CREDIT VALLEY CONSERVATION

Columbia Forest

Low Impact Development Infrastructure
Performance and Risk Assessment
May 2016

Monitoring Plan

Residential Lands

CONTENTS

1 PROJECT OVERVIEW

Municipalities across Canada are struggling to address a number of issues ranging from aging infrastructure to insufficient stormwater management, in order to prevent both the degradation of receiving streams and the Great Lakes, and damage to property and infrastructure from erosion and flooding. Low Impact Development (LID) is an innovative approach to stormwater management that can help meet some of these challenges.

The long-term performance of LID is an important consideration and a source of uncertainty for municipalities contemplating the use of green infrastructure. This study focuses on monitoring LID facilities that were installed over a decade ago in order to evaluate the long-term performance of Low Impact Development facilities relative to the following factors:

1) **Determine whether soakaway pits and infiltration galleries continue to perform as designed in terms of amount and rate of infiltration**

2) **Monitor water quality in effluent from stormwater management facility, representing the water quality performance of the treatment train**

3) **Monitor chloride concentrations in water leaving the study area,**

2 BACKGROUND

Our communities are supported by functions provided by our environment such as abundant, safe drinking water, and clean air. We need to integrate development of our communities with management of stormwater to support a sustainable environment. This approach is known as Low Impact Development (LID). Columbia Forest was designed with LID measures such as lot-level soakaway pits, and infiltration galleries, as well as a stormwater management facility designed as a wetland to reduce the impact of the subdivision on the environment by striving to maintain infiltration levels closer to the pre-development hydrology.

Since LID attempts to mimic natural processes, its performance depends on local conditions including climate, soils, and drainage. Individual LID measures should be examined with respect to basic hydrological cycle components including; evapotranspiration, infiltration, and runoff. Stormwater infiltration occurs on natural soils with pervious cover and at special facilities (infiltration galleries and soakaway pits) located throughout the catchment area. Long-term sustainable infiltration depends on soil cover, soils, hydrology, risk of clogging of infiltration sites, and infiltration facility maintenance. The process of maintaining the post-development water balance as close to the natural state as possible also supports the enhancement of runoff quality and the ecological integrity of receiving streams.

Development of rural areas results in increased impervious area as soil cover is replaced with roads and rooftops, and as a result infiltration is reduced and the natural hydrologic cycle is altered. This has numerous negative effects on receiving waterways, such as erosion, pollution, higher peak flows and reduced baseflow, as well as reduced groundwater recharge. Based on the Laurel Creek Watershed Study one of the guidelines outlined was that new developments in the watershed should be designed to try to match the pre-development infiltration rates, to help sustain and protect water resources. In the Columbia Forest subdivisions, LID features (infiltration galleries and soakaway pits) were designed to accept water from roadways and rooftops in order to acheive this goal. To help preserve water quality for groundwater recharge, pre-treatment is required for all infiltration facilities receiving water directly from roads in the Columbia Forest Subdivisions. In addition, the Environmentally Sensitive Protected Areas (ESPA) and related 10m buffers are preserved to provide some natural greenspace.

LID is a relatively new approach and one of the priority questions for many stakeholders is associated with the long-term performance and life cycle costs. Since the Columbia Forest subdivisions were developed over a decade ago, monitoring at these sites provides an opportunity to answer some of these questions related to long-term performance of LID. The new results on the ongoing performance of stormwater management facilities in Columbia Forest will be compared to results from the original monitoring activities that were conducted by consultants. To our knowledge, no additional monitoring or maintenance of the LID facilities has been conducted by the City of Waterloo since the subdivisions were assumed.

3 MONITORING OBJECTIVES AND TARGETS

The primary purpose of the proposed monitoring for these LID facilities is to evaluate their long-term performance. Therefore it is important to maintain consistency with past monitoring efforts conducted at this site. The original monitoring of the Columbia Forest subdivisions was conducted by consultants hired by the developers. They conducted baseline monitoring before the development, construction monitoring during the development, and short-term performance monitoring immediately after development was complete. The following objectives and targets for the LID practices in Columbia Forest are consistent with the original objectives and targets as specified by the consultants responsible for the immediate post-development monitoring. In addition, a new research objective related to the potential for contamination of groundwater by road salt has been added. Keeping the objectives and targets mostly consistent between previous and present monitoring efforts facilitates comparison between current results and those from old monitoring reports; however the current monitoring plan will be more comprehensive.

Original Water Quantity and Quality Targets and Monitoring Objectives:

A. Water Quantity Monitoring Objective

i. Determine infiltration rates in LID practices and estimate outflows from the study area relative to performance targets and previous monitoring results

a. Water Quantity Targets

1. Infiltrate first 20 mm of runoff from all rooftops

2. Match pre-development average infiltration of 221 mm/yr for Columbia Forest 1, and 192mm/yr for Columbia Forest 2.

B. Water Quality Monitoring Objectives

i. Monitor water quality of discharge from stormwater management facilities and assess ability to meet *Laurel Creek Watershed Study* performance targets.

b. Water Quality Targets

1. *Laurel Creek Watershed Study* water quality targets. Since these are in-stream targets with the exception of TSS, they are intended for comparison, rather than to determine strict compliance.

   - Temperature:
     - Cold Water Streams : <22°C from April 1 to Oct 31/ 4-14°C from November to March 31
     - Warm Water Streams: <26 °C from June 1 to August 1/<29°C from August 1 to October 31
   - Phosphorous: Upstream of Laurel Reservoir (<0.03 mg/L), Downstream of Laurel Reservoir (0.05-0.08 mg/L)

- Total Suspended Sediment: Stormwater management facility target: 25 mg/L

ii. Determine potential for contamination to surface water and groundwater recharge areas by road salt by continuous monitoring of conductivity within infiltration galleries and the effluent from stormwater management facilities.

4 STUDY AREA

The study site consists of two residential and mixed-use subdivisions developed in the late 1990s and early 2000s in a residential neighbourhood near Erbsville Rd., in Waterloo, Ontario. The first development, Columbia Forest 1 was developed between 1996 and 2003, while the second, Columbia Forest 2 was developed a couple years later, starting in 1999. The infiltration gallery for Columbia Forest 1 was brought online in 2006. The developed area was previously agricultural land. The Columbia Forest 1 subdivision is approximately 29 ha and is located in Subwatersheds 313 and 309, while Columbia Forest 2 is significantly larger at 61 ha and is located mainly in Subwatershed 309, but also parts of 310, 313, and 308. Columbia Forest 1 drains to the North Branch of Clair Creek, which is a tributary of Laurel Creek .

The soils underlying Columbia Forest 1 are predominantly silt and sand with average percolation rates of 30mm/hr. Columbia Forest 2 soils have been identified as Waterloo series soils (Hydrologic Soil Class B which can range in saturated hydraulic conductivity from 1.4-14.4 mm/hr). Both subdivisions consist of approximately 50% impervious area, with Columbia Forest 2 having a slightly greater imperviousness with 54% impervious area. The study area has also been identified as being located within a recharge area for groundwater in the Laurel Creek Watershed Study.

Each subdivision is served by stormwater management facilities designed as wetlands. The drainage area for the Columbia Forest 1 wetland is 53 ha, and it has a surface area of 19,484m^2. The wetland for Columbia forest 2 drains an area of 81 ha, and has a surface area of 25,816m^2. The wetland for Columbia Forest 2 drains into Wideman Tributary, but there is also drainage from the subdivision to a ditch at Erbsville Rd. and overland to an ESPA, as well as a tributary to Subwatershed 308.

5 LID INITIATIVES IN COLUMBIA FOREST SUBDIVISIONS

A significant groundwater recharge area is located in Subwatershed 313, and maintainenance of pre-development infiltration rates is required to sustain this groundwater resource. These rates will be maintained by a combination of LID practices; soakaway pits and infiltration galleries. The required pre-treatment to prevent contamination of groundwater by road runoff is provided by Stormceptor oil and grit separator (OGS) units. Since not all of the runoff can be infiltrated, stormwater management facilities designed as wetlands are used to provide detention control for all flows not infiltrated across the sites. Some variations in dimensions, location and details of facilities between the different subdivisions Columbia Forest 1, and 2 monitoring sites are selected based on feasibility as determined during field visits.

CF1 Subdivision:

- Two **infiltration galleries** with OGS pre-treatment are located within the development in park blocks 51, and 55. These facilities connect to the storm sewers and consist of a series of perforated pipes releasing water to a gallery of 50mm diameter clear stone, with no pipe outlet. There is a monitoring well installed within the trench. During the winter months these galleries are disconnected from the storm sewer system using the shut off valve in order to prevent contamination of the groundwater from road salt. Figure 1 shows the design for the gallery in block 51, including the position of the monitoring well.

CF2 Subdivision:

- Three **infiltration galleries** with OGS pre-treatment are located within the development, in the park blocks 27, 62, and 64. These facilities are filled with 40mm clear stone.

Both **Subdivisions**:

- All rooftops drain to lot-level **Soakaway pits,** which are underground storage areas that allow roof runoff to infiltrate into the ground. Roof leaders and foundation drains connect directly to a perforated pipe located in a stone filled trench, with 50mm diameter clear stone. These facilities are located in the road right of way, between the lot line and the curb to allow for maintenance access, and have monitoring wells installed in the pits. Because roof runoff is deemed relatively clean, no pre-treatment is required.

- The **SWM facilities** are designed as wetlands.

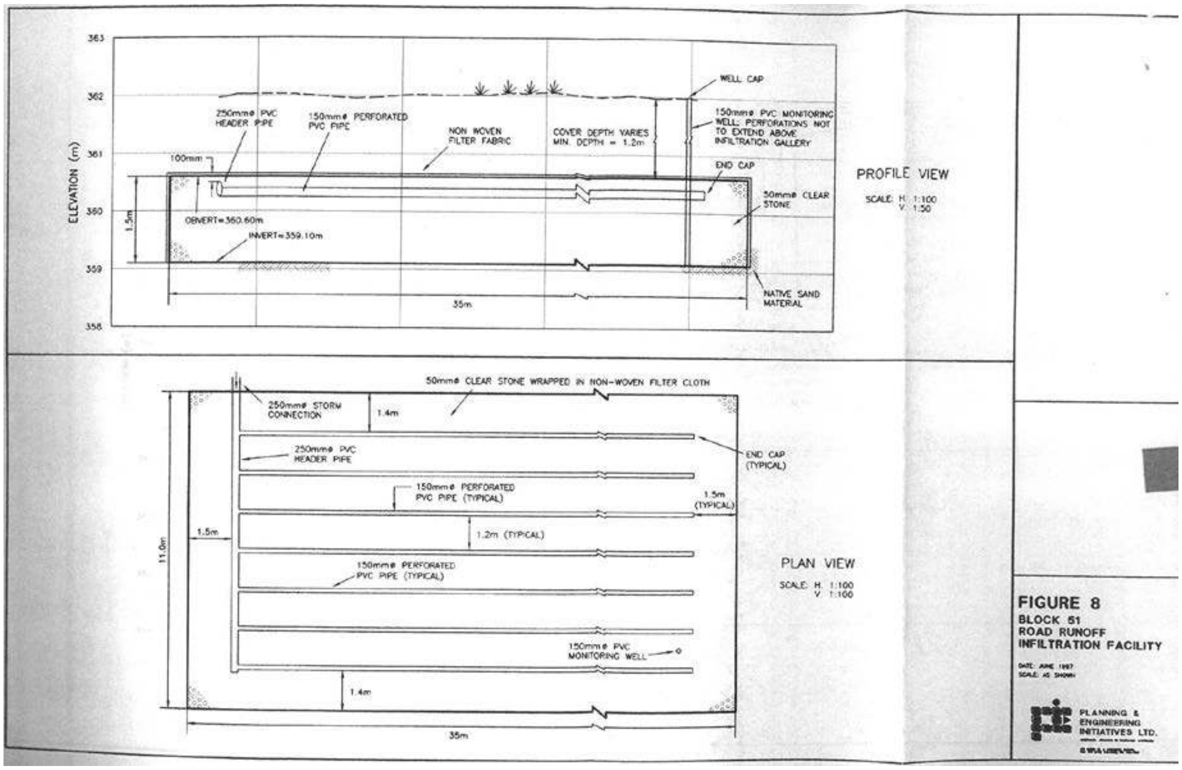

Figure 1 Infiltration gallery design from Planning & Engineering Initiatives Ltd. (1997). ***Final Stormwater Management Report Columbia Forest 1: City of Waterloo.***

6 PROPOSED MONITORING ACTIVITIES

Since the primary objective of this study is to compare current performance of stormwater management features to their performance at the time of development, it is necessary that the new monitoring initiative incorporates aspects of the original monitoring done when the subdivision was first developed. This will facilitate comparison with the results of the previous monitoring study.

A. Stormwater management facilities:

I. Monitoring will be performed at pond 45, which is the stormwater management facility for Columbia Forest 1
   i. Continue inspections, monitoring, and maintenance as per consultants' recommendations, to the degree practicable. The original monitoring program included:
      1. *Yearly pond inspection to assess maintenance needs.*
      2. *TSS, Temperature, flow measured at the outlet 3 times/ year and after rain events >15mm.*

II. To provide a more complete understanding of the stormwater management facility's present-day performance, the following additional monitoring activities will be performed:
   i. Inlets:
      a. During the site visit, it was determined that the inlets to pond 45 are not feasible for flow monitoring, due to being partially submerged.
      b. Grab samples can be taken for water quality, to compare to the outlets.
   ii. Outlets
      a. Instrument outlets for continuous flow monitoring, using ISCO Area-Velocity Flow Modules.
      b. Use loggers to continuously record temperature and conductivity at the outlets.
      c. Use autosamplers to facilitate event sampling, for events >15mm. In this study, distinct rain events will be defined as separated by a period of 6 hours with no rain or flow. These can be connected to the ISCO Flow Module to be triggered by increases in flow at the outlet. Refer to Figure 2 for an example of this setup.

B. Infiltration galleries:

a. Continue inspections, monitoring, and maintenance as per consultants' recommendations at all infiltration galleries to the degree practicable. The original monitoring program included:

a. Regular inspection

b. Depth measurement 3-4 times per year immediately after significant rainfall events (>15mm) as well as again 3 days later (gallery not functioning properly if water has not drained 3-4 days after storm, or if it fails to fill, facility may need to be dug up and replaced).

c. Spring/Fall visits to open/close valves (valves should be closed during the winter to prevent contamination by salt)

d. Stormceptor facilities inspection conducted annually—conduct when valve is closed for infiltration gallery so cleanout can be conducted before next season

- *Cleanout required when sediment depths reach 300mm*

b. Monitoring well in Forest Hill Park infiltration gallery will be instrumented for continuous water level, temperature and conductivity measurements

C. Soakaway Pits:

a. Continue inspections, monitoring, and maintenance as per consultants' recommendations, to the degree practicable. The original monitoring program included:

a. Regular inspections (5% of lots inspected each year, rotating)

b. Depth measurement 3-4 times per year and immediately after significant rainfall events (>15mm) as well as again 3 days later

c. Sediment removal performed if drainage time >4days

b. Water level loggers (no conductivity necessary) installed in a small number of soakaway pits to assess performance, inlet flows could be estimated based on roof area and rainfall depths to get an estimate of volumes infiltrated

Figure 2: Monitoring setup showing the ISCO Area-Velocity Flow Module and an autosampler

7 MONITORING OBJECTIVES MET

Each portion of the monitoring plan relates to meeting different aspects of the original monitoring objectives:

I. Water quality and quantity sampling at the outlets of the stormwater management facility will determine whether the treatment train as a whole continues to meet performance targets after more than a decade.

II. Inspections and water level measurements will determine whether the infiltration galleries and soakaway pits are functional and when they should be replaced.

III. The use of conductivity loggers in the infiltration galleries and at the outlet of the stormwater management facility will determine potential for groundwater and surface water contamination by road salt from water leaving the infiltration galleries and stormwater management facility.

IV. Continuous water level loggers in the infiltration galleries and soakaway pits will determine infiltration rates that can be compared with the original targets. They will also help to help characterize the long-term performance.

8 REFERENCES

Grand River Conservation Authority (1993). *Laurel Creek Watershed Study – Technical Appendix TA4: Hydrogeology.*

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