

**Functional Servicing Report for
1888 Gordon Street, Guelph,
ON**



Prepared for:
Tricar Developments Inc.

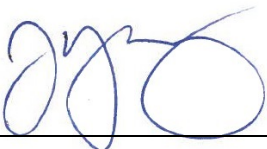
Prepared by:
Stantec Consulting Ltd.
100-300 Hagey Boulevard
Waterloo, ON, N2L 0A4
Tel: (519) 579-4410
Fax: (519) 579-6733

1614-01285

January 10, 2017

Sign-off Sheet

This document entitled Functional Servicing Report for 1888 Gordon Street, Guelph, ON was prepared by Stantec Consulting Ltd. ("Stantec") for the account of Tricar Development Inc. (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by  _____
(signature)

Jennifer Young, P. Eng. Senior Water Resources Engineer



Reviewed by _____
(signature)

Chris Hendriksen, P.Eng.

FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Introduction and Background
January 10, 2017

Table of Contents

1.0	INTRODUCTION AND BACKGROUND	1.2
1.1	OVERVIEW.....	1.2
1.2	BACKGROUND INFORMATION	1.3
1.3	EXISTING INFRASTRUCTURE	1.3
2.0	OVERALL GRADING AND DRAINAGE.....	2.1
2.1	DESIGN CONSTRAINTS AND PROCEDURES	2.1
2.2	PROPOSED ROAD PROFILES AND OVERALL SITE GRADING.....	2.2
3.0	SANITARY SERVICING.....	3.1
4.0	WATER DISTRIBUTION	4.2
5.0	STORMWATER DRAINAGE.....	5.1
6.0	STORMWATER MANAGEMENT FACILITIES.....	6.1
6.1	DESIGN CRITERIA.....	6.1
6.1.1	STUDY APPROACH	6.1
6.1.2	DESIGN CRITERIA	6.1
6.2	EXISTING CONDITIONS	6.1
6.2.1	Topography and Surface Drainage	6.1
6.2.2	Geotechnical Information	6.2
6.3	PROPOSED STORMWATER MANAGEMENT DESIGN.....	6.3
6.4	INFILTRATION GALLERY.....	6.3
6.4.1	Green Infrastructure Water Balance Design Spreadsheet.....	6.4
6.4.2	Sizing.....	6.5
6.4.3	Results.....	6.6
6.5	WATER QUALITY AND OVERALL SITE MONTHLY INFILTRATION AND GROUNDWATER WATER BALANCE	6.8
7.0	EROSION AND SEDIMENT CONTROL PLAN.....	7.1
7.1	STUDY APPROACH.....	7.1
7.2	EROSION AND SEDIMENT CONTROL PLAN	7.1
8.0	MONITORING, MAINTENANCE, AND MITIGATION PROGRAM.....	8.1
8.1	STORMWATER MANAGEMENT FACILITY	8.1
9.0	CONCLUSIONS AND RECOMMENDATIONS.....	9.1

LIST OF APPENDICES

Appendix A – Preliminary Servicing and Grading Plans
Appendix B – Design Sheets
Appendix C – Stormwater Management Design



FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Introduction and Background

January 10, 2017

1.0 INTRODUCTION AND BACKGROUND

1.1 OVERVIEW

This Functional Servicing Report has been prepared in support of the Zoning and Official Plan amendment and the Site Plan Application for the proposed development located at 1858 & 1888 Gordon Street (Site) in the City of Guelph (City). The subject property is approximately 3.2 ha in size, and is bounded to the northwest by Brock Road Nursery, to the northeast by former open space (now in the process of being converted to residential subdivision), to the southwest by a combination of agricultural lands and rural residential properties, and to the southwest by Gordon Street. The site location is shown on Figure 1.0.

The conceptual site plan for the proposed development that forms the basis of this servicing assessment includes a mix of development styles with two 14 story apartment buildings joined by a central, single storey pool and amenity building, one 10 storey standalone apartment building and two 4 storey apartment buildings (or townhouse units in their place), outdoor amenity space and roadways. The bulk of site parking will be achieved through underground and at/above grade enclosed parking. For the purposes of this report, a site density of 175 units per hectare has been used with an estimated mix of 485 apartments and 75 townhouse units.

This report outlines how the proposed development can be supplied with adequate services, including sanitary, domestic water, storm drainage and includes the preliminary design of the infiltration and water quality facilities proposed to provide the required water quality and quantity controls and the preliminary erosion and sediment control strategy to be implemented during construction.

FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Introduction and Background

January 10, 2017

1.2 BACKGROUND INFORMATION

A variety of sources have been referenced during the preparation of this report, and the following should be read in conjunction with this Report:

- *Hydrogeological Assessment, 1888 Gordon Street, City of Guelph, Ontario* (Stantec, October 2016)
- *Geotechnical Engineering Report, Residential Development, 1888 Gordon Street, Guelph, Ontario* (LVM, January 2014)
- *Low Impact Development Stormwater Management Planning and Design Guide* (Credit Valley Conservation Authority and Toronto and Region Conservation Authority, 2010)
- *Erosion & Sediment Control Guideline for Urban Construction*, (Greater Golden Horseshoe Area Conservation Authorities, December 2006)
- *Stormwater Management Planning and Design Manual (SWMPD Manual)*, (Ontario Ministry of the Environment, March 2003)
- *Clair-Gordon Sanitary Sewer Capacity Study - Civica*

1.3 EXISTING INFRASTRUCTURE

A summary of the municipal infrastructure that currently exists near the Site is as follows:

- A 200mm sanitary sewer located on Poppy Drive.
- A 400mm watermain on Gordon Street and 150mm watermain on Poppy Drive.
- A 675mm storm sewer on Poppy Drive.

Fully constructed municipal roads include Gordon Street to the west and Poppy Drive to the north

2.0 OVERALL GRADING AND DRAINAGE

2.1 DESIGN CONSTRAINTS AND PROCEDURES

Using existing topographic information provided by Callon Dietz, the proposed Site grading will be design to generally meet the following criteria:

- Match existing grades all site boundaries.
- Match existing grades at existing tree driplines wherever possible to facilitate tree retention.
- Match into existing road grades of Gordon Street and Poppy Drive.
- Account for future urbanization of adjacent lands.
- Have consideration for future pedestrian connections north of the site towards Poppy Drive.
- Provide adequate cover over underground services.
- Ensure all building openings are protected from flooding.
- Comply with Municipal standards for minimum and maximum grades.
- Ensure grades accommodate the seasonally high ground water level to allow for 0.5m elevation separation from the underside of house foundations.
- Provide major overland flow routes for flows exceeding the storm sewer capacity.
- Maintain drainage from Gordon Street right-of-way and neighbouring properties to the south.

Considering the results of the EIS and Hydrogeological investigation, we propose the existing low depression on the site adjacent to Gordon Street will be filled for development purposes. Existing drainage to this area from the adjacent property to the south and from the west half of the Gordon Street right-of-way will be maintained and accommodated with the proposed Site grading and servicing.

2.2 PROPOSED ROAD PROFILES AND OVERALL SITE GRADING

Road profiles within the subject site were established based on the proposed street pattern to satisfy the constraints outlined in the previous Section 2.1. The road profiles have been designed to accommodate the constraints set out by the site layout and underground parking limits with grades ranging from 0.5% to 6.0% with 3:1 and 4:1 transition slopes or retaining walls utilized to accommodate the various grade changes within the proposed subdivision and at various perimeter locations. The proposed centerline road elevations and lot grades are illustrated on the Preliminary Grading plan (Drawing No. C-400) included in Appendix A. Existing grades and cross sections of Gordon Street and Poppy Drive have been considered fixed constraints in the development of the preliminary grading. Internal roads, consisting of 6.7m wide asphalt, will be constructed to the applicable City of Guelph and Ontario Building Code standards.

FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Sanitary Servicing
January 10, 2017

3.0 SANITARY SERVICING

The City of Guelph undertook a sanitary sewer capacity review for the Clair-Gordon service area which identified flow control requirements for various developments, including this Site, to mitigate effects of surcharging on existing downstream sewers. The *Clair-Gordon Sanitary Sewer Servicing Capacity Review prepared by Civica* was referenced in the development of the sanitary servicing strategy for the Site.

Identified in the Civica report is area 12 which the Site is part of. Area 12 is 6.90 ha in size with an assigned unit count of 556 and population of 1340. The proposed storage system to address this development area has the following characteristics:

- Peak controlled flow – 20.2 L/s
- Pipe length – 100m
- Pipe size – 1800 x 900 mm
- Pipe slope – 0.5%
- Orifice Diameter – 90 mm
- Storage – 152 m³

The total population of the Site is summarized in the following table.

Unit Type	Number of Units	People per Unit	Population
Apartment	485	1.6	776
Townhouse	75	2.4	180
Total	560		956

This flow control system suggested by the Civica report is to be located upstream of the connection to the Poppy Drive sewer in the access to Poppy Drive as shown on the Preliminary Servicing plan (Drawing No. C-100).

Based on a Site area of 3.193 ha and a proposed population of 956, the peak flow generated from the Site is 11.415 L/s using the population calculated above, including infiltration (refer to design sheet calculations in Appendix B). The Civica report assumed a much higher flow generation based on 6.0 L/s/ha for this type of development which roughly doubles the flow generated from the site. The requirement for the flow control structure should be reviewed further.



FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Water Distribution
January 10, 2017

200 mm, 250 mm and 300 mm diameter sanitary sewers are anticipated throughout the Site to provide service to each building in accordance with the requirements of the Ontario Building Code. The sanitary design utilizes one outlet on Poppy Drive East.

4.0 WATER DISTRIBUTION

The existing water distribution system near the Site includes a 400mm watermain on Gordon Street and a 150mm watermain on Poppy Drive. The primary source for the proposed development will be the Gordon Street watermain with a secondary connection to the Poppy Drive watermain to create a looped system. It is anticipated that the following connections to the existing municipal infrastructure will be made:

- Tapping sleeve and valve connection to the 400mm Gordon Street watermain (200mm connection).
- 150mm mechanical joint connection to the 150mm Poppy Drive watermain.

Please refer to the Preliminary Servicing plan (Drawing No. C-100) for an illustration of the watermain layout.

Based on building information currently available, a conservative fire flow requirement for the site is 150 L/s, based on typical OBC calculations as provided in Appendix B.

A 200 mm diameter watermain is proposed for the development with 150mm connections provided to each building. They are positioned as illustrated on the Preliminary Servicing plan (Drawing No. C-100).

Fire protection will be provided via onsite hydrants, adequately spaced to ensure proper coverage to all buildings, in conjunction with standpipe connections for building sprinkler systems. The City of Guelph will confirm the pipe sizing proposed provides adequate pressure to meet MOE design criteria. No backflow prevention or pressure reducing valves (PRV) have been proposed for this development.

FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Stormwater Drainage
January 10, 2017

5.0 STORMWATER DRAINAGE

Storm drainage for the Development will discharge to two onsite infiltration facilities. These facilities have been designed to accommodate the flow within the Development for the ultimate build out. Please refer to the Preliminary Servicing Plan, Drawing No. C-100, included in the Appendix A for an illustration of the storm layout. For further details of the SWM Facility design refer to applicable section within this report.

The proposed storm sewer system is designed to convey all minor storm events or those less than 5-year return-period for the majority of the development, as per the City of Guelph standards. As part of the Engineering Design rational pipe sizing was completed and submitted to the City. The conveyance system for major flow events or those greater than a 5-year return-period frequency will be confined to the road right-of-ways and generally mimics the direction of the minor system. Major flows are directed to the surface of the infiltration facilities where ponding and a lawn catch basin will be provided to ensure the major events are captured by the facility.

6.0 STORMWATER MANAGEMENT FACILITIES

6.1 DESIGN CRITERIA

6.1.1 STUDY APPROACH

The objective of this SWM Plan is to ensure that the proposed development includes the necessary controls to protect the hydrology and water quality of the receiving water systems, primarily through adherence to SWM targets. This approach involved the following study components:

- Prepare green infrastructure water balance design spreadsheets for the proposed development to complete the preliminary design of infiltration facilities that will infiltrate up to the 100-year runoff for the whole site
- Assess infiltration potential for the site
- Summarize the study by identifying conclusions and recommendations

6.1.2 DESIGN CRITERIA

SWM criteria were established based on the *Hanlon Creek Watershed Study*, and the characteristics of the receiving systems. The SWM criteria applied to the site are as follows:

- Water Quantity – Control post-development peak flows to pre-development flow rates
- Infiltration – Infiltrate all flows up to the 100-year event
- Erosion and Sediment Control – Provide appropriate erosion and sediment control during construction to protect neighboring properties and the downstream receivers from potential siltation

6.2 EXISTING CONDITIONS

6.2.1 Topography and Surface Drainage

The ground surface of the site is moderately rolling with elevations ranging between approximately 343.5 m and 351.5 m AMSL (above mean sea level). The terrain generally slopes from the north west to a pond located across the property line, with a portion of the site draining to a small onsite wetland area located near the southeastern corner of the Site as shown on Figure 2.0.

The existing site is an existing single family residential use with grassed area with occasional trees located throughout the site.



FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Stormwater Management Facilities

January 10, 2017

6.2.2 Geotechnical Information

The *Geotechnical Engineering Report* (LVM, 2014) describes the site soils as comprised of topsoil overlying layers of silt, sand and gravel materials over clayey silt till at a depth of over 11 metres. The groundwater table documented in the Geotechnical Investigation ranges between elevations of 334.15 m and 340.4 m with some boreholes not encountering groundwater before termination.

The *Hydrogeological Assessment* (Stantec, 2015) noted that groundwater flow is westerly towards the Speed river, and:

1. Geological conditions beneath the onsite wetland and throughout the Site consist predominantly of ice-contact stratified deposits of silty sand and gravel to sandy gravelly silt that extend from the existing grade to the termination depth of onsite boreholes (i.e., from 5.0 to 14.2 m BGS).
2. Water levels near the onsite wetland in April were at approximately 345.1 m ASL.
3. Water levels within the onsite wetland are largely controlled by the positioning of the water table. The water table drops below the wetland substrate in the early spring, followed by a continued decline into the summer, resulting in the loss of a direct hydraulic connection between the wetland and the shallow groundwater system (i.e., does not receive groundwater inputs from the surrounding landscape).
4. The Site lies within the boundaries of the Paris Moraine that is understood to act as an area of groundwater recharge. Weak downward vertical hydraulic gradients (i.e., recharge condition) are present beneath the onsite wetland, which is in agreement with regional groundwater recharge mapping presented by the GRCA (2001). As such, the onsite wetland is not a groundwater discharge feature.
5. Over the monitoring period, the nearby Halls Pond PSW Complex maintained a connection to the water table, whereas the onsite wetland lost its direct hydraulic connection to the shallow groundwater system (i.e., local water table dropped and remained below the wetland substrate), suggesting that no hydrogeological interaction likely occurs between these two wetland features.
6. The onsite wetland covers approximately 2.5% of the Site area (0.076 ha of 3.1 ha). Consequently, it is reasonable to conclude that the loss of recharge function associated with the onsite wetland, if removed, will not detrimentally impact the overall groundwater recharge function provided by the Site.

Looking at the groundwater information for both studies, it was decided to assume that 345 m ASL was a reasonable estimate of the groundwater for the design of the infiltration facilities, as it represents a seasonably high groundwater table and is higher than any other monitored levels. Further groundwater monitoring should be completed in the locations of the proposed infiltration facilities to confirm that this assumption prior to construction of the facility. It is recommended that monitoring commence as soon as possible to ensure the seasonably high groundwater table at each location is adequately captured.



6.3 PROPOSED STORMWATER MANAGEMENT DESIGN

The site has several unique features and constraints, and as such, a creative stormwater approach has been taken to use a treatment train system and Low Impact Development (LID) techniques. These technologies must be looked at as a collective to fully understand the approach.

As this site is located on the Paris Moraine, the proposed scheme attempts to mimic the existing drainage patterns and infiltration while respecting the flood requirements. The site has both internal and external drainage to small wetland depressions. Groundwater was observed during geotechnical investigations, and should be confirmed at the location of the proposed infiltration galleries prior to construction. As per the attached drawing, the proposed stormwater management scheme consists of the following elements:

- Infiltration of all water will occur in two infiltration galleries located on site. The infiltration galleries will be approximately 1 m below grade with a trench depth of 2 m (2 m of active retention). Road runoff will be treated via a Stormceptor prior to infiltration to ensure the facilities do not silt up. Infiltration galleries have been located in areas where underground parking is absent. Details on the sizing and dimensions of the infiltration galleries is provided in Section 4.3 below.
- The infiltration galleries have been sized to provide for up to the 100-year storm, with an overland flow route for the regional flows to the North West to Poppy Drive East. The infiltration facilities are designed to overflow during the Regional storm to allow overland flow off the site.
- Ponding areas and swales with amended soils have been identified for pervious surfaces that do not have positive drainage to the infiltration galleries. These areas will pond during larger events allowing the runoff to infiltrate into the ground.

As discussed previously, the proposed development consists of a mix of park area, roadways, and multiple family residential lots/blocks. The site was modelled as one catchment. The site is 3.2 ha and conditions generally consist of the following:

- **Predevelopment** – Encompasses the entire area of the site. Water drains uncontrolled across the pervious areas following the topography of the site. The site is 5% impervious, including the existing residence, driveway, and ancillary buildings.
- **Post-Development** – Encompasses the entire area of the site. Runoff from the development is directed to LID facilities. The site is 63% impervious.

6.4 INFILTRATION GALLERY

A green infrastructure water balance design spreadsheet was used to determine the runoff and infiltration for the site for the pre- and post-development conditions to size the infiltration galleries to infiltrate the 100-year event. The 25 mm 4-hour water quality storm event as also modeled to ensure the galleries meet the water quality storage volumes required in the *SWMPD Manual* (MOE, 2003). The 2-, 5-, and 25-year 3-hour Chicago events and 48-hour Hurricane Hazel event

FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Stormwater Management Facilities
January 10, 2017

were then run to determine how the infiltration galleries perform during high flow events and provide adequate infiltration.

The water quality storage volume required for enhance water quality are shown in the table below.

Table 1: Water Quality Storage Volumes

Location	Tributary Area (ha)	Water Quality Volume Required (m ³ /ha)	Water Quality Volume Required (m ³)
Site	3.2	33	105
Water quality volume calculated as per Table 3.2 of the MOE <i>Stormwater Management Planning and Design Manual</i> for infiltration (2003) using 63% imperviousness			

6.4.1 Green Infrastructure Water Balance Design Spreadsheet

The green infrastructure water balance design spreadsheet used for this analysis tracks the volume of water in each part of the system (runoff, rock trench conditions, and groundwater) during each time-step for the infiltration gallery, swales and the remaining pervious area on site. The water balance spreadsheet uses the rainfall, soil characteristics, and drainage areas to calculate the volume of water for each of the following, for every time-step:

Table 2: Design Spreadsheet Parameters

Amended Soil	Infiltration Gallery	Lawns
<ul style="list-style-type: none"> • Rain water into swale; • Rain into Ponding; • Beginning of time-step Ponding Volume; • Volume out of Ponding; • Unsaturated runoff; • Rain into amended soil; • Beginning of time-step amended soil water volume (initial value is set to field capacity); • Water from amended soil to ground water; • Water that does not exfiltrate; • Water that stays in the amended soil; • Saturated runoff into Ponding; • Total runoff; and 	<ul style="list-style-type: none"> • Rain water directly to trench; • Beginning of time-step trench water volume; • Trench exfiltration; and • Trench underdrain flow 	<ul style="list-style-type: none"> • Rain water onto lawn; • Unsaturated runoff; • Rain into soil; • Beginning of time-step soil water volume (initial value is set to field capacity); • Water from soil to ground water; • Water that does not exfiltrate; • Water that stays in the soil; • Saturated runoff; • Total runoff; and • Evaporation from soil

FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Stormwater Management Facilities
January 10, 2017

Amended Soil	Infiltration Gallery	Lawns
<ul style="list-style-type: none"> Evaporation from soil 		

No initial abstractions or losses other than infiltration were assumed during the analysis of the scenarios. The initial condition of the amended soil water content was set to field capacity to represent a 'wet start' for the soil. It is expected that dry soils would have an increased capacity for capture above that shown in this analysis.

The volumes in each portion of the system are summed to give a total volume of water each component sees. For example, the total volume of drain flow for each time step is summed to determine the total volume of drain flow.

Amended soils are a special soil mix which is topsoil with additional materials added to increase infiltration and capture. Typically, amended soils are sandier than topsoil and the amendment changes the typical soil characteristics such as porosity, field capacity, wilting point, and infiltration rate. Table 3 below shows the soil characteristics for both topsoil and amended soil.

Table 3: Typical Soil Characteristics

Soil Characteristic	Typical Topsoil ¹	Amended Soil ²
Porosity	0.35	0.53
Field Capacity	0.15	0.32
Wilting Point	0.10	0.13
Infiltration rate (mm/hr)	1.5-3.5*	30-70*
*This infiltration rate assumes mature lawns with well-established grass, bare topsoil rates may differ ¹ Typical values for sandy-loam, loam soils adapted from the BC Agricultural, Food, and Fisheries Ministry ² Typical amended soil values as determined by soil testing for the standard amended soil mixes used in B.C., TRCA, and Markham		

6.4.2 Sizing

The post-development conditions assumed the roof of the buildings were directly connected to the infiltration galleries.

The site has a moderately high groundwater table and groundwater is approximately 4 meters (345 m ASL) below ground. The soils on site are well draining with an infiltration rate of approximately 50 mm/hr.

The site was divided into four drainage areas for the calculations:



FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Stormwater Management Facilities
January 10, 2017

- Swales and ponding areas with amended soil: These areas include the swales and ponding areas and all pervious areas draining to them.
- Central infiltration gallery: this area includes the proposed building roofs for the five central buildings including the proposed townhome buildings.
- North infiltration gallery: this area includes the remaining building roof (Building 3) and the all the site roads and sidewalks. The roads and sidewalks will pass through a stormceptor for treatment prior to infiltration.
- Lawns: this is the remaining pervious area on site with no ponding or amended soils.

The inputs for the all the drainage areas, including the LID features, for the water balance can be seen in Table 4. The green infrastructure water balance design spreadsheet can be seen in Appendix C.

Table 4: Summary of Post-Development Design Water Balance Inputs

Parameter	Amended Soil Swales	Central Infiltration Gallery	North infiltration Gallery	Lawn	Lawn to Ponding Area	Amended Soil Ponding Area	Unit
Impervious Area	0	10,761	9,402	0	0	0	Sq. m
Pervious Area	2,020	0	0	7,640	2,000	100	Sq. m
Total Area	2,020	10,761	9,402	7,640	2,000	100	Sq. m
Soil Depth	300	n/a	n/a	150	150	300	mm
Soil Exfiltration Rate	50	50	50	50	50	50	mm/hr
Soil Porosity	0.53	n/a	n/a	0.35	0.35	0.53	
Soil Field Capacity	0.32	n/a	n/a	0.15	0.15	0.15	
Soil Wilting Point	0.13	n/a	n/a	0.1	0.1	0.1	
Soil Infiltration Rate	30	n/a	n/a	10	10	30	mm/hr
Ponding Area	2,020	n/a	n/a	n/a	0 ¹	100	Sq. m
Ponding Depth	5	n/a	n/a	n/a	0 ¹	135	cm
Trench Surface Area	n/a	1,120	980	n/a	n/a	n/a	Sq. m
Trench Depth	n/a	2,000	2,000	n/a	n/a	n/a	mm
Trench Porosity	n/a	0.35	0.35	n/a	n/a	n/a	
¹ This area is directed to a low point with amended soils to infiltrate							

6.4.3 Results

The proposed LID measures infiltrate the 25 mm 4-hour water quality event, 2-, 5-, 25-, and 100-year 3-hour Chicago events.



FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Stormwater Management Facilities
January 10, 2017

Table 6 summarizes the modelled conditions.

Table 5: Post Development Site Flow and Runoff Volumes

Storm Event	Post-Development Conditions	
	Peak Flow (m ³ /s) ³	Runoff Volume (m ³)
25 mm ¹	0.14	72.8
2 year ²	0.21	126.6
5 Year ²	0.27	210.6
25 Year ²	0.38	351.3
100 Year ²	0.49	485.0
Hurricane Hazel 48-Hour	0.37	879.4
¹ 25 mm 4-hour Chicago storm ² 3-hour Chicago storm for Guelph ³ Flow from pervious is retained in depression storage for infiltration		

The post-development flows show some runoff occurring. The amended soil areas on site have a small amount of unsaturated runoff. Unsaturated runoff occurs when the intensity of the storm is higher than the infiltration rate of the grass. This runoff will be retained on site in small depressed areas that will pond until the water can be infiltrated into the soils.

Table 7 shows the water quality and design event infiltration and flow volumes for each area. Drain flow from the infiltration gallery is directed to the bioretention for further infiltration.

Table 6: Event Infiltration and Drain Flow Volumes

Storm Event	Amended Soil Areas		Central Infiltration Gallery		North Infiltration Gallery		Lawns	
	Infiltration Volume (m ³)	Runoff Volume (m ³) ⁴	Infiltration Volume (m ³)	Runoff Volume (m ³)	Infiltration Volume (m ³)	Runoff Volume (m ³)	Infiltration Volume (m ³)	Runoff Volume (m ³)
25 mm ¹	103.1	0	269.3	0	235.3	0	118.4	72.8
2 year ²	141.1	0	368.5	0	322.0	0	135.0	126.6
5 Year ²	194.6	0	508.2	0	444.0	0	150.2	210.6
25 Year ²	280.4	0	732.5	0	640.0	0	168.7	351.3
100 Year ²	359.4	0	938.8	0	820.2	0	181.5	485.0
Regional Event ³	1,104.6	69.6	2,237.2	829.7	1,956.4	723.2	1,367.6	809.8
¹ 25 mm 4-hour Chicago storm ² 3-hour Chicago storm for Guelph ³ 48-hour Hurricane Hazel ⁴ Unsaturated runoff from pervious is retained in depression storage for infiltration								

The recommend mitigation measures for the site infiltrate 100% of all storms up to the 100-year event for the proposed impervious areas. There is some unsaturated runoff from the lawn areas in the larger events, a portion of which will be held in the natural depression storage of the lawn for infiltration.

The gallery and bioretention volumes exceed those required for enhanced water quality, providing 735 cubic meters of storage. The infiltration gallery drains within 17 hours after the 100-year storm.

6.5 WATER QUALITY AND OVERALL SITE MONTHLY INFILTRATION AND GROUNDWATER WATER BALANCE

As previously noted in Section 3.2, various criteria exist for this site as it relates to water quality. This site is relatively unique in that it offers the following opportunities:

- Soils appropriate for infiltration.
- Moderately high groundwater levels.

As such, this site is a prime candidate to incorporate Low Impact Development (LID) features to achieve the identified stormwater management criteria.

The requirement for providing an MOECC enhanced level of water quality control and meeting infiltration targets (CVC) is easily achieved in the proposed scheme as there is no direct stormwater discharge proposed to the municipal storm system for up to the 100-year event.

All impervious surfaces and pervious surfaces over the proposed underground parking are directed to infiltration. The remaining pervious areas on site flow overland following the contours and depression storage for infiltration. The storage volume provided in the infiltration galleries allows for infiltration of all runoff from the proposed development.

It should be noted that oil-grit separator units are provided to ensure that spill potential (floatables) and sediment will be removed from road runoff prior to infiltration.

An overall site monthly infiltration and groundwater water balance analysis for both existing and proposed development conditions was undertaken to assess the potential reduction in recharge associated with the increase in impervious coverage, and the potential mitigation benefits associated with the proposed "engineered" infiltration practices using the Thornthwaite and Mather methodology. The existing topography and land cover were used to estimate an infiltration factor based on the approach presented in MOECC Stormwater Management Planning and Design (SWMPD) Manual (2003). Soil moisture capacities (also referred to as water holding capacity) were also obtained from the MOECC SWMPD Manual (2003) for soil types that were adopted based on the surficial geology.

Precipitation and temperature normals for the past 30 years (1981 to 2010) were obtained from the Environment Canada Website for the Waterloo Wellington Airport station, located approximately 15 km west of the Site.

These data were used to determine the saturation vapour pressure (e_{sat}) and monthly potential evapotranspiration (PET) using the following formulae (Dingman, 1994):

FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Stormwater Management Facilities
January 10, 2017

$$e_{\text{sat}} = 6.11 \exp (17.3T / (T + 23.7.3)),$$

Where T is temperature in degrees Celsius and e_{sat} is given in millibars (mb); and

$$\text{PET} = 0.409(e_{\text{sat}}),$$

Where PET is given in cm.

To determine the actual soil moisture content (S_m) at the end of each month, the following approach was used (Physical Hydrology (Dingman, 1994)):

When precipitation was greater than PET,

$$S_m = \min\{[(\text{Precip}_m - \text{PET}_m) + S_{m-1}], S_{\text{max}}\}; \text{ and}$$

When precipitation was less than PET,

$$S_m = S_{m-1} + (\text{Precip}_m - \text{PET}_m).$$

The actual evapotranspiration (ET) was in turn calculated as follows:

When precipitation was greater than PET,

$$\text{ET}_m = \text{PET}_m; \text{ and,}$$

Otherwise,

$$\text{ET}_m = \text{Precip}_m + S_{m-1} - S_m.$$

In summary, the analysis indicates that the average annual groundwater recharge rate occurring on the full 2.3 ha site under predevelopment conditions is approximately 306 mm/year, for a total of 9,776 m³, with this rate dropping to 265 mm/year post-development (total site recharge of 3,558 m³) under an **unmitigated** post-development condition. To address the projected groundwater recharge deficit, post-development groundwater recharge augmentation has been proposed for the site; namely, provision of at-source infiltration up to the 100-year event for all impervious and pervious over underground parking areas.

The retention volumes proposed within the infiltration galleries are sufficient to detain for infiltration / evapotranspiration the total runoff from the proposed rooftop and parking for the 25 mm 4 hour Chicago water quality design event. Within the current analysis, it has been conservatively estimated that only 80% of the runoff volume is converted to groundwater recharge (20% is evaporated or otherwise lost to the system), even though it is expected that 100% will infiltrate, showing the proposed development conditions have a predicted recharge **surplus** of 8,144 m³. Consequently, it is reasonable to assume that the pre-development groundwater recharge function of the site will be enhanced under the post-development condition if the above recharge measures are employed at the property.



FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Stormwater Management Facilities
January 10, 2017

Table 7: Summary Yearly Groundwater Recharge

Site Assumption	Expected Yearly Groundwater Surplus Volume
Post-development with no additional infiltration measures	-6,218
Assume 80% of water captured in infiltration galleries and bioretention are infiltrated	8,144

The detailed water balance spreadsheets can be seen in Appendix C.

7.0 EROSION AND SEDIMENT CONTROL PLAN

The erosion and sediment control (ESC) strategy has been developed to minimize the potential for offsite discharge of sediment and the resultant negative environmental impacts. This plan will focus on the protection of the Hanlon Creek watershed.

7.1 STUDY APPROACH

Erosion Potential Impact

The *Greater Golden Horseshoe Area Conservation Authorities' Erosion and Sediment Control Guideline for Urban Construction (2006)* was used to determine the erosion potential of the site. The erosion potential is based on slope gradient, slope length and soil texture and is then used to determine the appropriate erosion control methods.

Site slope gradients for the site can be summarized as gently sloped (0-5%) with an average slope in the order of 2%. The slope lengths are considered long (greater than 30 m). Site soils are comprised primarily of silty sand and gravel to sandy gravelly silt, thus, the erosion potential for the site is considered to be "high".

7.2 EROSION AND SEDIMENT CONTROL PLAN

The following approach to the ECS onsite has been prepared to minimize the potential impacts associated with onsite erosion and/or offsite transport of sediment to Hanlon Creek and other surrounding lands.

Prior to any grading or servicing works commencing onsite, ESC measures shall be implemented. The proposed erosion and sedimentation controls include the following items:

- Steep slopes (>3:1) shall have erosion blankets
- Light and/or heavy duty silt fencing will be erected on all site boundaries where there is potential for runoff to be discharged offsite, to protect adjacent and downstream lands from migration of sediment in overland flow. The location of this fencing will be adjacent to the limit of grading. Silt fencing should be erected before grading begins to protect adjacent and downstream areas from migration of sediment in overland flow

FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Erosion and Sediment Control Plan
January 10, 2017

- Temporary sediment basin will be constructed to provide sediment control for the site. Standards established by the Grater Golden Horseshoe Area Conservation Authorities require 125 m³/ha for dead storage or 185 m³/ha if the L:W ratio is less than 4:1 or the draw down time for active storage is less than 48 hours. Live storage of 125 m³/ha with a minimum 48-hour draw down time and a minimum 4:1 L:W ratio is also required. The sediment control basins are to be inspected regularly and sediment removed when the depth of dead storage is reduced by one-half of the design depth.
- Erosion control berms/swales will be located in appropriate (critical) areas to divert flows to the sediment basins
- A construction entrance feature ("mud mat") will be provided at all site entrances to minimize the offsite transport of sediment via construction vehicles
- Runoff will be directed to temporary sediment basins via swales to minimize untreated runoff discharged from site
- Swales constructed onsite will have temporary rock check dams to help attenuate flows and encourage deposition of suspended sediment where appropriate
- All disturbed areas where construction is not expected for 30 days shall be re-vegetated with 50 mm of topsoil and hydro-seeded according to OPSS 572
- During construction, all catchbasins are to be sealed until roads are paved to prevent sediment deposition in the batch basin's sumps and conveyance of silt to the SWMF
- Following completion of construction, defined as 90% house construction, and site stabilization, all erosion and sediment control measures and accumulated sediment are to be removed

FUNCTIONAL SERVICING REPORT FOR 1888 GORDON STREET, GUELPH, ON

Erosion and Sediment Control Plan
January 10, 2017

The erosion control measures shall be maintained in good repair during the entire construction period, and shall only be removed as contribution drainage areas are restored and stabilized. In addition, the condition of erosion control works, their overall performance, and any repairs, replacement or modifications to the installed item shall be noted in monitoring reports submitted to the Grand River Conservation Authority (GRCA) and the City of Guelph. Monitoring Reports should be submitted bi-monthly (quarterly during periods of inactivity or house construction) and should be based on inspection completed bi-weekly or after any significant rainfall events (>13mm), whichever is more frequent.

8.0 MONITORING, MAINTENANCE, AND MITIGATION PROGRAM

8.1 STORMWATER MANAGEMENT FACILITY

Monitoring and maintenance activities are an important part of a SWM Plan to ensure the designed features continue to operate as intended. As such, inspections will take place on a seasonal basis to observe any evidence of erosion or malfunctioning of the proposed site facility (3 per year). These inspections will occur following significant rainfall events, and will include inspection of the conditions of the infiltration Galleries and the OGS units to determine cleanout requirements.

The Monitoring Program described above will begin after the infiltration facilities come online and will continue for two years of post-construction monitoring. An annual report will be provided to the City to document ongoing monitoring observations, and a Final Report will be submitted at the end of the monitoring period. The Final Report will include recommendations for future inspection and maintenance requirements for the facility.

In order to monitor the performance of the infiltration facilities, observation ports will be installed to check the water levels.

The proponent will be responsible for the monitoring and inspections for the duration of the Monitoring Program as well as the long-term operation and maintenance of the facility. Long-term monitoring and maintenance should involve annual inspections of the infiltration facilities throughout their life span.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the preceding report, the following conclusions can be drawn:

- Sanitary service is provided by the municipal system located on Poppy Drive just east of the site access. A flow control pipe and structure was identified, by a previously prepared report by Civica, to be located within this access to restrict flow a development area that encompassed this site to 20.2 L/s. A detailed analysis of the actual peak flow leaving the development area should be undertaken to confirm the need/size for this structure.
- Water service is provided primarily from the existing 400mm watermain on Gordon Street fronting this site with a secondary connection point to the 150mm watermain on Poppy Drive to create a looped system.
- Enhanced (Level 1) water quality control will be provided for the site by a combination of OGS units, and infiltration galleries. Adequate water quality volumes will be provided to meet the MOE water quality requirements associated with infiltration facilities
- The proposed infiltration will infiltrate up to the 100-year event to maintain predevelopment conditions

Based on the findings of the report, the following recommendations are provided:

- The proposed SWM measures provided in this report be constructed as designed
- The ESC measures documented herein be implemented during construction
- The Stormwater Monitoring and Maintenance Program be carried out during and following construction
- The proposed development can be adequately serviced through the connection to the existing services
- Overall site grading will provide for "major" overland flow conveyance to the downstream municipal road allowance, provide adequate cover over municipal services and generally match existing roads and boundary grades
- The servicing and grading have been designed to meet MOE and municipal standards

APPENDIX A

Preliminary Servicing and Grading Plan

APPENDIX B

Design Sheets



SUBDIVISION
1888 Gordon Street

DATE: January 10, 2017
DESIGNED BY:
CHECKED BY: **CJH**

SANITARY SEWER DESIGN SHEET

FILE NUMBERS: 161401285

DESIGN PARAMETERS		City of Guelph	
AVERAGE DAILY FLOW PER PERSON =	350 l/p/day	RESIDENTIAL:	0.0030 L/s/ha
MINIMUM VELOCITY =	0.600 m/s	COMMERCIAL:	1.7000 L/s/ha
n =	0.013	INDUSTRIAL:	1.7000 L/s/ha
MAX PEAK FAC.=	4.500	INSTITUTIONAL:	2.5000 L/s/ha
MIN PEAK FAC.=	1.500	INFILTRATION:	0.1500 L/s/ha
		RESIDENTIAL HARMON PEAKING FACTOR	

LOCATION		RESIDENTIAL AREA AND POPULATION						COMM		INDUST		INSTIT		C+I			INFILTRATION			TOTAL FLOW	PIPE						
STREET	FROM M.H.	TO M.H.	AREA (ha)	POP. DENSITY (p/ha)	POP.	CUMULATIVE AREA (ha)	PEAK POP.	PEAK FACT.	PEAK FLOW (L/s)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	PEAK FLOW (L/s)	TOTAL AREA (ha)	ACCU. AREA (ha)	INFILT. FLOW (L/s)	FLOW (L/s)	DIST (m)	DIA (mm)	SLOPE (%)	CAP. (L/s)	VEL. (m/s)	VEL. (ACT.) (m/s)	
1888 Gordon St			3.19		956	3.19	956	3.813	10.936		0.00		0.00		0.00	0.000	3.19	3.19	0.479	11.415							
Total site			6.90		1340	6.9	1340	3.714	14.930		0.00		0.00		0.000	6.90	6.9	1.035	15.965								



FIRE FLOW CALCULATIONS AS PER OBC REQUIREMENTS

ONTARIO BUILDING CODE CLAUSE A-3.2.5.7.

$Q = K \times V \times S_{Tot}$

Q = MINIMUM SUPPLY OF WATER (L)
 K = WATER SUPPLY COEFFICIENT
 V = BUILDING VOLUME (m³)
 S_{Tot} = TOTAL OF SPATIAL COEFFICIENT VALUES FROM PROPERTY LINE EXPOSURES ON ALL SIDES AS OBTAINED FROM THE FORMULA
 where:
 $S_{Tot} = 1.0 + (S_{side1} + S_{side2} + \dots etc)$
values are obtained from Figure 1 A-3.2.5.7, OBC, as modified by Sections 6.3 (e) and 6.3 (f) of this guideline, and
S_{Tot} = need not exceed 2.0

As per Table 2, Section A-3.2.5.7, OBC

OBC Part 3 Buildings under Building Code	Required Minimum Water Supply Flow Rate (L/min)
One-storey building with area ≤ 600 m ²	1800
All other buildings	2700 (if Q ≤ 108,000 L)
	3600 (if Q > 108,000 L and ≤ 135,000 L)
	4500 (if Q > 135,000 L and ≤ 162,000 L)
	5400 (if Q > 162,000 L and ≤ 190,000 L)
	6300 (if Q > 190,000 L and ≤ 270,000 L)
	9000 (if Q > 270,000 L)

Major Occupancy Classification

Group C Residential Occupancies

Water Supply Coefficient - K

As per Table 1, Section A-3.2.5.7, OBC K= 10

Total Building Volume

Bldg	Area (m ²)	Flr Height (m)	Volume (m ³)
1	27772	3.2	88870.4
			0
			0
Total			88870.4

*Assuming single 14 storey apartment is critical

Exposures

	Separation (m)	Spatial Coeff
North	10	0.00
South	20	0.00
East	26	0.00
West	30	0.00
S _{Tot}		1.00

**above separation distances conservative estimates.

Minimum Water Supply

$Q = K \times V \times S_{Tot}$
 $Q = 10 \times 88870.4 \times 1.00 = 888,704 \text{ L}$
 since Q > 270,000 L
 Required Fire Flow (from Table 2 above) = 9000 L/min
 = 150 L/s



APPENDIX C

Stormwater Design Calculations

1888 Gordon Street, Guelph Stormwater Management Parameters

MOE Water Quality Parameters

	Total SWMF	Site	
Tributary Area (ha)	3.20		
Tributary Area requiring quality control (ha)	3.20	3.20	
MOE Quality Control Requirement	Level 1		
Basin Design	Infiltration		
¹ Quality Control Volume Requirement (m ³ /ha)	33	33	
Quality Control Volume Requirement (m ³)	105	105	
² Permanent Pool (m ³)	-23	-23	
³ Extended Detention - Quality Control (m ³)	128	128	

¹ Based on MOE guidelines and overall percent impervious

² Permanent Pool sized for quality control - All but 40 m³/ha of required quality control volume

³ Extended Detention sized for quality control - 40 m³/ha

Catchment Number	Area (ha)	% Imperv (XIMP)
Site	3.20	63%
Total Quality Control	3.20	100%
Quantity Control	3.20	100%

100-Year Input

Amended soil Swales		Centre RT		North RT		Lawn no Amended Soils		Lawn to amended soils ponding area		Amended soil ponding Area	
Impervious area	sq.m	Roof area	0 sq.m	Roof area	sq.m	Paved Area	0 sq.m	Paved Area	0 sq.m	Paved Area	0 sq.m
Amended area	2020 sq.m	RG Area	0 sq.m	RG Area	0 sq.m	Pervious Areas	7640 sq.m	Pervious Areas	2000 sq.m	Pervious Areas	100 sq.m
		Directly to Tench	10761 sq.m	Directly to Tench	9402 sq.m						
Total area:	2020 sq.m	Total area:	10761 sq.m	Total area:	9402 sq.m	Total area:	7640 sq.m	Total area:	2000 sq.m	Total area:	100 sq.m
Trench surf. area:	0 sq.m	Trench surf. area:	1120 sq.m	Trench surf. area:	980 sq.m	Trench surf. area:	0 sq.m	Trench surf. area:	0 sq.m	Trench surf. area:	0 sq.m
Trench depth:	0 m	Trench depth:	2 m	Trench depth:	2 m	Trench depth:	0 m	Trench depth:	0 m	Trench depth:	0 m
Trench porosity:	0.35	Trench porosity:	0.35	Trench porosity:	0.35	Trench porosity:	0.35	Trench porosity:	0.35	Trench porosity:	0.35
Trench full:	0 cu.m	Trench full:	784 cu.m	Trench full:	686 cu.m	Trench full:	0 cu.m	Trench full:	0 cu.m	Trench full:	0 cu.m
Trench initial vol:	0 cu.m	Trench initial vol:	0 cu.m	Trench initial vol:	0 cu.m	Trench initial vol:	0 cu.m	Trench initial vol:	0 cu.m	Trench initial vol:	0 cu.m
Subsoil exfil. rate:	50 mm/hr	Subsoil exfil. rate:	50 mm/hr	Subsoil exfil. rate:	50 mm/hr	Subsoil exfil. rate:	50 mm/hr	Subsoil exfil. rate:	50 mm/hr	Subsoil exfil. rate:	50 mm/hr
Soil depth:	300 mm	Soil depth:	mm	Soil depth:	mm	Soil depth:	150 mm	Soil depth:	150 mm	Soil depth:	300 mm
Soil porosity:	0.53	Soil porosity:		Soil porosity:		Soil porosity:	0.35	Soil porosity:	0.35	Soil porosity:	0.53
Soil field cap:	0.32	Soil field cap:		Soil field cap:		Soil field cap:	0.15	Soil field cap:	0.15	Soil field cap:	0.32
Soil wilt point:	0.13	Soil wilt point:		Soil wilt point:		Soil wilt point:	0.1	Soil wilt point:	0.1	Soil wilt point:	0.13
Soil infil. rate	30 mm/hr	Soil infil. rate	mm/hr	Soil infil. rate	mm/hr	Soil infil. rate	10 mm/hr	Soil infil. rate	10 mm/hr	Soil infil. rate	30 mm/hr
Soil wilt point vol:	78.8 cu.m	Soil wilt point vol:	0.0 cu.m	Soil wilt point vol:	0.0 cu.m	Soil wilt point vol:	114.6 cu.m	Soil wilt point vol:	30.0 cu.m	Soil wilt point vol:	3.9 cu.m
Soil porosity vol:	321.2 cu.m	Soil porosity vol:	0.0 cu.m	Soil porosity vol:	0.0 cu.m	Soil porosity vol:	401.1 cu.m	Soil porosity vol:	105.0 cu.m	Soil porosity vol:	15.9 cu.m
Soil field cap vol:	193.9 cu.m	Soil field cap vol:	0.0 cu.m	Soil field cap vol:	0.0 cu.m	Soil field cap vol:	171.9 cu.m	Soil field cap vol:	45.0 cu.m	Soil field cap vol:	9.6 cu.m
Soil initial vol:	193.9 cu.m	Soil initial vol:	0.0 cu.m	Soil initial vol:	0.0 cu.m	Soil initial vol:	171.9 cu.m	Soil initial vol:	45.0 cu.m	Soil initial vol:	9.6 cu.m
Ponding	0.05 m	Ponding	0 m	Ponding	0 m	Ponding	0.00 m	Ponding	0.00 m	Ponding	1.35 m
I/P	0.0	I/P	9.6	I/P	9.6	I/P	0.0	I/P	0.0	I/P	0.0

100-Year Output

Summary	Ameded Soil Swales	Centre RT	North RT	Lawn Areas	Amended Ponding Area	Total
Total evaporation	0.0	0.0	0.0	0.0	0.00	0.0
Total exfiltration	176.2	938.8	820.2	181.5	183.20	2299.9
Total drainflow	0.0	0.0	0.0	0.0	0	0.0
Total runoff	0.0	0.0	0.0	485.0	0.00	485.0
Total Reused						
Sum	176.2	938.8	820.2	666.5	183.2	2784.9
Total rainfall	176.2	938.8	820.2	666.5	183.2	2784.9
% Treated	100%	100%	100%	27%	100%	83%
% untreated	0%	0%	0%	73%	0%	17%
% Captured	100%	100%	100%	27%	100%	83%
EIA	0%	0%	0%	73%	0%	17%

Peak Flow= 0.49 cms
runoff Volume= 485.0 c.m.

Month #	Month	Days	Monthly Evap (mm)
1	Jan	31	
2	Feb	28	
3	Mar	31	
4	Apr	30	
5	May	31	
6	Jun	30	
7	Jul	31	
8	Aug	31	
9	Sep	30	
10	Oct	31	
11	Nov	30	
12	Dec	31	

Amended Soil Swales		Centre RT		North RT		Lawn no Amended Soils		Lawn to amended soils ponding area		Amended soil ponding Area	
6%	Impervious area	0 sq m	Roof area	0 sq m	Roof area	0 sq m	Paved Area	0 sq m	Paved Area	0 sq m	Paved Area
37%	Amended area	2020 sq m	910 Area	0 sq m	Roof Area	7640 sq m	Pervious Areas	2000 sq m	Pervious Areas	100 sq m	
19523	Total area	2020 sq m	10761 sq m	10761 sq m	Total area	9402 sq m	Total area	2000 sq m	Total area	100 sq m	
	Trench surf. area	0 sq m	Trench surf. area	1120 sq m	Trench surf. area	860 sq m	Trench surf. area	0 sq m	Trench surf. area	0 sq m	
	Trench depth	0 m	Trench depth	2 m	Trench depth	0 m	Trench depth	0 m	Trench depth	0 m	
	Trench porosity	0.35	Trench porosity	0.35	Trench porosity	0.35	Trench porosity	0.35	Trench porosity	0.35	
	Trench full	0 cu m	Trench full	784 cu m	Trench full	0 cu m	Trench full	0 cu m	Trench full	0 cu m	
	Trench initial vol	0 cu m	Trench initial vol	0 cu m	Trench initial vol	0 cu m	Trench initial vol	0 cu m	Trench initial vol	0 cu m	
	Subsoil exfil. rate	60 mm/hr	Subsoil exfil. rate	60 mm/hr	Subsoil exfil. rate	60 mm/hr	Subsoil exfil. rate	60 mm/hr	Subsoil exfil. rate	60 mm/hr	
	Soil depth	300 mm	Soil depth	mm	Soil depth	168 mm	Soil depth	300 mm	Soil depth	300 mm	
	Soil porosity	0.35	Soil porosity		Soil porosity	0.35	Soil porosity	0.35	Soil porosity	0.35	
	Soil field cap	0.15	Soil field cap		Soil field cap	0.15	Soil field cap	0.15	Soil field cap	0.15	
	Soil wet point	0.13	Soil wet point		Soil wet point	0.1	Soil wet point	0.1	Soil wet point	0.13	
	Soil infil. rate	30 mm/hr	Soil infil. rate		Soil infil. rate	10 mm/hr	Soil infil. rate	10 mm/hr	Soil infil. rate	30 mm/hr	
	Soil wet point vol	78.8 cu m	Soil wet point vol	0.0 cu m	Soil wet point vol	114.8 cu m	Soil wet point vol	30.0 cu m	Soil wet point vol	3.9 cu m	
	Soil porosity vol	321.2 cu m	Soil porosity vol	0.0 cu m	Soil porosity vol	401.1 cu m	Soil porosity vol	100.0 cu m	Soil porosity vol	15.9 cu m	
	Soil field cap vol	193.9 cu m	Soil field cap vol	0.0 cu m	Soil field cap vol	171.9 cu m	Soil field cap vol	45.0 cu m	Soil field cap vol	9.6 cu m	
	Soil initial vol	0.0 cu m	Soil initial vol	0.0 cu m	Soil initial vol	171.9 cu m	Soil initial vol	45.0 cu m	Soil initial vol	9.6 cu m	
	Ponding	0.0 m	Ponding	0 m	Ponding	0.0 m	Ponding	0.0 m	Ponding	1.35 m	
	IP	0.0	IP	0.0	IP	0.0	IP	0.0	IP	0.0	

Summary	Amended Soil Swales	Centre RT	North RT	Lawn Areas	Amended Ponding Area	Total
Total evaporation	0.0	0.0	0.0	0.0	0.0	0.0
Total drainflow	0.0	0.0	0.0	0.0	0.0	0.0
Total runoff	0.0	0.0	0.0	480.0	0.0	480.0
Total Reused						
Total rainfall	176.2	938.8	820.2	686.5	183.2	2784.9
Sum	176.2	938.8	820.2	686.5	183.2	2784.9
% Reused	0%	0%	0%	73%	0%	17%
% Unreused	100%	100%	100%	27%	100%	83%
EIA	0%	0%	0%	73%	0%	17%

Peak Flow: 0.49 cms
runoff Volume: 480.0 c.m.

Month	Date	Precip (mm)	ETD	Amended Soil Swales											Roof and Road to RT																
				Rain Water into Swale	Rain into Ponding	24 hr out ponding	Unsat. Runoff	Rain into Soil	beginning Soil Water Volume	Water from Soil to SW	Water that does not exfiltrate	Water that stays in Soil	Saturated beginning water to Ponding	Total Runoff	Evaporation	Rain Water into Swale	Rain into Ponding	24 hr out ponding	Unsat. Runoff	Rain into Soil	beginning Soil Water Volume	Water from Soil to Trench	Water that stays in Soil	beginning Trench Water Volume	Trench Evaporation	Underdrain Discharge	Evaporation				
7	30/06/1964 23:55	0.35	0.000	0.79	0.00	0.00	0.00	0.00	0.79	193.92	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:05	0.39	0.000	0.86	0.00	0.00	0.00	0.00	0.86	193.92	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
7	01/07/1964 00:10	0.45	0.000	1.04	0.00	0.00	0.00	0.00	1.04	193.92	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:15	0.52	0.000	1.23	0.00	0.00	0.00	0.00	1.23	193.92	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:20	0.61	0.000	1.47	0.00	0.00	0.00	0.00	1.47	193.92	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:25	0.73	0.000	1.80	0.00	0.00	0.00	0.00	1.80	193.92	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:30	0.89	0.000	2.26	0.00	0.00	0.00	0.00	2.26	193.92	2.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:35	1.12	0.000	2.96	0.00	0.00	0.00	0.00	2.96	193.92	2.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:40	1.46	0.000	4.07	0.00	0.00	0.00	0.00	4.07	193.92	4.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:45	2.01	0.000	6.02	0.00	0.00	0.00	0.00	6.02	193.92	6.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:50	2.98	0.000	10.01	4.96	0.97	0.00	0.00	5.05	193.92	5.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	01/07/1964 00:55	4.96	0.000																												

MONTHLY WATER BALANCE SUBCATCHMENT - ****name****

Monthly Water Balance Analysis - Groundwater Recharge
1888 Gordon Road
Pre Development

Land Description Factors	Site
Topography	0.2
Soils	0.4
Cover	0.15
Sum (Infiltration Factor)	0.75
Soil Moisture Capacity (mm)	150
Percentage of Total Site Area	100%
Total Site Area (ha)	3.2

Land Cover Descriptions

Site **Silt, Sand, Gravel, Pasture/Shrub, rolling**

Check
100% OK

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Climate Data (Data from Waterloo Wellington Airport - Climate Normals from 1981-2010)													
Average Daily Temperature (°C)	-6.5	-5.5	-1.0	6.2	12.5	17.6	20.0	18.9	14.5	8.2	2.5	-3.3	
Precipitation (mm)	65.2	54.9	61.0	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.4	71.2	916.6
Evapotranspiration Analysis													
Saturation Vapour Pressure (mb)	3.75	4.05	5.68	9.49	14.52	20.17	23.45	21.89	16.55	10.89	7.32	4.79	
PET (Malstrom, 1969) (mm/month)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	508.3
Precipitation - PET (mm)	65.20	54.90	61.00	35.68	22.91	-0.11	2.71	-5.64	20.13	22.86	57.47	71.20	
Weighted Soil Storage Capacity (mm)	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	
Actual Soil Moisture (mm)	150.00	150.00	150.00	150.00	150.00	149.89	150.00	144.36	150.00	150.00	150.00	150.00	
Change in Soil Moisture (mm)	0.00	0.00	0.00	0.00	0.00	-0.11	0.11	-5.64	5.64	0.00	0.00	0.00	
Actual Evapotranspiration (mm)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	508.3
Recharge/Runoff Analysis													
Surplus	65.2	54.9	61.0	35.7	22.9	0.0	2.6	0.0	14.5	22.9	57.5	71.2	408.3
Deficit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weighted Infiltration Factor	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	
Runoff (mm)	0.00	0.00	0.00	71.99	5.73	0.00	0.65	0.00	3.62	5.72	14.37	0.00	102.1
Recharge (mm)	0.00	0.00	0.00	215.98	17.18	0.00	1.95	0.00	10.86	17.15	43.10	0.00	306.2
Balance Check (should equal zero)													0

Volume-Based Balance (m ³)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation	2,081	1,753	1,947	2,378	2,627	2,630	3,148	2,678	2,803	2,152	2,790	2,273	29,261
Evapotranspiration	0	0	0	1,239	1,896	2,634	3,061	2,858	2,160	1,422	955	0	16,226
Runoff	0	0	0	2,298	183	0	21	0	116	182	459	0	3,259
Groundwater Recharge	0	0	0	6,895	548	0	62	0	347	547	1,376	0	9,776
Total Groundwater Recharge	0	0	0	6,895	548	0	62	0	347	547	1,376	0	9,776
Balance Check (should equal zero)													0

Post Development

Land Description Factors	Site	Impervious
Topography	0.2	-
Soils	0.4	-
Cover	0.05	-
Sum (Infiltration Factor)	0.65	-
Soil Moisture Capacity (mm)	75	-
Percentage of Total Site Area	37%	63%
Total Site Area (ha)	3.2	

Land Cover Descriptions

Site **Silt, Sand, Gravel, Pasture/Shrub, rolling**

Check
100% OK

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Climate Data (Data from Waterloo Wellington Airport - Climate Normals from 1981-2010)													
Average Daily Temperature (°C)	-6.5	-5.5	-1.0	6.2	12.5	17.6	20.0	18.9	14.5	8.2	2.5	-3.3	
Precipitation (mm)	65.2	54.9	61.0	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.4	71.2	916.6
Evapotranspiration Analysis													
Saturation Vapour Pressure (mb)	3.75	4.05	5.68	9.49	14.52	20.17	23.45	21.89	16.55	10.89	7.32	4.79	
PET (Malstrom, 1969) (mm/month)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	508.3
Precipitation - PET (mm)	65.2	54.90	61.00	35.68	22.91	-0.11	2.71	-5.64	20.13	22.86	57.47	71.20	
Weighted Soil Storage Capacity (mm)	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	
Actual Soil Moisture (mm)	27.75	27.75	27.75	27.75	27.75	27.64	27.75	22.11	27.75	27.75	27.75	27.75	
Change in Soil Moisture (mm)	0.00	0.00	0.00	0.00	0.00	-0.11	0.11	-5.64	5.64	0.00	0.00	0.00	
Actual Evapotranspiration (mm)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	508.3
Recharge/Runoff Analysis													
Surplus	65.2	54.9	61.0	35.7	22.9	0.0	2.6	0.0	14.5	22.9	57.5	71.2	408.3
Deficit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weighted Infiltration Factor	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	
Runoff (mm)	0.00	0.00	0.00	100.79	8.02	0.00	0.91	0.00	5.07	8.00	20.11	0.00	142.9
Recharge (mm)	0.00	0.00	0.00	187.19	14.89	0.00	1.69	0.00	9.42	14.86	37.36	0.00	265.4
Balance Check (should equal zero)													0

Volume-Based Balance (m ³)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation	2,081	1,753	1,947	2,378	2,627	2,630	3,148	2,678	2,803	2,152	2,790	2,273	29,261
Evapotranspiration	0	0	0	459	702	975	1,133	1,058	799	526	354	0	6,004
Runoff	0	0	0	1,191	95	0	11	0	60	95	238	0	1,688
Impervious Runoff	0	0	0	6,572	1,655	1,657	1,983	1,687	1,766	1,356	1,758	0	18,434
Total Runoff	0	0	0	7,763	1,750	1,657	1,994	1,687	1,826	1,450	1,995	0	20,122
Groundwater Recharge from Pervious Areas	0	0	0	2,211	176	0	20	0	111	176	441	0	3,135
Balance Check (should equal zero)													0

Infiltration Augmentation - All Impervious Areas - 20,163 square meters to infiltration, assume 80% infiltrates													
Rooftop Runoff to Infiltration Trenches	0	0	0	5,271	1,328	1,329	1,590	1,353	1,416	1,087	1,410	0	14,785
Final Groundwater Recharge	0	0	0	7,482	1,503	1,329	1,610	1,353	1,527	1,263	1,851	0	17,920
Final Recharge Surplus	0	0	0	588	955	1,329	1,548	1,353	1,181	715	475	0	8,144

Monthly Water Balance - Groundwater Recharge (Site) 1614-01285- 1888 Gordon Road Guelph

