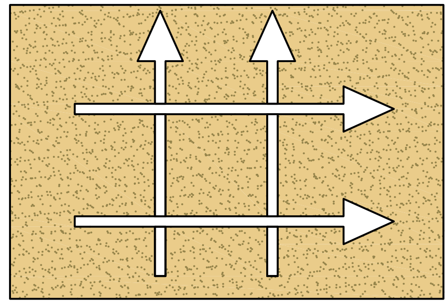
City Verification/Inspection

Verification may occur after the minimum one (1) week settlement period. Verification is suggested prior to turf placement. Non-compliant sites shall be rectified at the expense of the owner.

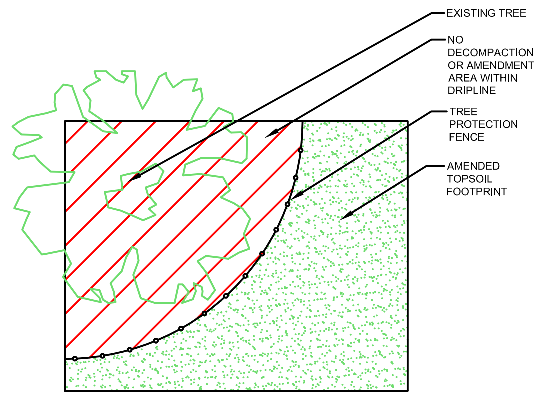
At random, the City inspector shall dig at least one (1) test hole to verify amended topsoil depth and uncompacted soil depths.

Requirements:

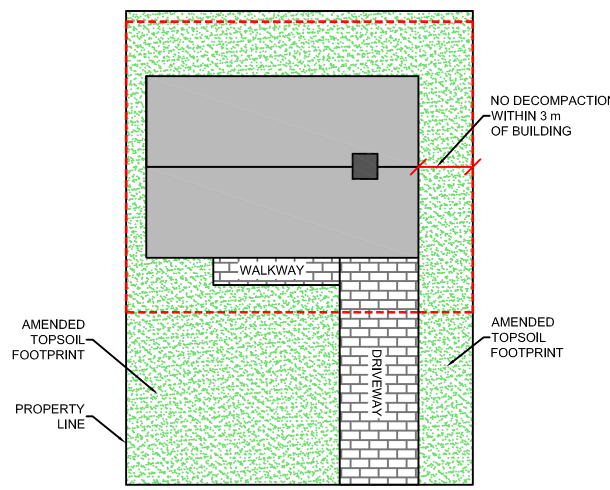
1. Amended topsoil layer shall be easily dug using only the inspector's weight or cored without other mechanical assistance.
2. The amended topsoil layer shall be darker in color than the unamended-decompacted subsoil and particles of organic matter should be easily visible.
3. Measured amended topsoil depths shall be deemed to be in conformance based on the following:
   - Using a common garden spade, the measured depth of amended topsoil shall be equal to the required 300mm depth (±25mm)
   - Using a small diameter coring unit, the measured core depth of amended topsoil shall be equal to the required 300mm depth (±50mm)



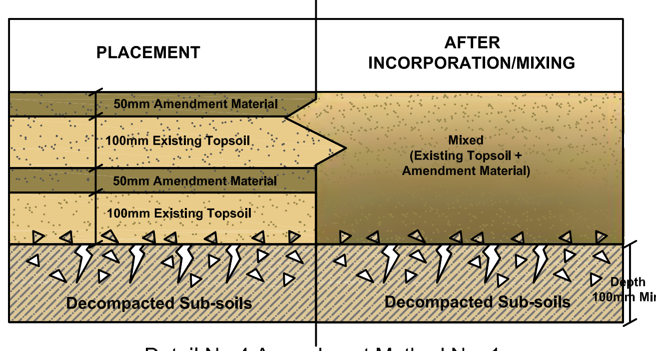
Detail No.1 - Perpendicular Decompaction Pattern



Detail No.2 - No Decompaction within Tree Protection Areas or Amendment



Detail No.3 - No Decompaction within 3.0m of Building Foundation (Amendment Only)



Detail No.4 Amendment Method No. 1

Soil Amendment Requirements for Pinecrest Creek/Westboro Area - For Development Requiring a Building Permit Only

City of Ottawa
June 24, 2013

On-Site Soil Amendment
Import and Replace Topsoil with Amendment Material

Figure 48

Materials

- Amendment material shall be obtained from a Compost Quality Assurance (CQA) licensed and OMOE/ CCME approved facility and shall comply with the Category "A" compost designation. The amendment material must contain:
  - Organic matter primarily leaf, yard and bark waste compost of 8-15% by dry weight as determined by Loss-on-Ignition (LOI) and a pH of 6.0 to 8.0.
  - No uncomposted manure or other organic materials, sphagnum peat or organic amendments that contain sphagnum peat.

Placement and Amendments

1. Remove existing topsoil and dispose off-site in accordance with OPSS 206 and OPSS 180, O. Reg. 153/06, the Environmental Protection Act or municipal by-laws and policies, whichever supersedes.
2. Decompact native subsoil at depth of 100-200mm. Decompaction using a perpendicular pattern (See Detail No.1) ensuring full site coverage. No decompaction within tree protection areas (See Detail No.2) or within 3m of building foundations (See Detail No.3).
3. Import pre-mixed amended topsoil (300mm depth of coverage required).
4. Place imported pre-mixed amended topsoil in 150mm lifts, lightly roll or smooth using machinery bucket and repeat. Adjust layer quantities to ensure a settled amended topsoil depth of 300mm and compliance with site grading. (See Detail No.4). Placement should account for 10% settlement.

Amended topsoil should be wetted after application, allowed to settle for a minimum of one (1) week and grades adjusted as required prior to installation of turf.

-IMPORTANT-

Documentation Requirements

As part of verification, the owners shall produce delivery tickets, receipts and specifications detailing the delivery address, quantities and product description and sources for verification by City inspectors. Delivery address is to be listed and must correspond to the property/site being inspected. Sites without proper documentation may be subject to additional verification procedures including laboratory testing at the expense of the owner.

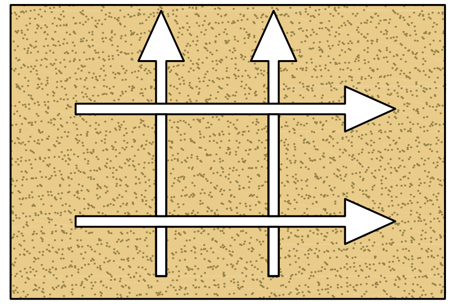
City Verification/Inspection

Verification may occur after the minimum one (1) week settlement period. Verification is suggested prior to turf placement. Non-compliant sites shall be rectified at the expense of the owner

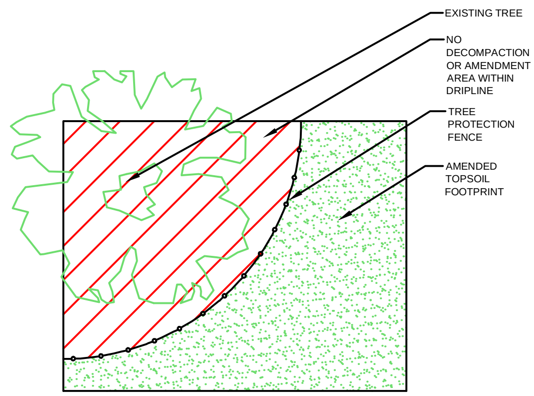
A random, the City inspector shall dig at least one (1) test hole to verify amended topsoil depth and uncompacted soil depths.

Requirements:

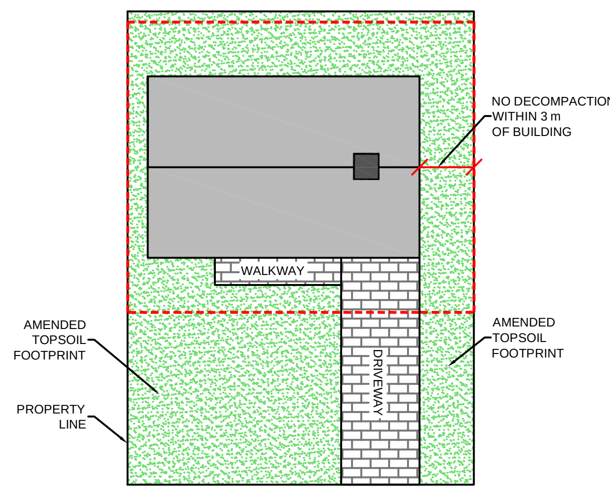
1. Amended topsoil layer shall be easily dug using only the inspector's weight or cored without other mechanical assistance.
2. The amended topsoil layer shall be darker in color than the unamended-decompacted subsoil and particles of organic matter should be easily visible.
3. Measured amended topsoil depths shall be deemed to be in conformance based on the following:
   - Using a common garden spade, the measured depth of amended topsoil shall be equal to the required 300mm depth (±25mm)
   - Using a small diameter coring unit, the measured core depth of amended topsoil shall be equal to the required 300mm depth (±50mm)



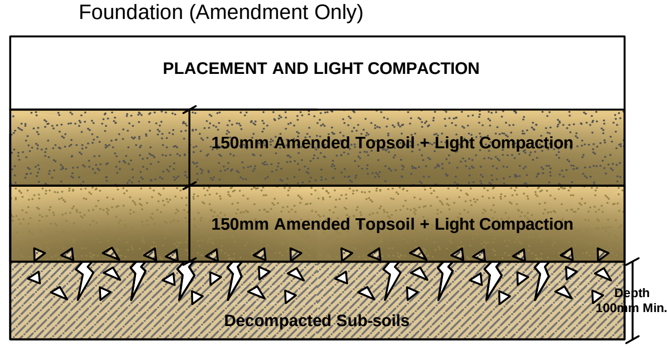
Detail No.1 - Perpendicular Decompaction Pattern



Detail No.2 - No Decompaction within Tree Protection Areas or Amendment



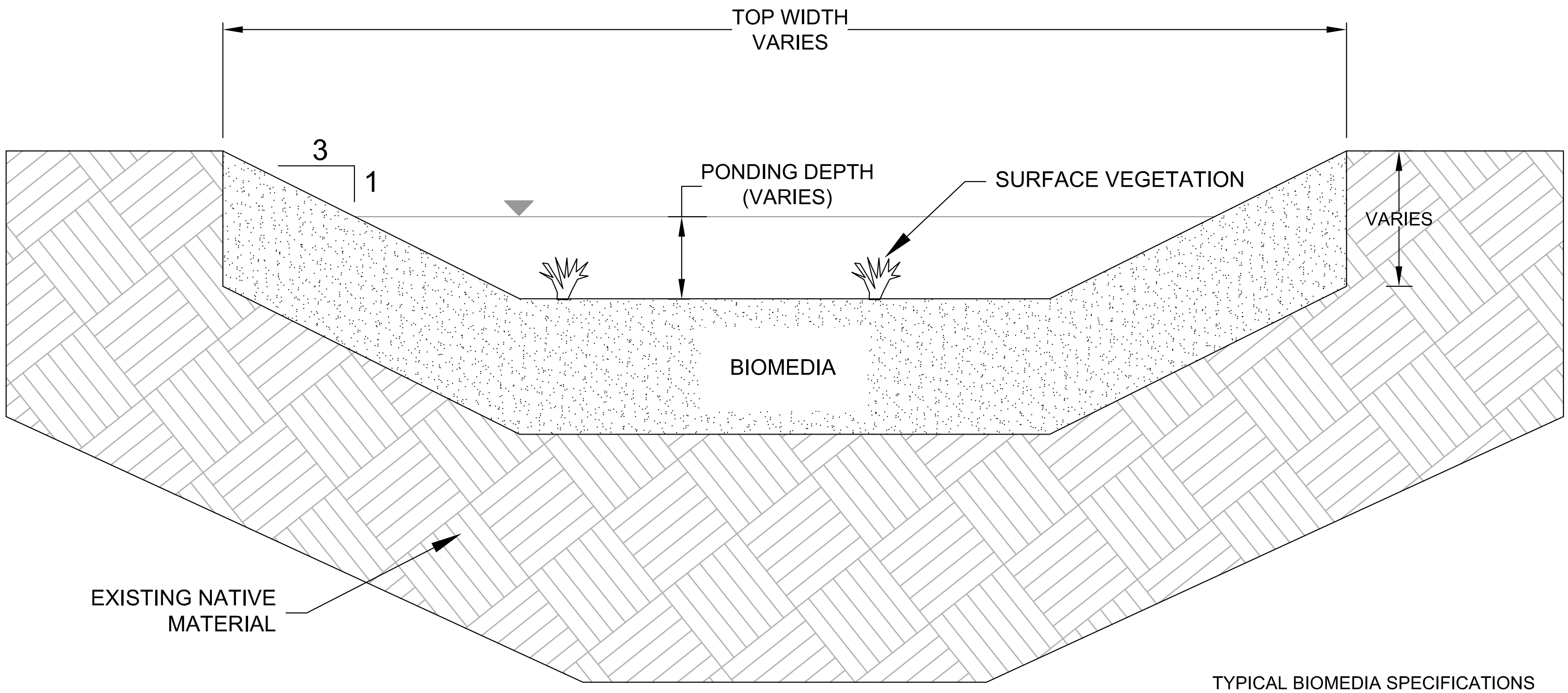
Detail No.3 - No Decompaction within 3.0m of Building Foundation (Amendment Only)



Detail No.4 Placement and Compaction Lifts for Amended Topsoil

Soil Amendment Requirements for Pinecrest Creek/Westboro Area - For Development Requiring a Building Permit Only

City of Ottawa
June 24, 2013



ENHANCED SWALE - CROSS-SECTION VIEW

N.T.S

TYPICAL BIOMEDIA SPECIFICATIONS

MEDIA	SIZE	% BY WEIGHT
1 - SAND	2 to 0.05mm	85 - 88%
2 - FINES	< 0.050mm	8 - 12%
3 - LEAF COMPOST (Organic Matter)	–	3 - 5%

Notes:

- CEC greater than 10 mg/100g
- PH = 5.5 - 7.5
- K greater than 25mm/hr

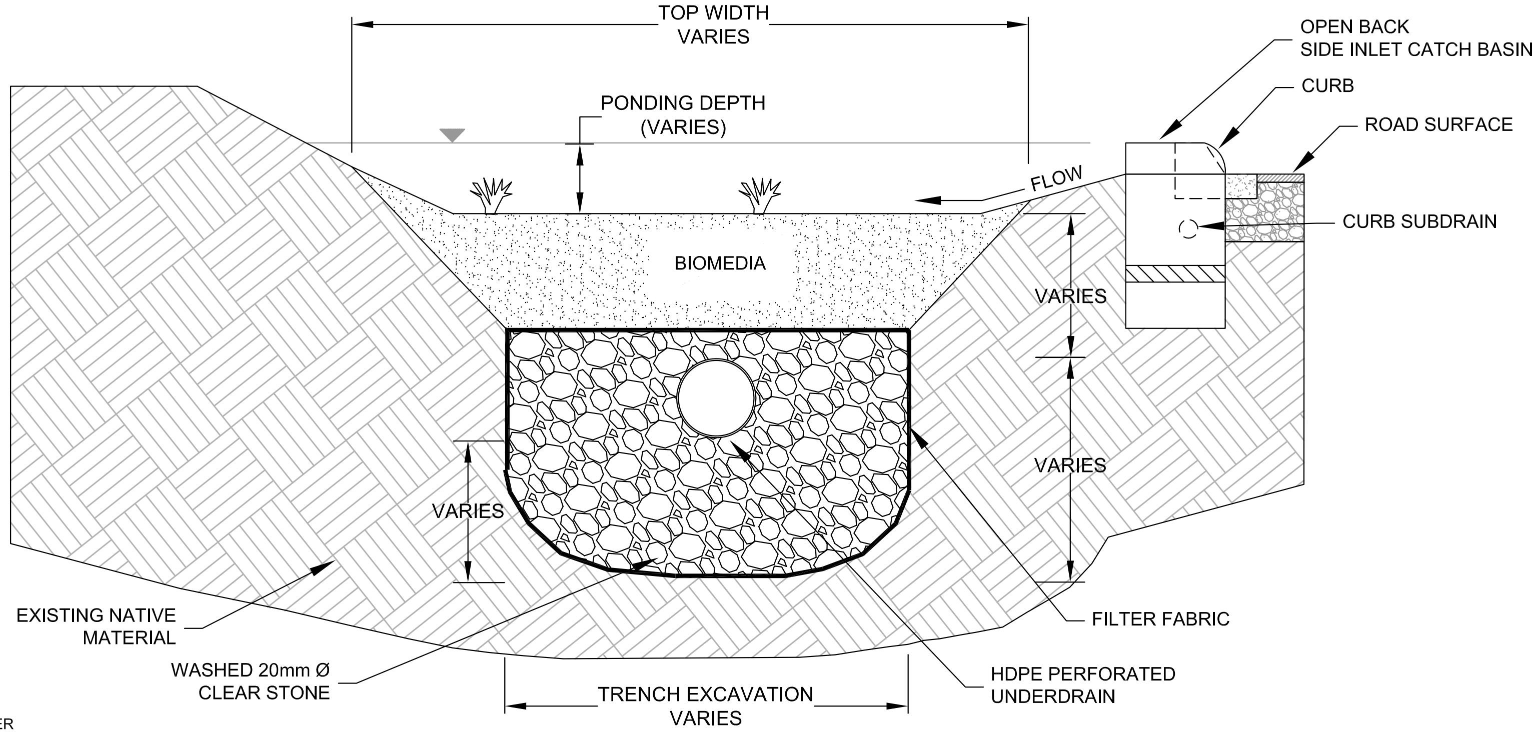
Soil Texture Classification:

- No objects greater than 50mm
- Media obtained from vendor to be tested to confirm design specifications prior to installation. Field engineer to confirm conformance with specification prior to installation.

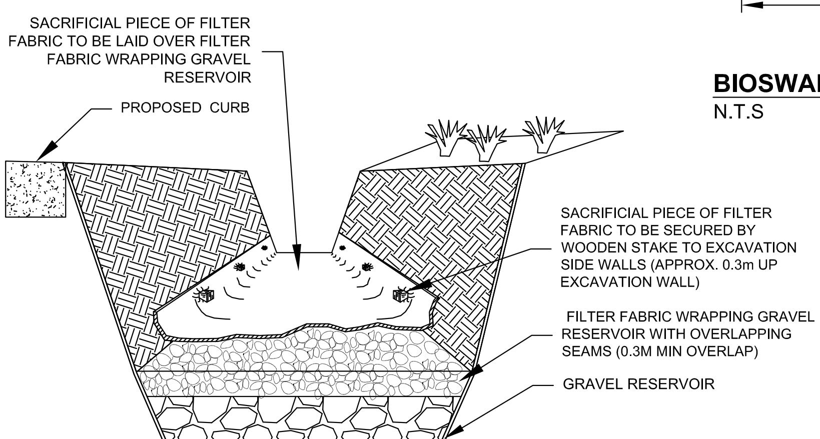
Aquafor Beech Limited

ENHANCED SWALE TYPICAL

STANDARD DETAIL	
APPROVED	DWG No.
REVISION No.	Figure 49
DATE 2015	



BIOSWALE - CROSS-SECTION VIEW
N.T.S



BIOSWALE - TYPICAL EROSION & SEDIMENTATION CONTROL
N.T.S

TYPICAL BIOMEDIA SPECIFICATIONS

MEDIA	SIZE	% BY WEIGHT
1 - SAND	2 to 0.05mm	85 - 88%
2 - FINES	< 0.050mm	8 - 12%
3 - LEAF COMPOST (Organic Matter)	–	3 - 5%

Notes:

- CEC greater than 10 mg/100g
- PH = 5.5 - 7.5
- K greater than 25mm/hr

Soil Texture Classification:

- No objects greater than 50mm
- Media obtained from vendor to be tested to confirm design specifications prior to installation. Field engineer to confirm conformance with specification prior to installation.

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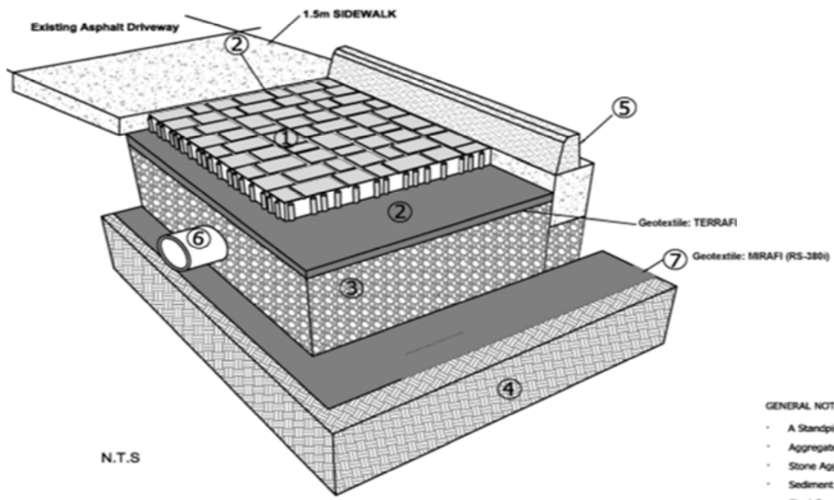
BIOSWALE TYPICAL

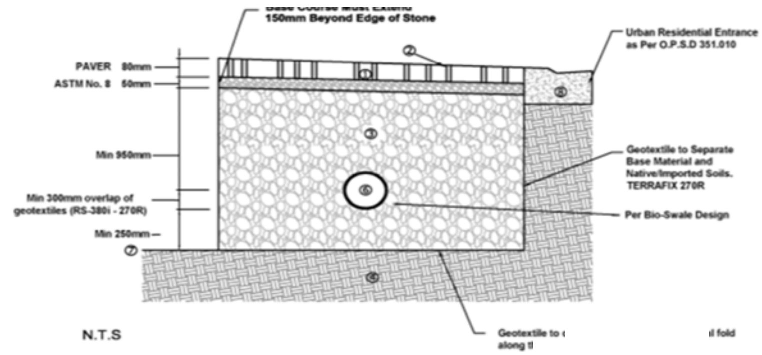
STANDARD DETAIL

APPROVED	DWG No.
REVISION No.	Figure 50
DATE **2015**	

Figure 51 –Example Permeable Interlocking Concrete Pavement Detail (Reference Only)



DETAIL C1: PERMEABLE PAVEMENT DRIVEWAY DETAIL



DETAIL C2: PERMEABLE PAVEMENT DRIVEWAY CROSS-SECTION

GENERAL NOTES

- A Standpipe With Cap to be Installed From the Underdrain to the Pavement Surface for Monitoring and Maintenance of the Underdrain System.
- Aggregate Materials Used in the Construction of Permeable Pavements Shall Be Clean, Have Zero Plasticity and Contain no No. 200 Sieve Size Materials.
- Stone Aggregate Should Be Placed in 100mm to 150mm Lifts and Compacted with a Minimum 9,070 Kilograms (10 Ton) Steel Drum Roller. Stone Materials Should Be Moist During Compaction.
- Sediment Control Fencing to be Installed Prior to the Commencement of Construction to Prevent Runoff From Contaminating Excavated Surface of the Native Soils And or the Aggregate Base Courses.
- Final Grade of the Permeable Pavement Subbase to be Excavated Immediately Prior to Backfilling With Specified Base Course to Avoid Premature Facility Clogging.
- All Construction Materials are to be Stored Down-Gradient of Excavated Site Whenever Possible. Materials Stored Up-Gradient of the Excavated Site are to be Enclosed By Appropriate Sediment Control Fencing.

PERMEABLE PAVEMENT COMPONENT NOTES:

1. Paver - Must Conform to ASTM C396 Standard Specification for Solid Interlocking Paving Units or CAN3-A231.2 Standard Specification for Precast Concrete Pavers
   a) Average compressive strength 8000 psi (55MPa) with no individual unit under 7,250 psi (50MPa) in accordance with ASTM C396 or CAN3-A231.2-M85.
   b) Average absorption of 5% with no unit greater than 7% when tested according to ASTM C 140.
   c) Resistance to 50 freeze-thaw cycles, when tested according to ASTM C 67 or CAN3-A231.2-M85, with no breakage greater than 1.0% loss in dry weight of any individual unit. This test method shall be conducted not more than 12 months prior to delivery.
   d) Pigment in concrete pavers shall conform to ASTM C 979. ACI Report No. 212.3R provides guidance on the use of pigments.
   Maximum allowable breakage of product is 5%.
2. Joint aggregate – crushed, washed angular Chip Stone (ASTM 8, 9, or 89) Referred to as HPB (High Performance Base).
3. Granular aggrrgate – 20mm Ø free draining, clean, have zero plasticity and contain no material below the No. 200 sieve size. Crushed stone shall be 90% fractured face, L.A. Abrasion to ASTM C131, a mnimum CBR of 805 per ASTM D 1883 and shoudl be cleaned washed and have no visible fines present
4. Native Material
5. Curb
6. Underdrain - Perforated Pipe Constructed in Accordance with OPS 405. Pipe Diameter 200mm, 10mm Diameter perforations in Pipe.
7. Filter Fabric must conform to one of the following:
   a. AOS (Apparent Opening Size) - maximum Avg. roll value < 0.3m for non-woven needle punched fabrics
   b. OA (Percent Open Area) > 4% for woven monofilament fabrics must also conform to OPSS 1860 for class II geotextile - fabrics that are 'woven silt film' or 'non-woven heat bonded fabrics' are unacceptable and shall not be used.

5.13 SPECIFIC PROJECTS

The following section highlights specific stormwater management projects which are proposed as a component of the overall SWM and LID demonstration project, including those beyond Phase 1A.

Dry Ponds

As discussed previously, three (3) dry ponds are proposed across the site for the purpose of surface storage and flow routing (Figure 26 and Figure 27):

1. Park Dry Pond
2. Eastern Dry Pond
3. Central Dry Pond

In addition, in Block 22 (area PH1D), a park, is provided to provide 230 m^3 during the 100 year event. Major flow from portions of the study area will be directed to the three (3) dry ponds for attenuation prior to release, specifically 16.2, 2.5 and 0.5 m3/s for the 100 year event for the Park, Eastern and Central dry ponds respectively. While the Park and Eastern dry ponds are required for major system attenuation, the Central pond is required, but for only for a small amount of attenuation (0.5cms). in that regard the central facility, although providing a major system function, is primarily an infiltration opportunity.

The infiltration potential component of these ponds is discussed below. Regardless of the provision of infiltration capabilities within the detailed design, the storage volume designated for the ponds is for major system storage. Per the MSS (IBI, 2015) the functional design for the major system storage provides flexibility in terms of the potential future use for LID techniques.

Function

Water which enters the Infiltrating Dry Ponds will infiltrate into the amended soils and either recharges the groundwater system or is collected by an underground perforated pipe network and discharged to a downstream outlet. In lower permeability soils, soil amendments or manufactured media shall be included to increase recharge potential and water holding capacity.

The primary function of Infiltrating Dry Ponds is to mitigate the impacts that urbanization normally has on the water balance (i.e., increased surface runoff, reduced soil moisture replenishment and groundwater recharge). Concentrated infiltration of stormwater collected from larger areas (e.g., infiltration basins, an end-of-pipe infiltration type control) will not match the characteristics of distributed infiltration which occurred under existing conditions, but can form an important part of the 'treatment train approach' to SWM. An example of end-of-pipe infiltration control is illustrated below.

Infiltration Basin Amended with Engineered Media – Oakville, ON

Isolation of existing trees stands from a hydrologic perspective can cause die-off or community alteration of established tree communities over a long-term period. While the three (3) dry ponds facilities are not explicitly designed for infiltration purposes, they do present an opportunity to enhance infiltration and maintain groundwater sources to existing tree communities. Water balance objectives will not be compromised by the loss of these areas from the overall LID system, however if designed with infiltration capabilities, they can form a significant portion of the overall SWM system.

The location of the potential infiltration pipe inlets have been located within exiting roadways (Eastern Dry Pond – Figure 30) or proposed roadways (Park and Central Dry Pond - Figures 19 and 31) in order to minimize tree community disturbances. In addition, the proposed facilities, with only minor exceptions, have been located outside the limits of the existing tree cover (drip-line). Minor disturbances are anticipated only however It should be noted that the facility shape and configuration can be amended at detailed design to minimize any disturbances.

Surficial Geology and Proposed SWM

There exists considerable heterogeneity of the materials in the areas of the proposed infiltrating Dry Ponds, especially in areas of shallow soils over relatively impermeable bedrock, which are characterized by considerable fill. The geology layers in the immediate vicinity of the Central and Eastern Infiltrating Dry Ponds are summarized in Table 27 from DST boreholes and test pits. The information presented in Table 27 indicates that it is feasible to maintain the 0.5m to 1.0m separation from the groundwater table and bedrock to permit infiltration. Note: the groundwater elevations as listed to not necessarily represent seasonally high groundwater elevations, as such additional groundwater monitoring is recommended prior to detailed design.

Infiltrating Dry Ponds designed to promote infiltration constructed in these materials are expected to effectively provide point sources for groundwater recharge. In this case, when runoff from the areas covered by clay material is diverted into infiltration ponds situated in areas with surficial deposits with higher infiltration rates, the actual groundwater recharge conditions for the area may improve compared to predevelopment conditions.

Impacts of site development (including remedial excavation and construction dewatering) in overburden deposits will be localized due to low permeability of deposits. As a precautionary measure, groundwater elevation monitoring in areas serviced by private wells such as the Fairhaven community and the Canadian Aviation and Space Museum is recommended before, during and after site development activities

MSS Review

Based on a review of the proposed conceptual SWM system per the MSS (IBI, 2015), the following attributes are noted which are suitable and in keeping with design guidelines for infiltration based LIDs:

- Dry ponds have been designed with flat bottoms
- Dry ponds have moderate side slopes 3H:1V.
- Dry ponds have been designed with no permanent pool in the facility
- Maximum water level within the three Dry Ponds is limited to a maximum of 0.6m during the 100year event

It is therefore proposed that with minor modifications, the proposed facilities as presented in Figures 29 – 31 can be modified to promote infiltration of stormwater runoff. As such, it is feasible to direct minor system flows up to the 25mm event to the proposed Infiltrating Dry Pond facilities and that the designs be amended to encouraging infiltration, reducing stormwater runoff and to minimize runoff volumes. Like the enhanced swale detailed earlier (Figure 48), the proposed Infiltrating Dry Ponds are recommended to include the following attributes:

- Amendment of the subsurface soil profile below the swale invert to encourage infiltration using a typical biomedia as specified in Figure 49.
- Where required to ensure rapid drawdown or where soils are not capable of infiltrating stored runoff within 24- 48 hours, the use of perforated underdrains shall be incorporated.
- Where the peak flows are such that excessive erosion may occur or may limit infiltration potential, internal check-dams and or plunge pools or other energy dissipation measures may be required, respectively.
- Vegetation should be selected that is non-invasive, and where feasible native and should complement and enhance the adjacent vegetation communities with consideration for localized habitat requirements.
- Conveyance capacity of must consider the ultimate surface roughness parameters of mature vegetation in hydraulic analysis and design.

Table 27: Subsurface Investigation Results within 50 Metres of Proposed SWM Infiltration Facilities Locations DST (2013-2014) Appendix A

SWM Infiltration Facilities	Subsurface Observations within 50 m	Geology	Water Level (m below existing ground Surface)
Central Ex. Ground Surface ≈83.0m Proposed Inv. 82.3m	TP13-04	Silty clay to 3.0 m	-
	TP5	NA	-
	BHMW22	Fill 0.6, till to 2.3, bedrock at 2.3 m	1.82 – 2.56
	BHMW21	Sand fill 1.4, till 2.35, bedrock at 2.35	2.8
	BHMW23	Sand 2.65, bedrock 2.65 m	1.4
	BH14-27	Sand & gravel 1.6 m, bedrock at 1.6 m	-
	BHMW12	Sand fill to 1.4, bedrock at 1.5 m	3.98 – 4.34
	BHMW13	Silty sand 2.0, bedrock at 2.0 m	4.85 – 5.14
	BHMW14	Sandy silt Fill 1.5 m, bedrock at 1.5 m	3.95 - 4.23
	BHMW15	Silt Fill 2.6, till to 3.2, bedrock at 3.2 m	3.2 – 3.78
	BH14-26	Clay to 2.6, bedrock at 2.6 m	-
East Ex. Ground Surface ≈85.0m Proposed Inv. 85.5m	BH14-28	Sand to 3.4, Silty clay to 5.6 m	-
	TP13-01	Sand fill 0.5, silty clay to 2.4 m	-
	TP13-02	Sand & clay 0.8, Silty clay 2.7 m	Sewer pipe 1.6
	BH13-16	Silty clay to 4.4 m	2.91
	BH14-40	Sand to 1.0, silt to 2.2 m,	1.50
	BH14-41	Sand to 1.0, bedrock at 1.0 m	-
	BHMW10	Sand Fill 1.5, till 1.8, BR 1.8	4.93 – 5.9

Overland Drainage & Waterfall (Block 26)

There are significant grade changes along the north perimeter. The significant slope across the site limits site servicing routing to a general southeast to northwest direction. The rock escarpment provides an opportunity for a natural feature in the form of a waterfall. The escarpment also presents a constraint to development since safe setback distances must be respected.

Woking in concert with Infiltrating Dry Pond within Park Block 26, it is proposed that a portion (i.e. low flows to maximum of the 25mm event) of the main north/south storm sewer will be day-lighted within Block 26, outlet to the proposed Infiltrating Dry Pond facility and continue towards the north as a shallow overland drainage feature designed using natural channel design principles, augmented with buffer vegetation and integrated into park elements. It is intended that the overland drainage feature will terminate at the northern escarpment and will form a waterfall feature. The waterfall will flow into the Eastern SWM pond for treatment and discharge. Final determination of the feasibility of the waterfall feature will be subject to further geotechnical studies relating to bedrock stability.

Constructed Waterfall Feature - Princess Louise water falls located in Fallingbrook.

Constructed Waterfall Feature - Princess Louise water falls located in Fallingbrook.

Special Design Area (Block 44)

The Special Design Area (Block 44) is located in the north east corner of the Former CFB Rockcliffe site. Development and servicing of this site is not anticipated until Phase 3 (starting in the year 2024). At that time it is anticipated that the LID demonstration project will be nearing completion and the full benefits will be characterized though monitoring. As such, it is suggested that the stormwater management within the Special Design Area be a full LID community block, without conventional stormwater management to service the minor systems or major system flows. This would amend the proposed use of a storm sewer for conveyance and an OGS system for water quality as described in the MSS (IBI, 2015).

It is proposed that the Special Design Area will utilize the full extent of the knowledge gained throughout the demonstration project and will employ the full-suite of proposed LID controls. The built form of the Special Study Area would include minimal building footprints and rural cross-sections roadways with integrated shallow LID features (0.20 - 0.5m depression). Proposed LID measures would include:

1. Permeable pavements (parking areas and or sidewalk trails)
2. Bioswales & Bioretention facilities
3. Soakaway pits
4. Green roofs and
5. Rainwater Harvesting techniques
6. Perforated pipe systems

The Special Design Area currently outlets to the Northeastern Escarpment Tributary (over the escarpment) via an existing 1050mm Ø CSP. Site investigations have identified the existing escarpment outlet channel as showing signs of increasing erosion. In the ultimate condition it is proposed that this existing outlet be maintained and serve as the outlet for the full LID community block.

The objective of the LID design for the Special Design Area will be to:

- Reduce site outflows to maximum extent possible
- Reduce erosion at the existing escarpment outlet and the Northeastern Escarpment Tributary
- Provide full water quality control in conformance with Level 1 MOE Water Quality Control
- Encourage infiltration within the community block itself to maintain the existing hydrologic regime of the significant and important tree groupings within the Former CFB Rockcliffe and beyond.

An example of a full LID community can be found in the Meadows in the Glen Subdivision located in the Hamlet of Glen Williams in the Town of Halton Hills. The Meadows in the Glen Subdivision is the first Greenfield Low Impact Development subdivision in the Credit River Watershed. The subdivision design includes LID measures such as, narrower road widths, porous pavement, street swales, rain gardens, bioretention, soakaway pits, preservation of forests, and water and energy conservation measures, which will help to reduce the impact of the subdivision on the environment.

Watercourse Restoration

Per Section 6.8 of the MSS (IBI, 2015), the intent of the preferred alternative is to direct the increase in flow to the Ottawa River, away from the two creeks, via a single storm sewer. At this time, watercourse restoration is not proposed based on discussion with the landowner, the National Capital Commission (NCC). Watercourse restoration would require approval from the National Capital Commission (NCC).

Thermal Mitigation for End-of-Pipe Ponds

Although not considered an LID technique, the use of alternative approaches, such as floating islands, bottom draw outlets and or rock cribs) for the mitigation of thermal impacts to downstream receivers from end-of-pipe facilities is recommended for consideration as part of the LID pilot program.

The thermal impacts of end-of-pipe (EOP) SWM facilities have been well documented, Galli (1990) found infiltration basins, wetlands, dry ponds and wet ponds to increase release temperatures by 1.4°C, 3.4°C, 2.9°C and 5.1°C respectively. The sensitivity of aquatic resources to relatively small increases in water temperature are such that watercourse classified as coldwater are intolerant of waters >22°C, mixed streams are intolerant of >24°C and warm water streams are intolerant of >26°C. This intolerance to thermal change can result in altered food requirements (change in digestion rate), reduced dissolved oxygen, formation of a thermal gradients, macrophyte and algae decomposition and fish mortality.

Example Floating Island within an EOP Pond in Brampton, Ontario (Source: CVC)

The use of floating islands for thermal impact mitigation is increasingly being applied throughout Ontario. The floating Islands play a critical role to reducing water temperature and improving water quality in end-of-pipe SWM facilities and connecting waterways. By blocking sunlight, islands create shadier conditions for stormwater ponds resulting in cooler conditions. Water continues to flow underneath the islands and plant roots act as a filter removing pollutants as water flows along.

In regards to the Former CFB Rockcliffe, the floating islands have the added benefit of discouraging waterfowl. The presence of birds is a concern of the nearby Rockcliffe Airport. The use of floating islands also has the added ability to be reconfigured in the future to further assist in this matter.

Eastern SWM Facility

The conceptual Eastern SWM Facility, designed as a wet pond (refer to Section 6.4.2 of the MSS), is comprised of a stilling basin, and a wet cell, with an outlet structure to a new storm sewer to the Ottawa River. At the upstream end of the facility, the stilling basin will provide energy dissipation for the proposed waterfall. Runoff will then flow into the sediment forebay, prior to the downstream wet cell. The proposed design creates a series of smaller open water surfaces, considered less desirable to birds, augmented by floating islands. Outflow from the facility is would discharge via the outlet structure to a new storm sewer which will convey runoff from the pond directly to the Ottawa River. Additional geotechnical work will be required to facilitate detailed design.

Western SWM Facility

Runoff will flow from the two inlets to sediment forebays, from which flow is conveyed to the main cell of the facility. Downstream of the southern sediment forebay, the Southwest Channel will tie into the main cell of the facility. Similar to the Eastern SWM Facility, the proposed design creates a series of smaller open water surfaces, considered less desirable to birds, possibly augmented with floating islands.

5.14 LID SIMULATIONS (POST DEVELOPMENT)

Building upon the EPA SWMMM hydrologic model developed as part of the predevelopment water balance assessment (see Section 3.5.2) a post-development predictive water budget model was developed. Modeling the hydrology under post-development conditions includes five (5) scenarios:

1. Post-development No LID Control (Total Area)
2. Post- Development LID Control (Total Area)
3. Existing conditions LID Pilot (baseline conditions for LID Pilot)
4. Post-development LID Pilot No Control
5. Post-development LID Control

Two of these scenarios (Scenarios 1 and 2) cover the total developed area and the rest (Scenarios 3, 4, and 5) cover the LID Pilot area (Phase 1A). All of the scenarios were evaluated using a continuous rainfall simulation from 1996 to 2013 using data from the ROPEC rain gauge as provided by the City of Ottawa, and snowfall data was obtained from Environment Canada station separately (45°23'00.00"N, 75°43'.00.000' W, 79.2 masl).

Model Development

In order to develop a hydrologic model for post-development conditions, the proposed land use was overlain over the drainage areas and boundaries assigned as part of the existing conditions model (Figure 52).

Parameters such as imperviousness values and depression storage were adjusted to reflect physical changes expected under post-development conditions. To estimate imperviousness, each land use was assigned an imperviousness values, and weighted averages were calculated based on the area coverage for each land use (Table 28).

LID Scenario Assumptions

The following assumptions were made for inclusion in the scenarios which include LID lot-level and conveyance controls. The assumptions are based on the proposed type and extent of LID control implementation for the Former CFB Rockcliffe development in Phase 1A as described in previous sections. The modelling assumptions for Phase 1A include the following:

- 60% of the total impervious areas is directed to lot-level controls
  - Phase 1A: Soakaways and Soil Amendments
- 30% of the ROW impervious areas is directed to conveyance controls
  - Bioswales and vegetated swales (includes the turf portion of the ROW treated with soil amendments)
- 10% of the total impervious areas is uncontrolled
- LIDs are not assumed be applied on Parks (Blocks 22 and 18) and School (Block 14) areas based on discussions with City staff as part of the SWM Working Group. The City will nevertheless encourage school boards to consider incorporating LID measures as feasible. With respect to parks, the potential for various LID measures (amended topsoil, bioretention for landscaped areas, etc.) is also not precluded at this stage but shall be subject to the

support of City Parks and Recreation department and staff.

As such the LID Pilot Area is 11.6 ha per the following:

- o Pilot Area = Total Phase 1A area (16 ha) – Parks (1.3 ha) - School (2.5 ha) – surface area of the LID feature itself (0.32 ha)

The Phase 1A general assumptions were subsequently extended to the total development area in order to develop a high-level predictive model of the potential benefit of LID implementation for all phases of development (Phases 1A-3). The types of LIDs proposed for Phases 1B to 3 are detailed in previous sections; however the extent of implementation is unknown at this time. As such the general modelling assumptions for the total development area (Phases 1A-3) included:

- 60% of the total impervious areas is directed to lot-level controls

- 30% of the ROW impervious areas are directed to conveyance controls (per proposed LIDs in the municipal ROW.

- 10% of the total impervious areas is uncontrolled (conservative assumption)

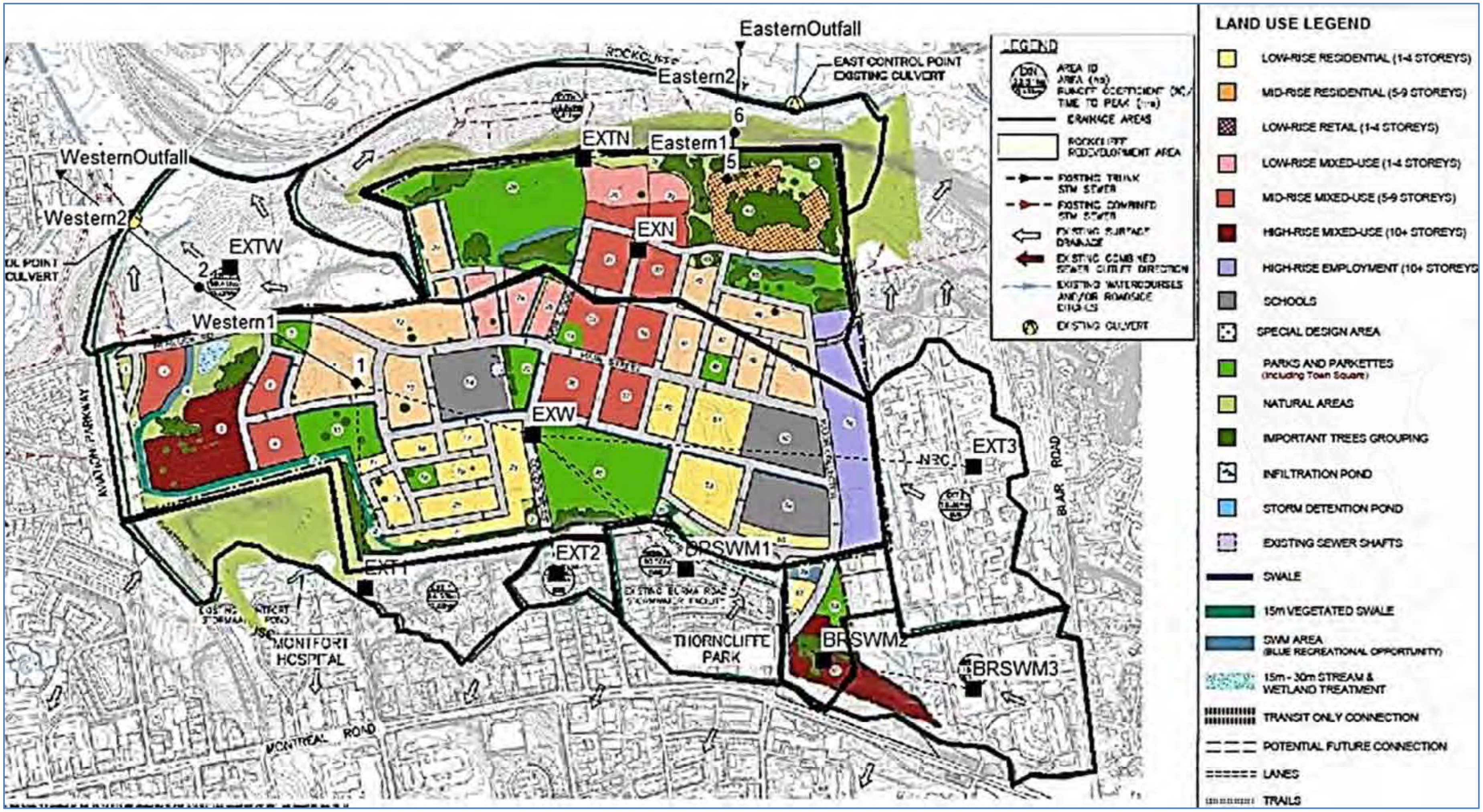


Figure 52 - Post-Development Land Use within the Delineated Subcatchments

Table 28 - Subcatchment Characteristics under Post-Development Conditions

Subwatershed	Subcatchment	To be Developed (Yes/No)	Area (ha)	Imperviousness	Depression Storage in mm (Pervious)	Depression Storage in mm (Impervious)
Western Creek Subwatershed	EXW	Yes	85.75	49.8	3	0.06
	EXTW	No	18.41	10	5	1
	EXT3	No	18.39	20	3	1
	EXT2	No	2.95	50	3	1
	EXT1	No	14.38	20	3	1
	BRSWM3	Partially	15.98	54	3	0.06
	BRSWM2	Yes	6.1	74	3	0.06
	BRSWM1	No	10.56	50	3	1
Eastern Creek Subwatershed	EXN	Yes	36.34	35.4	5	0.06
	EXTN	No	23.82	10	5	1

Model Scenarios

The following section describes each of the five (5) scenarios.

Scenario 1 – Post Development No LID Control

This scenario represents the post-development conditions for the total area assuming no LID lot-level or conveyance controls. Scenario 1 is considered the baseline conditions and represents the effect of developing the Former CFB Rockcliffe using only conventional SWM infrastructure and techniques. Note: SWM ponds and or pipes are not included in this assessment, but are include in the MSS (IBI, February 2015).

Scenario 2 – Post Development with LID Control

This scenario includes the application of LID lot-level control measures and LID conveyance control measures over the proposed land use in order to mitigate any increase in surface runoff volume and/or decrease in infiltration volume.

The infiltration assumptions for the LID measures followed the Green-Ampt model as follows:

- Existing soils were modeled based primarily on the results of the field saturated hydraulic conductivity (Kfs) as determined through the in-situ infiltration testing described in Section 3.2, with consideration for previously completed hydraulic conductivity testing and geotechnical reports by DST and previously published values. A sensitivity analysis was performed and the average saturated hydraulic conductivity of 9.5 mm/hr for Western Creek subwatershed, and 5.2 mm/hr for Eastern Creek subwatershed was developed. Table 29 summarizes the infiltration parameters used in the all analyses.

Table 29: Infiltration Parameters for the Soils Encountered in the Study Area

Subwatershed	Suction Head (mm)	Conductivity (mm/hr)	Initial Deficit (fraction)
Western Creek Subwatershed	133.9	9.5	0.180
Eastern Creek Subwatershed	188.6	5.2	0.159

- Engineered soil media (i.e. bioretention media) for the conveyance control measures were modeled as Sandy Loam, with the following characteristics as detailed in Table 30.

Table 30 - LID Engineered Soil Characteristics (Green-Ampt Model)

LID Soil	Suction Head (mm)	Conductivity (mm/hr)	Initial Deficit (fraction)
Sandy Loam	110.1	21.8	0.246

Scenario 3 –Existing conditions LID Pilot (baseline conditions for LID Pilot)

In order to evaluate baseline conditions for the LID Pilot (Phase 1A), existing conditions conditions were studied and key characteristics were quantified for the Western Creek subwatershed as follows:

- Area (ha): 11.6
- Weighted Imperviousness (%): 20
- Hydraulic conductivity of 9.5mm/hr.

Scenario 4 - Post-development LID Pilot No Control

Post-development conditions were studied and key characteristics for the Western Creek subwatershed as follows:

- Area (ha): 11.6
- Weighted Imperviousness (%): 39
- Hydraulic conductivity of 9.5mm/hr.

With the imperviousness value almost doubling under post-development conditions, the hydrology of the LID Pilot area is expected to change. More specifically, and increase in surface runoff and a decrease in infiltration are predicted.

Scenario 5- Post-development Pilot LID Control

Similar to the post-development LID control scenario for the total developed area, this scenario includes the application of LID lot-level control measures and LID conveyance control measures for Phase 1A with related assumptions.

Model Results

The following section describes the post-development predictive water budget model results for:

1. The Total Development Area (Phases 1A-3)
2. The LID Pilot/ Demonstration Area (Phase 1A)

Water Budget- Total Development Area

The results of three (3) modeling scenarios are summarized below:

- Existing conditions (Total Area) – completed as part of the existing conditions assessment (see Section 3.5.2).
- Scenario 1 - Post-development no LID control, and
- Scenario 2 - Post-development with LID control

The results show that with the increase in imperviousness, surface runoff volume (mm) is expected to increase and infiltration volume (mm) is expected to decrease (Table 31) for the total area in the post development condition when LID controls are not implemented as compared to the existing conditions.

Following the implementation of LID lot-level control measures and LID conveyance control measures, surface runoff and infiltration (mm) are predicted to be restored to existing conditions values (or improved). Changes in surface runoff and infiltration volumes (mm) are demonstrated in Figure 53.

Table 31 - Water Budget over Total Area

Scenario	Total Precipitation (mm)	ET (mm)	Surface Runoff (mm)	Infiltration (mm)
Baseline - Existing conditions (total area) - See Section 3.2	887	532	120	235
1 - Post Development no control (total area)	887	532	250	105
2 - Post Development LID Lot-level and Conveyance Control (total area)	887	532	113 (< 120)	242 (> 235)

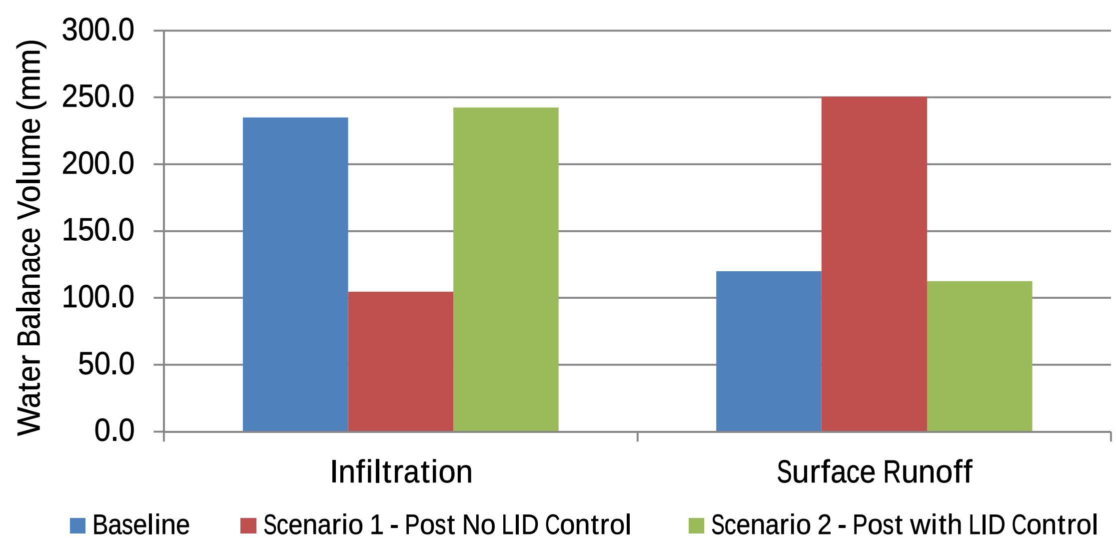


Figure 53 - Water Budget Volumes within the Proposed Development under Different Scenarios

Water Budget- LID Pilot Area

The results of three (3) modeling scenarios for the LID Pilot area (Phase 1A) are summarized below:

- Scenario 3 – Existing conditions LID Pilot (baseline conditions for LID Pilot)
- Scenario 4 – Post-development LID Pilot No Control
- Scenario 5 - Post-development LID Control

The results show that with the increase in imperviousness, surface runoff volume (mm) is expected to increase and infiltration volume (mm) is expected to decrease (Table 32) for the Pilot area (Phase 1A) in the post development condition when LID controls are not implemented as compared to the existing conditions.

Following the implementation of LID lot-level control measures and LID conveyance control measures, surface runoff and infiltration (mm) are predicted to be restored to existing conditions values (or improved). Changes in surface runoff and infiltration volumes (mm) are demonstrated in Figure 54.

Table 32 - Water Budget over LID Pilot Area (Phase 1A)

Scenario	Total Precipitation (mm)	ET (mm)	Surface Runoff (mm)	Infiltration (mm)
3- Existing conditions LID Pilot (Phase 1A)	887	532	161	194
4- Post Development LID Pilot no control	887	532	303	52
5- Post Development LID Pilot Lot-level + Conveyance	887	532	106 (< 161)	249 (> 194)

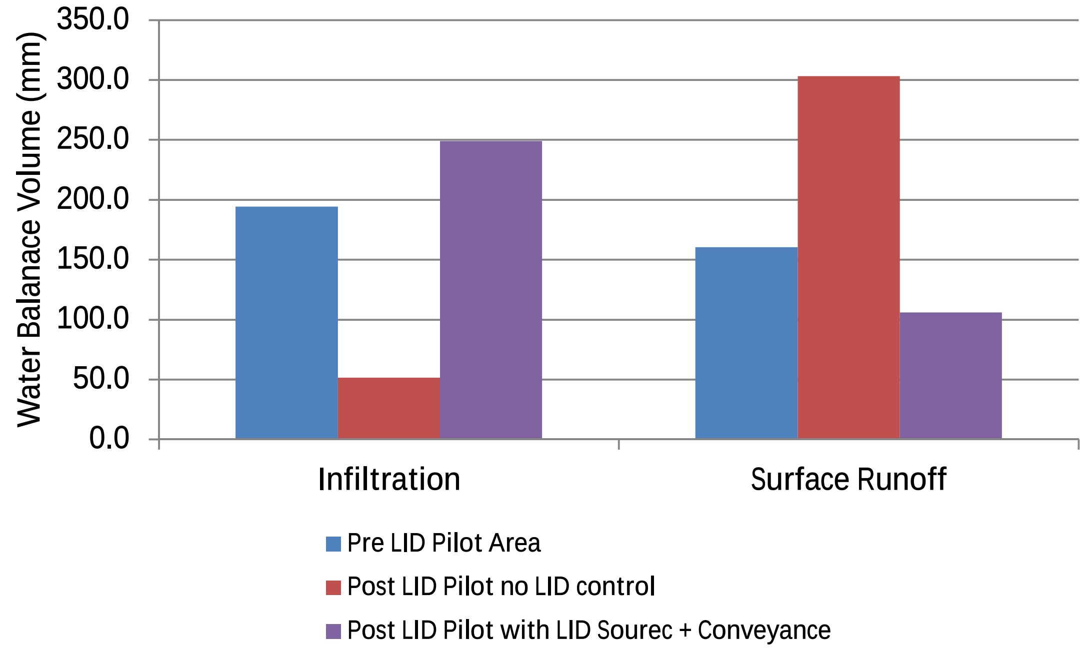


Figure 54 - Water Budget Volumes within the LID Pilot Area (Phase 1A) under Different Scenarios

It should be noted that in regards to the aforementioned modelling assumptions, per Table 26, overall targets for the LID measures in Phase 1A will not be met specifically 56% vs. 60% for lot level controls and 4% vs. 30% for conveyance level controls. However, as illustrated in Table 32 and Figure 54, the existing surface runoff and infiltration targets will be exceeded for Phase 1A.

In this regard, in is recommended that a comprehensive water balance model which includes piped systems and end-of-pipe ponds be developed to track how overall targets are being achieved (or not and or include in later phases), evaluate, assess and refine modelling assumptions.

Water Budget- 100yr Event

Using the hydrologic model, surface runoff and infiltration volumes were modeled under the 100-year storm event (3 hour Chicago per the Ottawa Sewer Design Guidelines, 2012) in order to roughly estimate the potential benefit of the LID control under extreme conditions. Note: conservative assumptions were chosen for infiltration potential and storage capacity of LIDs. Tables 33 and 34 show the results for the three (3) following scenarios in regards to the Total Area and the LID Pilot Area (Phase 1A) respectively:

1. Existing conditions
2. Post-development with no control
3. Post-development with LID

It is observed that using LID measures will not be able to restore water budget to existing conditions. However, there will be some improvement in terms of decreasing surface runoff and increasing infiltration volumes during extreme events. More detailed modelling which integrates the LID scenarios with the conventional SWM pipes and ponds modelling completed as part of the MSS (IBI, February 2015) will be required to refine these preliminary estimates. In this regard a calibrated model is recommended. This is discussed in additional detail in Section 5.15.

Table 33 - Surface Runoff Depth (mm) and Volumes (m³) over the Total Developed Area

Water Budget Component (mm)	100-year (71.7 mm) over Total Area Volume in mm			100-year (71.7 mm) over Total Area Volume in m^3		
	Existing conditions	Post-development no control	Post-development with LID	Existing conditions	Post-development no control	Post-development with LID
Infiltration	37.4	29.5	31.5	45628	35990	38430
Surface Runoff	34.3	42.2	40.2	41846	51484	49044
Change in Runoff from Existing conditions	n/a	+7.9mm (+ 21%)	+5.9mm (+17%)	n/a	9638 m^3 (23%)	2440 m^3 (17%)
Change in Runoff from Conventional SWM (No LID Controls)	n/a	n/a	- 2mm (- 5%)	n/a	n/a	- 2440 m^3 (- 5%)

Table 34 - Surface Runoff Depth (mm) and Volumes (m³) over the LID Pilot Area (Phase 1A)

Water Budget Component (mm)	100-year (71.7 mm) Pilot Area Volume in mm			100-year (71.7 mm) over Pilot Area Volume in m^3		
	Existing conditions	Post-development no control	Post-development with LID	Existing conditions	Post-development no control	Post-development with LID
Infiltration	39.7	29.4	34.1	4605.2	3410.4	3955.6
Surface Runoff	32	42.3	37.6	3712	4906.8	4361.6
Change in Runoff from Existing conditions	n/a	+10.3mm (+ 32%)	+5.6mm (+18%)	n/a	+ 1194 m^3 (+ 32%)	+ 649 m^3 (+ 18%)
Change in Runoff from Conventional SWM (No LID Controls)	n/a	n/a	- 4.7mm (- 11%)	n/a	n/a	- 545 m^3 (- 11%)

LID Design Targets

Using the EPA SWMMM hydrologic model developed as part of the predevelopment water balance assessment and the five (5) scenarios detailed above, LID design targets were developed for water balance (infiltration), water quality, and erosion controls. Note: flood control requirements are detailed within the parallel MMS study prepared by IBI (February, 2015).

It should be acknowledged that the LID design targets provided in this document are minimum targets only and as such it is anticipated that practitioners applying and implementing the proposed LID lot-level and conveyance controls will do so in full recognition of the goals and objectives of the LID Pilot/ Demonstration project being undertaken by the City of Ottawa and the CLC which form the foundation of the treatment train approach (LID lot-level and conveyance controls) proposed for the Former CFB Rockcliffe. It is further anticipated that both parties will strive for a "best achievable" implementation strategy on a lot level basis based on local soils and other relevant site characteristics to better protect the local environment-features and function. It is only with greater adoption and implementation of LID controls - that transcend stormwater management into areas of energy efficiency, water conservation and re-use, green space maximization, tree conservation and better site design - that the additional environmental and economic benefits of LID as part of a multi-use development can be fully realized.

Water Quality Targets

Per the MSS (IBI, February 2015), the proposed SWM facilities servicing the Former CFB Rockcliffe site will provide an Enhanced Level of Protection, which corresponds to 80% TSS removal as per the Stormwater Management Planning and Design Manual (Ontario Ministry of the Environment, March 2003).

Per the MOE guide "any stormwater management practice that can be demonstrated to approval agencies to meet the required long-term suspended solids removal for the selected levels under the conditions of the site is acceptable for water quality objectives." All proposed LID controls shall demonstrate the ability to reduce the average long term annual load of suspended sediment by 80% or better.

The Ministry of the Environment 2003 Stormwater Management Planning and Design (SWMPD) Manual contains guidance for stormwater management facilities that employ infiltration including lot level and conveyance controls. More specifically and in relation to the soils within the Former CFB Rockcliffe, the 2003 SWMPD manual Section 4.2 and Table 4.1 provides guidance that relates to "physical constraints which could limit the use of lot level, conveyance…", but does not in any way indicate that area soil with lower relative infiltration rates be excluded from infiltration practices. The infiltration rate of soils will have an obvious effect on the drawdown-time of the facility between events and therefore should be sized accordingly based on design guidance from sources such as the Low Impact Development Stormwater Management Planning and Design Guide Version 1.0 (TRCA/CVC - 2010) or others. As such, soil infiltration capacity guidance in the SWMPD manual should not be interpreted as a prohibition but as a caution that controls relying primarily on infiltration may not be as effective as they could be on soils with higher relative rate of infiltration.

It should be noted, that a compendium document the 2003 MOE SWMPD is being prepared by the MOECC and is anticipated to provide volume based criteria relating to LID controls. This document when finalized may supersede the 2003 SWMPD.

Furthermore, LID controls can utilize multiple mechanisms (beyond simply infiltration) such as, but not limited to; Filtration, Retention, Evaporation and/or Transpiration. If sized such that they empty between events and will not be perceived as a nuisance, should not exclude the implementation of such measures to realize water quality objectives.

Provided that the proposed LID techniques incorporate the appropriate runoff storage volumes, empty within inter-event periods and are otherwise appropriately sited, designed, monitored and maintained (similar to all other stormwater management facilities), there should be no impediment to the application of infiltration technologies, in the soils of the Former CFB Rockcliffe, for the realization of water quality.

The minimum water quality event for LID lot-level and conveyance controls for the Former CFB Rockcliffe shall be the 15mm event. The selection of the minimum water quality event of 15mm event is based on the anticipated functionality of local soils as well as understanding that Phase 1A and others will likely have some form of redundant SWM control (i.e. end-of-pipe ponds). As such, LID controls that are sized to treat the minimum 15mm water quality event shall be require to discharge to another LID in the treatment train and or an end-of-pipe pond to achieve the full enhanced level of control per the MOE SWMPD.

To achieve the enhanced level of control, per the MSS, the target water quality event for LID lot-level and conveyance controls shall be the treatment of the 25mm event. Infiltration targets for LID lot-level and conveyance controls for the Former CFB Rockcliffe are presented in Table 35.

The water quality target is not to be confused with the water balance (infiltration). To achieve the water quality targets (15mm minimum or 25mm enhanced) the LIDs must be sized to treat the respective event from the impervious area which is directly contributing to the LID control. The 'treatment' of the event can be accomplished through a combination of filtration, storage and release, evaporation and infiltration. Note: the water quality target shall include the required water balance (infiltration) targets.

Infiltration Targets

There is a growing body of evidence which suggests that 'traditional' end-of-pipe stormwater management techniques alone are not achieving the level of watershed management we now realize is necessary to protect hydrologic function. As such, considerable effort has been placed on the characterization of the pre and post development water budgets as part of the hydrologic analysis performed as part of this LID Scoping Study and the development of LID infiltration targets.

The intent of characterizing the pre and post development water budgets is to provide planners, designers and other practitioners with catchment based existing conditions water balances from which to plan and design LID lot-level and conveyance controls with the goal of re-establishing/matching existing conditions infiltration after development has occurred. Maintaining existing conditions infiltration is key to maintaining existing environmental features and processes within the study area.

The infiltration targets for the Former CFB Rockcliffe shall be 4mm applied over the full catchment area to generate the required infiltration volume. The infiltration targets as presented in (Table 35) are similar to those prescribed by other jurisdictions including the City of Toronto, CVC and TRCA (3-5mm).

Erosion Targets

Integrated into the definition of erosion control targets for the Former CFB Rockcliffe site and its respective watercourses is the understanding of how hydro-modification affects the elements of natural channel form that can lead to watercourse destabilization and destruction of aquatic habitat. Hydro-modification is defined as changes in hydrology due to land use changes and specifically increased imperviousness with urbanization. Watercourse erosion is cause by hydro-modification, which contains three key concepts:

1. Magnitude or peak flow rate;
2. Duration of flow measured in hours or days and is linked to the runoff volume; and
3. Frequency (i.e. number) of rainfall events which cause runoff.

Magnitude

Excessive erosion occurs post-development, even with the inclusion of 'traditional' erosion controls because peak flow management often results in flows that are in excess of the watercourse erosion thresholds for prolonged periods of time when compared to existing conditions.

Duration of flow

Natural features, such as the existing low-lying areas and existing woodlots/ vegetative communities found within the Former CFB Rockcliffe site function to attenuate runoff and reduce runoff volumes. Runoff which is naturally directed to these features under existing conditions, function to reduce erosion within local watercourses. The preservation of the existing flow pathways is critical to reduction of flow duration that the Eastern Creek, Western Creek and Northeastern Escarpment Tributary experience. LID controls which utilize infiltration ensure the existing shallow groundwater pathways currently discharging to these features are maintained within the shallow groundwater system.

To further mitigate the geomorphic impacts that result from development including increases in imperviousness, LID practices utilize multiple mechanisms such as infiltration, filtration, retention, evaporation and/or transpiration to reduce runoff volumes and to more closely return the post-development water budget to existing conditions levels. It is however, the water budget that ultimately determines watercourse flow and the flow which dictates the channel form.

Frequency

When dealing with watercourse erosion, the frequency of runoff events is important. It is during these frequent runoff events and corresponding watercourse flows (effective discharge) that the majority of the annual sediment load is conveyed. LID controls are inherently designed to manage the smaller, more frequent rainfall events and as such are highly effective at reducing runoff frequency, thereby reducing watercourse erosion.

Therefore, by better matching the existing conditions water budget the effects of hydro-modification (magnitude, duration and frequency) can be diminished. The use of LID lot-level and LID conveyance controls are essential in order to maintain the existing conditions water budget. As such the infiltration targets shall be considered the erosion control targets for LID controls. The erosion targets are presented in (Table 35).

Table 35 – LID Design Targets for Former CFB Rockcliffe

<table>
<tr><th rowspan="2">Applicable Area</th><th colspan="3">LID Design Targets</th></tr>
<tr><th>Infiltration*</th><th>Erosion*</th><th>Water Quality†</th></tr>
<tr><td>LID Pilot Area (Phase 1A)</td><td rowspan="2"><u>LID Infiltration target = 4mm</u>

Maintain groundwater recharge per the existing conditions water budget. Groundwater recharge includes hydrological connection and linkages to wetlands, woodlots, streams and other natural features

LID lot-level and conveyance controls shall infiltrate an equivalent volume a 4mm event applied to the full catchment area.</td><td rowspan="2"><u>LID Erosion Control Target = 4mm</u>

LID lot-level and conveyance controls shall match the existing conditions water balance through the application of the infiltration targets in order to reduce or eliminate the effects of hydro-modification (magnitude, duration and frequency) form the contributing drainage area.

As such the infiltration targets shall be considered the erosion control targets for LID controls.</td><td rowspan="2"><u>Min. Target = 15mm</u>
The minimum water quality event for LID lot-level and conveyance controls for the Former CFB Rockcliffe shall be the 15mm event. LID controls shall treat the runoff from a 15mm event through filtration, detention, evapotranspiration, detention and release and infiltration. Drainage areas which achieve the minimum 15mm water quality target shall be require to discharge to another LID in the treatment train and or an end-of-pipe pond to achieve the full enhanced level of control per the MOE SWMPD.

<u>Enhanced Target = 25mm</u>
To achieve the enhanced level of control, per the MSS, the target water quality event for LID lot-level and conveyance controls shall be the 25mm event. LID controls shall treat the runoff from a 25mm event through filtration, detention, evapotranspiration, detention and release and infiltration. Drainage areas which achieve the enhanced water quality target do not require treatment in an end-of-pipe facility.</td></tr>
<tr><td>Total Development Area (Phase 1A-3)</td></tr>
</table>

* Catchment Based Target – target applied over the full catchment area.

† Contributing Impervious Area Target – applied to the directly contributing impervious area to the LID control and should focus on the "treatment' of the required event through a combination of filtration, storage and release, evaporation and infiltration. Note: the water quality target shall include the required water balance (infiltration) targets i.e. water quality treatment = 15mm water quality event – 4mm infiltration/ erosion target.

5.15 SCALED CONVENTIONAL SWM INFRASTRUCTURE CONSTRUCTION

To coincide with the phased approach of the LID Pilot/ Demonstration Project and the anticipated performance monitoring which will evaluate the effectiveness of the alternative LID stormwater management systems, it is proposed that the construction of the Eastern and Western SWM Ponds be scaled to service the lands within the respective developments phases (1A- 3).

It is acknowledged that all stormwater piping and pond infrastructure required to service Phase 1A will be constructed in addition to the proposed LID controls as part of the LID Demonstration Project.

The scaled construction will ensure that:

- The benefits and potential associated credits for water quality, water quantity and erosion control can be realized during subsequent development and servicing phases
- Infrastructure redundancy is limited to the greatest extent possible
- End-of-pipe ponds function optimally for all phases of development. LID controls have been shown to reduce stormwater peak flows and volumes, which can:
    - Affect the ability of a pond to adequately flush the permeant pool creating algae blooms and degraded water quality.
    - Impact submergent and emergent vegetation communities
    - Create unacceptable mosquito breeding conditions

Changes to the MSS

The MSS (IBI, 2015) develops a servicing strategy for the preferred concept plan developed in the CDP. The servicing strategy has built flexibility into the design of the municipal services to allow for changes in land use to be accommodated as build out occurs in several phases over several years. The configuration of the trunk watermains, trunk sanitary sewers and trunk storm sewers has also been arranged to build flexibility into the potential phasing options to accommodate changing market demands for building product type and quantity required to build out. In recognition of the probability that the preferred concept plan may not be entirely built out as currently planned due to unforeseen circumstances or as a result of modifications to proposed stormwater management plan based on the outcomes of the LID Pilot/ Demonstration Project, the MSS identifies the following process to deal with changes which occur after approval of the Environmental Assessment, but prior to construction.

The change process distinguishes between minor and major changes. A major design change would require completion of an amendment to this EA, while a minor change would not. For either kind of change, it is the responsibility of the proponent to ensure that all possible concerns of the public and affected agencies are addressed.

Minor Changes

Minor design changes may be defined as those which do not appreciably change the expected net impacts associated with the project. For example, a design change in a utility location within a road right-of-way or the size of a pipe would be considered minor. Changes in utility alignment between road allowances, which do not affect other landowners, would also be considered as minor. All appropriate stakeholders will be provided details of the modification. The majority of such changes could likely be dealt with during the detailed design phase and would remain the responsibility of the proponent to ensure that all relevant issues are taken into account.

Major Changes

Major changes may be defined as those which change the intent of the EA or appreciably change the expected net impacts associated with the project. An example of a major change would result from a proposed shift in a preferred design alignment or configuration which would warrant changes in mitigation as described in the EA and affect other landowners.

LID Pilot/ Demonstration Project & Changes to the MSS

Based on the above definitions, it is anticipated that changes to the storm sewer system, dry ponds and the implementation of lot-level and conveyance controls would be considered minor changes. Significant changes to end-of-pipe ponds may be considered major changes.

Comprehensive Model Development

As discussed previously, it is recommended that a consolidated model be developed for the Former CFB Rockcliffe development using a single modelling platform which combines the water balance model (EPA SWMM) developed by Aquafor Beech to assess LIDs and the infrastructure model (SWMHYMO) developed by IBI to assess the subsurface piped infrastructure and end-of-pipe ponds.

It is recommended that EPA SWMM or an equivalent comprehensive deterministic watershed distributed model platform be used which has the following capabilities:

- Water quantity and quality modeling
- Detailed data input capabilities
- Event-based and continuous hydrologic model
- Spatially and time varying rainfall
- Evaporation of standing surface water
- Snow accumulation and melting
- Interception from depression storage
- Infiltration using various infiltration models
- Percolation into shallow groundwater
- Interflow between groundwater & surface water
- Nonlinear reservoir routing of overland flow
- Pollutant buildup over different land uses, pollutant washoff during runoff events and reduction in washoff using LID measures
- Has LID modelling capabilities (unit commands or simulation routines) for water quantity and quality simulation

The consolidated model should be updated based on finalized catchment areas, discretized for the development phasing where possible, developed to represent the as-constructed LIDs and conventional SWM facilities (subsurface piped infrastructure and end-of-pipe ponds), refined/ calibrated based on monitoring data and used to predict the anticipated performance of future phases.

The consolidated model should be prepared such that:

- Subcatchment discretization coincides with development phasing.
- A single SWMM engine is used for all future modeling efforts.
- Any missing catchment areas are addressed.
- The routing method used for the comprehensive model should

account for backwater effects, entrance/exit losses, flow reversal, or pressurized flow, etc.). The routing method shall be confirmed with SWM Working Group.

- A common post development catchments nomenclature is selected and vetted by the SWM Working Group.
- Full documentation of the basis for hydrologic parameters selected (e.g., depression storage, etc.).
- Provision of a detailed description of the various model scenarios, such that each scenario can be easily linked to the specific modeling files/runs.
- The results of any future sensitivity analysis of parameters that informs final values used in the modeling be documented.
- Adjustments to parameters via calibration efforts (e.g., length) are to be documented, i.e., documentation of original (unadjusted) values compared to calibrated values.
- Spilling (or flooding) in the model does not occur for all events.

The consolidated model would also serve to track how overall targets are being achieved (or not and or include in later phases), evaluate, assess and refine modelling assumptions.

Canada Lands Company has submitted and is seeking approval of a Draft Plan of Subdivision for the entire Former CFB Rockcliffe site. Since registration of blocks and construction of public infrastructure is to occur on a phased basis, CLC is working with the City to link certain Draft Plan of Subdivision approval conditions to phases when clearance of those conditions will be required. Phases 1A and 1B will be developed and constructed with a conventional SWM system per the MSS. LIDs will be implemented in phased pilot projects per the LID Scoping Document. No SWM credits or deviations from the MSS will be requested from the City of Ottawa prior to Phase 2 registration. This timing will permit the collection of LID performance monitoring data during Phases 1A and 1B, including any Phase 2 SWM and LID infrastructure that may be constructed in advance of Phase 2 registration. It is recommended that the consolidated model be developed, based in part upon the Phase 1A and 1B monitoring data, in consultation with the SWM Working Group prior to or in conjunction with Phase 2 Registration."

5.16 LID DESIGN GUIDEANCE

The following section provides additional guidance with respect to available resources for LID lot-level and LID conveyance control design as well as geotechnical assessment and site specific in-situ infiltration testing requirements.

Available Resources

The following resources are available for the purposes of designing LID lot-level and LID conveyance controls, they include:

- MOE 2003 Stormwater Planning and Design Guide (SWMPD)
- TRCA/CVC LID Planning and Design Guide (2010) or most current
- Permeable Interlocking Concrete Pavements guide (ICPI, 3rd Edition)
- The North American Permeable Interlocking Concrete Pavement Standard (ASCE, Pending).
- TRCA/ CVC LID Landscape Design Guide
- CVC LID Construction Guide
- MOE - Showcasing Water Innovation (SWI) - five (5) Retrofit Guides focusing on the implementation of LID and GI within individual land uses. Although the following guides are retrofit based, considerable guidance on design requirements, construction, construction verification and inspection is included. The relevant guides include:

1. Grey to Green Road Retrofits: Optimizing your Infrastructure Assets Through Low Impact Development (September 2013)
2. Grey to Green Business and Multi-Residential Retrofits: Optimizing your Bottom-line Through Low Impact Development (October 2013)
3. Grey to Green Grey to Green Public Lands Retrofits: Optimizing Parks, Public Buildings, Schools and Places of Worship through Low Impact Development (November 2013)

Geotechnical Assessments

A soils report will be required to accompany the design of all infiltration facilities to ensure adequate soil permeability and depth to the seasonally high water table. This report should include

- Borehole information, including soil stratigraphy, composition, grain-size and chemical analysis (additional testing may be required for individual LID techniques per the requirement of the Low Impact Development Stormwater Management Planning and Design Guide, Version 1.0 (TRCA/CVC - 2010); number of boreholes can range from 2 to greater than 20 based on size of facility and site specific conditions. Boreholes should be extended a minimum of 1.5m below the proposed invert of the proposed LID facility. Geotechnical assessment will generally include:
    - particle size distribution (ASTM D422 and D2217),
    - Stratigraphy,

- Piezometer(s) and Standpipes –to determine seasonally high (March – April or Late fall before snowfall) groundwater elevation information per O.Reg 389/09 natural moisture content (ASTM D2216),
- plasticity characteristics (ASTM D4318),
- soil strength assessment (CBR and Soaked CBR) for permeable pavement designs.

The scope of the geotechnical assessment shall be determined based on the need to confirm that the following conditions are not present. The following conditions are considered unsuitable or may increase facility failure rate for infiltration based controls.

1. Slopes ≥20% and contributing catchment area slopes ≥15%;
2. Seasonally-high water table elevations that are within 1.0 - 0.60 metre of the bottom of proposed infiltration based facilities including Infiltrating Dry Ponds
3. Bedrock within 1 metre of the bottom of the proposed infiltration facility;
4. Wetlands and associated hydric soils;
5. Proposed Land uses that are classified as potential "hot spots";
6. Drinking water wells within 30 metres; and
7. Karst topography.

It is not anticipated that conditions 1, 6 or 7 above will be of concern for the Former CFB Rockcliffe site.

Site Specific In-situ Infiltration Testing

For design purposes, the preferred approach to measure field saturated hydraulic conductivity (Kfs) at a subject site include:

- Guelph Permeameter
- Double Ring Infiltrometers (constant head)
- Single ring (constant head pressure)

It is likely that at least one (1) test will be required at 2 soil depths for each 450 square metres footprint surface area at each location. Note: Infiltration rates derived from borehole analysis, T-test, slug or other generalizes test shall not be accepted for design purposes;

In-situ Infiltration Testing Guidance
All infiltration testing should be completed per Appendix C of the TRCA/CVC LID Planning and Design Guide (2010).

It is important to note that variations in the soil profile will result in variations in the infiltration rates. In order to arrive at a representative design infiltration rate, it is necessary to compensate for differences in infiltration across the soil profile extending to a depth beneath the infiltration facility.

Once several profiles have been determined, a preferred approach is then to adjust the infiltration rate by a correction factor to obtain an overall infiltration rate.

Recommended correction factors are listed in Table 36 per Appendix C of the TRCA/CVC LID Stormwater Planning and Design Guide (2010). The measured infiltration rate is divided by the correction factor to derive an adjusted rate.

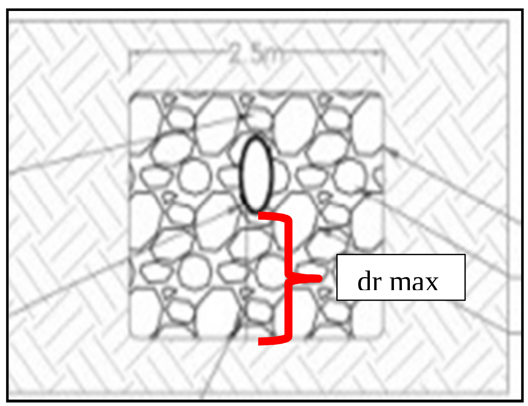
Table 36: Correction Factor Divided into Measured Kfs Rates in Layered Soils

Ratio of design Infiltration Rates (K_{fs})	Correction Factor
≥1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
>16	8.5

For example, suppose a measurement with a permeameter shows the field saturated hydraulic conductivity Kfs at the base of a proposed infiltration facility is 8.3 x 10-4 cm/sec (30 mm/hour). The least permeable soil encountered in a test pit was a fine sand (Kfs = 12.7 mm/hour). The ratio between the two (30/12.7) = 2.4. The correction factor (Table 36) is 3.5 and the design infiltration rate Kfs is 30/3.5 = 8.6 mm/hour.

Partial Infiltration Designs

Based on the in-situ soil testing as detailed in Section 3.5.2, it is anticipated that the soils tested at the Former CFB Rockcliffe will have a field saturated hydraulic conductivity below 15mm/hr and therefore will require the installation of a underdrain per the TRCA/CVC LID Stormwater Planning and Design Guide (2010). As such it the LID infiltration based lot-level and conveyance controls shall be designed as partial infiltration systems, where the volume to be infiltrated shall be the volume stored below the underdrain pipe.



The location of the pipe within the LID profile shall be governed by the following equation per the TRCA/CVC LID Stormwater Planning and Design Guide (2010).

$$dr\ max = i * ts / Vr$$

Where:

dr max = Maximum stone reservoir depth (mm)
i = Infiltration rate for native soils (mm/hr)
Vr = Void space ratio for aggregate used (typically 0.4 for 20 mm clear stone)
ts = Time to drain (design for 48 hour time to drain is recommended)

5.17 APPROVALS

As part of all approvals, continued consultation and ultimate approval from affected City departments (Public Works, Infrastructure Services, utilities, etc.) will be required as the development process proceeds.

Enhanced protection as defined in the 2003 Stormwater Management Planning & Design shall reduce the average long term annual load of suspended sediment by 80% or better. Per the MOE 2003 Manual any stormwater management practice that can be demonstrated to approval agencies to meet the required long-term suspended solids removal for the selected levels under the conditions of the site is acceptable for water quality objectives.

ECA Policy Overview

Pursuant to the Ontario Water Resources Act (OWRA) O.Reg 525/98, all water quality controls must receive an ECA. Per O.Reg 525/98), subsection 53(1) and (3) ROWs are not exempt from requiring and ECA (formerly CofA) as one or all of the noted exemption requirements listed below will be contravened.

O. Reg. 525/98 – Approval Exemption, last amendment O.Reg. 396/0, Section 3, Subsection 53(1) and (3) of the Act do not apply to the establishment, alteration, extension or replacement of or a change in a stormwater management facility that,

a) Is designed to service one lot or parcel of land;
b) Discharges into a storm sewer that is not a combined sewer;
c) Does not service industrial land or a structure located on industrial land; and
d) Is not located on industrial land O. Reg 525/98, s. 3.

Approvals for LID on Private Property

Per Ontario Water Resources Act (OWRA) O.Reg 525/98, it is not anticipated that an ECA will be required for private residential property LID installations such as Soakaway pits or soil amendments as part of the LID Pilot Project Phase 1A (due to everything draining to the end-of-pipe SWM facilities and that SWM control system was designed assuming no LIDs in place) as all facilities will:

- Service one lot and
- Will discharge a storm sewer that is not a combined sewer

In addition, as Phase 1A will ultimately discharge to a water quality facility, the LIDs will not be the primary water quality or quantity control.

In subsequent phases in which the LID lot-level and conveyance controls are to be a component of the overall water quality strategy, an ECA will be required.

The requirements relating to acquisition of an ECA for private property should be confirmed through the MOECC ECA pre-consultation process for all development phases, including Phase 1A.

Approvals for LID on Public Property

Per Ontario Water Resources Act (OWRA) O.Reg 525/98, an ECA requirement will be required for LID controls servicing municipal property including LID within park lands and within the municipal ROW with the exception of Phase 1A due to the redundant SWM controls in the form on end-of-pipe ponds.

The requirements relating to acquisition of an ECA LID controls servicing municipal property including LID within park lands and within the municipal ROW should be confirmed through the MOECC ECA pre-consultation process for all development phases, including Phase 1A.

LID Monitoring and Enforcement

As part of the standard ECA process, monitoring, inspection and reporting to the MOE local office can be anticipated. By working with the local OMOE enforcement officer, the City through the MOECC will have the ability to inspect and request the aforementioned documentation, as well enforcement abilities. See Section 5.22 for additional recommendations regarding maintenance and enforcement of LIDs on private property.

5.18 ASSUMPTION PROTOCOLS & MONITORING

The following section provides a discussion regarding assumption protocols and monitoring approach for LIDs. Topics include:

- a general summary of potential assumption protocols and monitoring approaches based on the Stormwater Management Certification Protocols for Low Impact Development (CVC, Draft 2012)
- Specific protocols and monitoring requirements for:
    - Soil amendment
    - Soakaways
    - Bioswales, specifically bio-medias
- Overall System monitoring requirements & During Construction monitoring requirements.

The following provides potential approaches for assumption protocols for consideration by City of Ottawa staff in regards to the proposed LID Pilot/ Demonstration project, future phases of the Former CFB Rockcliffe (Phase 1A -3) and even future LID projects within the City of Ottawa.

Note: All detailed/final monitoring plan for each phase, including Phase 1A, will be reviewed and approved by the City of Ottawa prior to proceeding.

General Summary of Potential Assumption Protocols and Monitoring Approaches

Following a post-construction period of BMP stabilization and vegetation establishment, the site developer may be required to complete a Certificate of Completion that verifies BMP specifications and performance for approval prior to property transfer.

The Stormwater Management Certification Protocols for Low Impact Development (CVC, Draft 2012) document details five (5) levels of SWM Certification Protocols (simple to complex) that can be used to verify a variety of infiltration and filtration practice designs and performance. The certification protocol takes place as a 3rd step, following 1) Design and Plan Review and 2) Construction Inspection & Maintenance (up to assumption by the municipality).

Certification protocols ensure that knowledgeable personnel (e.g. inspector, design engineer, or permitting agency) evaluate whether the LID practices have been installed properly before the contractor is released of responsibility.

The certification process is the last opportunity to identify issues due to improper construction and/or unforeseen site condition issues. These issues can then be addressed before the owner takes over maintenance responsibilities.

- Formally transition from construction and establishment to functioning practice prior to assumption by land owner
- Confirming practice performance for regulatory requirements

Principles for LID Certification

When developing a municipal LID BMP certification program, the following principles should be considered:

1. Constructed to Specifications
Municipalities (and property owners) will need to verify that stormwater BMPs are installed properly, meet or exceed the design standards, and is functioning hydrologically as designed prior to assumption.

2. Public Safety
While it may be impractical or impossible to eliminate all safety risks associated with stormwater management practices, most risk can be mitigated through proper design. Typical public safety inspection tasks for LID include checking ponding depths and drawdown times, eliminating trip hazards and ensuring that vegetation doesn't obscure important sight lines.

3. Pre-treatment Practices
Filtration/infiltration BMPs generally include some level of pre-treatment to prevent clogging of filtration beds. Typical pre-treatment measures include the use of perennial grass buffers and vegetated swales, hydrodynamic separators, sedimentation and the use catch basins with enhanced sedimentation. Issues related to pre-treatment practices should be noted for maintenance or upgrades as required.

4. Transfer of Certification Methodology
There are broad categories of LIDs in which the certification methodologies will be similar for each (e.g. bioretention, infiltration galleries, permeable pavements, dry swales etc.).

5. Building upon existing municipality capabilities
Inspection and certification of LID BMPs may be a new task for municipalities. To limit administrative burden, the municipalities may choose from a range of certification methods varying from simple to complex, as best fits their staff's training and experience and management goals (see Table 37).

6. BMP Verification as Adaptive Management
The purpose of verification is to maintain or enhanced the performance of existing and future local stormwater infrastructure assets. Field assessments are used to identify which LIDs are working well and which ones require preventative or corrective maintenance. In the case of poorly or non-performing practices, 'forensic' examinations may yield important information for future efforts. In addition, field verification enables the municipality to analyze their inventory of private and public stormwater BMPs to identify which individual projects present the best opportunities for reducing stormwater impacts through retrofits or restoration of existing BMPs.

Levels of Certification

Property owners and municipalities have varying capacities for performing monitoring and certification protocols. Also, there are LID practices that require varying levels of monitoring.

The Stormwater Management Certification Protocols for Low Impact Development (CVC, Draft 2012) document presents five (5) levels of certification protocols as presented in Table 37.

The advantages and disadvantages of the varying levels are presented in Table 38.

Each approach is summarized in the subsequent section.

Table 37 –Level of Certification & Associated Protocols

Level of Certification	1. Visual Inspection	2. Infiltration testing	3. Synthetic Runoff Testing	4. Water Level Monitoring	5. Comprehensive Monitoring
Checklist Inspection	✓	✓	✓	✓	✓
Soil Sampling and Testing	✓ **(optional)**	✓	✓	✓	✓
Sedimentation Monitoring	✓ **(optional)**	✓ **(optional)**	✓ (optional)	✓ (optional)	✓ (optional)
Vegetation Surveys, photos over time	✓	✓	✓	✓	✓
As-built Survey, Including topo.		✓	✓	✓	✓
Infiltration Testing		✓	✓ (optional)	✓ (optional)	✓ (optional)
Synthetic Runoff Test			✓	✓ (optional)	✓ (optional)
Water Level Monitoring				✓	✓ (optional)
Flow Monitoring					✓
Water Quality Monitoring					✓

Optional elements = level of certification that can be included if desired but may be redundant or duplicated through the provision of reauired program elements.

Table 38 – The Advantages and Disadvantages of the Varying Level of Certification

Level of Certification	1. Visual Inspection	2. Infiltration testing	3. Synthetic Runoff Testing	4. Water Level Monitoring	5. Comprehensive Monitoring
Objectives	Determine: · constructed to design plan · deficiencies	Determine: · storage capacity · infiltration rate and drawdown time · sedimentation rate	Determine: · storage capacity, · infiltration rate and drawdown time · sedimentation rate	Determine: · storage capacity · infiltration rate and drawdown under various conditions · sedimentation rate · volume reduction	Determine: · storage capacity · infiltration rate and drawdown time · sedimentation rate · flow, volume, and water quality
Time Requirement	1 day	1 day – 1 week	1 day – 1 week	1-2 years	1-3 years
Advantage	· Quick & inexpensive	· less expensive, no equipment left in field · short timeframe	· more accurate than infiltration testing (2) · no equipment left in field · short timeframe	· controlled experiments · more accurate · equipment left in the field, but hidden in observation well	· most comprehensive · most accurate · includes drainage area specific evaluation
Disadvantage	· limited knowledge gained	· Requires specialized equipment to perform test. · uncertainties in testing can be substantial	· Synthetic runoff test cannot be used without sufficient water supply · practice may perform differently with varied antecedent conditions	· higher cost and time commitment than level 1 and 2.	· Requires knowledgeable personnel · High cost to undertake · Equipment is left in field
Adapted from University of Minnesota's *Assessment of Stormwater Best Management Practices*					

Level 1 – Visual Inspection

Considering to the minimal effort and lowest cost requirement. It is recommended that visual inspection be used as the initial assessment tool for all LIDs. Visual inspection involves inspecting a LID for evidence of malfunction or deviation from the design plans. This can be accomplished with a brief site visit, the original plans and a checklist. Visual inspection can be used to quickly and cost-effectively determine if, and potentially why, an LID practice is not operating properly. Simplified techniques focus on these aspects:

- General confirmation of site draw-down time (hours) and Inspection of soil properties
- Presence of ponded water on site beyond specified time to drain (typically 24- 48 hours following a rainfall event

Visual inspection alone cannot provide quantitative information about the LID performance. Quantitative information on performance will require additional assessment via capacity testing and monitoring (level 2 -5).

Level 2 – Capacity Testing

A step beyond visual inspection involves the collection of additional data through testing and measurements including:

- Soil characterization sampling and testing - ensures that the installed bioretention soil meets the specification.
- Elevation surveys - confirms that the depths, storage volumes, and drainage areas correspond to the design plan.
- Sedimentation monitoring and vegetation surveys - these tasks help to establish the necessary maintenance schedules for sediment removal from inlets/pre-treatment areas and vegetation care. Due care to observe preferential flow paths that can be prone to plugging.
- Infiltration testing - will provide an estimate of expected drawdown times.

This level of certification will establish if the practice was built to the design plan, including the soil composition, the storage volume, and drainage area.

The infiltration testing will provide an estimation of expected drawdown times depending on the number of infiltrometer or permeameter measurement tests spatially distributed throughout the practice. Capacity testing will not provide the same level of accuracy as the real world monitoring that occurs in level 3 and 4.

Level 3 – Synthetic Runoff Testing

Synthetic runoff testing, one step beyond infiltration testing, is a more accurate method for determining capacity and infiltration or drawdown performance.

Synthetic runoff testing uses a clean water source (e.g., a fire hydrant or water truck), which is applied to the stormwater treatment practice under well-controlled conditions (to prevent erosion and scouring of the landscaped surfaces) and while performance is measured. For filtration or infiltration rate assessment, the following four conditions must be met for synthetic runoff testing to be feasible:

- There must be a water supply that can provide the required discharge and total volume of runoff needed.

- The BMP must be offline and/or no precipitation is expected for at least 48 hours.
- Outflow paths other than infiltration are either measurable or can be temporarily plugged.
- The water surface elevation in the stormwater treatment practice can be measured

Once the stormwater treatment practice is filled with synthetic runoff, the change in water level with time can be used to evaluate the infiltration rate. A perforated observation well which extends to the bottom of the practice is necessary to measure subsurface water level drawdown within a bioretention soil or other subsurface storage area.

Level 4 - Continuous Water Level Monitoring

After infiltration testing (level 2) and synthetic runoff testing (level 3) have been considered and either dismissed or performed, low intensity monitoring can be considered to measure LID performance. A newer and innovative method of tracking runoff infiltration through the soils has been developed based on use of inexpensive continuous water level/temperature data loggers. This type of monitoring provides cost-effective monitoring alternative by tracking temperature and groundwater levels over time including evaluation of seasonal and winter infiltration performance, potentially affected by frozen soils. One of the larger BMP performance questions facing cold climate Stormwater managers is the performance of LIDS during the winter months. Continuous recording water level/temperature data loggers will allow more detailed annual and winter infiltration performance tracking.

Subsurface water levels and temperatures can be continuously monitored with a water level logger installed in an observation port/well. For a continuous water level assessment, the following conditions must be met:

- A perforated observation well (or piezometer) must be installed which extends from the bottom of the practice to 300 mm above the surface.
- Two water level loggers which are small and relatively inexpensive monitoring equipment need to be installed. One logger is installed in the observation well and the other is installed in a protected open air space to measure the atmospheric pressure.
- A rain gauge must be in the vicinity, onsite is preferable, but within 1 km is acceptable. The rainfall data and known drainage area are necessary to know for comparison to the water level drawdown data.

The water level data in combination with the rainfall data can then be used to determine how long it took the practice to drain down after the end of an event and what size events resulted in overflows.

Level 5 - Comprehensive Monitoring

If capacity testing (level 2) and low intensity monitoring (level 3) are not feasible assessment approaches for a specific location, or do not achieve the goals of the assessment, a more intensive monitoring program should be considered.

Level 5 Monitoring is the most comprehensive and expensive assessment technique and can be used to effectively document water volume reduction and peak flow reduction for most stormwater treatment practices by measuring discharge during natural runoff events.

This level of monitoring is recommended for larger demonstration purposes when a stormwater practice is being implemented for the first time in a specific jurisdiction or development context (e.g. pilot testing of a new technology, challenging soil or geologic contexts, unique or hybrid facility design).

Another situation where this level of monitoring might be warranted is if the facility has been designed to meet higher standards due to the sensitivity of the receiving water or present of species of concern.

To assess runoff volume and pollutant load reduction, peak flow reduction, or both by monitoring a stormwater treatment practice, the inflow(s) and outflow(s) must be measured or estimated as in conducting a water budget. The summation of the inflows can then be compared to the summation of the outflows to determine the runoff volume reduction, peak flow reduction, or both.

Typical urban runoff events are flashy (rapid response) and require continuous flow measurement (or estimation). Pollutant loading changes will require state-of-the-art automated sampling devices to obtain flow-weighted or time-weighted sampling that coupled with continuous flows allow estimation of loads and development of Event Mean Concentrations (EMC).

Besides having considerable additional costs, comprehensive monitoring has more potential for missed or erroneous data as compared to synthetic runoff tests for the following reasons:

1. Weather is unpredictable and can produce various runoff volumes of various durations with varying pollutant concentrations at various times.

2. In order for a storm event to be monitored correctly and accurately, all the monitoring equipment must be operating correctly and the parameters (water depth, etc.) must be within the quality control limit ranges for the equipment.

3. Equipment malfunction due to rodents, electrical interferences, routine wear, storm damage/loss, or vandalism are common.

4. State-of-the-art continuous monitoring of stormwater runoff is the most expensive of monitoring techniques as it requires trained technicians, proper installation, frequent inspection, runoff flow-gauging, maintenance and adherence to quality control protocols. Continuous monitoring can provide accurate mass-balance summaries that have been used to accurately assess (NRC/NSF 2008):

- Individual LID performance (volume and pollutant reductions) over seasons and
- Annually, particularly for new and innovative techniques;
- Drainage area runoff quality over seasons for comparison to water quality criteria or goals
- Treatment train performance seasonally and annually.

Soil amendment – Assumption Protocols

Per the Implementation Guide for the Pinecrest Creek/ Westboro SWM Guidelines: Development Requiring a Building Permit Only (Draft, 2013), the following verification program proposed for consideration by the City of Ottawa. It is proposed that verification will be undertaken by City staff or constructor responsibility via engineer to confirm:

1. Amended soil quality
2. Amended soil depth
3. Compliance with site grading

The following shall encompass all monitoring tasks in regards to the implementation of LID Soil Amendments at the Former CFB Rockcliife site.

Verification Timing

Verification may occur after a minimum of one (1) week settlement period and after grades have been adjusted, but may occur before or after the installation of turf. If non-compliance is confirmed, the contractor/owners shall be responsible for rectification including replacement of turf as required. As such, verification is suggested prior to turf placement. Note: verification by City staff can be coordinated with other verification tasks including the connection of downspouts to soakaway pit inlet piping which would occur at generally the same time.

Documentation Verification - Amended Soil Quality

As part of verification, the constructor shall produce delivery tickets, receipts and specifications detailing the delivery address, quantities and product description and sources for verification by City inspectors. Delivery address is to be listed and must correspond to the property/site being inspected. Sites without proper documentation may be subject to additional verification procedures including laboratory testing at the expense of the owner.

Amended Soil Depth Verification

At random, the site inspector shall dig at least one (1) test hole within the amended topsoil area to verify amended topsoil depth and uncompacted soil depths. Test holes can be dug using a common garden spade or a small diameter coring unit (i.e. Ogeechee corer©) see inset photo. Test holes may be up to 30cm in diameter and shall extend a minimum of 400mm.

Requirements:

1. Amended topsoil layer shall be easily dug using only the inspector's weight or cored without other mechanical assistance.

2. The amended topsoil layer shall be darker in color than the unamended- decompacted subsoil and particles of organic matter should be easily visible.

3. Measured amended topsoil depths shall be deemed to be in conformance based on the following:

a) Using a common garden spade, the measured depth of amended topsoil is greater than or equal to ±25mm of the required 300mm depth

Field Verification of Topsoil Depths using Common Garden Spade (Aquafor Beech, 2011)

b) Using a small diameter coring unit, the measured core depth of amended topsoil shall be equal to ±50mm of the required 300mm depth

Field Verification of Topsoil Depths using Small Diameter Coring Unit
(3 cm diameter core is displayed)
(Aquafor Beech, 2011)

Note: ± accounts for minor compaction resulting from various testing methods.

Non-compliant Sites and Disputes

If a site is deemed by the inspector as non-compliant with the aforementioned requirements the site inspector shall:

- Notify the owner of what steps are needed to comply and provide guidance or clarification as required.

When results are disputed and cannot be resolved between the owner and the City, an independent consultant shall be contracted to conduct verification and sampling for submission for laboratory analysis and may include:

- Bulk density (g/cm3)
- organic matter content (%) as determined by Loss-On-Ignition Test
- pH
- Particle size distribution (i.e. % sand, % silt and % clay)

Soakaways

The following section details the assumption protocols and monitoring requirements for the construction of the proposed LID soakaway pits.

Assumption Protocol

Per the proposed construction sequencing (see Section 5.20), it is recommended that the constructor's engineer certify the construction of each soakaway pit and related piping connections. The Engineer shall certify the facility footprint, materials, construction methods and will approve backfilled and compaction activities. The engineer shall provide the City with a stamped confirmation letter detailing that the facility was constructed per the design drawings.

The City shall inspect the constructed soakaways on complaint basis only.

Monitoring Requirements

The proposed monitoring program to assess the effectiveness of the LID soakaway pits within the residential area of Phase 1A is detailed in Table 39. Detail is provided in regards to the required equipment and approach, monitoring period (time frame), equipment and information requirements and potential outcomes.

Table 39 – Proposed Soakaway Pit Monitoring Program

<table>
<tr><th>Element</th><th>Equipment/ approach</th><th>Time Period</th><th>Requirements</th><th>Outcome</th></tr>
<tr><td>Soakaways</td><td>Piezometer installed in monitoring well at model home</td><td>Immediately following construction until sale (min 1-2 years)</td><td rowspan="2">As built survey of excavation and piping, certification of material and installation required.
Pressure transducer (Hobo U20) or equivalent
Utilize existing City of Ottawa Ropec rain gauge - upgrade to full season (heated)</td><td rowspan="2">1. Water level
2. Drawdown time
3. Volume capture
4. # of overflows
5. Rainfall capture effectiveness (10, 15, 25mm etc.)
6. Winter performance
7. Annual GW recharge mm/yr
8. Confirmation of native infiltration rate</td></tr>
<tr><td>Soakaway (optional monitoring location)†</td><td>Piezometer installed in monitoring well at a soakaway pit servicing a community building within a park setting</td><td>Immediately following construction (min 1-2 years)</td></tr>
<tr><td colspan="5">† Subject to agreement from all parties – City and others.</td></tr>
</table>

Bioswales, Enhanced Swales, Infiltrating Dry Ponds

Assumption Protocol

Per the proposed construction sequencing (see Section 5.20), it is anticipated that when construction Bioswales, Enhanced Swales, Infiltrating Dry Ponds that the subsurface infrastructure (piping and catch basins etc.) may be installed during site servicing, however media placement and planting must occur following stabilization of contributing area or areas to remain off-line (inlets blocked) during major construction activities.

However, it is recommended that specific construction sequencing plans be developed for each individual roadway cross-section and facility type based on the proposed development phasing, other, utility requirements, size of contributing drainage area and the risk of facility failure.

Irrespective of the specific construction sequencing plans, it is acknowledged that all Bioswales, Enhanced Swales, Infiltrating Dry Ponds are proposed to include the use of manufactured or engineered infiltration medias (or biomedia). As such a comprehensive during construction quality assurance and verification program is recommended as an integral part of assumption and monitoring protocols.

The following details the requirements for a biomedia QA/QC program as part of construction. The biomedia program includes five (5) Steps:

1. Submission of hand-mixed sample (s)
2. Approved by engineer or designer prior to step 3
3. Submission of mechanically-mixed sample(s)
4. Approved by engineer or designer prior to installation
5. Verification once installed

The following minimum requirements are recommended in regards to five (5) step biomedia QA/QC program.

- The vendor must provide a hand mixed sample of the proposed media to be submitted for analysis. Hand mix samples are intended to roughly gauge the proportions of materials required in order to satisfy the specifications. Depending on the soil manufacturer/vendor, submission of hand mixed samples may have to be conducted several times to obtain a passing sample. Analytical results must be submitted to and approved by the engineer prior to beginning mechanical mixing operations.
- Media samples from mechanically mixed operations must be submitted for analysis and satisfy the media specifications. To minimize contamination and clean out the mixing system prior to sampling, a minimum of ten (10) cubic meters of media must be passed through the mixing system and disposed of. A minimum of three (3) samples shall be collected from the next ten (10) cubic meters of material including one from the bottom of the pile (1-3 m^3 of material), the middle (4-6 m^3 of material), and top (7-10m^3 of material). Approved mechanically mixed samples shall be issued for installation.
- All hand and mechanically mixed samples must be submitted to a

certified laboratory. Chain of Custodies which details the required testing to be conducted should be assemble by the contract administrator and provided to the contractor.

- Obtaining media samples shall be conducted by the contractor.

- The contractor shall notify the contract administrator when the mechanically mixing operations shall be taking place and be provided the opportunity to observe the source material being used for media development and mixing operations. Contractor must ensure that access for sampling is provided to the contract administrator if necessary.

- Delivered media shall be tested and approved by engineer prior to installation and originate from the same location and use the same materials as the approved samples.

- Media installed without engineer approval shall be removed at the contractor's expense if deemed necessary by the engineer.

- The contractor is solely responsible for all required media testing expenses.

- The contractor is responsible for any delays suffered as a result of testing. No compensation will be provided for delays due to media analysis.

- On-site mixing is not acceptable

Bioswales, Enhanced Swales, and Infiltrating Dry Ponds Inspection Requirements

The following inspection requirements are suggested for Bioswales, Enhanced Swales, and Infiltrating Dry Ponds after construction:

- Inspect bioswale after each storm >10mm or min. 2 times/year. Coordinate with other inspection activities

- Inspect bioswale immediately after each event greater than 60mm

Monitoring Requirements

The proposed monitoring program to assess the effectiveness of the LID Bioswales, Enhanced Swales, within the residential area of Phase 1A is detailed in Table 40 respectively. Detail is provided in regards to the required equipment and approach, monitoring period (time frame), equipment and information requirements and potential outcomes.

Table 40 – Proposed Bioswale and Enhanced Swale Monitoring Program

Element	Equipment/ approach	Time Period	Requirements	Outcome
Bioswale	Primary device (weir) and pressure transducer for flow measurements Automated water quality sampler (ISCO or equivalent) to develop EMC	Immediately following construction and stabilization of surrounding/ contributing area	Inclusion of a dedicated monitoring MH & valve at the downstream end of the bioswale system prior to entering the Municipal system Selection of a representative 'Control area – "no LID" Minimum 2m MH depth to house sampler and weir. Automated Water Quality Samplers • 1 sites (phase 1A) to establish EMCs • 2 sampling events per season (8/year) • Chloride, Copper, Lead, Zinc, TP, TKN, TSS, pH, temperature	Water quality 1. Removal efficiency (%) 2. Total contaminant load (kg/yr) Flow 1. Flow reductions (peak and time series) 2. Lag Time 3. Volume capture 4. Rainfall capture effectiveness (10, 15, 25mm etc.) 5. Winter performance
Element	**Equipment/ approach**	**Time Period**	**Requirements**	**Outcome**
Enhanced Swale	Optional Potential for: Flow monitoring at outflow point within Culvert, DICB, MH or Pipe using pressure transducer	Immediately following construction for min. 2 years	Defined outflow point Culvert, DICB, MH or Pipe Utilize existing City of Ottawa Ropec rain gauge - upgrade to full season (heated)	1. Flow characteristics: (measured) vs, predicted (model) using continuous rainfall data Ropec

Overall System Monitoring

It is proposed that comprehensive monitoring (Level 5) be competed in regard to the Eastern and Western Creek and the stormwater infrastructure (pipes and ponds).

This additional level of effort is required to quantify the overall performance of the LID lot-level and conveyance controls in order to, per the study objectives:

- Quantify the type and extent of the stormwater management 'credits' attributed to the individual LIDs and to be applied to subsequent phases (1B-3) of the Former CFB Rockcliffe development.

  Note: the credits will be based on the cumulative collected monitoring data from each successive phase of development.

- To quantify the performance and net effect of the individual LID controls.

- To quantify overall system benefits such as a reduction in–stream erosion, habitat enhancements, vegetation community health etc.

- To calibrate the recommended integrated stormwater model for the Former CFB Rockcliffe site (LID and conventional SWM model) to the quantified performance as measured in the field and re-assess the development wide flood, erosion and water quality requirements. Comprehensive monitoring is required in order to develop a calibrated model.

Monitoring Requirements

The proposed overall system monitoring program is detailed in Table 41. Detail is provided in regards to the required equipment and approach, monitoring period (time frame), equipment and information requirements and potential outcomes.

Table 41 – Proposed Overall System Monitoring Program

Element	Equipment/ approach	Time Period	Requirements	Outcome
Creeks (Eastern and Western)	Continuous streamflow gauge using: • Area Velocity Meter (west creek) • Pressure transducer with rating curve (east creek)	Existing conditions for min. 1 year (anticipated start 2015 – 2016) Immediately following construction for min. 2 years	Industry standard monitoring methodology with consistent measurements (15 min. intervals). Utilize existing City of Ottawa Ropec rain gauge - upgrade to full season (heated)	Pre vs. Post: 1. Flow duration curve 2. Flow frequency analysis 3. Q baseflow
SWM Infrastructure (pipes and ponds)	Flow monitoring at convergence of SWM system or pond inlet and outlet using pressure transducer	Immediately following construction for min. 2 years	Industry standard monitoring methodology with consistent measurements (15 min. intervals). Utilize existing City of Ottawa Ropec rain gauge - upgrade to full season (heated)	1. Flow characteristics: (measured) vs, predicted (model) using continuous rainfall data Ropec 2. Determination of excess capacity (if relevant) 3. Calibrate model to LID performance and re-compute flood and water quality requirements.

During Construction Monitoring

The proposed during construction monitoring program is detailed in Table 42. It is intended that the specified monitoring program be undertaken by the developer/ constructor for all LID lot-level and conveyance controls from construction until assumption by the City of Ottawa. The intent of this monitoring is to monitor the LIDs in order to create resource information for the developer/ constructor and the City of Ottawa. Desired outcomes include but are not limited to:

- Physical performance (see Tables 39-41)
- Maintenance requirements & frequency
- Rehabilitation/ repairs undertaken
- Success of Construction phasing and staging
- Design modifications
- Recommendations for future design modifications

All outcome and recommendations are to be summarized in an annual consolidated monitoring report and submitted to the City of Ottawa.

elevation monitoring in areas serviced by private wells such as the Fairhaven community and the Canadian Aviation and Space Museum is recommended before, during and after site development activities.

Table 42 – Proposed Construction Monitoring Program

Element	Equipment/ approach	Time Period	Requirements/ Outcome
During Construction	Monitor to create resource information Developer to maintain: • Maintenance log books • Repair log book • Red-lined construction drawings and notes • Outcome and recommendations to be summarized in annual consolidated monitoring report	Start of construction to assumption	• Physical performance (see Tables 39-41) • Maintenance requirements & frequency • Rehabilitation/ repairs undertaken • Success of Construction phasing and staging • Design modifications • Recommendations for future design modifications

<u>Groundwater Quantity</u> – It is further noted that per the MSS (IBI, 2015), groundwater quantity monitoring will be required. The MSS states that impact of site development (including remedial excavation and construction dewatering) in overburden deposits will be localized due to low permeability of deposits. As a precautionary measure, groundwater

Reporting Requirements

It is recommended that all monitoring program as detailed above, be included within a consolidated report by the developer/ constructor for submission to the City of Ottawa on an annual basis. The reports shall contain the information as presented in the Section 5.18.

It is further recommended that the Stormwater Working Group be recreated as the Former CFB Rockcliffe LID Pilot Committee. This committee will include City and CLC staff. The committee will be tasked with:

- The review of submitted annual reports
- The facilitation of regular meetings (min. 2x per year) to discuss interim and final results
- The definition of credits or outcomes for next phases of development (Phase 1B-3)
- The refinement of the monitoring program for the subsequent year/ development phase.

It is also recommended that the Former CFB Rockcliffe LID Pilot Committee work collaboratively to develop:

- A project charter
- Detailed monitoring plan and scope for each monitoring year per the proposed development schedule
- Cost sharing arrangement (if relevant)
- Annual reporting template and data collection, storage and transfer guidelines.

5.19 OPERATION & MAINTENANCE

Adequate operation and maintenance is essential to ensure the long-term achievement of stormwater management performance targets. This section sets out operation and maintenance guidelines and recommendations that are specific to the recommended LID stormwater management measures. These guidelines are of particular importance due to the shift away from conventional end-of-pipe stormwater management strategy to decentralized, landscape-based Low Impact Development techniques. Accordingly, the following sections discuss operation and maintenance procedures, strategies, costs and requirements.

O&M of LID Controls - Frameworks

Adequate Operation and maintenance activities and costs associated with the implementation of LID measures on private property will be the responsibility of the private property owner. Generally, maintenance requirements for most lot-level control technologies have little difference from most turf, landscaped, or natural areas and do not typically require new or specialized equipment (EPA, 2007).

Typical landowner activities will include:

- General inspection;
- Litter removal;
- Weed control;
- Grass Cutting; and
- General landscape upkeep i.e. pruning, mulching and seasonal clean-up activities.

Using this approach, private property owners are responsible for performing ongoing on-site lot-level control maintenance per the operations and maintenance schedule as developed by the SWM practitioner and submitted as a requirement of the proponent's SWM Plan (see Section 5.22). As part of private ownership maintenance, the minimal level of municipal involvement includes:

1. Review and approve operation and maintenance program documents; and
2. Establish tracking system to document lot-level control measure location, type, size etc. for use in future management scenarios.

In general there are three (3) comprehensive O&M approaches for LID measures as part of development for consideration by the City of Ottawa. They include:

1. LID on Private Property "Private Owner Maintenance" – private property owners are responsible for performing ongoing stormwater facility maintenance with municipal guidance and oversight of LIDs on private property;
2. LID on Municipal Property "Municipal Maintenance" – the municipality is responsible for performing ongoing on-site stormwater facility maintenance of LIDs on municipal property; and
3. Hybrid – a combination of Approach 1 and 2

Table 43 summarizes the requirements/ steps associated with each approach and the advantages and disadvantages to each.

Table 43 – Summary of O&M Approaches for LID Controls

Maintenance Approach	Typical Requirements /Steps	Advantages and Disadvantages
Private Owner Maintenance	1. Municipality to review and approve adopt program documents 2. Mandatory maintenance plan required for site plan approval 3. Mandatory easement requirement for site plan approval (new development) 4. Owner to submit annual maintenance reports 5. Develop periodic inspection procedures 6. Establish tracking system 7. Compliance enforcement procedures	Reduced costs to the municipality Oversight is required Municipality required to undertake steps 1-2 & 6-7 Policy and By-law revision may be required
Municipal Maintenance	1. Collect a detailed inventory of all LID controls 2. Establish maintenance policies 3. Train inspectors and approvals staff 4. Develop tracking system 5. Perform and document maintenance activities	Higher costs, additional staffing requirements and administrative burden Avoidance of enforcement issues, and increased control over maintenance frequency
Hybrid	Combination of Approaches 1 and 2	Provides maximum flexibility Ability to shift 'some' (typically more frequent) maintenance to the landowner.

It is recommended that for the Former CFB Rockcliffe that the Hybrid approach for operations and maintenance (a combination of Approach 1 and 2) be adopted. This approach requires that the individual landowner assume all operations and maintenance activities and related costs for the approved LID stormwater management systems within their property limits.

For all LID stormwater management systems on municipal lands, the municipality shall assume all operations and maintenance activities and related costs. This provides the greatest flexibility for the municipality and reduces the operations and maintenance burden (resources and costs) relating to the retail, mixed-use and employment land uses proposed for the Former CFB Rockcliffe site.

With the hybrid model, there is a general requirement for a transfer of 'traditional' SWM maintenance resources and funds (outlet inspections, pond dredging, vacuum trucks to empty OGS systems etc.) to a more landscaped based SWM maintenance program. Municipalities generally have the required staff and infrastructure within other departments (such as Parks Departments – arborists, horticulturalists) and as such require only a transfer of funding and additional training for municipally owned LID controls. Furthermore, in developing the recommendations to guide the maintenance of the landscape components of LID stormwater management facilities, it must be recognized that a landscape is a living system that evolves in response to the environment and natural successional processes. Consequently, the maintenance program must be implemented with an understanding of the long-term evolution of the landscape and with a view to the desired state of the landscape in the future.

The following are the objectives that served as the basis for developing the landscape maintenance program for privately owned and municipally owned facilities:

- promote the succession of naturally occurring species and associations;
- support the process of natural succession;
- manage for the control of non-native invasive or undesirable species;
- manage to ensure public safety with respect to preservation of sightlines, removal of hazards and control of noxious species; and
- ensure that the primary stormwater management function of the facility is achieved.

Looking Forward - Level of Service Models

When developing a broader LID O&M program, the development of a "level of service" model will be required; more specifically at what frequency and scope will the maintenance programs be completed? Key considerations include:

- Inspections Frequency – Annual, semi-annually, quarterly inspections etc;
- Scale of implementation - How will size and number of BMPs effect the program;
- Ownership – private or public LID BMPs
- Maintenance triggers – complaints driven, emergency driven, inspection driven
- Risk factors –water quality etc.

Table 44 below illustrates a typical maintenance program service model matrix, where the components and maintenance responses can increase or be scaled as the program matures in response to increasing LID implementation. This model allows for minimal upfront investment but is a tool to set priorities and plan for future program expansion, as required. Table 44 has been included for future consideration by City of Ottawa operations staff and will be of value when broader LID implementation is to take place within City.

Table 44 – Maintenance Program Service Matrix (CWP, July 2008)

Program Service Level & Budget Requirements	Elements included in maintenance program	Maintenance task	Maintenance Response	Inspectors	Inspection Response	Program Feedback based on inspection and Maintenance experience
LOWER HIGHER	BMPs on public land and within public rights-of-way + High-priority, high risk, and/or large BMPs on private land with necessary easements and agreements + All or most BMPs on private land within easements and covered by deeded maintenance agreement + Completely private BMPs + All conveyances measures	Repair Immediate threats to public health and safety + Repair structural items: erosion, outfalls, clogged or broken pipes + Also include routine maintenance: mowing, weeding, removal of trash and debris, replacement of vegetation + Program includes system to retrofit or reconstruct BMPs	React to complaints and emergencies + Establish schedule for mowing and trash/debris removal + Conduct maintenance in response to inspection reports, checklists, and performance criteria	Rely on owners to inspect Public inspectors send report to responsible party Co-inspections with public inspector and responsible party System of certified private inspectors with spot inspections and compliance checks by public agency	Complaint-driven Every 3 years Annual or semiannual More frequent for high-priority BMPs	Feedback is anecdotal + Feedback used to modify list of recommended BMPs in design manual based on maintenance burden + Feedback used to modify design standards in manual to reduce maintenance burden through initial design

LID General O&M Requirements

As stated previously, maintenance requirements for most LID technologies including lot-level and conveyance control practices have little difference from most turf, landscaped, or natural areas and do not typically require new or specialized equipment (EPA, 2007). However, LID techniques are green 'infrastructure' and do therefore provide a necessary function in communities. The relative importance of this function requires that maintenance personnel and inspectors are well versed in the design, intended function and maintenance requirements of each system. Just as contractor education is critical to ensure proper post-construction function, the education and training of the individuals servicing LID facilities is vital to their long continued operation. Table 45 provides a summary of the maintenance requirements for soakaway systems, perforated pipes and sub-surface storage systems; bioretention, bioswale, enhanced swales and bioretention planters; permeable pavements and rainwater harvesting systems.

Note: there are no operation and maintenance requirements for soil amendments.

Table 45 – Summary of Maintenance Requirements for LID Controls

LID Technique	Maintenance Requirements	Notes:
Soakaways, perforated pipe & Subsurface storage systems	Regular Maintenance · Clean debris and litter · Inspect perforated pipe for clogging · Lawn maintenance Annual · Vacuum debris from any catch basins · Inspection of stone drainage area Long-term - Perforated pipe clean out	Ensure that perforated piping, grating, catch basins are not clogged with sediment or debris. Clean debris from grating, catch basins, and perforated pipe using high pressure sprayers or vacuum
Bioretention, Bioswales, Enhanced Swales and Bioretention planters	Post Installation (1st 6 months) · Inspection after each storm >10mm or min. of twice · Irrigate until established (weekly for 1st yr and bi-weekly for 2nd year; as needed based on rainfall) Annual · Inspect each spring and events >60mm · Replace mulch as required · Reinforce planting as required · Pruning and Weeding Regular · Integration into existing landscape maintenance program (additional training required) · Trash Removal · Mow grass to remove woody material. Maintain minimum grass height of 150 mm	Lost plants should be re-planted to maintain desired plant density Core aerating or deep tilling may be required to alleviate clogging due to fines accumulation
Permeable Pavement	Post Installation (1st 6 months) · Inspection after each storm >10mm or min. of twice Regular · Surface cleaning - Integration into existing sweeping/vacuuming programs	Post signs identifying permeable pavement areas & discourage storage/ dumping of soils, heavy vehicle use etc.
Rainwater Harvesting	Varies with usage. Outdoor use (Irrigation) = low maintenance. Indoor use = higher maintenance requirements. Semi-annual inspections are recommended to clean debris, patch holes in mosquito screens. Refer to manufacture specification if proprietary system is used.	standard manhole opening should be provided Drain plug or clean-out sump: to allow for complete system drainage

Permeable Pavement O&M Specifics

From past project experience, it has been demonstrated that the implementation of permeable pavers in multi-use and commercial land-uses can form a significant portion of the development. As such, the following procedures should be incorporated into maintenance plans for permeable pavements:

- Surface Sweeping: Vacuum and/or sweeping should occur on the porous surface to mitigate sediment accumulation and ensure continued porosity. Sweeping should occur on a quarterly to biannual basis with a commercial cleaning unit. Compressed air units are not recommended (PWD, 2007).
- Inlet Structures: Drainage pipes and structures within or draining to the subsurface bedding beneath porous pavement should be cleaned out on regular intervals (PWD, 2007).
- Heavy Vehicles: Trucks and other heavy vehicles can compact dirt into the porous surface and lead to clogging. These vehicles should be prevented from tracking or spilling dirt onto the pavement (PWD, 2007). Signage and training of facilities personnel is suggested.
- Construction and Hazardous Materials: Due to the potential for contamination, all construction or hazardous material carriers should be prohibited from entering a permeable paver or porous pavement site (PWD, 2007).
- Drainage Areas: Areas contributing to the permeable pavers site need to be mowed and bare areas should be seeded.
- Deicers: Non-toxic organic deicers are preferable and can be applied either as blended magnesium chloride-based liquid products, or as pretreated salt. In any case, all deicers should be used in moderation (PWD, 2007).
- Snow Plowing: No changes to snow plowing operations are required for permeable pavements, however operators may wish to reduce plowing speeds. Operators should be aware of permeable pavement locations and adjust operations as required based on their equipment.

Annual inspections of permeable pavers should be conducted in the spring to ensure continued infiltration performance. These inspections should check for spilling or deterioration. Adequate drawdown should occur within 24 to 48 hours.

Plant Based LIDs - O&M Requirements

With respect to the landscape components of stormwater management facilities/ techniques, the monitoring program is focused on gauging the sustainability, performance and evolution of the vegetation community to identify remedial maintenance activities that may be required. A description of the recommended vegetation community monitoring program is provided in Table 46.

Table 46 - LID Vegetation Community Monitoring Program

Vegetation Community	Description	Frequency
Trees and Shrubs	Visual inspection to identify dieback, stress or presence of disease.	Biannually: i. Spring - after leaf out ii. Fall – before leaf drop
Groundcover	Visual inspection to confirm adequate	Biannually: i. Spring - after leaf out ii. Fall - before leaf drop
Presence of Noxious Weeds/ Invasives	Visual inspection to identify undesirable species and requirements for control	Biannually: i. Midsummer and early fall

Maintenance activities of vegetation communities within LID control practices include, but are not limited to the following:

Tree and Shrub Maintenance

- Adjust stakes and guys to prevent girdling.
- Ensure rodent protection remains in contact with the ground.
- Prune out any dead or damaged limbs.
- Water trees as required to maintain health in consideration of meteorological, soil and site conditions as well as species requirements.
- Top of mulch to ensure soil moisture is maintained

Seeded Area Maintenance

- Monitor after initial seeding to ensure that adequate cover density has been achieved.
- Overseed as required to eliminate bare patches.
- Repair and reseed any rills or gullies that may form during the grow-in period.
- Remove weeds that may have become established during the germination and grow-in periods.
- Monitor to ensure that established species correspond with specified seed mix species composition. Overseed as required to achieve specified composition and distribution.
- For areas designed to be maintained, mow to maintain a height of 60-75mm.
- Irrigate seeded areas as required to ensure germination and establishment.

Shrubs and Shrub Bed Maintenance

- Prune out dead or damaged branches.
- Remove weeds from mulched beds.
- Water shrubs as required to ensure healthy growth in consideration of soil, meteorological and site conditions as well as species requirements.

The Maintenance program should include inspections of the LID facility on a routine basis to monitor the health of the plant community and the rate of establishment of seed as well as to determine the amount of weed establishment to implement maintenance actions

Typical O&M Costs for LID Lot-level and Conveyance Controls

Table 47 provides typical maintenance costs by individual maintenance activity for LID techniques

Table 47 – Typical Maintenance Costs by Activity for LID Measures

Activity	Maintenance Interval (years)	Unit	Cost Per unit
Litter Removal	½	ha	$ 1,000 – 2,000
LID Litter Removal	½	m^2	$ 0.20
Weed Control	1	ha	$ 1,000
LID Weed Control	1	m^2	$ 0.20
Grass Cutting	*	ha	$ 250
Landscape Restoration (Terrestrial Vegetation)	10	ha	$ 1,000
LID Landscape Restoration	½	m^2	$ 0.20
Sediment Removal and Disposal (Heavy machinery)	10	m^3	$ 300-350
Sediment Removal and Disposal (Vacuum Truck)	½	m^3	$120-250
LID Sediment Removal (manual)	½	m^3	$ 50-100
Soil sampling and infiltration testing	10	L.S.	$ 1,000-1,200
Inspection of Inlet/Outlet	1	L.S	$ 150
Pervious pipe/ underdrain cleanout (8-10m/hr)	**	hr	$ 850
Infiltration media restoration (tilling and re-vegetation)	**	m^2	$ 150
Shrub Replacement	**	each	$ 20-40

* Routine maintenance **when necessary (repair item) (Source: MOE, 2003; Halton Hills, 2009)

5.20 CONSTRUCTION SEQUENCING

The following section provides additional detail with regards to construction sequencing of the proposed LID lot-level and conveyance controls as part of the LID Pilot/ Demonstration Project.

Soakaways

A three (3) stage construction sequence is recommended for the implementation of residential soakaway pits. Figure 55 illustrates the three (3) stage implementation process in relation to the typical soakaway pit design presented previously.

1. Site Servicing - Connection to storm sewer made during site servicing. Overflow is stubbed to the Property line (PL)
2. Building Foundation Construction - Excavation and construction of the soakaway pit shall take place during construction of the building foundation. Piping is connected to the overflow and inflow lateral is stubbed to foundation and capped. Excavation is not to be left open during rainfall or longer than 72 hours. Installation of a sacrificial geotextile is required if backfilling is not completed within 24 hours. Engineer to certify construction and connections. Upon certification, the facility footprint may be backfilled, compacted and protected as required. It is suggested that the footprint be marked with flags, fencing of survey stakes.
3. Final Grading Approval - Connection of downspouts to inflow lateral and installation of splash pad upon approval of final grading.

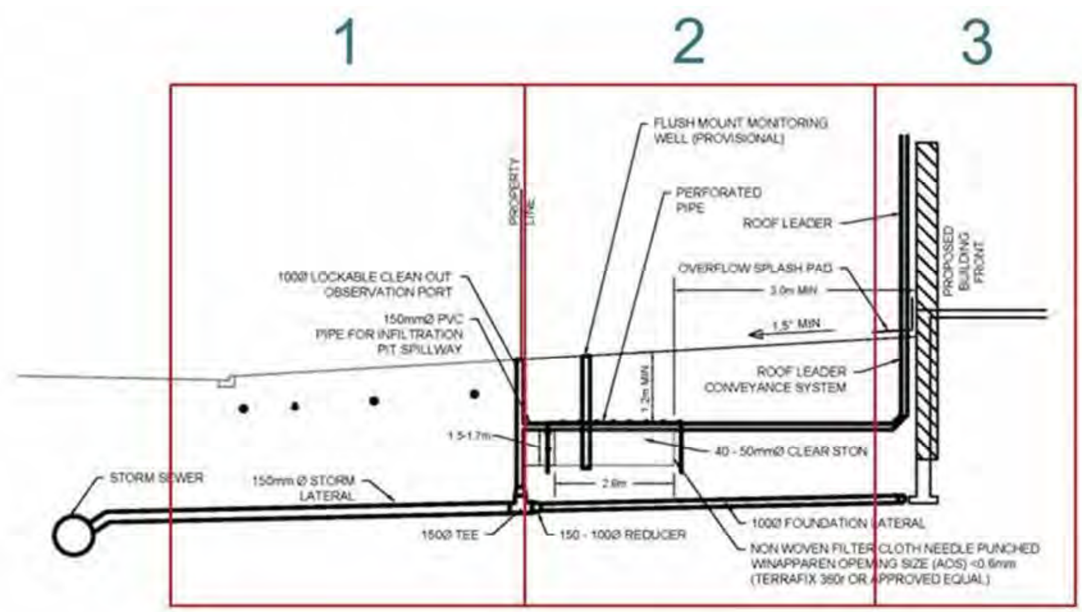


Figure 55 – Construction Sequencing for Residential Soakaways

Bioswales

In general, when construction bioswales, the subsurface infrastructure (piping and catch basins etc) may be installed during site servicing, however media placement and planting must occur following stabilization of contributing area or areas to remain off-line (inlets blocked) during major construction activities. However, construction sequencing plans must be developed for each individual roadway cross-section and LID based on phasing, other, utility requirements, size of contributing drainage area and risk of facility failure.

Sequencing of bioswales should consider the following:

1. Construction sequencing is an integral part of ESC plan
2. Silt protection shall be installed prior to all excavation activities
3. Rough excavation is permitted to maximum of 100mm of facility bottom
4. Excavation and backfilling with biomedia shall only be permitted after the stabilization of the contributing area. Per Figure 50, the installation of a sacrificial geotextile is recommended prior to media placement. Sacrificial geotextile is to be removed immediately prior to media placement.
5. Construction sequencing – filter media bed placement:
    - Place geotextile fabric, install washed stone, install piping and underdrains, install remaining washed stone, cover with geotextile, apply approved biomedia in lifts, match design elevations for finish grade.
    - Planting is not to occur prior to 5 days after media placement
    - Install shredded hardwood mulch
6. Plant and irrigate a min. 1 time/week during 1st 2 month
7. Remove weeds monthly, irrigate and replace dead plant material immediately upon discovery for a minimum period of 2 years or until assumption.

Permeable Pavements

It is recommended that permeable pavement lay-bys within the municipal ROW be constructed in combination with the placement of surface asphalt.

Subsurface piping, infrastructure, aggregates, geotextiles and curbing shall be installed during site servicing and roadway construction. Temporary asphalt shall be placed directly over sacrificial geotextiles placed over the specified aggregates until such time as it is removed and replaced with the permeable interlocking concrete pavers and bedding aggregates in coordination with asphalt top coat.

5.21 EROSION AND SEDIMENT CONTROL (ESC)

The evolution of ESC control methodologies and approaches, suggest a hierarchical strategy. This stepped approach is supported by national certification boards including the CISEC program (Certified Inspector of Erosions and Sediment Control program - www.cisec.org) which recommends and ESC approach of:

Step 1 – Eliminate or Reduce erosion

Step 2 – Control sediment releases

In this 2 step process, the development of subject site eliminates the erosion of soils during construction, reduces the reliance on sediment controls to reduce releases and thereby more completely protects the LID controls and receiving watercourse form sediment releases. The previous focus on sediment control fails to deal with the root cause of the problem- the erosion. In this regard, it is important to note the following:

- Sediment control does not control erosion, but erosion control does minimize sediment
- Sediment control BMPs do not removal all suspended sediment found runoff water.

The basic principles of any ESC plan so strategy should include:

- A multi-barrier approach which begins with erosion controls, followed by sediment controls and avoids reliance on a single control point for sediment
- Retain existing vegetation to the greatest extent possible for a long as possible
- Minimizes land disturbance areas
- Reduces runoff velocities and detains runoff to promote settling
- Diverts runoff from problem areas and away for LIDs/ infiltration based controls.
- Minimizes slope length and gradient of disturbed areas
- Maintains overland sheets flow and avoids concentrated flows
- Stores and stockpiles soils away from LID controls, watercourses, drainage features and top-of-slope
- The acknowledgment that ESC plans are dynamic and require application of the Adaptive Management Approach (AMA) whereby the ESC plan is continually updates as a result of site inspections

In addition to the typical ESC control BMPs listed above, the following erosion control BMPs and sediment control BMPs listed in Table 48 may also be implemented. Note erosion controls are generally referred to as “non-structural” methods

Table 48 – Summary of Erosion Control BMPs and Sediment Control BMPs

Erosion Control BMPs	Sediment Control BMPs
Diversion Structures · Slope drains · Diversion berms · Conveyance channels *Erosion Control Methods (ECMs)* · Soil Roughening · Seeding or turf establishment – sprayed, drilled or spread · Turf Reinforced mats (TRMs) o For drainage channels/ conveyance · Soil binders - tackifier or polymers · Rolled Erosion Control Products (RECP) o For hillsides · Mulch application (wet or dry) o Dry muscles such as straw, hay, compost, RECPs or Rock o Wet mulches such as shredded wood, corn stalk fiber with or without tackifier or polymers	*Perimeter Controls* · Silt fence barrier · Fiber log/ roll · Compost socks · Compost berms *Check Structures* · Straw bale barrier- check dam · Rock check dam · Geosynthetic check structure *Inlet barriers* · Rock bags · Curb inlet "sump bariers' · Curb opening to vegetated areas · Area bale/ rock barrier · Inlet inserts *Stabilized Construction Access controls* · Vehicle tracking pad/ mud mat · Entrance Grates or ridge systems · Tire washing

Recommendations

Due to the proposed extensive use of LID infiltration based lot-level and conveyance controls, the following recommendations have been developed in regard to sediment management during construction for consideration by City of Ottawa staff:

- All ESC Plans require the placement of topsoil and seed for all areas not schedule for immediate development following site grading (by June 1 of the following year for winter conditions. In addition, it is suggested that "immediate development" be defined as "within 30 days following site grading".
- All ESC plans focus of Erosion Control using the Erosion Control BMPs and ECMs listed in Table 48
- All ESC plans implement a multi-barrier approach which begins with erosion controls, followed by sediment controls and avoids reliance on a single control point for sediment
- That the developer/ constructor retain a full-time Certified Inspector of Sediment and Erosion Control (CISEC) who has completed and is accredited through the CISEC program. To qualify for admission into the CISEC certification program, applicant must meet the following minimum criteria:
    - 2+ years of construction site field experience involving erosion and sediment
    - Through understanding of erosion and sedimentation process and how they impact the environment
    - Complete understanding of key federal, provincial and local regulations
    - Ability to read and interpret ESC plans
- Complete site inspections by the CISEC certified inspector be completed according to the following frequency:
    - On a weekly basis
    - After every rainfall event
    - After significant snowfall event
    - Daily during extended rain or snowmelt periods
    - During inactive construction periods where the site is left unattended for 30-days or longer, a monthly inspection should be conducted.
- The site inspector shall maintain a inspection log-book (per the Construction Monitoring Program)
- ESC reports be prepared by the CISEC certified inspector for submission to the contractor/ developer in advance of each meetings and that all records be kept for period of 2 year following construction. Reports should details, a minimum of:
    - Site location and boundaries
    - Permitting or approval information
    - Inspector name and qualification

- Ration for inspection (see inspection frequency i.e. weekly, following precipitation etc)
- Observations/ findings relating to the inspection (both positive and negative) including:
  - Written,
  - Annotated ESC plans
  - Photographic using a GIS/ coordinate enabled camera (date stamped)
  - Person(s) informed/ notified of findings and or observations
  - Actions required

- All sediment releases and spills outside the designated control area (development limits) be recorded and reported to the City within 24 hours.
- The acknowledgment that ESC plans are dynamic and require application of the Adaptive Management Approach (AMA) whereby the ESC plan is continually updates as a result of site inspections

5.22 POLICY CONSIDERATIONS

The following section outlines potential policy considerations for integration into the CDP for the Former CFB Rockcliffe. The following policy considerations are for consideration only by City of Ottawa staff.

- It is recommended that as part of development approvals process, monitoring and reporting requirements for developer constructors be clearly outlined in order that municipal and agency staff can be assured that private stormwater measures are properly maintained and functioning.

- All designs shall be submitted within a design brief completed by a Professional Engineer and shall furnish details for the facility owner with respect to ongoing operation and maintenance activities, frequency, responsibility and reporting requirements to the City of Ottawa.

- The proponent shall develop and submit a salt management plan for proposed private permeable pavement parking lots and submit the plan to the City of Ottawa for review and approval as a requirement of approval of the SWM plan. As a condition of approval, the salt management plan must specify that all property maintenance contractors and or staff responsible for the snow removal and or the application of de-icers shall be aware of the salt management plan and the requirement for its implementation.

Design Policies

The following design related policies are suggested for consideration by the City of Ottawa.

- LID design and material specification shall be in accordance with the MOE 2003 SWMPD, TRCA/CVC LID Planning and Design Guide, the Permeable Interlocking Concrete Pavements guide (ICPI, 3rd Edition) and the North American Permeable Interlocking Concrete Pavement Standard (ASCE, Pending).

- The design shall incorporate an overflow connection to the storm sewer (or suitable surface outlet);

- All information shall be submitted within a design brief completed by a Professional Engineer and shall furnish details for the facility owner with respect to ongoing:

    - operation and maintenance activities,
    - frequency,
    - responsibility and
    - reporting requirements to the City.

O&M Report Requirements (Private facilities)

As a component of the SWM plan to support development, it is recommended that the proponent complete and provide a report to the City detailing the maintenance recommendations based on the approved stormwater management BMPs. The report shall include, but is not limited to, the following recommendations:

- Inspection frequency of all structures, apertures and functional design elements (minimum of once annually);

- Sediment removal frequency, technique and equipment;
- Method for the re-stabilization of all disturbed areas;
- Sediments testing protocols and method of disposal (if applicable);
- Effluent sampling protocol (if applicable);
- BMP design life expectancy; and
- Replacement/ refurbishment recommendations/ plans at the conclusion of BMPs life cycle.

The costs associated with the maintenance of the various stormwater management plan elements may vary with the type and size. The proponents shall submit a maintenance program estimate for the duration of the anticipated life-cycle of each element of the proposed BMPs. Sources such as the TRCA/CVC LID Planning and Design Guide (2010) and the STEP (TRCA) Assessment of Life Cycle Costs for Low Impact Development Stormwater Management Practices (2013) or most recent should be consulted when developing life-cycle costs.

Agreements and Acceptance Policies

The following agreements and acceptance policies related policies are suggested for consideration by the City of Ottawa.

- The developer/ constructor agrees to construct required lot level controls (i.e. soakaways etc) and convey related easements to the satisfaction of the City. Further, the developer's consulting engineer will supervise and certify installation prior to occupancy of the affected lot or block to the satisfaction of the city.

Private Facilities (Future phases)

The following policies relating to private SWM and LID facilities in future phases (Phase 1B-3) are suggested for consideration by the City of Ottawa.

For stormwater management facilities designed to service only one property. Note: SWM facility shall include all LID lot-level and conveyance control.

- The land required for the SWM Facility is to be retained by the owner.
- All costs for constructing and maintaining the SWM Facility or structure shall be the responsibility of the owner.
- An easement shall be placed over the private SWM facility, including an easement for access from the nearest vehicular entrance off of the City's right-of-way and extending to the facility, and shall be dedicated to the City. This easement (if required) shall be such that it grants the City with the right-to enter and inspect the facility. The easement shall include access to any controls structure(s).
- Maintenance activity requirements and facility function should be measured against the property specific Environmental Compliance Approval (ECA) as issued and approved by the Ontario Ministry of the Environment.
- An annual report shall be submitted by the property owner to the City verifying that the required maintenance activities as defined with the design brief and ECA has been completed and the facility(ies)

are functional and meeting the designed performance. The City shall reserve the right to inspect all such facility(ies) at its discretion provided 48 hour notice is given prior to inspection.

- Repairs of private facilities by the City shall be considered a last resort, however should repairs or maintenance be required and undertaken by the City, the costs incurred can be collected through an amendment of the existing property standards by-laws to permit collection of incurred costs through property tax collection. This approach has proven effective in many Ontario municipalities in the collection of maintenance costs for private stormwater facilities and in recommended for consideration.

5.23 SWM WORKING GROUP SUMMARY

A SWM Working Group has been formed, consisting of key members of the City of Ottawa, CLC staff, and consultants engaged by CLC.

In the development of this document, the SWM Working Group convened for three (3) meetings:

1. November 7, 2014,
2. December 16, 2014 &
3. February 2, 2015

Topics presented and comments received on:

- Project goals, objectives, scope and purpose
- Suitability and selection of LIDs with Ontario examples
- LID targets
- Typical details
- Anticipated performance
- LIDs for future phases of development
- Construction phasing and Erosion & Sediment Control (ESC)
- Assumption & Operations and Maintenance (O&M) protocols
- Monitoring and Reporting requirements
- CDP implications - Policy considerations

Provided below is a summary of the comments received to date from City of Ottawa staff who participated as a member of the SWM Working Group (Table 49).

Presentations made to the SWM Working Group on November 7, 2014, December 16, 2014 & February 2, 2015 are included as Attachment E.

Table 49 – SWM Working Group Comments Received to Date

Comment	Response
How will snow melt be considered and factored into the effectiveness of LID and modelling results?	Modelling results used full year climate data which includes temperature and converts snowfall into equivalent water depth for inclusion in the water balance
The soil in Ottawa is predominantly clay. How will this impact the effectiveness of LID infiltration?	Infiltration rates of native on-site soils were quantified in Phase 2 (SWM WKG #2) and included in the model. Kfs of 9.5mm/hr and 5.2 mm/hr for Western & Eastern SWS
How will City staff and contractors know where LID (perforated pipes, cisterns) are located when doing lifecycle or emergency infrastructure work in the future?	Piping will be recorded in as-built drawings and included in City archives like all infrastructure. Also, perforated pipes can be traced like other sub-surface infrastructure.
What are the maintenance requirements for bioswales, bioretention and permeable pavers? Will these features be placed on private property so the responsibility will be placed on property owner? If on City property, which department will be responsible for maintenance?	· O&M was presented in SWM Working Group No. 2 · They may be placed on private property with the owners responsible for maintained. · It is unclear at this point which City department will be responsible for maintenance
Re: Operation and Maintenance Issues for LID measures on private property: Three approaches have been discussed in the presented documents. How will potential house buyers be informed of the cost associated with these approaches? Will information be included in the house sales package?	Information packages have been proposed by CLC.
Re: Slide 82 referencing snow operations and sweeping: Note there are Maintenance Quality Standards that have been approved by Council for all City roadway, sidewalks and pathway maintenance, therefore if this is a City owned roadway/sw/pw maintenance including snow removal, clearing and sweeping it is mandated by that document.	Acknowledged and thank-you
Noted in photos are river rock, if in areas where snow is stored and removal occurs this may be a projectile, will this impede drainage. The City does not perform nor have budget for shrub maintenance.	River rock can be substituted with another material or designed to remain in place. The responsibility and cost of vegetation maintenance is something the City hopes to better understand through this process.
Further comment is being sought from staffs who manage operations planning. Not sure re: permeable asphalt if responsibility to maintain/repair is City's - does this differ from the materials we presently use?	We would be interested in hearing the results of these discussions with City Staff
As part of this LID, will the schools or office uses in the employment zones be required/strongly encouraged to construct their parking areas with either permeable interlocking pavers or porous asphalt	Yes, depending on the outcomes of Phase 1A, to achieve the water balance gaols via the targets, all sites will be required/strongly encouraged to implement infiltration based LIDs identified in this study.
Is there opportunity to include a section in the CDP that pertains to parking areas, such that any parking area over x m2 (area to be determined) be required to consider a low impact parking area?	This will be considered, but as it is a pilot project, future requirements cannot be guaranteed.
Could development incentives/reduction in application fees be tied to providing a low impact parking area?	This could be considered. Direction would come from City staff.
The City should review whether the proposed single lot front yard soak-away pits should be the responsibility of private residents or whether the City should have an easement over this infrastructure.	City to review. An easement (if required) has been shown in the typical details

5.24 RECOMMENDATION SUMMARY

The following section provides a summary of the recommendations as presented within the previous sections. Table 50 lists the recommendation and identifies the relevant stage in the development process to which the recommendation applies.

Table 50 – Summary of Recommendations and Associated Development Timing

Recommendation	Relevant Development Stage
Application of the Site Specific Impacts Screening Process (Section 5.10, Table 23)	Detailed Design - of individual blocks or sites.
Seasonally High Groundwater Monitoring for Infiltrating Dry Ponds from April – May or Oct- Nov (Section 5.13)	Detailed Design –for Central, Eastern and Park Dry Ponds.
Groundwater Elevation Monitoring (Section 5.13) As a precautionary measure, groundwater elevation monitoring in areas serviced by private wells such as the Fairhaven community and the Canadian Aviation and Space Museum is recommended before, during and after site development activities	Prior (2015-2016), during and after site development activities
Comprehensive Model Development (Section 5.15 – Scaled Conventional SWM Infrastructure Construction) Canada Lands Company has submitted and is seeking approval of a Draft Plan of Subdivision for the entire Former CFB Rockcliffe site. Since registration of blocks and construction of public infrastructure is to occur on a phased basis, CLC is working with the City to link certain Draft Plan of Subdivision approval conditions to phases when clearance of those conditions will be required. Phases 1A and 1B will be developed and constructed with a conventional SWM system per the MSS. LIDs will be implemented in phased pilot projects per the LID Scoping Document. No SWM credits or deviations from the MSS will be requested from the City of Ottawa prior to Phase 2 registration. This timing will permit the collection of LID performance monitoring data during Phases 1A and 1B, including any Phase 2 SWM and LID infrastructure that may be constructed in advance of Phase 2 registration.	It is recommended that the consolidated model be developed, based in part upon the Phase 1A and 1B monitoring data, in consultation with the SWM Working Group prior to or in conjunction with Phase 2 Registration.
Infiltrating Dry Ponds (section 5.11) The infiltrating Dry Ponds are recommended to be designed such that it attenuates small-event hydrology (i.e. frequent low intensity rainfall) and shall ensure hydroperiods and time of inundation does not impact existing vegetation communities or habitats.	Detailed Design – for Central, Eastern and Park Dry Ponds.

Recommendation	Relevant Development Stage
Earthworks and Soil management (Section 3.1) Consideration of teh general environmental stewardship practices for earthwork and soil management recommended by the American Association of State Highway and Transportation Officials (AASHTO) Center for Environmental Excellence should be considered (AASHTO, 2011). Regarding stockpiling and preserving topsoil the following best practices should be implemented (TRCA, 2012 adapted from AASHTO, 2011)	Development of ESC Plans as part of Detailed Design
SWM techniques maintain and enhance the form and function of existing vegetation communities (Section 3.8) SWM controls be designed as passive stormwater management systems that maintain the hydrologic connection of both surface and groundwater to the identified vegetation and tree communities within and off-site of the Former CFB Rockcliffe CDP site including three (3) significant on-site vegetation communities: 1) North of Dubhe Private at the headwaters of the Western Creek; 2) North of Hemlock Private on both sides of Hurley Crescent; and 3) North of Arcturus Private, east of Burma Road and two (2) UNAs downstream of shallow groundwater system including: 1) the Airbase Woods; and 2) the NRC Woods North.	Detailed Design –for Central, Eastern and Park Dry Ponds as well as the Southwest Channel
Thermal Mitigation/ Waterfowl Management for End-of-Pipe Ponds Using Floating Islands (Section 5.13) For mitigation of thermal impacts to downstream receivers from end-of-pipe facilities is recommended for consideration as part of the LID pilot program.	Consideration by City Staff/ SWM Working Group prior to Detailed Design of the Eastern and Western SWM Facilities.
Recommendations regarding maintenance and enforcement of LIDs on private property. (section 5.22)	For inclusion in Subdivision agreement/ conditions
Visual Inspections (Level 1) for LIDs (Section 5.18) It is recommended that visual inspection be used as the initial assessment tool for all LIDs.	Post Construction
Soil Amendments Assumption Protocol (Section 5.18) It is proposed that verification will be undertaken by City staff or constructor responsibility via engineer to confirm: Amended soil quality; Amended soil depth and Compliance with site grading	During and Post Construction
Soakaway Assumption Protocol (Section 5.18) Per the proposed construction sequencing (see Section 5.20), it is recommended that the constructor's engineer certify the construction of each soakaway pit and related piping connections. The Engineer shall certify the facility footprint, materials, construction methods and will approve backfilled and compaction activities. The engineer shall provide the City with a stamped confirmation letter detailing that the facility was constructed per the design drawings. The City shall inspect the constructed soakaways on complaint basis only.	During and Post Construction
Soakaway Monitoring Program (Section 5.18) Per Table 39, monitoring of a soakaway at a model home and a provisional monitoring location within servicing a community building within a park setting.	Immediately following construction until sale (min 1-2 years)
Soakaway Construction Sequencing (Section 5.20) Per Figure 55, a three (3) stage construction sequence is recommended for the implementation of residential soakaway pits.	Detailed Design (plan development), During and Post Construction (implementation)

Recommendation	Relevant Development Stage
Bioswales, Enhanced Swales, Infiltrating Dry Ponds Construction Sequencing (Section 5.18) It is recommended that specific construction sequencing plans be developed for each individual roadway cross-section and facility type based on the proposed development phasing, other, utility requirements, size of contributing drainage area and the risk of facility failure. Bioswales - Section 5.20) In general, when construction bioswales, the subsurface infrastructure (piping and catch basins etc) may be installed during site servicing, however media placement and planting must occur following stabilization of contributing area or areas to remain off-line (inlets blocked) during major construction activities. Permeable Pavements – Section 5.20) It is recommended that permeable pavement lay-bys within the municipal ROW be constructed in combination with the placement of surface asphalt. Subsurface piping, infrastructure, aggregates, geotextiles and curbing shall be installed during site servicing and roadway construction. Temporary asphalt shall be placed directly over sacrificial geotextiles placed over the specified aggregates until such time as it is removed and replaced with the permeable interlocking concrete pavers and bedding aggregates in coordination with asphalt top coat.	Detailed Design (plan development), During and Post Construction (implementation)
Bioswales, Enhanced Swales, Infiltrating Dry Ponds Construction QA/QC Program (Section 5.18) The above are proposed to include the use of manufactured or engineered infiltration medias (or biomedia), as such a comprehensive during construction quality assurance and verification program is recommended as an integral part of assumption and monitoring protocols.	Detailed Design (plan development), During and Post Construction (implementation)
Overall System Monitoring (Section 5.18) Comprehensive monitoring (Level 5) be competed in regard to the Eastern and Western Creek and the stormwater infrastructure (pipes and ponds).	Eastern and Western Creeks - Existing conditions for min. 1 year (anticipated start 2015 – 2016). Immediately following construction for min. 2 years SWM Infrastructure (pipes and ponds) - Immediately following construction for min. 2 years
During Construction Monitoring (Section 5.18) Per Table 42, during construction monitoring program be undertaken by the developer/ constructor for all LID lot-level and conveyance controls from construction until assumption by the City of Ottawa. The intent of this monitoring is to monitor the LIDs in order to create resource information for the developer/ constructor and the City of Ottawa. All outcome and recommendations are to be summarized in an annual consolidated monitoring report and submitted to the City of Ottawa.	During Construction until Assumption (developer) and Post Assumption (City)
Reporting Requirements (Section 5.18) It is recommended that all monitoring program as detailed in Section 5.18, be included within a consolidated report by the developer/ constructor for submission to the City of Ottawa on an annual basis	Annual starting in 2015-2016

Recommendation	Relevant Development Stage
SWM Working Group/ LID Pilot Committee (Section 5.18) That the Stormwater Working Group be recreated as the Former CFB Rockcliffe LID Pilot Committee. This committee will include City and CLC staff. LID Pilot Committee work collaboratively to develop: · A project charter · Detailed monitoring plan and scope for each monitoring year per the proposed development schedule · Cost sharing arrangement (if relevant) · Annual reporting template and data collection, storage and transfer guidelines.	Immediately starting in 2015
Operation and Maintenance (Section 5.19) Per Table 43, It is recommended that for the Former CFB Rockcliffe that the Hybrid approach for operations and maintenance (a combination of Approach 1 and 2) be adopted. This approach requires that the individual landowner assume all operations and maintenance activities and related costs for the approved LID stormwater management systems within their property limits. For all LID stormwater management systems on municipal lands, the municipality shall assume all operations and maintenance activities and related costs.	For inclusion in Subdivision agreement/ conditions (plan), Post Construction (implementation)
Erosion and Sediment Control (ES&C) (Section 5.21) A hierarchical strategy ESC is recommended in conformance with the CISEC program (Certified Inspector of Erosions and Sediment Control program - www.cisec.org) or equivalent. Recommendations: · All ESC Plans require the placement of topsoil and seed for all areas not schedule for immediate development following site grading (by June 1 of the following year for winter conditions. In addition, it is suggested that "immediate development" be defined as "within 30 days following site grading". · All ESC plans focus of Erosion Control using the Erosion Control BMPs and ECMs listed in Table 48 · All ESC plans implement a multi-barrier approach which begins with erosion controls, followed by sediment controls and avoids reliance on a single control point for sediment · That the developer/ constructor retain a full-time Certified Inspector of Sediment and Erosion Control (CISEC) who has completed and is accredited through the CISEC program.	Detailed Design (plan development), During and Post Construction (implementation)

Recommendation	Relevant Development Stage
Policy Considerations (Section 5.22) Potential policy considerations for integration into the CDP for the Former CFB Rockcliffe for consideration only by City of Ottawa staff: · It is recommended that as part of development approvals process, monitoring and reporting requirements for developer constructors be clearly outlined in order that municipal and agency staff can be assured that private stormwater measures are properly maintained and functioning. · All designs shall be submitted within a design brief completed by a Professional Engineer and shall furnish details for the facility owner with respect to ongoing operation and maintenance activities, frequency, responsibility and reporting requirements to the City of Ottawa. · The proponent shall develop and submit a salt management plan for proposed private permeable pavement parking lots and submit the plan to the City of Ottawa for review and approval as a requirement of approval of the SWM plan. As a condition of approval, the salt management plan must specify that all property maintenance contractors and or staff responsible for the snow removal and or the application of de-icers shall be aware of the salt management plan and the requirement for its implementation.	For inclusion in development approvals process
Design Policy Recommendations (Section 5.22) The following design related policies are suggested for consideration by the City of Ottawa. · LID design and material specification shall be in accordance with the MOE 2003 SWMPD, TRCA/CVC LID Planning and Design Guide, the Permeable Interlocking Concrete Pavements guide (ICPI, 3rd Edition) and the North American Permeable Interlocking Concrete Pavement Standard (ASCE, Pending). · The design shall incorporate an overflow connection to the storm sewer (or suitable surface outlet); · All information shall be submitted within a design brief completed by a Professional Engineer and shall furnish details for the facility owner with respect to ongoing: o operation and maintenance activities, o frequency, o responsibility and o reporting requirements to the City.	Detailed Design
O&M Report Requirements (Private facilities) (Section 5.22) As a component of the SWM plan to support development, it is recommended that the proponent complete and provide a report to the City detailing the maintenance recommendations based on the approved stormwater management BMPs.	For inclusion in development approvals process
Agreements and Acceptance Policies (Section 5.22) The developer/ constructor agrees to construct required lot level controls (i.e. soakaways etc) and convey related easements to the satisfaction of the City. Further, the developer's consulting engineer will supervise and certify installation prior to occupancy of the affected lot or block to the satisfaction of the city.	For inclusion in development approvals process

Recommendation	Relevant Development Stage
Private Facilities (Future phases) (Section 5.22) For stormwater management facilities designed to service only one property. Note: SWM facility shall include all LID lot-level and conveyance control. · The land required for the SWM Facility is to be retained by the owner. · All costs for constructing and maintaining the SWM Facility or structure shall be the responsibility of the owner. · An easement shall be placed over the private SWM facility, including an easement for access from the nearest vehicular entrance off of the City's right-of-way and extending to the facility, and shall be dedicated to the City. This easement (if required) shall be such that it grants the City with the right-to enter and inspect the facility. The easement shall include access to any controls structure(s). · Maintenance activity requirements and facility function should be measured against the property specific Environmental Compliance Approval (ECA) as issued and approved by the Ontario Ministry of the Environment. · An annual report shall be submitted by the property owner to the City verifying that the required maintenance activities as defined with the design brief and ECA has been completed and the facility(ies) are functional and meeting the designed performance. The City shall reserve the right to inspect all such facility(ies) at its discretion provided 48 hour notice is given prior to inspection. · Repairs of private facilities by the City shall be considered a last resort, however should repairs or maintenance be required and undertaken by the City, the costs incurred can be collected through an amendment of the existing property standards by-laws to permit collection of incurred costs through property tax collection. This approach has proven effective in many Ontario municipalities in the collection of maintenance costs for private stormwater facilities and in recommended for consideration.	For inclusion in development approvals process Phase 1B-3

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End-notes

[i] Oversteepening is the principal cause of landslides, whether from natural causes, such as erosion; or by activities such as grading, construction, or diversion of stream flow. Another important factor affecting the stability of slopes in the Ottawa area is the sensitivity of the clay, defined as the ratio of its undisturbed strength to its remoulded strength at the natural water content. It has been suggested that every slope higher than 10 feet or with a grade of 1:4 or more should be examined for stability (Klugman and Chung, 1976).