Preliminary
Stormwater Management Report

556 and 576 Conservation Drive
City of Waterloo

July 2016

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July 12, 2016

2115881 Ontario Limited
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Attention: Mr. Ian Cook
Partner

Dear Mr. Cook,

Re: Preliminary Stormwater Management Report
556 and 576 Conservation Drive
City of Waterloo

Enclosed please find our Preliminary Stormwater Management Report for the above-noted project, in support of the current Draft Plan Application.

Our report summarizes the stormwater management requirements and presents a preliminary design configuration. The stormwater management plan satisfies the criteria set forth by the municipality, conservation authority, and the MOECC. It has been co-ordinated with the Environmental Impact Study, the North Waterloo Phase 1 Groundwater and Surface Water Monitoring Program and the North Waterloo Scoped Subwatershed Study.

The proposed stormwater management plan consists of a sediment forebay, wetland facility and infiltration trenches. Together, these components satisfy the design objectives for quality, quantity, and a water balance, as well as being aesthetically pleasing and an asset to the project.

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Yours very truly,

MERITECH ENGINEERING





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Project Engineer

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Senior Project Manager

AF/ct
Enclosures (2)

cc GSP Group (10 for distribution)

Executive Summary

The proposed residential development is located on the north side of Conservation Drive at the northern terminus of Beaver Creek Road in Waterloo. It is bordered by residential, agricultural and recreational lands.

The site will be developed for single-family, multi-family units with a school parcel, park block, open space and a stormwater management facility. The development is being processed through the Draft Plan of Subdivision process with the City of Waterloo and the Region of Waterloo. The lots will become individual private properties and condominium blocks. The street, park block and stormwater management block will become property of the City of Waterloo.

The stormwater management plan has been developed through the recommendations in the North Waterloo Scoped Subwatershed Study, along with coordination with the Environmental Impact Study for the property and standard municipal and provincial guidelines and documents.

The site is comprised of two separate drainage catchments within the North Waterloo Subwatershed Study, one catchment discharges to the east and an off-site stormwater management facility for quality control. This catchment is to discharge uncontrolled post development peak flows to the Laurel Creek reservoir via Beaver Creek Road. The western drainage catchment discharges to the Beaver Creek and its wetlands after attenuation and treatment in the on site stormwater management facility.

The on site facility is comprised of a sediment forebay and constructed wetland to meet the MOECC's Enhanced level for water quality and peak flow attenuation. The pond outlet is comprised of a reverse slope pipe with an orifice and an overflow weir. It is expected that the design quality storm will be directed to an infiltration trench located in the park block. The construction details will be determined through the detailed design.

A water balance for infiltration is proposed to be accomplished through the end-of-pipe facility, lot level infiltration galleries, and potentially a clean water conveyance system. it has been shown that more than enough water can be infiltrated within the development concept to allow for flexibility in the detailed design.

The development configuration as shown can accommodate all the stormwater management design criteria required to satisfy the post development condition as described in the North Waterloo Scope Subwatershed Study, and agency guidelines.

The SWM block is large enough to house a facility to meet the targets, a water balance can be met for infiltration, it is a easily accessible location for maintenance, enhances the buffers to the wetland and will be aesthetically pleasing and an asset to the development.

The treatment train, and construction level details for infiltration should be determined through the detailed design process for approval by the City of Waterloo and MOECC.

Approval agencies should approve the Draft Plan and the SWM design as presented.

Disclaimer

This Preliminary Stormwater Management report was prepared by Meritech Engineering for 2115881 Ontario Limited to identify the stormwater management measures necessary to obtain Draft Plan Approval. The comments, recommendations and materials presented in the stormwater management plan and attached drawings reflect our best judgement in light of the information available at the time of preparation. Except for approval and commenting municipalities and agencies in their review and approval of this project, any use which a third party makes of this stormwater management plan, or any reliance upon, or decisions as a result of, are the responsibility of such third parties. Meritech Engineering accepts no responsibility for damages suffered by any third party, other than an approval or commenting municipality or agency, as a result of decisions made or actions taken based on this stormwater management plan.

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Table of Contents

Introduction 3
Approach 4
Policy Framework 5
Planning Documents 5
Watershed Plan 5
Sub-Watershed Plan 5
MOE Guidelines 5
Regional Guidelines 6
Municipal Guidelines 6
Conservation Authority Guidelines 6
Environmental Studies 6
Geotechnical Studies 6
Hydrogeological Studies 7
Pre-Consultation/Design Criteria 7
Reconnaissance 8
Objectives and Targets 9
Environmental 10
Quantity 10
Quality 11
Water Balance, Infiltration and Groundwater Conditions 11
Baseflow and Channel Erosion 11
Site Erosion and Sedimentation Control 12
Proposed Stormwater Management Plan 12
Operation of Stormwater Management Facility 14
Minor/Major System Routing 14
Winter Conditions 14
Quantity 14
Catchment Numbering Convention 15
Hydrologic Model 15
Rainfall Data 16
Post-Development 16
Quality 20
Treatment Train Approach 20
Pre-Treatment 20
Forebay 20
Water Quality and Extended Detention 20
Water Balance, Infiltration and Groundwater Conditions 21
Pre-Development 21
Post-Development 22
Performance of the Stormwater Management Facility 23
Landscaping 25
Construction Staging 26
Site Erosion and Sedimentation Control 26
Monitoring, Maintenance and Mitigation 26
Proposed Stage II Monitoring 27
Proposed Stage III Monitoring 27
Conclusions 28

Recommendations 28
References 29

List of Figures

Figure 1: Subdivision Location 3
Figure 2: Approach Flowchart 4
Figure 3: Existing Conditions Photographs 8
Figure 4: Proposed Stormwater Management Facility 13
Figure 5: Post-Development Catchments 18
Figure 6: Post-Development Routing 19
Figure 7: Drawdown of the Proposed Pond, 2-Year 3-hour Storm Event 21
Figure 7: Infiltration Gallery Modeling 24

List of Tables

Table 1: Selection of Stormwater Management Practises 9
Table 2: Catchment Naming Convention 15
Table 3: Coefficients for Synthetic Design Storms 16
Table 4: Post-Development Modelling Parameters 17
Table 5: Water Quality Storage Requirements 20
Table 6: Pre-Development Infiltration 21
Table 7: Post-Development Infiltration 22
Table 8: Stage Storage Discharge for Forebay and Constructed Wetland 23
Table 9: Comparison of Attenuated Peak Flows (Flows to Beaver Creek) 24
Table 10: Peak Uncontrolled Flows for the Eastern Half of the Site.....25
Table 11: Pond Performance Summary 25

Appendices

Appendix A: Draft Plan
Appendix B: Design Drawings
Appendix C: Design Calculations
Appendix D: Modelling
Appendix E: Agency Correspondence
Appendix F: Geotechnical Investigation

Introduction

The proposed subdivision is located on Conservation Drive in Waterloo, Ontario as shown in Figure 1. The site is bordered by existing residential lands to the east, agricultural lands to the north, Beaver Creek to the west, agricultural lands to the south on the west side of Beaver Creek Road, and the Green Acre Park campground to the south-east.

The site is an irregularly shaped parcel used for agricultural lands with two homes located on the site. The drainage is split; with roughly half of the site going west to Beaver Creek and the remainder draining to the south-east corner of the site where it drains towards Green Acre Park and eventually to the Laurel Creek Reservoir.

The development shown of the Draft Plan of Subdivision in Appendix A is primarily composed of a mix of low density residential, medium density townhomes, a block reserved for a school location, and open space/parkland.

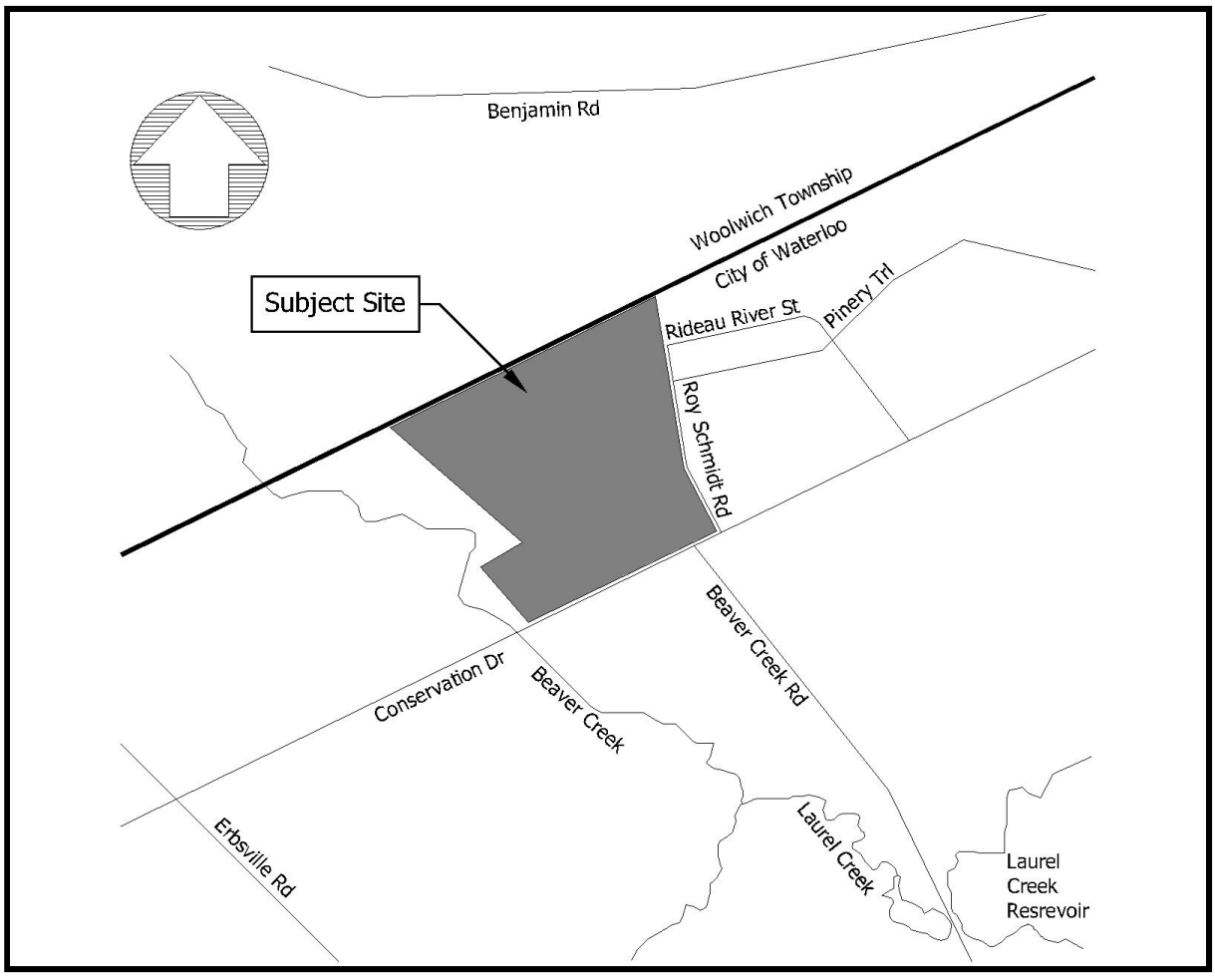


Figure 1: Subdivision Location

Approach

The following flowchart explains a typical submission and approval process. The section highlighted in grey indicates the status of this circulation:

Step One
Design Criteria
This circulation establishes the framework for the project and provides a direction for how the stormwater management plan is to develop.

⇩

Step Two
Preliminary Design
This circulation describes how the stormwater management plan satisfies the objectives for the site, confirms spatial relationships of the plan within the confines of the site, and provides recommendations to be implemented in the detailed design. For subdivisions, Draft Plan approval is contingent upon approval of the Preliminary Design Report.

⇩

Step Three
Detailed Design or Final Design
This circulation integrates the recommendations of the preliminary design into the final site engineering. Approval of this report allows for construction of the proposed stormwater management works.

⇩

Step Four
Implementation
If required by step 3, an implementation report is prepared in order to confirm that the facility is operating in accordance with the detailed design. The report describes the monitoring and maintenance program undertaken and also describes any modifications necessary to mitigate any noted deficiencies during the maintenance period. Acceptance of the stormwater management facilities by the municipality is contingent upon their acceptance of the Implementation Report.

Figure 2: Approach Flowchart

Policy Framework

This chapter outlines the framework upon which the stormwater management plan, which is described in more detail in subsequent chapters, is built upon. Previous studies, municipal and provincial standards, as well as any field investigations undertaken to support the project, are examples of information described in this chapter. This background information is then used to build an appropriate plan for the site. The next chapter, Objectives and Targets, describes the site-specific requirements noted from the following sources:

Planning Documents

City of Waterloo Official Plan, October 2014
The subject lands are designated Low Density Residential with a future node shown at the intersection of Conservation Drive and Beaver Creek Road.

City of Waterloo Zoning By-law, August 23, 2012
The subject lands are zoned Agricultural.

Beaver Creek Meadows District Plan, January 8, 2015
The Beaver Creek Meadows District Plan was approved by council on January 25, 2016. It provides detail regarding the design and development of the community. The site is shown as a mix of low density residential, medium density residential and an elementary school site and is anticipated to be part of the initial phase of development of the community district.

Watershed Plan

Laurel Creek Watershed Study, 1992
This document analyses various elements of the watershed, notably the hydrology and the response to the creek during various rainfall events and recommendations to mitigate flooding. The subject site is within catchments 301 and 310.

Sub-Watershed Plan

North Waterloo Scoped Subwatershed Study, 2013
This document, hereafter referred to as the "NWSSS", provides technical information to assist in the development of a District Plan, the completion of Class Environmental Assessment processes and the design of subdivisions.

MOE Guidelines

Stormwater Management Planning and Design Manual, 2003
This manual provides guidelines on the planning and design of stormwater management facilities in Ontario.

Regional Guidelines

Region of Waterloo and Area Municipalities Design Guidelines and Supplemental Specifications for Municipal Services Guidelines (DGSSMS)
The design portion of this annually-updated document (Part B) should be considered as guidelines that provides the municipalities' design preferences under normal circumstances. These guidelines are read together with Municipal guidelines and standards in place.

Municipal Guidelines

City of Waterloo Development Engineering Manual, 2013
This manual provides design guidelines for servicing and grading of subdivisions. It also includes a list of coefficients to be used in modelling of synthetic design storms.

Aesthetic Principles for Storm Water Management, City of Waterloo, 1996
In accordance with accepted practice throughout the Region of Waterloo, this document describes the preferred features to be incorporated into stormwater management facilities in order to achieve aesthetic and functional objectives.

Conservation Authority Guidelines

Greater Golden Horseshoe Area Conservation Authority Erosion & Siltation Control Guideline for Urban Construction, December 2006
This document describes the methodology for determining the erosion potential of a site and the measures that should be undertaken to mitigate construction disturbance.

Environmental Studies

Beaver Creek Road and Conservation Drive Upgrades and Extension of Municipal Service Class Environmental Assessment, Stantec Consulting Ltd., December 14, 2015
The EA is ongoing and will address upgrades to Beaver Creek Road and Conservation Drive. Water, storm, sanitary and transportation upgrades are planned adjacent to the subject lands. This report and the detailed design coming from it account for the storm drainage on the eastern half of the property into a separate facility and then to an outlet into Laurel Creek

An Environmental Impact Study has been prepared by NRSI (July 2016) for submission. The SWM design and facility location were proposed in conjunction with NRSI as appropriate for the site. Further recommendations from this report guide the site servicing, grading, and stormwater management design, and monitoring programs.

Geotechnical Studies

A geotechnical investigation by LVM (March 20, 2015) has revealed that:

- Native soils consist primarily of topsoil overlaying a thick layer of sand with silt being encountered at some locations

- Groundwater is unconfined and generally 3.0 to 6.0m in depth across the site. Groundwater elevations nearer to the existing surface elevation occur near Beaver Creek on the west side of the site
- Subdrains should be used where silt is encountered in the subgrade
- Infiltration is feasible in areas where the native soils are comprised of sand

Excerpts from the report are included in Appendix F.

Hydrogeological Studies

The North Waterloo, Phase 1 - Groundwater and Surface Water Monitoring Program, prepared by Stantec has been reviewed for co-ordination of the hydrogeology of the site.

Four monitoring wells are on the subject property: MW2, MW3, MW6, and MW7. A summary of key findings are that:

- The water level elevations at these four wells varies seasonally and in response to years of above and below average rainfall
- The wells respond to these climactic factors synchronously (e.g. the water level rises and drops across the site at once)
- There is up to about 1m variation in seasonally high to seasonally low elevations
- Elevations are highest in the spring and lowest in the late fall/early winter

In section 4.2, the report states that "periods of above average precipitation and groundwater recharge in 2013 and 2014, resulted in higher shallow groundwater levels observed at all monitoring wells than suggested by the 2009/2010 data. The spring groundwater levels were compared to those originally presented in the NWSSS to evaluate the difference in levels." … "spring groundwater levels increased by 0.9 m at MW3-10S and MW7-10, 0.4 m at MW2-10 and 0.5 m at MW6-10." … "In general, the data indicated the potential for shallower groundwater conditions […] than previously expected. Within the northeastern portion of the Site, where an increase in spring groundwater levels of up to 0.9m was predicted, there is a thick unsaturated zone and minimal impact to proposed construction is expected due to this change in peak spring levels."

To date, the seasonally-high elevations at the four monitoring wells are approximately 353.0, 354.9, 352.8, and 354.4.

Excerpts from the report are included in Appendix F.

Pre-Consultation/Design Criteria

Pre-Submission Comments from the Grand River Conservation Authority dated September 14, 2015 have been included in Appendix E. Key items from these comments are included in the following chapter 'Objectives and Targets'.

Reconnaissance

Meritech staff visited the site on November 17, 2015 in order to verify existing drainage patterns of the site and adjacent properties, to confirm existing infrastructure surrounding the site, and to make note of all aboveground features on neighbouring properties.



Figure 3: Existing Conditions Photographs

Objectives and Targets

This chapter describes typical stormwater management concerns associated with development. In each section, a brief commentary on the application of these requirements to this project is provided, along with their associated objectives and targets. In the next chapter, Proposed Stormwater Management Plan, a more complete description is provided for how the proposed plan addresses these objectives.

The following table presents typical stormwater management solutions. Each one is ranked as to the level of performance for Water Quality, Erosion, Water Quantity and Infiltration. The last two columns present whether or not the control is proposed in the stormwater management solution, along with a commentary of its suitability to this project. The proposed stormwater management features follow the recommendations included in the subwatershed study (NWSSS)'s "Preliminary Screening of Stormwater Management Practices" Table 11.1 as well as the Recommended Stormwater Management Strategy, section 11.5, of the NWSSS.

Lot Level & Conveyance Controls	Water Quality	Erosion	Water Quantity	Infiltration	Incl. In Plan?	Comments
Flat Lot Grading	M	M	L	H	N	Developer preference
Control of Roof Leaders	M	M	L	H	N	
Control of Foundation Drains	M	M	L	H	N	
Grassed Swales	M	M	M	H	Y	
Filter Strips	M	M	L	H	Y	
Infiltration Trench	H	M	L	H	Y	
Pervious pipes, catchbasins	H	M	L	H	Y	Clean roof runoff only
Oil / Grit Separator	M	L	L	L	N	Forebay preferred
Rooftop Storage	L	M	H	L	N	Not suitable
Parking Lot Storage	L	M	H	L	N	Not suitable
Underground Storage	L	M	H	L	N	
End of Pipe Controls						
Sediment Forebay	H	M	L	L	Y	
Wet Pond	H	H	H	L	N	Wetland preferred
Constructed Wetland	H	H	H	L	Y	c/w infiltration trench
Dry Pond	M	H	H	L	N	Wetland preferred
Infiltration Pond	H	M	L	H	Y	Wetland to infiltration

Table 1: Selection of Stormwater Management Practises
(Compiled From 2003 MOE Manual)

The NWSS recommends SWM plans incorporate:

- Lot level stormwater practices installed in public ownership, lot level soak away pits and ponding areas in areas of high density developments with suitable soils.
- Conveyance controls with roof leader connections for single, semi-detached and townhouses.
- End of pipe facilities with wetland basins and infiltration trenches with a bypass for winter conditions depending on the situation.
- Temperature mitigation is to be through subterranean infiltration features.

Environmental

A 30m buffer to the wetland to the west is described in NRSI's report. The SWM facility is proposed to extend within this buffer and has been justified in the Environmental Impact Study as appropriate. It will provide for a further buffer from human intrusion as well as opportunity to spread the infiltration over the buffer area. Limited grading can occur between the 15m and 30m buffer limits, in accordance with recommendations in the NWSSS and the Environmental Impact Study. Maintained or increased groundwater flows to the wetland are recommended for a water balance. It also recommends quantity, quality and Sediment and Erosion Control measures to be in accordance with the NWSSS.

Quantity

Development of land from rural to urban causes an increase in runoff due to the increase in impervious cover. Additionally, the increased runoff flows faster to receiving watercourses, which combined with other developed sites, may cause downstream flooding. It is, therefore, usual to provide either on-site or regional "holding" areas that act to contain the increased runoff and discharge it over a longer period of time while not exceeding the targeted peak flow.

Target unit flow rates are established within the NWSSS for the lands flowing to Beaver Creek and are provided below. The contributing area is defined in the NWSSS as the pre-development catchments. For this development, the allowable flow is calculated with catchment 3913 (12.3has) less approximately 0.74 hectares outside of the subdivision to the northwest.

- 2-year 1.1 L/s/ha x 11.56ha = 12.7L/s or 0.013m^3/s
- 5-year 10 L/s/ha x 11.56ha = 115.6L/s or 0.116m^3/s
- 100-year 55 L/s/ha x 11.56ha = 635.8L/s or 0.636m^3/s
- Regional Proposed is 1.344m^3/s for entire catchment
  So (11.56ha / 12.3ha) x 1.344m^3/s = 1.263m^3/s

There are no quantity requirements for the lands flowing southeast, as the NWSSS has determined that the Laurel Creek Reservoir will attenuate flows satisfactorily. This runoff will have quality control through a facility south of Conservation Drive. Storm sewers are to be sized for a 5-year storm event and major flows will be via the road network as surface flows. The drainage divide is shown on Figure 11.1 of the NWSSS and is included in Appendix B.

Quality

Water quality control is provided for several reasons, including sediment and contaminant (chemical) removal. It is now standard practise to incorporate water quality treatment into the design of any stormwater management facility. This often includes:

- Pre-treatment (for example, grassed swales)
- Treatment (for example, sediment forebay/permanent pool)
- Enhancement (for example, extended detention)

An enhanced (80% suspended solids removal) level of water quality is required by the NWSSS for all developed areas.
The NWSSS specifies parameters for Quality Control:

- Temperature targets of 22°C from April 1 to October 31st and between 4°C and 14°C from November1 to March 31st in stream,
- Dissolved Oxygen target of 5 mg/L in stream,
- Phosphorus target of 0.03mg/L in stream,
- Sediment target concentration of 25mg/L in stream,
- Bacteria target based on Provincial Water Quality Objectives of 100 CFU/100ml in stream.

Water Balance, Infiltration and Groundwater Conditions

Another example of the impact of development on the natural water cycle is groundwater recharge. The increase in impervious cover prevents water from soaking into the ground. Cumulatively, these minor losses can cause significant loss to the groundwater regime. Analysis of these impacts, in the form of a water budget, is sometimes undertaken with the intent of designing appropriate mechanisms for recharge.

In accordance with the NWSSS the existing infiltration rates should be maintained or increased to ensure there is no reduction in base flow to Laurel Creek or Beaver Creek, no change in existing aquifer recharge, and no disruption in the pattern of groundwater recharge.

Groundwater information has been provided in the geotechnical report and the NWSSS. The NWSSS, Figure 5.23, shows groundwater at elevations of 354 to 350 metres draining from east to west, towards Beaver Creek. The geotechnical report reports groundwater occurring in unconfined water table conditions at depths generally between 3.0 to 6.0 metres across the site, at elevations between 354 and 351. Groundwater elevations are nearer to the existing ground surface on the west side of the site, directly adjacent to Beaver Creek and the surrounding wetlands.

Baseflow and Channel Erosion

Changes to land use can cause impacts on receiving watercourses, including erosion or a change to the baseflow. While erosion is a natural and important phenomenon, analysis of the potential erosion of the receiving watercourse is sometimes necessary. Erosion potential of Beaver Creek was addressed in the NWSSS. Existing erosion conditions will be

maintained or improved by achieving the peak flow targets outlined in the quantity requirements as the creek was deemed stable in its existing condition. SWM Plans are to incorporate a treatment train approach including at-source infiltration and end of pipe facilities.

Site Erosion and Sedimentation Control

Without proper controls, construction activities can cause erosion of disturbed land by either water (alluvial) or wind (aeolian) action. Eroded soil can then be transported off the construction site to environmentally sensitive areas. However, with proper planning of construction activities, along with a concerted effort to install and maintain siltation/erosion control measures, the potential for damage is minimized. The Environmental Impact Study and the NWSSS recommend best management practices for erosion and sediment control during construction including timing of works, restricted access to buffer areas, silt ponds, steep slope stabilization, rock check dams in swales, timely revegetation and fencing along with inspection and monitoring. The plan should consider the need for wildlife movement if necessary.

Proposed Stormwater Management Plan

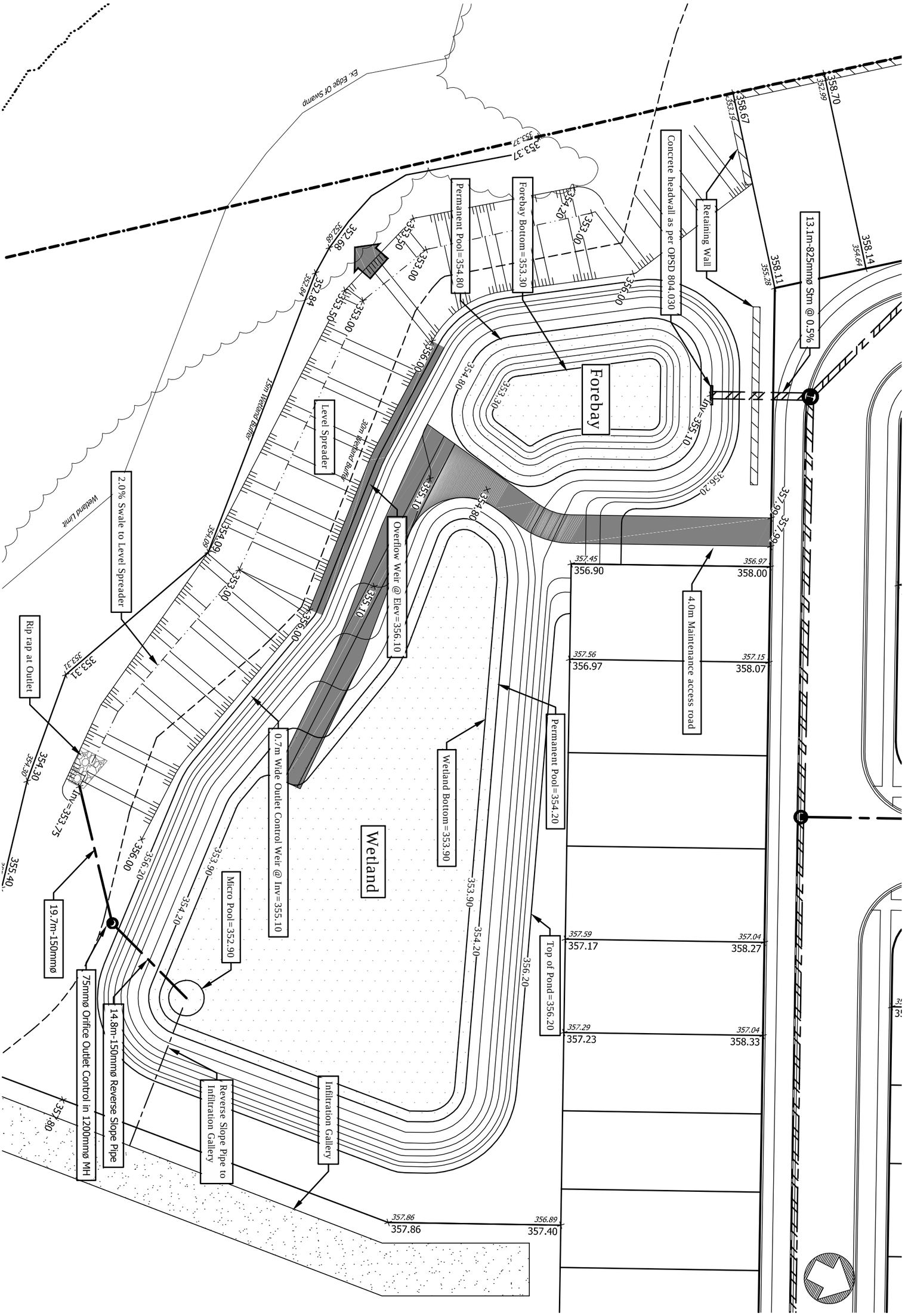
From the background information and criteria presented in previous chapters, an appropriate stormwater management plan was developed. This chapter describes the project-specific stormwater plan in detail.

The development is comprised of two catchments within North Waterloo Scoped Subwatershed Study (NWSSS) and therefore has two separate outlet locations, a drainage divide and two stormwater management solutions. The west side of the site will outlet to a proposed stormwater management facility (Figure 4) within the subject site. The facility is designed with a sediment forebay and wetland cell. The design quality storm event of 2-year storm is directed to the forebay, with major storms directed to the wetland cell. The facility is proposed to outlet to an infiltration system to allow for cooling, and increased infiltration per the NWSSS. This constructed wetland will discharge to Beaver Creek and includes the following:

- A central location, with easy access, for sediment removal
- Extended detention water quality treatment
- Flood control up to the Regional storm event, matching flows provided in the subwatershed study
- A "baseflow" component (extended detention drawdown)
- An aesthetically pleasing facility designed to blend into surrounding lands
- Easily maintainable and accessible inlets and outlets

Lot level and conveyance systems for infiltration are also discussed and can be implemented in the detailed design based on municipal acceptance.

The east side of the site will outlet to proposed infrastructure south of the intersection of Conservation Drive and Beaver Creek Road, and it will be necessary to provide peak flow rates to ensure the proposed infrastructure is designed with sufficient capacity. The minor



DRAWING:

Proposed Stormwater Management Facility
556 & 576 Conservation Drive

DRAWN BY:	JEL	CHECKED BY:	CHT	SCALE:	1:500
FILE NAME:	1279.Figures	DATE:	Jul, 2016		Figure 4

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flow conveyance will be through the storm sewer system and the major storm conveyance will be along the roads. Quantity control for the catchment discharging to Laurel Creek is not required in accordance with the NWSSS.

Quality control for this portion of the development is to be incorporated into a pond on a downstream property and will be designed and addressed in a separate stormwater management report.

Operation of Stormwater Management Facility

Minor/Major System Routing

Stormwater management is addressed as directed in the North Waterloo Scoped Subwatershed Study. Drainage from the east side of the site is directed uncontrolled to the intersection of Conservation Drive and Beaver Creek Road and will be directed to/towards the Laurel Creek Reservoir. Drainage from the west side of the site is to be directed to Beaver Creek and receive quantity and quality control.

A constructed wetland is proposed to provide control to runoff from the west side, the location of which is influenced by existing topography. As a result, the stormwater management block is proposed at the west side of the site adjacent to Beaver Creek.

As with most new subdivisions, the foundation drain for each house should discharge to a sump in the basement and pumped over the foundation wall before being directed to the storm connection at the street. Downspouts should discharge to grade in order to promote infiltration. The use of rain barrels should be encouraged. Where possible at source infiltration is to be provided for clean water.

Winter Conditions

Should the stormwater management facility outlet become clogged or frozen in winter conditions, the facility will overflow away from the development via the overflow weir toward Beaver Creek to the west. In order to protect lots backing on to the SWM block, the rear lot corners have been set above the freeboard elevation.

Infiltration measures that receive runoff from the streets should be designed to bypass in the winter months.

Quantity

As presented in the NWSS Figure 11.1, the drainage divide for the site is approximately through the centre of the property, with figure 3913 being 11.0ha and 3107 being 13.0ha in that study's proposed condition. The intent of this current design was to generally honour that divide. The divide can be seen in Figures 5 and 6 of this report and basically divides the school property in half, with the eastern and southern portions discharging to the Laurel Creek Reservoir and the western portion discharging to Beaver Creek.

The stormwater management facility meets the water quantity targets by attenuating peak flows leaving the site for the requisite storm events. Catchments 701-704 are directed to

the end-of-pipe facility and are over controlled to meet the targets within the NWSSS. Catchment 506 and 505 are rear yards and half the roof area directed to infiltration systems that result in a zero outflow for minor events. The uncontrolled flow from these two catchments are necessary to support the wetland in this location and was proposed in response to the need within the Environmental Impact Study. Catchment 504 discharges to an infiltration system as well. A portion of road runoff is directed to this facility, and therefore would include an oil-grit separator, bio-swale or some form of quality treatment before discharge.

Catchment Numbering Convention

The following catchment number convention was used to identify the characteristics of each catchment:

Description:			Catchment #
Existing	Internal	Uncontrolled	100
Existing	External	Uncontrolled	200
Existing	Internal	Controlled	300
Existing	External	Controlled	400
Proposed	Internal	Uncontrolled	500
Proposed	External	Uncontrolled	600
Proposed	Internal	Controlled	700
Proposed	External	Controlled	800

Table 2: Catchment Naming Convention

Hydrologic Model

Hydrologic modelling was performed using MIDUSS software, which is a widely accepted model for urban developments. It has been used for many years in the Region of Waterloo.

The NWSSS requires that detailed design for the individual stormwater management facilities is to use an event based assessment using both the 24-hour SCS data from the Guelph Arboretum as well as the City of Waterloo 3-hour Chicago data with the most conservative result incorporated into the design. Thus, both sets of rainfall parameters have been used. The NWSSS states that the 2-year through the regional storm events are to be modeled. The regional event is the worst-case of either the 100-year event or the 48-hour Hurricane Hazel event. Table 3 has the design parameters and Appendix C has information on the Hurricane Hazel storm.

Rainfall Data

Storm Event	Definition	a	b	C
City of Waterloo				
2-year, 4 hour	Design quality	1101	9.258	0.882
5-year, 3 hour	Minor system	1755	12.347	0.895
25-year, 3-hour				
100-year, 3 hour	Major system	4692	17.437	0.956
Guelph Arboretum				
2-year, 24 hour	Design quality	583.44	3.561	0.783
5-year, 24 hour	Minor system	956.51	5.608	0.815
25-year, 24 hour				
100-year, 24 hour	Major system	2221.21	9.093	0.866

Table 3: Coefficients for Synthetic Design Storms

Post-Development

Post-development catchments incorporate the routing of the minor and major storm systems to the proposed stormwater management facility. Figure 5 shows the catchment areas for the proposed project, and Figure 6 shows the routing used in the model.

Suitable modelling parameters were selected for each catchment, as presented in Table 4. The percentage impervious values were selected based on a comparison with standard coefficients used in the Rational Method, using the formula:

$$C = 0.14 + (0.65 \times \%imp) + (0.05 \times S)$$

where %imp = percent impervious (e.g. 60%), and

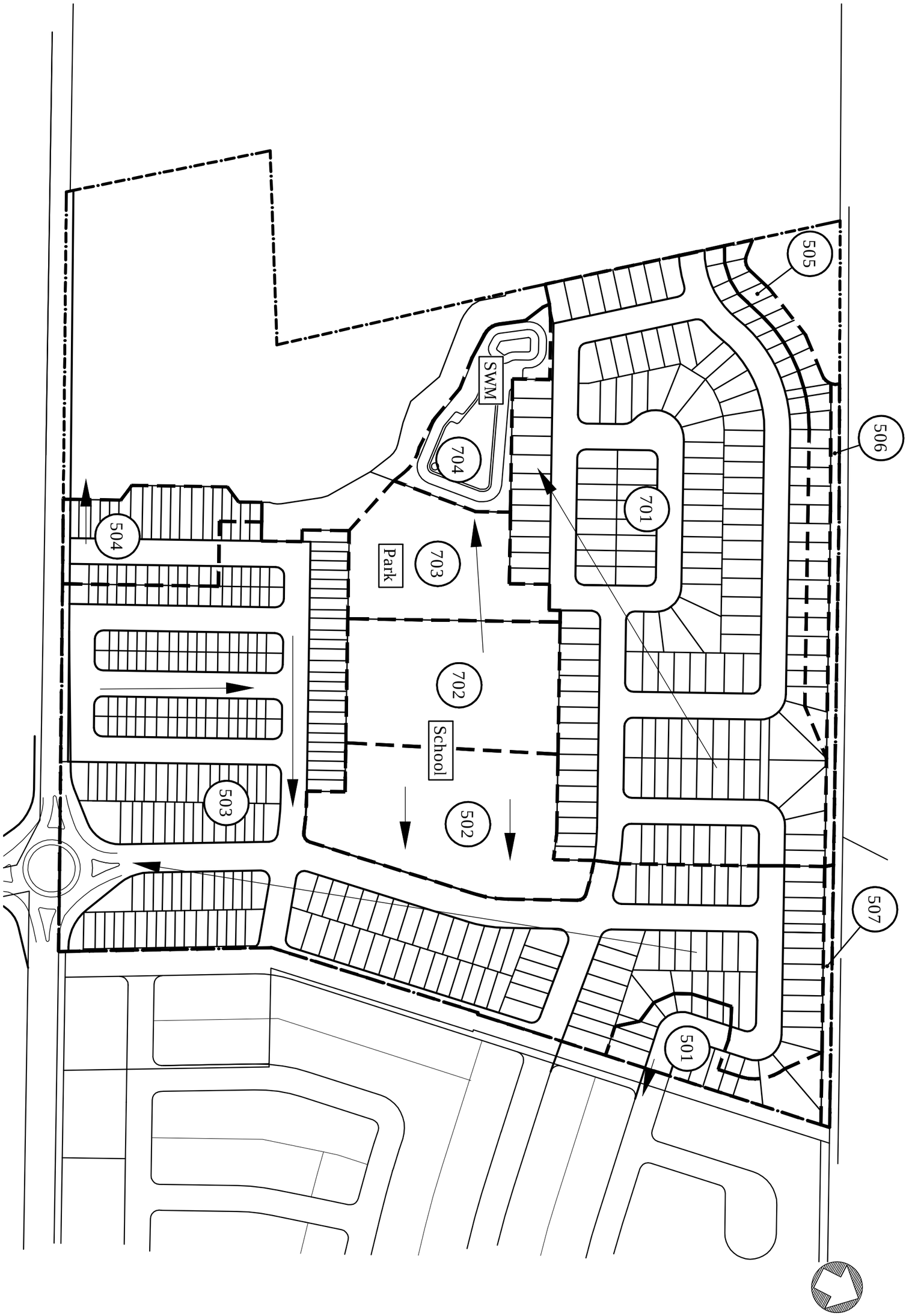
S = slope in percent (e.g. 2).

For example, a catchment of 60% impervious results in a rational design coefficient of 0.63, which is representative of this type of development.

Catchment	Area (ha)			Imper-vious	Slope Length	Slope Gradient	SCS CN	Uncontrolled Peak Flow (m^3/s)	
	Controlled	Uncontrolled	Total	(%)	(m)	(%)	(perv)	2-year	100-year
501		0.577	0.577	60	15	3	74	0.084	0.219
502		1.557	1.557	50	30	3	74	0.179	0.488
503		8.765	8.765	60	15	3	74	1.269	3.333
504		0.760	0.760	60	15	3	74	0.110	0.289
505		0.562	0.562	60	15	3	74	0.081	0.214
506		0.203	0.203	50	5	2	74	0.026	0.74
507		0.111	0.111	50	5	2	74	0.014	0.040
701	7.666		7.666	60	15	3	74	1.110	2.915
702	1.322		1.322	30	90	3	74	0.078	0.240
703	1.002		1.002	10	80	3	74	0.022	0.144
704	0.732		0.732	60	15	0.5	74	0.101	0.299
Total	10.722	12.535	23.257						

Table 4: Post-Development Modelling Parameters

The resultant uncontrolled peak flows from each catchment are summarized in Table 4. The Guelph Arboretum 24 hour storm was the most conservative for the 2-year event and Waterloo 3 hour rainfall for the 100-year was conservative, these are the values represented in Table 4. Refer to the MIDUSS modelling results in Appendix D for further information.



DRAWING: Post-Development Catchment Areas
556 & 576 Conservation Drive

DRAWN BY:	JEL	CHECKED BY:	CHT	SCALE:	1:2500
FILE NAME:	1279.Figures	DATE:	Jul, 2016		Figure 5

MERITECH engineering
1315 Bishop Street North, Suite 202 Cambridge
T 519.623.1140 F 519.623.7334 www.meritech.ca

501

To Existing Subdivision

502

503

Minor

Roof Area Infiltration

SWM Facility South of Conservation Drive

701

704

Wetland

Infiltration

702

703

Minor

Roof Area Infiltration

Beaver Creek

Major

507

Minor

Infiltration

Major

Uncontrolled to Lands North or Subdivision to East

505

504

Minor

OGS and Infiltration

506

Minor

Infiltration

Major

Wetland Finger

MERITECH engineering
1315 Bishop Street North, Suite 202 Cambridge
T 519.623.1140 F 519.623.7334 www.meritech.ca

DRAWING: Post-Development Flow Chart
556 & 576 Conservation Drive

DRAWN BY: JEL	CHECKED BY: CHT	SCALE: Not to Scale	
FILE NAME: 1279.Figures	DATE: Jul, 2016		Figure 6

Quality

Treatment Train Approach

The site was designed to meet the MOE Enhanced level of water quality control by implementing a sediment forebay and extended detention along with pre-treatment through grassed swales. However more can be done in a treatment train approach to meet the objectives for sedimentation, temperature and infiltration. Implementing lot level infiltration, roof leader connections to a perforated pipe system, reduced lot grading and local ponding areas can be incorporated into the detailed design.

Pre-Treatment

Downspouts and/or parking lot drainage are to be directed to grass areas wherever possible. This provides 'pre-treatment' and helps to capture much of the grit carried by the runoff. Specifically for the institutional block, roof leaders to soak away pits and/or grassed swales to infiltration trenches should be incorporated.

Forebay

The proposed stormwater management pond includes a sediment forebay designed in accordance with the Aesthetic Design Principles for Storm Water Management Facilities in the Region of Waterloo, and Ministry of the Environment guidelines. The forebay blends into the proposed walking trails and maintenance access routes. The forebay design is included in Appendix C.

Water Quality and Extended Detention

The wetland pond was designed in accordance with Table 3.2 of the MOE Planning & Design Manual to ensure that quality control conditions could be met. Based on an "enhanced" level of protection and an imperviousness of 60%, the following volumes are required for the forebay and wetland:

Contributing Area (ha)	Permanent Pool Required (m^3/ha)	Permanent Pool Required (m^3)	Permanent Pool Provided (m^3)	Extended Detention Required (m^3/ha)	Extended Detention Required (m^3)	Extended Detention Provided (m^3)
7.7	70	539	1,250	40	308	1,745

Table 5: Water Quality Storage Requirements

The extended detention shown in Table 5 is defined as the active storage in the design quality (2-year) storm event; the smaller of the two volumes from the two storm models is shown. Figure 7 shows the inflow and outflow to the pond for the design quality storm. The inflow hydrograph, as shown, is attenuated by the outlet control structure resulting in a longer drawdown time at a lower peak flow. The result is that runoff is retained in the pond over the recommended 24-hour period in order to enhance water quality. The flow drops to 1 l/s more than 4.5 days after the storm event.

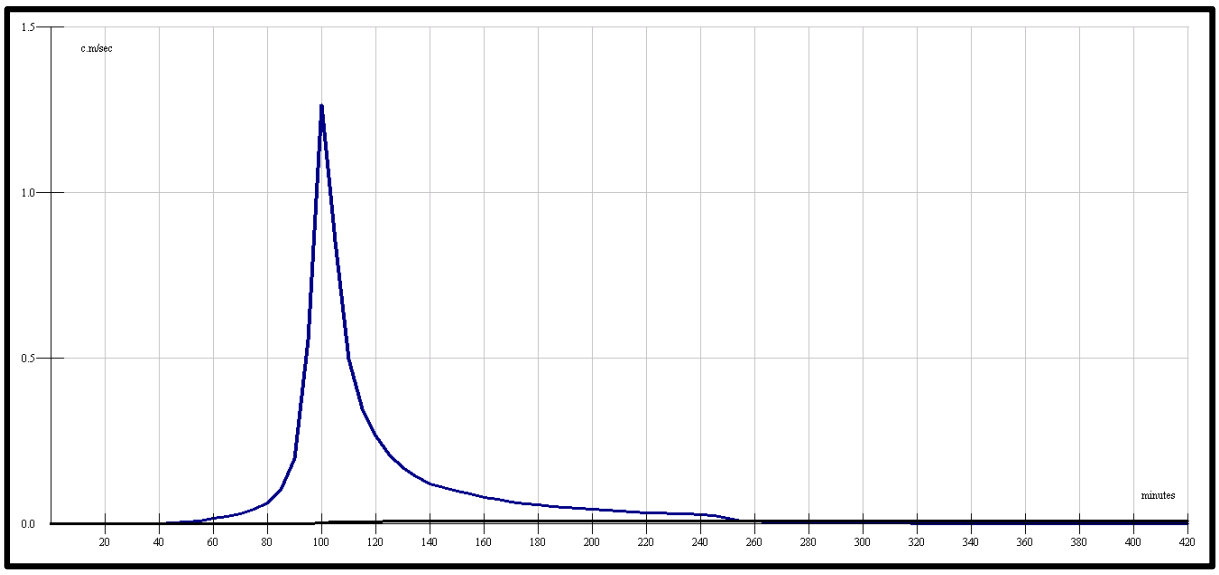


Figure 7: Drawdown of the Proposed Pond, 2-Year 3-hour Storm Event

Water Balance, Infiltration and Groundwater Conditions

This section examines the pre- and post-development infiltration occurring on the site. The two key points are the average annual infiltration volume and the directionality of the groundwater flow. Taken together, these factors will influence how the post-development infiltration plan has been designed.

A water balance can be provided through the use of some combination of lot-level soak away pits, roof water to soak away pits, a clean water "third pipe" system, and an end-of-pipe infiltrating facility.

Pre-Development

The NWSSS presents average annual pre-development infiltration rates for the subdivision, as included below in Table 6.

Description	NWSSS Catchment #	Area (ha)	Infiltration Rate (mm/yr)	Annual Infiltration (m^3/yr)
East part of site	3101	11.7	183.4	21,500
West part of site	3913	11.6	222.5	25,800
Total		23.3		47,300

Table 6: Pre-Development Infiltration

Post-Development

Matching or exceeding the annual pre-development infiltration volume can be accomplished through a mix of lot level, conveyance, and end-of-pipe infiltration and will be investigated further within the detailed design phase. It is recommended that the City of Waterloo Engineering Group be consulted on types of facilities to be placed in the public right of way.

Lot-level infiltration is proposed to consist of naturally-occurring infiltration on pervious surfaces (predominantly grass yards), with several small catchments also employing infiltration galleries. Roof leaders directed to side-yard swales and grassed areas promotes infiltration of this water. Direct connection to soak away pits or infiltration trenches can be incorporated as well. Further infiltration is able to be accomplished though the use of a third pipe or clean water collector (CWC) option is suggested in the NWSSS as a tool to infiltrate clean roof runoff and sump pump discharge. This would most likely only accept roof runoff from the front halves of roofs.

Multiple end-of-pipe infiltration facilities are proposed, as shown on the Conceptual Servicing Plan in Appendix B:

- Southeast corner, 2-year runoff volume of 222m³ (catchment 504)
- Northeast corner, 2-year runoff volume of 217m³ (catchments 505 and 506)
- School site, all roof runoff to infiltration (25mm runoff depth)
- Clean Water Conveyance system and
- End of Pipe SWM facility infiltration trench

The NWSSS recommends an end-of-pipe infiltration gallery connected to the stormwater management facility and sized for at least 5mm runoff from the contributing catchment area. This relates to a storage volume of 385m³ for the 7.7ha area.

The possible annual post-development infiltration volumes are summarized in Table 7. Refer to hand calculations in Appendix C.

Description	Catchment #	Area (ha)	Infiltration Rate (mm/yr)	Annual Infiltration (m³/yr)
Pervious areas	All	A_P=10.396	228	23,700
School roof to infiltration	502/702	Approx. 50,000ft²	90% of 844	3,400
Infiltration galleries	504, 505, 506	A_P=0.894	90% of 844	6,800
Conveyance (CWC)	503, 701	Roofs=2.46	90% of 844	18,700
End-of-pipe	701	A_I=4.60	90% of 844	35,000
Pre-development				47,300
Total post-development			With conveyance With end-of-pipe	52,600 68,900

Table 7: Post-Development Infiltration

Table 7 shows that either a third-pipe system and/or an end-of-pipe system, taken together with the lot-level infiltration measures, are able to provide an increase to the annual pre-development infiltration volume.

Performance of the Stormwater Management Facility

The pond configuration and outlet control structure, Figure 4, combine to satisfy the various objectives, such as peak flow attenuation of post-development conditions to pre-development rates, and extended detention of the design quality storm. For wetlands, the MOE SWM Planning & Design Manual recommends a detention time of at least 24 hours.

Pond volumes were calculated using the "average end area" method based on the areas for each contour. The resulting stage-storage characteristics of both the forebay and wetland cells are summarized in Table 8. The forebay is sized for the 5-year flow pipe capacity entering the forebay, major flows will be directed to a low point in the road coincident with the maintenance road, and will flow directly into the wetland cell to prevent resuspension of sediment.

The outlet structure consists of a 75mm diameter orifice designed for the 2-year outflows, and a concrete weir that allows outflow in larger storm events. The two-year storm is proposed to be directed to an infiltration gallery located under the adjacent park block. This provides for easy maintenance, inspection and good distribution of the infiltrating water. The park has very limited potential of heavy live loads over the trench prolonging the life of the system.

Elev.	Depth	Description	Discharge			Volumes			
			Orif.	Weir	Total	Area	Incr. Vol.	Dead Stor.	Live Stor.
(m)	(m)		(m^3/s)	(m^3/s)	(m^3/s)	(m^2)	(m^3)	(m^3)	(m^3)
Constructed Wetland									
353.9	-0.3	Bottom				2,056			
354.2	0.0	**Permanent Pool**				2,415	671	671	0
354.5	0.3		0.006		0.006	2,788	780		780
354.8	0.6		0.009		0.009	3,175	894		1,675
355.1	0.9	Concrete Weir	0.011		0.011	4,321	1,124		2,799
355.4	1.2		0.013	0.177	0.190	4,789	1,366		4,166
335.7	1.5		0.015	0.499	0.514	5,129	1,488		5,653
355.9	1.7		0.016	0.768	0.784	5,350	1,048		6,701
356.2	2.0	Freeboard	0.017	1.239	1.256	5,678	1,654		8,356
Forebay									
353.3	-1.5	Bottom				204	0	0	
353.6	-1.2					262	70	70	
353.9	-0.9					325	88	158	
354.2	-0.6					393	108	266	
354.5	-0.3					518	137	402	
354.8	0.0	**Permanent Pool**				657	176	579	

Table 8: Stage Storage Discharge for Forebay and Constructed Wetland

Table 9 presents the total peak flows towards Beaver Creek (SWM facility outflow plus outflows from catchments 504-506) for the range of design storms.

Event/Condition	2-year (m^3/s)	5-year (m^3/s)	100-year (m^3/s)	Hazel (m^3/s)
Allowable	0.013	0.116	0.636	1.263
Attenuated post-development (CoW ABCs)	0.009	0.094	0.502	1.233
Attenuated post-development (Guelph Arboretum ABCs)	0.010	0.039	0.372	

Table 9: Comparison of Attenuated Peak Flows (Flows to Beaver Creek)

The runoff from catchments 504 through 506 is directed to infiltration, and then once the facility has filled up, additional runoff overflows towards the Beaver Creek wetlands. Figure 7 shows how these hydrographs are modeled in MIDUSS. The red shaded area represents the volume of the 2-year runoff.

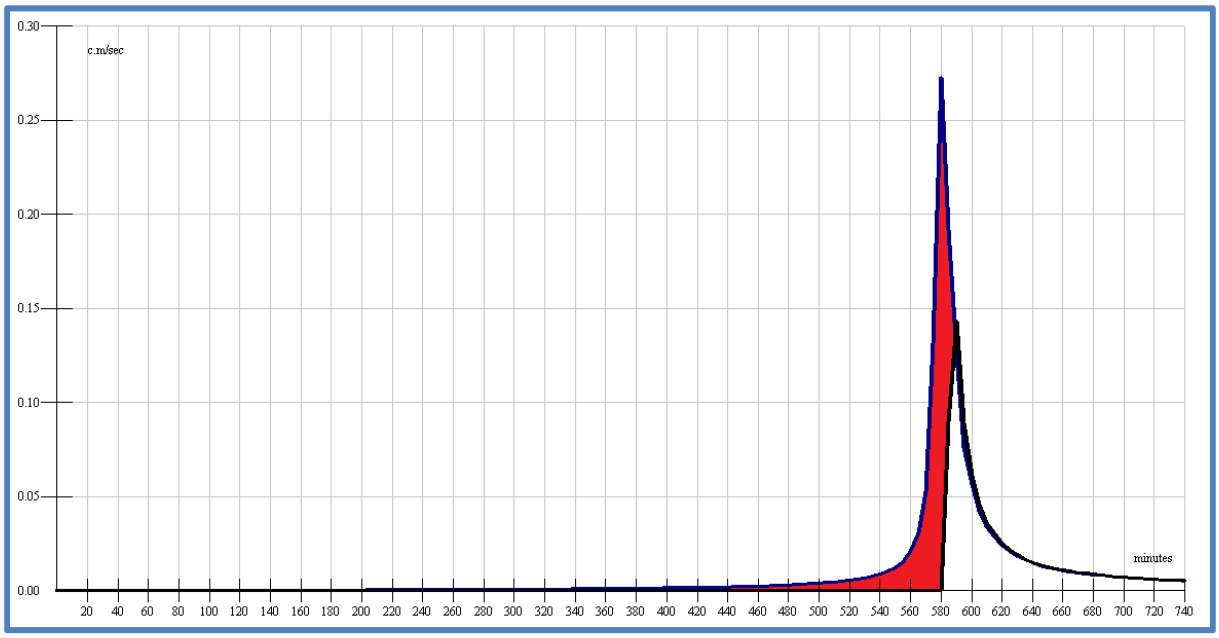


Figure 7: Infiltration Gallery Modeling

Runoff from the eastern and southern portions of the site is directed to the existing subdivision to the east (Rideau River Street) and to the proposed stormwater management facility south of Conservation Drive along Beaver Creek Road. Table 10 shows these flows (worst-case of the Waterloo and Guelph ABC parameters).

Outlet	Catchments	2-year (m^3/s)	5-year (m^3/s)	100-year (m^3/s)	Hazel (m^3/s)
Existing subdivision	501, 507	0.098	0.135	0.260	0.097
SWM south of Conservation Drive	502, 503	1.448	1.986	3.821	1.463

Table 10: Peak Uncontrolled Flows for the Eastern Half of the Site

Table 11 summarizes the overall performance of the pond, including storage volumes of the various storm events and peak discharge rates.

Description	Rainfall Parameters	Elevation (m)	Depth (m)	Volume (m^3)	Discharge (m^3/s)
Permanent pool		354.2	0.0	0	0
2-year ponding	Waterloo Guelph	354.82 354.97	0.62 0.77	1,745 2,308	0.009 0.010
Concrete control weir		355.10	0.90	2,799	0.011
5-year ponding	Waterloo Guelph	355.10 355.14	0.90 0.96	2,784 2,973	0.011 0.034
100-year ponding	Waterloo Guelph	355.57 355.47	1.37 1.27	4,991 4,510	0.370 0.265
Hurricane Hazel ponding	-	356.09	1.89	7,728	1.077
Maximum ponding		356.10			
Freeboard		356.20	2.00	8,356	1.256

Table 11: Pond Performance Summary

Outflow from the constructed wetland is to a level spreader between the facility and Beaver Creek. This results in numerous benefits including converting a point source discharge point to a sheet flow, allows for additional infiltration, provides an easy-to-inspect location to ensure the facility outflows are occurring, and may even add wildlife habitat.

Landscaping

The Environmental Impact Study has recommendations for the Landscape Plan. This plan will be prepared for approvals with the detailed design of the facility following Draft Plan Approval. It is recommended to include:

- Native plantings replicating what occurs within the wetland fringe to be planted in the stormwater management block
- Use of a diverse mix of trees, and species tolerant to water level changes
- Slope erosion can be reduced through proper plant species
- Providing a 3m clearance to maintenance roads from woody plants.
- To mitigate temperature increases in the facility, planting of shade trees and shrubs along the wetland and forebay and cooling trench through shading.

Construction Staging

A staging plan will be prepared in support of engineering approvals, following Draft Plan approval. The plan should include consideration for:

- Whether the pond should initially be constructed in its final form or whether it will be part of the siltation and erosion control works during construction
- Seasonal concerns, such as wet spring conditions, dry dusty summer conditions, suitability for re-vegetation and landscaping, and herpetofaunal movement times (see page 326 of the NWSSS)
- Anticipated maintenance and assumption schedules with the municipality

Site Erosion and Sedimentation Control

Construction activities can cause erosion of native soils, and deposition of sediment on other properties or in receiving watercourses. To avoid these problems siltation control measures, such as silt ponds, silt fencing and construction staging are utilized.

The following issues will be considered:

- Construction staging
- Disturbed areas should be protected from erosion caused by rain
- Disturbed areas should be kept to a minimum and revegetated in a reasonable timeframe in order to minimize dust
- Maintenance of the installed measures
- Where the topsoil stockpile will be located, from where it will be accessed, and appropriate siltation control measures
- The facility shall be cleaned out and reinstated to the final design configuration before transfer of ownership

Best management practices during construction are listed on page 279 of the NWSSS and include timing of works, restricted access to future buffer areas for works and materials storage, implementation of the erosion and sediment control plan.

Section 13.1.4.2 of the NWSSS recommends that an E&S plan should be prepared in support of development applications to mitigate impacts on vegetation, wildlife habitat and aquatic resources. Elements that will form part of the E&S plan for this subdivision will include: E&S fencing at grading limits, preventing sedimentation in adjacent natural features; temporary rock check dams in swales; timely re-vegetation of exposed soils; and regular site inspection, maintenance and reporting to ensure the controls are working properly.

Monitoring, Maintenance and Mitigation

There is currently a monitoring program underway in accordance with the North Waterloo Scoped Subwatershed Study and the City of Waterloo Development Monitoring Policy. Stage I consists of 2 years pre-development monitoring, Stage II is during construction and Stage III extends for 2 years post substantial completion of the subdivision. Stage II and Stage III monitoring programs are to be developed within the Draft Plan of Subdivision

Application and recommendations are presented in this report as well as the Environmental Impact Study.

The current Stage I monitoring Program includes:

- Surface water flow and depth measurements monitored along Beaver Creek and Laurel Creek 3 times annually
- Groundwater levels and chemistry are recorded 3 times annually in the 12 monitoring wells and 5 piezometers. Chemistry recorded is for:
    - Temperature
    - Dissolved Oxygen
    - Total Phosphorus
    - Total Suspended Solids
    - Bacteria
- Terrestrial field surveys, with wildlife observations recorded (further described in the EIS)

Proposed Stage II Monitoring

During construction, the monitoring is to mimic the Stage I work as well as compliance monitoring per the Development Monitoring Protocol. This program will include:

- Surface water flow and depth measurements monitored along Beaver Creek and Laurel Creek 3 times annually
- Groundwater levels and chemistry are recorded 3 times annually in the 12 monitoring wells and 5 piezometers. Chemistry recorded is for:
    - Temperature
    - Dissolved Oxygen
    - Total Phosphorus
    - Total Suspended Solids
    - Bacteria
- Terrestrial field surveys, with wildlife observations recorded (further described in the EIS)

Plus,

- Weekly Siltation and Erosion Control Inspections during the active construction phase,
- Quarterly E&S inspections outside active construction including inspection prior to anticipated rain events and post rain events.
- Inspection reports are to be provided to the City of Waterloo and the Grand River Conservation Authority.

Proposed Stage III Monitoring

After 90% build out of the subdivision, the monitoring program frequency is proposed to be reduced with the same parameters being monitored off site and additional monitoring of on site facilities as follows:

- Surface water monitoring (same parameters) with a minimum of one wet and one dry weather sample (low flow) per year.
- Ground water monitoring (same parameters) with a minimum of one wet and one dry weather sample (low flow) per year.
- Aquatic and terrestrial monitoring per the EIS

- Infiltration trenches/galleries and soak away pits on public property are to be inspected within 24 hours after a rainfall event to document the existence of water in the system and 72 hours after to show the water left the system. This should be done a minimum once annually and in the late spring to late fall months.
- Depth of the wetland and forebay cells should be recorded at the same time as the infiltration trenches, after a rainfall event plus one dry weather event to record the permanent pool level.
- Siltation and Erosion Inspections are to continue quarterly and at the time of proposed removal of any E&S Measures.

Conclusions

Post-development unattenuated flows exceed allowable flows and, therefore, peak flow attenuation is required.

The proposed stormwater management facility meets the design objectives for water quality and water quantity (flood) control. The facility includes: a forebay and constructed wetland and an outlet structure comprising a pipe and weir to attenuate various storm events.

Extended detention of the 2-year storm event is provided over a 24-hour period.

The block on the draft plan is adequate to construct the proposed facility to meet the Aesthetic Design Principles.

The facility has been designed to accommodate easy access for maintenance of the inlet and outlet structures as well as being easily accessible for sediment removal.

The proposed stormwater management facility is aesthetically pleasing, will blend in with the surrounding environment, and is an amenity to the development.

Infiltration forms a key part of the stormwater management design and is a mix of lot-level, conveyance, and/or end-of-pipe features.

Recommendations

Buildings should have sump pumps that are connected to the internal storm sewer system.

Storm connections should be provided to each lot and connect to the internal storm sewer discharging into the SWM facility which either discharges to Beaver Creek and the proposed storm sewer in Conservation Drive.

Roof drains should discharge to grade to promote infiltration.

The pond size and sewer routing should be refined in final design to incorporate the final servicing design.

A detailed siltation and erosion control plan should be developed as part of the final design and prior to any grading. Consideration should be given to the use of the proposed facility as an interim siltation pond until such time as upstream areas are revegetated and stabilized.

A landscape plan should be completed for the final design in accordance with the Aesthetic Design Principles for Storm Water Management Facilities.

A Monitoring, Maintenance and Mitigation plan should be further developed as part of the final design to address the need for adjustments as may be required in order to meet theoretical targets.

Investigate the possible requirement of establishing a minimum basement elevation above the seasonally high water table at the southwest corner of the development.

Approval agencies should review and approve this document as a suitable approach to a final design configuration and approval of the draft plan of subdivision.

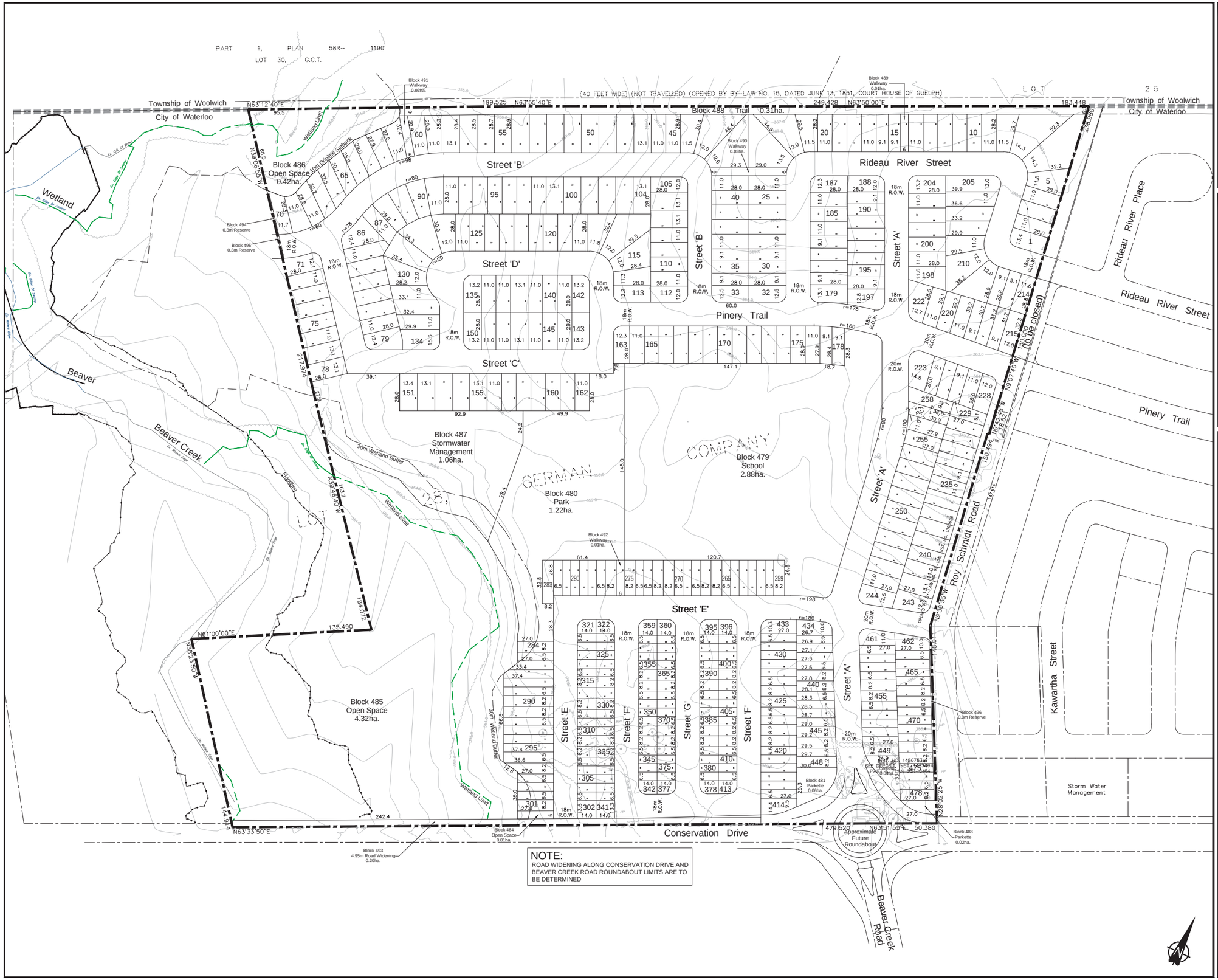
References

Ministry of the Environment, Stormwater Management Planning & Design Manual, Toronto ON, March 2003

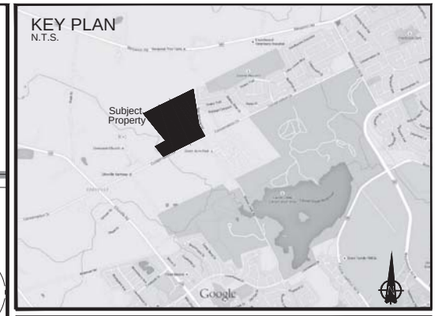
Greater Golden Horseshoe Area Conservation Authorities, Erosion & Sediment Control Guideline for Urban Construction, December 2006

City of Waterloo, Design Principles for Stormwater Management Facilities, Kitchener ON, April 1997

Appendix A: Draft Plan



NOTE:
ROAD WIDENING ALONG CONSERVATION DRIVE AND BEAVER CREEK ROAD ROUNDABOUT LIMITS ARE TO BE DETERMINED



DRAFT PLAN OF SUBDIVISION

Part of Lot 28
German Company Tract
City of Waterloo
Regional Municipality of Waterloo

LAND USE SCHEDULE

DESCRIPTION	LOTS/BLKS.	UNITS	AREA (ha.)
Residential (single detached)	1-258	258	8.62
Street Townhouses	259-301, 414-478	108	2.22
Back-to-Back Townhouses	302-413	112	1.14
School	479		2.88
Park	480		1.22
Parkette	481-483		0.12
Open Space	484-486		4.75
Stormwater Management	487		1.06
Trail	488		0.31
Walkway	489-492		0.07
Road Widening	493		0.20
0.3m Reserve	494-496		0.00
Roads			6.05
Total		478	28.64

ADDITIONAL INFORMATION
(UNDER SECTION 51(17) OF THE PLANNING ACT)

INFORMATION REQUIRED BY CLAUSES a,b,c,d,e,f,g,j and I ARE AS SHOWN ON THE DRAFT PLAN.
h) Municipal water supply
i) Well-drained sandy loam on lacustrine deposits
k) All sanitary and storm sewers as required

OWNER'S CERTIFICATE
I AUTHORIZE THE GSP GROUP INC. TO PREPARE AND SUBMIT THIS DRAFT PLAN OF SUBDIVISION TO THE REGIONAL MUNICIPALITY OF WATERLOO.

OWNER _____ DATE _____

SURVEYOR'S CERTIFICATE
I CERTIFY THAT THE BOUNDARIES OF THE LAND TO BE SUBDIVIDED AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE CORRECTLY SHOWN.

SURVEYOR _____ DATE _____

GSP group
PLANNING I URBAN DESIGN I LANDSCAPE ARCHITECTURE
gspgroup.ca

REVISIONS
February 1, 2016
March 3, 2016
March 30, 2016
May 2, 2016

Date: July 29, 2015	Drawn By: S.L.	Dwg. File Name: dp09009h.dwg
Scale: 1:1250 metric	Project No.: 09009.40	

Appendix B: Design Drawings

Ex. CA. Of Creek

Ex. Edge of Swamp

Infiltration gallery

Street 'B'

Street 'D'

Street 'C'

Max 6.0m high retaining wall

Beaver Creek

Ex. Hedge row

SWM Pond

Infiltration gallery

Park

Infiltration gallery

Infiltration gallery

Ex. Edge of Swamp

Ex. Edge of Swamp

Match existing elevations along entire northern limit

Rideau River Street

Street 'B'

Street 'A'

Pinery Trail

Infiltration gallery

School

Street 'A'

Rideau River Place

Rideau River Street (to be closed)

Pinery Trail

Roy Schmidt Road

Street 'E'

Street 'F'

Street 'G'

Street 'F'

Street 'A'

Kawartha Street

Conservation Drive

POLE

Ex Gutter

MERITECH
Engineering
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DRAWING: Conceptual Grading Plan
556 & 576 Conservation Drive

DRAWN BY:	JEL	CHECKED BY:	CHT
FILE NAME:	1279-Figure	DATE:	Jul. 2016

SCALE: 1:1000

1279-SG

Rear yards over/through wall to infiltration gallery under trail, sized for 2-yr volume. (See detail below)

Rear yards over/through wall to infiltration gallery, sized for 2-yr volume.

Ex. Post & Wire Fence

Ex. CA. Of Creek

Ex. Edge Of Swamp

Ex. Edge Of Swamp

Ex. Edge Of Swamp

Ex. Edge Of Swamp

Ex. Edge Of Swamp

Street 'B'

Rideau River Street

150mmø Wmn, Streets B, C & D

150mmø Wmn, Street A (Pinery Trail to Rideau River Street) & Rideau River Street

Street 'D'

Street 'B'

Street 'A'

Rideau River Place

Rideau River Street

Pinery Trail

300mmø Wmn

(to be closed)

200mmø Wmn Pinery Trail (Street B to Street A)

Street 'C'

825mmø Stm into SWM Pond

Beaver Creek

Ex. Hedge Row

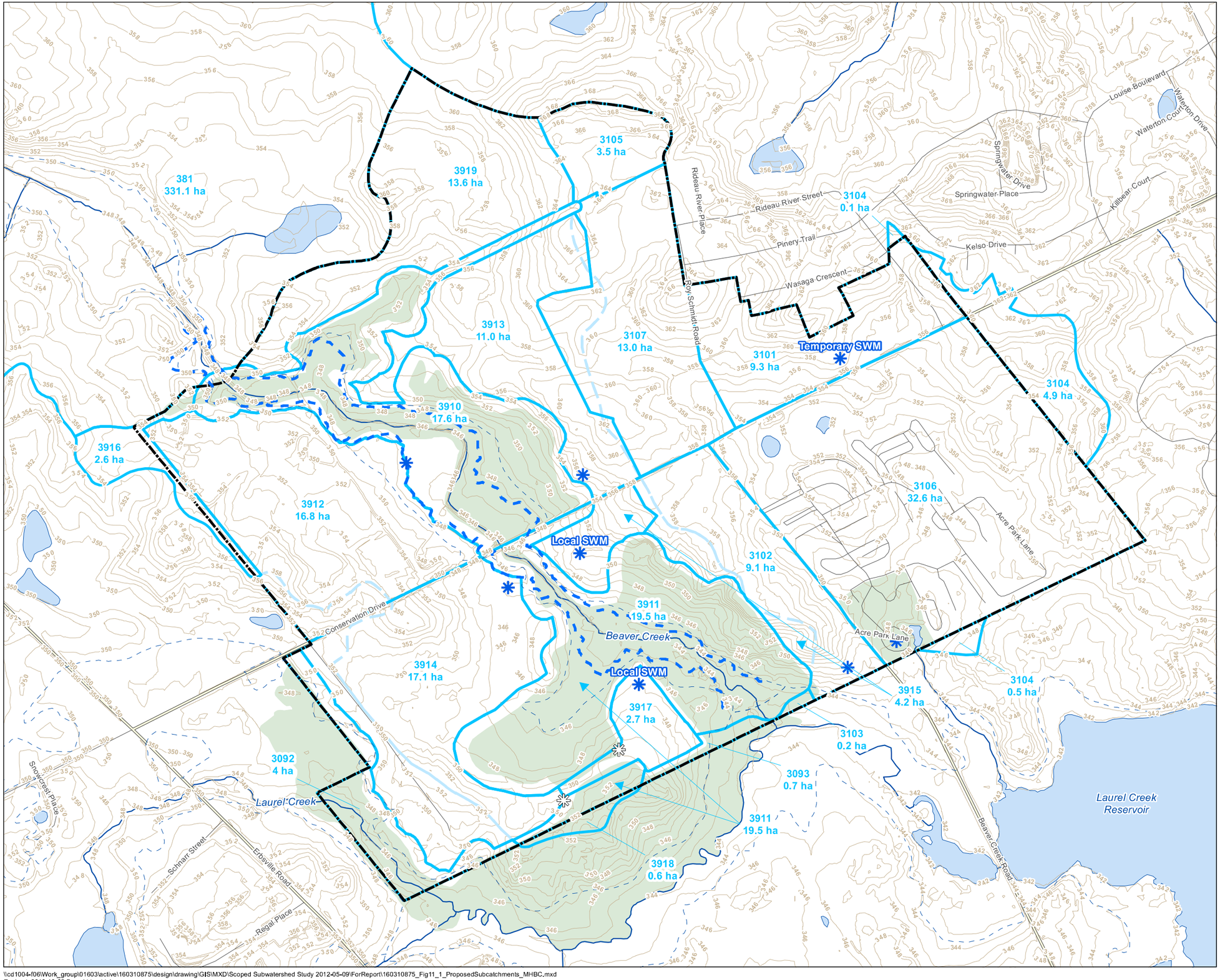
Ex. Hedge Row

Ex. Hedge Row

NORTH WATERLOO SCOPED SUBWATERSHED STUDY

PROPOSED SUBCATCHMENTS

FIGURE 11.1



- Primary Study Area
- SWM Facility
- Future Study Area
- Highway
- Major Road
- Local Road
- Topographic Contour (mAMSL)
- Watercourse
- Waterbody
- Delineated Floodplain
- GRCA Floodplain
- Proposed Detailed Subcatchment
- Existing Detailed Subcatchment
- Natural Heritage Features

0 50 100 200 300 400 m

1:7,500

NOTES

1. Coordinate System: UTM NAD 83 - Zone 17 (N).
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2011.

NORTH

October 2013

Stantec

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE
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160310875

\\cd1004-f06\Work_group\01603\active\160310875\design\drawing\GIS\MXD\Scoped Subwatershed Study 2012-05-09\ForReport\160310875_Fig11_1_ProposedSubcatchments_MHBC.mxd
Revised: 2013-10-25 By: mkirkpatrick

Appendix C: Design Calculations

MERITECH

Project Name: Conservation Drive
Project Number: 1279
Calc'd by: STV
Date: 15-Apr-16
Chk'd by: CHT
Date: 19-May-16

Sediment Forebay Sizing Calculations

(in accordance with MOE 2003)

Forebay Dimensions

				Calculated min.	Actual	
Average bottom width	8.6	m	Average top width	19.1	20.0	m
Maximum bottom width	10.0	m	Maximum top width	20.5	21.0	m
Average bottom length	23.0	m	Average top length	33.5	34.0	m
Average depth	1.50	m	Total Volume	578	m³	
Average sideslope	3.5	:1	Usable Volume	374	m³	

1) Forebay Settling Length

Dist = forebay length (m)
r = length to width ratio at average depth
= **2.0** (should be greater than 2:1)
Q_p = peak flow rate from facility during design quality storm
= **0.010** m³/s **2 year** storm event
V_s = settling velocity (dependent on particle size)
= **0.0003** m/s for 150 μm particle
Therefore, distance = **8.2** m vs. **34.0** m provided

2) Dispersion Length

Dist = length of dispersion (m)
Q = flowrate into forebay (lesser of actual pipe capacity or 10-year peak runoff rate)
= **1.400** m³/s Pipes sized for: **5-year** storm event
d = depth of the permanent pool above the maximum sediment depth
= **0.750** m
V_f = desired velocity in the forebay
= **0.50** m/s
Therefore, distance = **29.9** m vs. **34.0** m provided
Also, min. bottom width = Dist./8 = **3.7** m vs. **8.6** m provided

3) Check Velocity Across Full Width of Forebay Above Maximum Accumulated Sediment Depth

V_a = average velocity in the forebay (m/s)
Q_i = flowrate into forebay
= **1.400** m³/s **5-year** storm event
A_x = cross sectional area of forebay perpendicular to flow
= **13.6** m² above the maximum sediment depth
Therefore, velocity = V_a = **0.10** m/s should be < tha **0.50** m/s

4) Cleanout Interval

V_u = usable accumulation storage volume of forebay at a
max. depth, d_u = **0.75** m
= **204** m³
L_a = annual loading
for **60.0** % impervious
= **2.200** m³/ha/yr
A_c = **7.700** ha of contributing land
Therefore, interval = I = **12.0** yrs between cleanouts **5.0** years min. preferred

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5) 10 year Accumulated Sediment Depth

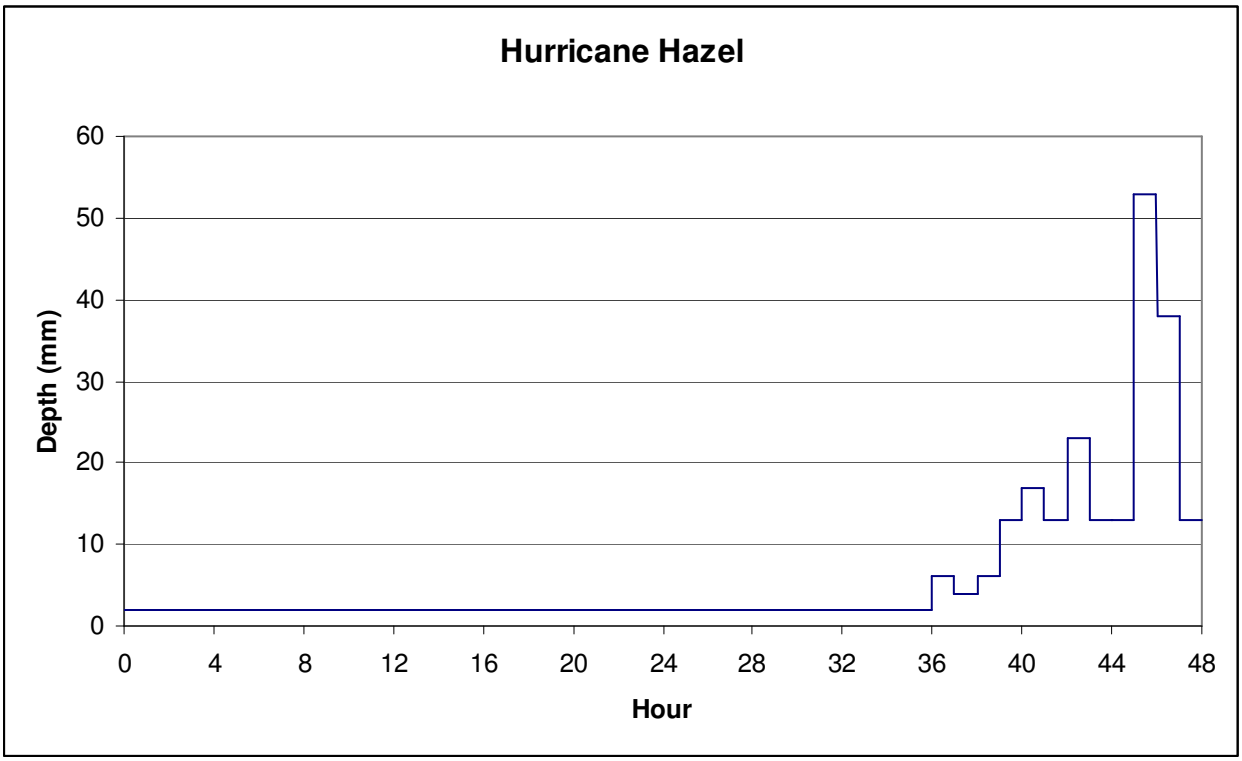
A_c = contributing area
= **7.700** ha.
L_a = annual loading
= **2.200** m^3/ha/yr
I = cleanout interval
= **10** years
V_r = required total storage volume
= **169.4** m^3
Actual total storage volume
= **577.7** m^3

6) Forebay Size in relation to Remainder of Facility

Type of facility: **Wetland**

Forebay permanent pool **area**	**657**
Wetland permanent pool area	**2415**
Forebay's percentage	**21%**
Minimum criteria	**Maximum 20%**
Forebay permanent pool **volume**	**579**
Wetland permanent pool volume	**671**
Forebay's percentage	**46%**
Preferred criteria	**No criteria**

285mm total depth, 48 hour storm with 1 hour time steps



Time step	Fraction of total rainfall
0	0.0000
1	0.0071
2	0.0142
3	0.0213
4	0.0285
5	0.0356
6	0.0427
7	0.0498
8	0.0569
9	0.0640
10	0.0712
11	0.0783
12	0.0854
13	0.0925
14	0.0996
15	0.1067
16	0.1138
17	0.1210
18	0.1281
19	0.1352
20	0.1423
21	0.1494
22	0.1565
23	0.1636
24	0.1708
25	0.1779
26	0.1850
27	0.1921
28	0.1992
29	0.2063
30	0.2135
31	0.2206
32	0.2277
33	0.2348
34	0.2419
35	0.2490
36	0.2561
37	0.2772
38	0.2912
39	0.3123
40	0.3579
41	0.4175
42	0.4632
43	0.5439
44	0.5895
45	0.6351
46	0.8211
47	0.9544
48	1.0000

MERITECH

Designed by: CHT
Date: May 20 2016
Checked by:
Date:

Project Name: Conservation Drive
Project No.: 1279
Sheet: 1 of 1

Post-Development Infiltration

1) Lot-level infiltration on pervious areas

Table 3.1 of the MOE SWM manual gives annual infiltration for urban lawns & soil type B of 228 mm/yr.

Catchment	Area	%I	%P	AxP
501	0.577	60	40	0.231
502	1.577	50	50	0.788
503	8.765	60	40	3.506
504	0.760	60	40	0.304
505	0.562	60	40	0.225
506	0.203	50	50	0.101
507	0.111	50	50	0.056
701	7.666	60	40	3.066
702	1.322	30	70	0.925
703	1.002	10	90	0.901
704	0.732	60	40	0.293
Σ=23.257				Σ 10.396 ha

Σ 10.396 ha × 228 $\frac{mm}{yr}$ = 23,700 m^3/yr

2) Infiltration from lot-level runoff

Catchment	Area	%I	AxI
502+702	0.45	roof ±	0.450
504	0.760	60	0.456
505	0.562	60	0.337
506	0.203	50	0.101

Σ 1.344 ha × 90% × 0.844 m rain/yr

= 10,200 m^3/yr

3) Infiltration (Conveyance or end-of-pipe) in Catchment 701

If a third-pipe system is used, only roofs will infiltrate. Say 701 & 503.
16.431 ha × 15% is roof × 90% of rainfall × 0.844 m/yr = 18,700 m^3/yr

If infiltration after pond, 7.666 × 0.6 × 90% of 844 $\frac{mm}{yr}$ = ± 35,000 m^3/yr max.

Appendix D: Modelling

```
"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                        Thursday, March 24, 2011"
"           10   Units used:                                          ie METRIC"
"                Job folder:                             K:\1279\60-Design\SWM"
"                Output filename:                      1279d2yr3hrMay202016.out"
"                Licensee name:                             Any Authorised User"
"                Company                                  Meritech Engineering"
"                Date & Time last used:                5/20/2016 at 12:32:02 PM"
" 81           ADD COMMENT=====================================================
"           2  Lines of comment"
"              SWM Analysis of 2-yr 4 hr post-development storm event "
"              for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"         5.000   Time Step"
"       240.000   Max. Storm length"
"      7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"             1   Chicago storm"
"      1101.000   Coefficient A"
"         9.258   Constant B"
"         0.882   Exponent C"
"         0.400   Fraction R"
"       240.000   Duration"
"         1.000   Time step multiplier"
"              Maximum intensity           101.723    mm/hr"
"              Total depth                  33.885    mm"
"             4   2hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT=====================================================
"           1  Lines of comment"
"              Area to SWM facility on west side"
" 33           CATCHMENT 701"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           701   Northwest corner - lots"
"        60.000   % Impervious"
"         7.666   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.066   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         4.600   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.161   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.837   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.070     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           3.066      4.600      7.666      hectare"
```

```
"             Time of concentration  15.530     1.324      2.937      minutes"
"             Time to Centroid       151.167    115.087    119.185    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        1039.04    1558.56    2597.60    c.m"
"             Rainfall losses        28.436     5.533      14.694     mm"
"             Runoff depth           5.449      28.352     19.191     mm"
"             Runoff volume          167.09     1304.08    1471.16    c.m"
"             Runoff coefficient     0.161      0.837      0.566      "
"             Maximum flow           0.057      1.062      1.070      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.070     1.070     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        1.322   Total Area"
"       90.000   Flow length"
"        3.000   Overland Slope"
"        0.925   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.397   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.839   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.078     1.070     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.925      0.397      1.322      hectare"
"             Time of concentration  45.505     3.879      16.753     minutes"
"             Time to Centroid       191.220    119.242    141.504    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        313.57     134.39     447.95     c.m"
"             Rainfall losses        28.430     5.460      21.539     mm"
"             Runoff depth           5.455      28.424     12.346     mm"
"             Runoff volume          50.48      112.73     163.21     c.m"
"             Runoff coefficient     0.161      0.839      0.364      "
"             Maximum flow           0.009      0.077      0.078      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.078     1.147     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.002   Total Area"
```

```
"        80.000   Flow length"
"         3.000   Overland Slope"
"         0.902   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.100   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.161   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.834   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.020     1.147     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           0.902      0.100      1.002      hectare"
"              Time of concentration  42.400     3.614      28.226     minutes"
"              Time to Centroid       187.069    118.866    162.145    minutes"
"              Rainfall depth         33.885     33.885     33.885     mm"
"              Rainfall volume        305.57     33.95      339.52     c.m"
"              Rainfall losses        28.431     5.616      26.149     mm"
"              Runoff depth           5.454      28.269     7.736      mm"
"              Runoff volume          49.18      28.33      77.51      c.m"
"              Runoff coefficient     0.161      0.834      0.228      "
"              Maximum flow           0.009      0.020      0.020      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.020     1.167     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         0.732   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.293   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.439   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.160   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.841   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.098     1.167     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.293      0.439      0.732      hectare"
"             Time of concentration  8.790      2.266      3.002      minutes"
"             Time to Centroid       142.163    116.604    119.487    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        99.21      148.82     248.04     c.m"
"             Rainfall losses        28.453     5.399      14.621     mm"
"             Runoff depth           5.431      28.486     19.264     mm"
"             Runoff volume          15.90      125.11     141.01     c.m"
"             Runoff coefficient     0.160      0.841      0.569      "
"             Maximum flow           0.007      0.097      0.098      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.098     1.265     0.000     0.000"
" 54          POND DESIGN"
"        1.265   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       1852.9   Hydrograph volume    c.m"
"           9.   Number of stages"
"      353.900   Minimum water level    metre"
"      356.200   Maximum water level    metre"
"      354.200   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.900     0.000     0.000"
"                354.200  1.00E-07   0.01000"
"                354.500   0.00616   780.000"
"                354.800   0.00914  1675.000"
"                355.100   0.01137  2799.000"
"                355.400    0.1897  4166.000"
"                355.700    0.5140  5653.000"
"                355.900    0.7844  6701.000"
"                356.200     1.256  8356.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                355.100     0.900     0.700     0.000     0.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                354.200     0.630    0.0750     1.000"
"             Peak outflow                  0.009    c.m/sec"
"             Maximum level               354.819    metre"
"             Maximum storage            1745.358    c.m"
"             Centroidal lag               37.887   hours"
"                  0.098     1.265     0.009     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.009    c.m/sec"
"             Hydrograph volume          1772.797    c.m"
"                    0.098     1.265     0.009     0.009"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501/507 are to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
```

```
"                    0.098     0.000     0.009     0.009"
" 33          CATCHMENT 501"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           501   Northeast corner of subdivision"
"        60.000   % Impervious"
"         0.577   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.231   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.346   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.161   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.837   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.081     0.000     0.009     0.009 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.231      0.346      0.577      hectare"
"             Time of concentration  15.530     1.324      2.937      minutes"
"             Time to Centroid       151.167    115.087    119.185    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        78.21      117.31     195.51     c.m"
"             Rainfall losses        28.436     5.533      14.694     mm"
"             Runoff depth           5.449      28.352     19.191     mm"
"             Runoff volume          12.58      98.15      110.73     c.m"
"             Runoff coefficient     0.161      0.837      0.566      "
"             Maximum flow           0.004      0.080      0.081      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.081     0.081     0.009     0.009"
" 33          CATCHMENT 507"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           507   Trail block - east part"
"        50.000   % Impervious"
"         0.111   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.056   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.056   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.160   Pervious Runoff coefficient"
```

```
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.805   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.013     0.081     0.009     0.009 c.m/sec"
"              Catchment 507          Pervious   Impervious Total Area "
"              Surface Area           0.056      0.056      0.111      hectare"
"              Time of concentration  9.072      0.773      2.151      minutes"
"              Time to Centroid       142.537    114.446    119.110    minutes"
"              Rainfall depth         33.885     33.885     33.885     mm"
"              Rainfall volume        18.81      18.81      37.61      c.m"
"              Rainfall losses        28.451     6.593      17.522     mm"
"              Runoff depth           5.434      27.292     16.363     mm"
"              Runoff volume          3.02       15.15      18.16      c.m"
"              Runoff coefficient     0.160      0.805      0.483      "
"              Maximum flow           0.001      0.013      0.013      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.013     0.094     0.009     0.009"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                      0.013     0.094     0.094     0.009"
" 40           HYDROGRAPH   Combine    507"
"             6   Combine "
"           507   Node #"
"                 To N and NE"
"              Maximum flow                  0.094    c.m/sec"
"              Hydrograph volume           128.893    c.m"
"                      0.013     0.094     0.094     0.094"
" 81           ADD COMMENT================================================="
"           4  Lines of comment"
"              Flows from 502 and 503 are to a proposed SWM facility "
"              south of Conservation Drive. Rooftop runoff from the "
"              school (502) up to 25mm rainfall depth to infiltration"
"              but conservatively ignored in this modeling."
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.013     0.000     0.094     0.094"
" 33           CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         1.557   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         0.779   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         0.779   Impervious Area"
"        30.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.161   Pervious Runoff coefficient"
```

```
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.842   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.174     0.000     0.094     0.094 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.779      0.779      1.557      hectare"
"              Time of concentration  23.539     2.006      5.463      minutes"
"              Time to Centroid       161.855    116.161    123.495    minutes"
"              Rainfall depth         33.885     33.885     33.885     mm"
"              Rainfall volume        263.79     263.79     527.58     c.m"
"              Rainfall losses        28.433     5.369      16.901     mm"
"              Runoff depth           5.452      28.515     16.984     mm"
"              Runoff volume          42.44      221.99     264.44     c.m"
"              Runoff coefficient     0.161      0.842      0.501      "
"              Maximum flow           0.011      0.173      0.174      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.174     0.174     0.094     0.094"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        60.000   % Impervious"
"         8.765   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.506   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         5.259   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.161   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.837   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       1.223     0.174     0.094     0.094 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           3.506      5.259      8.765      hectare"
"              Time of concentration  15.530     1.324      2.937      minutes"
"              Time to Centroid       151.167    115.087    119.185    minutes"
"              Rainfall depth         33.885     33.885     33.885     mm"
"              Rainfall volume        1187.99    1781.99    2969.99    c.m"
"              Rainfall losses        28.436     5.533      14.694     mm"
"              Runoff depth           5.449      28.352     19.191     mm"
"              Runoff volume          191.04     1491.03    1682.07    c.m"
"              Runoff coefficient     0.161      0.837      0.566      "
"              Maximum flow           0.065      1.214      1.223      c.m/sec"
```

```
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    1.223     1.397     0.094     0.094"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    1.223     1.397     1.397     0.094"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"               Maximum flow                  1.397    c.m/sec"
"               Hydrograph volume          1946.509    c.m"
"                    1.223     1.397     1.397     1.397"
" 81          ADD COMMENT==================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 (townhouses "
"             at SW corner) are through an OGS (road runoff) and into "
"             infiltration"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    1.223     0.000     1.397     1.397"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       60.000   % Impervious"
"        0.760   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.304   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.456   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.837   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.106     0.000     1.397     1.397 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.304      0.456      0.760      hectare"
"             Time of concentration  15.530     1.324      2.937      minutes"
"             Time to Centroid       151.167    115.087    119.185    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        103.01     154.51     257.52     c.m"
"             Rainfall losses        28.436     5.533      14.694     mm"
"             Runoff depth           5.449      28.352     19.191     mm"
"             Runoff volume          16.57      129.28     145.85     c.m"
"             Runoff coefficient     0.161      0.837      0.566      "
"             Maximum flow           0.006      0.105      0.106      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
```

```
"            4   Add Runoff "
"                    0.106     0.106     1.397     1.397"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    0.106     0.106     0.106     1.397"
" 40          HYDROGRAPH   Combine    504"
"            6   Combine "
"          504   Node #"
"                Minor to infiltration"
"               Maximum flow                 0.106    c.m/sec"
"               Hydrograph volume          145.850    c.m"
"                    0.106     0.106     0.106     0.106"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Flows from catchment 505/506 are infiltrated (2-year "
"             and less) with overflows to the wetland finger, which "
"             then is combined with pond outflows towards Beaver Ck "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    0.106     0.000     0.106     0.106"
" 33          CATCHMENT 505"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          505   Rear yards of lots at NW corner"
"       60.000   % Impervious"
"        0.562   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.225   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.337   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.837   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.078     0.000     0.106     0.106 c.m/sec"
"             Catchment 505          Pervious   Impervious Total Area "
"             Surface Area           0.225      0.337      0.562      hectare"
"             Time of concentration  15.530     1.324      2.937      minutes"
"             Time to Centroid       151.167    115.087    119.185    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        76.17      114.26     190.43     c.m"
"             Rainfall losses        28.436     5.533      14.694     mm"
"             Runoff depth           5.449      28.352     19.191     mm"
"             Runoff volume          12.25      95.60      107.85     c.m"
"             Runoff coefficient     0.161      0.837      0.566      "
"             Maximum flow           0.004      0.078      0.078      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
```

```
"                    0.078     0.078     0.106     0.106"
" 33          CATCHMENT 506"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           506   Trail block - west part"
"        50.000   % Impervious"
"         0.203   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.101   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.101   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.160   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.805   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.024     0.078     0.106     0.106 c.m/sec"
"              Catchment 506          Pervious   Impervious Total Area "
"              Surface Area           0.101      0.101      0.203      hectare"
"              Time of concentration  9.072      0.773      2.151      minutes"
"              Time to Centroid       142.537    114.446    119.110    minutes"
"              Rainfall depth         33.885     33.885     33.885     mm"
"              Rainfall volume        34.39      34.39      68.79      c.m"
"              Rainfall losses        28.451     6.593      17.522     mm"
"              Runoff depth           5.434      27.292     16.363     mm"
"              Runoff volume          5.52       27.70      33.22      c.m"
"              Runoff coefficient     0.160      0.805      0.483      "
"              Maximum flow           0.002      0.023      0.024      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.024     0.102     0.106     0.106"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                    0.024     0.102     0.102     0.106"
" 40          HYDROGRAPH   Combine    506"
"             6   Combine "
"           506   Node #"
"                 Minor to infiltration"
"              Maximum flow                 0.102    c.m/sec"
"              Hydrograph volume          141.069    c.m"
"                    0.024     0.102     0.102     0.102"
" 38          START/RE-START TOTALS 506"
"             3   Runoff Totals on EXIT"
"              Total Catchment area                    23.257    hectare"
"              Total Impervious area                   12.870    hectare"
"              Total % impervious                      55.336"
" 19          EXIT"
```

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"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                        Thursday, March 24, 2011"
"           10   Units used:                                          ie METRIC"
"                Job folder:                    K:\Projects\1279\60-Design\SWM"
"                Output filename:                     1279d5yr3hrMay202016.out"
"                Licensee name:                           Any Authorised User"
"                Company                                Meritech Engineering"
"                Date & Time last used:                5/20/2016 at 1:24:58 PM"
" 81           ADD COMMENT=================================================="
"           2  Lines of comment"
"              SWM Analysis of 5-yr 3 hr post-development storm event "
"              for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"         5.000   Time Step"
"       180.000   Max. Storm length"
"      7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"             1   Chicago storm"
"      1755.000   Coefficient A"
"        12.347   Constant B"
"         0.895   Exponent C"
"         0.400   Fraction R"
"       180.000   Duration"
"         1.000   Time step multiplier"
"              Maximum intensity           136.512    mm/hr"
"              Total depth                  47.549    mm"
"             4   5hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT=================================================="
"           1  Lines of comment"
"              Area to SWM facility on west side"
" 33           CATCHMENT 701"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           701   Northwest corner - lots"
"        60.000   % Impervious"
"         7.666   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.066   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         4.600   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.245   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.870   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.474     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           3.066      4.600      7.666      hectare"
```

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"             Time of concentration  11.586     1.166      2.812      minutes"
"             Time to Centroid       112.272    87.475     91.391     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        1458.04    2187.07    3645.11    c.m"
"             Rainfall losses        35.905     6.164      18.061     mm"
"             Runoff depth           11.644     41.385     29.488     mm"
"             Runoff volume          357.04     1903.54    2260.58    c.m"
"             Runoff coefficient     0.245      0.870      0.620      "
"             Maximum flow           0.151      1.446      1.474      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.474     1.474     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        1.322   Total Area"
"       90.000   Flow length"
"        3.000   Overland Slope"
"        0.925   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.397   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.245   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.873   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.114     1.474     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.925      0.397      1.322      hectare"
"             Time of concentration  33.949     3.417      15.504     minutes"
"             Time to Centroid       139.361    90.804     110.028    minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        440.02     188.58     628.60     c.m"
"             Rainfall losses        35.884     6.017      26.924     mm"
"             Runoff depth           11.665     41.532     20.625     mm"
"             Runoff volume          107.95     164.72     272.67     c.m"
"             Runoff coefficient     0.245      0.873      0.434      "
"             Maximum flow           0.025      0.109      0.114      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.114     1.582     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.002   Total Area"
```

```
"        80.000   Flow length"
"         3.000   Overland Slope"
"         0.902   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.100   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.245   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.874   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.033     1.582     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           0.902      0.100      1.002      hectare"
"              Time of concentration  31.633     3.183      23.559     minutes"
"              Time to Centroid       136.562    90.449     123.475    minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        428.80     47.64      476.44     c.m"
"              Rainfall losses        35.890     5.968      32.898     mm"
"              Runoff depth           11.659     41.581     14.651     mm"
"              Runoff volume          105.14     41.66      146.80     c.m"
"              Runoff coefficient     0.245      0.874      0.308      "
"              Maximum flow           0.026      0.027      0.033      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.033     1.611     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         0.732   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.293   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.439   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.243   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.879   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.136     1.611     0.000     0.000 c.m/sec"
```

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"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.293      0.439      0.732      hectare"
"             Time of concentration  6.558      1.996      2.705      minutes"
"             Time to Centroid       106.354    88.629     91.385     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        139.22     208.84     348.06     c.m"
"             Rainfall losses        36.011     5.764      17.863     mm"
"             Runoff depth           11.538     41.785     29.686     mm"
"             Runoff volume          33.78      183.52     217.31     c.m"
"             Runoff coefficient     0.243      0.879      0.624      "
"             Maximum flow           0.019      0.131      0.136      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.136     1.746     0.000     0.000"
" 54          POND DESIGN"
"        1.746   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       2897.3   Hydrograph volume    c.m"
"           9.   Number of stages"
"      353.900   Minimum water level    metre"
"      356.200   Maximum water level    metre"
"      354.200   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.900     0.000     0.000"
"                354.200  1.00E-07   0.01000"
"                354.500   0.00616   780.000"
"                354.800   0.00914  1675.000"
"                355.100   0.01137  2799.000"
"                355.400    0.1897  4166.000"
"                355.700    0.5140  5653.000"
"                355.900    0.7844  6701.000"
"                356.200     1.256  8356.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                355.100     0.900     0.700     0.000     0.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                354.200     0.630    0.0750     1.000"
"             Peak outflow                  0.011    c.m/sec"
"             Maximum level               355.096    metre"
"             Maximum storage            2784.350    c.m"
"             Centroidal lag               43.478   hours"
"                  0.136     1.746     0.011     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.011    c.m/sec"
"             Hydrograph volume          2723.774    c.m"
"                    0.136     1.746     0.011     0.011"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501/507 are to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
```

```
"                    0.136     0.000     0.011     0.011"
" 33          CATCHMENT 501"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           501   Northeast corner of subdivision"
"        60.000   % Impervious"
"         0.577   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.231   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.346   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.245   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.870   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.111     0.000     0.011     0.011 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.231      0.346      0.577      hectare"
"             Time of concentration  11.586     1.166      2.812      minutes"
"             Time to Centroid       112.272    87.475     91.391     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        109.74     164.61     274.36     c.m"
"             Rainfall losses        35.905     6.164      18.061     mm"
"             Runoff depth           11.644     41.385     29.488     mm"
"             Runoff volume          26.87      143.27     170.15     c.m"
"             Runoff coefficient     0.245      0.870      0.620      "
"             Maximum flow           0.011      0.109      0.111      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.111     0.111     0.011     0.011"
" 33          CATCHMENT 507"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           507   Trail block - east part"
"        50.000   % Impervious"
"         0.111   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.056   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.056   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
```

```
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.831   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.018     0.111     0.011     0.011 c.m/sec"
"              Catchment 507          Pervious   Impervious Total Area "
"              Surface Area           0.056      0.056      0.111      hectare"
"              Time of concentration  6.768      0.681      2.056      minutes"
"              Time to Centroid       106.624    87.093     91.503     minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        26.39      26.39      52.78      c.m"
"              Rainfall losses        36.021     8.022      22.021     mm"
"              Runoff depth           11.528     39.527     25.528     mm"
"              Runoff volume          6.40       21.94      28.34      c.m"
"              Runoff coefficient     0.242      0.831      0.537      "
"              Maximum flow           0.004      0.017      0.018      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.018     0.129     0.011     0.011"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                      0.018     0.129     0.129     0.011"
" 40           HYDROGRAPH   Combine    507"
"             6   Combine "
"           507   Node #"
"                 To N and NE"
"              Maximum flow                  0.129    c.m/sec"
"              Hydrograph volume           198.484    c.m"
"                      0.018     0.129     0.129     0.129"
" 81           ADD COMMENT================================================="
"           4  Lines of comment"
"              Flows from 502 and 503 are to a proposed SWM facility "
"              south of Conservation Drive. Rooftop runoff from the "
"              school (502) up to 25mm rainfall depth to infiltration"
"              but conservatively ignored in this modeling."
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.018     0.000     0.129     0.129"
" 33           CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         1.557   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         0.779   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         0.779   Impervious Area"
"        30.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.245   Pervious Runoff coefficient"
```

```
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.879   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.239     0.000     0.129     0.129 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.779      0.779      1.557      hectare"
"              Time of concentration  17.561     1.767      5.208      minutes"
"              Time to Centroid       119.503    88.287     95.087     minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        370.17     370.17     740.34     c.m"
"              Rainfall losses        35.905     5.740      20.823     mm"
"              Runoff depth           11.644     41.809     26.726     mm"
"              Runoff volume          90.65      325.48     416.13     c.m"
"              Runoff coefficient     0.245      0.879      0.562      "
"              Maximum flow           0.032      0.235      0.239      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.239     0.239     0.129     0.129"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        60.000   % Impervious"
"         8.765   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.506   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         5.259   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.245   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.870   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.686     0.239     0.129     0.129 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           3.506      5.259      8.765      hectare"
"              Time of concentration  11.586     1.166      2.812      minutes"
"              Time to Centroid       112.272    87.475     91.391     minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        1667.07    2500.61    4167.68    c.m"
"              Rainfall losses        35.905     6.164      18.061     mm"
"              Runoff depth           11.644     41.385     29.488     mm"
"              Runoff volume          408.23     2176.43    2584.66    c.m"
"              Runoff coefficient     0.245      0.870      0.620      "
"              Maximum flow           0.173      1.653      1.686      c.m/sec"
```

```
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    1.686     1.924     0.129     0.129"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    1.686     1.924     1.924     0.129"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"               Maximum flow                  1.924    c.m/sec"
"               Hydrograph volume          3000.784    c.m"
"                    1.686     1.924     1.924     1.924"
" 81          ADD COMMENT==================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 (townhouses "
"             at SW corner) are through an OGS (road runoff) and into "
"             infiltration (222m3)"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    1.686     0.000     1.924     1.924"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       60.000   % Impervious"
"        0.760   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.304   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.456   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.245   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.870   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.146     0.000     1.924     1.924 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.304      0.456      0.760      hectare"
"             Time of concentration  11.586     1.166      2.812      minutes"
"             Time to Centroid       112.272    87.475     91.391     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        144.55     216.82     361.37     c.m"
"             Rainfall losses        35.905     6.164      18.061     mm"
"             Runoff depth           11.644     41.385     29.488     mm"
"             Runoff volume          35.40      188.71     224.11     c.m"
"             Runoff coefficient     0.245      0.870      0.620      "
"             Maximum flow           0.015      0.143      0.146      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
```

```
"            4   Add Runoff "
"                     0.146     0.146     1.924     1.924"
" 54          POND DESIGN"
"         0.146   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         224.1   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.00E-04   145.000"
"                 102.000    10.000  1000.000"
"               Peak outflow                  0.043    c.m/sec"
"               Maximum level               101.005    metre"
"               Maximum storage             148.865    c.m"
"               Centroidal lag               20.576   hours"
"                    0.146     0.146     0.043     1.924 c.m/sec"
" 40            HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"               Maximum flow                  0.053    c.m/sec"
"               Hydrograph volume          2835.864    c.m"
"                       0.146     0.146     0.043     0.053"
" 81            ADD COMMENT================================================="
"           3  Lines of comment"
"               Flows from catchment 505/506 are infiltrated (2-year "
"               and less=216m3) with overflows to the wetland finger, "
"               which then is combined with outflows towards Beaver Ck "
" 40            HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                       0.146     0.000     0.043     0.053"
" 33            CATCHMENT 505"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           505   Rear yards of lots at NW corner"
"        60.000   % Impervious"
"         0.562   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.225   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.337   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.245   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.870   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
```

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"         0.518   Impervious Initial abstraction"
"                       0.108     0.000     0.043     0.053 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.225      0.337      0.562      hectare"
"              Time of concentration  11.586     1.166      2.812      minutes"
"              Time to Centroid       112.272    87.475     91.391     minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        106.89     160.34     267.23     c.m"
"              Rainfall losses        35.905     6.164      18.061     mm"
"              Runoff depth           11.644     41.385     29.488     mm"
"              Runoff volume          26.18      139.55     165.72     c.m"
"              Runoff coefficient     0.245      0.870      0.620      "
"              Maximum flow           0.011      0.106      0.108      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.108     0.108     0.043     0.053"
" 33           CATCHMENT 506"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           506   Trail block - west part"
"        50.000   % Impervious"
"         0.203   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.101   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.101   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.831   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.034     0.108     0.043     0.053 c.m/sec"
"              Catchment 506          Pervious   Impervious Total Area "
"              Surface Area           0.101      0.101      0.203      hectare"
"              Time of concentration  6.768      0.681      2.056      minutes"
"              Time to Centroid       106.624    87.093     91.503     minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        48.26      48.26      96.52      c.m"
"              Rainfall losses        36.021     8.022      22.021     mm"
"              Runoff depth           11.528     39.527     25.528     mm"
"              Runoff volume          11.70      40.12      51.82      c.m"
"              Runoff coefficient     0.242      0.831      0.537      "
"              Maximum flow           0.007      0.032      0.034      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.034     0.142     0.043     0.053"
" 54           POND DESIGN"
"         0.142   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
```

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"        217.5   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000   0.00100   141.000"
"                102.000    10.000  1000.000"
"             Peak outflow                  0.041    c.m/sec"
"             Maximum level               101.004    metre"
"             Maximum storage             144.422    c.m"
"             Centroidal lag               24.120   hours"
"                  0.034     0.142     0.041     0.053 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.094    c.m/sec"
"             Hydrograph volume          3044.288    c.m"
"                     0.034     0.142     0.041     0.094"
" 38          START/RE-START TOTALS 506"
"           3   Runoff Totals on EXIT"
"             Total Catchment area                     23.257    hectare"
"             Total Impervious area                    12.870    hectare"
"             Total % impervious                       55.336"
" 19          EXIT"
```

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"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                            Version 2.25  rev. 473"
"                MIDUSS created                          Thursday, March 24, 2011"
"           10   Units used:                                          ie METRIC"
"                Job folder:                      K:\Projects\1279\60-Design\SWM"
"                Output filename:                     1279d100yr3hrMay202016.out"
"                Licensee name:                             Any Authorised User"
"                Company                                  Meritech Engineering"
"                Date & Time last used:                 5/20/2016 at 1:25:36 PM"
" 81           ADD COMMENT=================================================="
"           2  Lines of comment"
"              SWM Analysis of 100-yr 3 hr post-development storm event "
"              for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"         5.000   Time Step"
"       180.000   Max. Storm length"
"      7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"             1   Chicago storm"
"      4692.000   Coefficient A"
"        17.437   Constant B"
"         0.956   Exponent C"
"         0.400   Fraction R"
"       180.000   Duration"
"         1.000   Time step multiplier"
"              Maximum intensity           239.793    mm/hr"
"              Total depth                  89.960    mm"
"             6   100hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT=================================================="
"           1  Lines of comment"
"              Area to SWM facility on west side"
" 33           CATCHMENT 701"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           701   Northwest corner - lots"
"        60.000   % Impervious"
"         7.666   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.066   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         4.600   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.425   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.903   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     2.915     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           3.066      4.600      7.666      hectare"
```

```
"             Time of concentration  6.945      0.919      2.359      minutes"
"             Time to Centroid       102.209    85.375     89.397     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        2758.53    4137.80    6896.34    c.m"
"             Rainfall losses        51.719     8.749      25.937     mm"
"             Runoff depth           38.241     81.211     64.023     mm"
"             Runoff volume          1172.63    3735.38    4908.01    c.m"
"             Runoff coefficient     0.425      0.903      0.712      "
"             Maximum flow           0.696      2.661      2.915      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     2.915     2.915     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        1.322   Total Area"
"       90.000   Flow length"
"        3.000   Overland Slope"
"        0.925   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.397   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.428   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.920   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.240     2.915     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.925      0.397      1.322      hectare"
"             Time of concentration  20.349     2.693      11.887     minutes"
"             Time to Centroid       118.809    87.835     103.964    minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        832.49     356.78     1189.27    c.m"
"             Rainfall losses        51.433     7.220      38.169     mm"
"             Runoff depth           38.527     82.740     51.791     mm"
"             Runoff volume          356.53     328.15     684.67     c.m"
"             Runoff coefficient     0.428      0.920      0.576      "
"             Maximum flow           0.128      0.212      0.240      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.240     3.144     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.002   Total Area"
```

```
"        80.000   Flow length"
"         3.000   Overland Slope"
"         0.902   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.100   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.428   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.922   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.144     3.144     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           0.902      0.100      1.002      hectare"
"              Time of concentration  18.961     2.510      15.783     minutes"
"              Time to Centroid       117.075    87.552     111.372    minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        811.26     90.14      901.40     c.m"
"              Rainfall losses        51.458     6.998      47.012     mm"
"              Runoff depth           38.502     82.962     42.948     mm"
"              Runoff volume          347.21     83.13      430.34     c.m"
"              Runoff coefficient     0.428      0.922      0.477      "
"              Maximum flow           0.127      0.054      0.144      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.144     3.216     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         0.732   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.293   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.439   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.422   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.927   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.299     3.216     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.293      0.439      0.732      hectare"
"             Time of concentration  3.931      1.573      2.122      minutes"
"             Time to Centroid       98.452     86.185     89.038     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        263.40     395.10     658.51     c.m"
"             Rainfall losses        52.037     6.542      24.740     mm"
"             Runoff depth           37.923     83.418     65.220     mm"
"             Runoff volume          111.04     366.37     477.41     c.m"
"             Runoff coefficient     0.422      0.927      0.725      "
"             Maximum flow           0.073      0.250      0.299      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.299     3.515     0.000     0.000"
" 54          POND DESIGN"
"        3.515   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       6500.4   Hydrograph volume    c.m"
"           9.   Number of stages"
"      353.900   Minimum water level    metre"
"      356.200   Maximum water level    metre"
"      354.200   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.900     0.000     0.000"
"                354.200  1.00E-07   0.01000"
"                354.500   0.00616   780.000"
"                354.800   0.00914  1675.000"
"                355.100   0.01137  2799.000"
"                355.400    0.1897  4166.000"
"                355.700    0.5140  5653.000"
"                355.900    0.7844  6701.000"
"                356.200     1.256  8356.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                355.100     0.900     0.700     0.000     0.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                354.200     0.630    0.0750     1.000"
"             Peak outflow                  0.370    c.m/sec"
"             Maximum level               355.566    metre"
"             Maximum storage            4991.121    c.m"
"             Centroidal lag               22.692   hours"
"                  0.299     3.515     0.370     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.370    c.m/sec"
"             Hydrograph volume          6295.503    c.m"
"                    0.299     3.515     0.370     0.370"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501/507 are to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
```

```
"                    0.299     0.000     0.370     0.370"
" 33          CATCHMENT 501"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           501   Northeast corner of subdivision"
"        60.000   % Impervious"
"         0.577   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.231   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.346   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.425   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.903   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.219     0.000     0.370     0.370 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.231      0.346      0.577      hectare"
"             Time of concentration  6.945      0.919      2.359      minutes"
"             Time to Centroid       102.209    85.375     89.397     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        207.63     311.44     519.07     c.m"
"             Rainfall losses        51.719     8.749      25.937     mm"
"             Runoff depth           38.241     81.211     64.023     mm"
"             Runoff volume          88.26      281.15     369.41     c.m"
"             Runoff coefficient     0.425      0.903      0.712      "
"             Maximum flow           0.052      0.200      0.219      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.219     0.219     0.370     0.370"
" 33          CATCHMENT 507"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           507   Trail block - east part"
"        50.000   % Impervious"
"         0.111   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.056   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.056   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.423   Pervious Runoff coefficient"
```

```
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.847   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.040     0.219     0.370     0.370 c.m/sec"
"              Catchment 507          Pervious   Impervious Total Area "
"              Surface Area           0.056      0.056      0.111      hectare"
"              Time of concentration  4.057      0.537      1.709      minutes"
"              Time to Centroid       98.588     85.158     89.629     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        49.93      49.93      99.86      c.m"
"              Rainfall losses        51.941     13.760     32.851     mm"
"              Runoff depth           38.019     76.200     57.109     mm"
"              Runoff volume          21.10      42.29      63.39      c.m"
"              Runoff coefficient     0.423      0.847      0.635      "
"              Maximum flow           0.014      0.031      0.040      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.040     0.260     0.370     0.370"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                      0.040     0.260     0.260     0.370"
" 40           HYDROGRAPH   Combine    507"
"             6   Combine "
"           507   Node #"
"                 To N and NE"
"              Maximum flow                  0.260    c.m/sec"
"              Hydrograph volume           432.805    c.m"
"                      0.040     0.260     0.260     0.260"
" 81           ADD COMMENT================================================="
"           4  Lines of comment"
"              Flows from 502 and 503 are to a proposed SWM facility "
"              south of Conservation Drive. Rooftop runoff from the "
"              school (502) up to 25mm rainfall depth to infiltration"
"              but conservatively ignored in this modeling."
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.040     0.000     0.260     0.260"
" 33           CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         1.557   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         0.779   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         0.779   Impervious Area"
"        30.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.427   Pervious Runoff coefficient"
```

```
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.925   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.488     0.000     0.260     0.260 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.779      0.779      1.557      hectare"
"              Time of concentration  10.526     1.393      4.280      minutes"
"              Time to Centroid       106.545    85.939     92.452     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        700.34     700.34     1400.68    c.m"
"              Rainfall losses        51.510     6.752      29.131     mm"
"              Runoff depth           38.450     83.208     60.829     mm"
"              Runoff volume          299.33     647.78     947.11     c.m"
"              Runoff coefficient     0.427      0.925      0.676      "
"              Maximum flow           0.149      0.448      0.488      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.488     0.488     0.260     0.260"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        60.000   % Impervious"
"         8.765   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.506   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         5.259   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.425   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.903   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       3.333     0.488     0.260     0.260 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           3.506      5.259      8.765      hectare"
"              Time of concentration  6.945      0.919      2.359      minutes"
"              Time to Centroid       102.209    85.375     89.397     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        3154.00    4731.00    7885.00    c.m"
"              Rainfall losses        51.719     8.749      25.937     mm"
"              Runoff depth           38.241     81.211     64.023     mm"
"              Runoff volume          1340.74    4270.88    5611.63    c.m"
"              Runoff coefficient     0.425      0.903      0.712      "
"              Maximum flow           0.796      3.043      3.333      c.m/sec"
```

```
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    3.333     3.821     0.260     0.260"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    3.333     3.821     3.821     0.260"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"               Maximum flow                  3.821    c.m/sec"
"               Hydrograph volume          6558.735    c.m"
"                    3.333     3.821     3.821     3.821"
" 81          ADD COMMENT==================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 (townhouses "
"             at SW corner) are through an OGS (road runoff) and into "
"             infiltration (222m3)"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    3.333     0.000     3.821     3.821"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       60.000   % Impervious"
"        0.760   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.304   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.456   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.425   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.903   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.289     0.000     3.821     3.821 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.304      0.456      0.760      hectare"
"             Time of concentration  6.945      0.919      2.359      minutes"
"             Time to Centroid       102.209    85.375     89.397     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        273.48     410.22     683.70     c.m"
"             Rainfall losses        51.719     8.749      25.937     mm"
"             Runoff depth           38.241     81.211     64.023     mm"
"             Runoff volume          116.25     370.32     486.58     c.m"
"             Runoff coefficient     0.425      0.903      0.712      "
"             Maximum flow           0.069      0.264      0.289      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
```

```
"            4   Add Runoff "
"                     0.289     0.289     3.821     3.821"
" 54          POND DESIGN"
"         0.289   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         486.6   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.00E-04   145.000"
"                 102.000    10.000  1000.000"
"               Peak outflow                  0.248    c.m/sec"
"               Maximum level               101.025    metre"
"               Maximum storage             166.161    c.m"
"               Centroidal lag                7.390   hours"
"                    0.289     0.289     0.248     3.821 c.m/sec"
" 40            HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"               Maximum flow                  0.398    c.m/sec"
"               Hydrograph volume          6661.876    c.m"
"                       0.289     0.289     0.248     0.398"
" 81            ADD COMMENT================================================="
"           3  Lines of comment"
"              Flows from catchment 505/506 are infiltrated (2-year "
"              and less=216m3) with overflows to the wetland finger, "
"              which then is combined with outflows towards Beaver Ck "
" 40            HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                       0.289     0.000     0.248     0.398"
" 33            CATCHMENT 505"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           505   Rear yards of lots at NW corner"
"        60.000   % Impervious"
"         0.562   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.225   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.337   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.425   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.903   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
```

```
"         0.518   Impervious Initial abstraction"
"                       0.214     0.000     0.248     0.398 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.225      0.337      0.562      hectare"
"              Time of concentration  6.945      0.919      2.359      minutes"
"              Time to Centroid       102.209    85.375     89.397     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        202.23     303.35     505.58     c.m"
"              Rainfall losses        51.719     8.749      25.937     mm"
"              Runoff depth           38.241     81.211     64.023     mm"
"              Runoff volume          85.97      273.84     359.81     c.m"
"              Runoff coefficient     0.425      0.903      0.712      "
"              Maximum flow           0.051      0.195      0.214      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.214     0.214     0.248     0.398"
" 33           CATCHMENT 506"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           506   Trail block - west part"
"        50.000   % Impervious"
"         0.203   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.101   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.101   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.423   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.847   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.074     0.214     0.248     0.398 c.m/sec"
"              Catchment 506          Pervious   Impervious Total Area "
"              Surface Area           0.101      0.101      0.203      hectare"
"              Time of concentration  4.057      0.537      1.709      minutes"
"              Time to Centroid       98.588     85.158     89.629     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        91.31      91.31      182.62     c.m"
"              Rainfall losses        51.941     13.760     32.851     mm"
"              Runoff depth           38.019     76.200     57.109     mm"
"              Runoff volume          38.59      77.34      115.93     c.m"
"              Runoff coefficient     0.423      0.847      0.635      "
"              Maximum flow           0.025      0.057      0.074      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.074     0.287     0.248     0.398"
" 54           POND DESIGN"
"         0.287   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
```

```
"        475.7   Hydrograph volume    c.m"
"            3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000   0.00100   141.000"
"                102.000    10.000  1000.000"
"             Peak outflow                  0.244    c.m/sec"
"             Maximum level               101.024    metre"
"             Maximum storage             161.860    c.m"
"             Centroidal lag               11.871   hours"
"                  0.074     0.287     0.244     0.398 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.502    c.m/sec"
"             Hydrograph volume          7118.520    c.m"
"                     0.074     0.287     0.244     0.502"
" 38          START/RE-START TOTALS 506"
"           3   Runoff Totals on EXIT"
"             Total Catchment area                     23.257    hectare"
"             Total Impervious area                    12.870    hectare"
"             Total % impervious                       55.336"
" 19          EXIT"
```

```
"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                        Thursday, March 24, 2011"
"           10   Units used:                                          ie METRIC"
"                Job folder:                    K:\Projects\1279\60-Design\SWM"
"                Output filename:                    1279d2yr24hrMay202016.out"
"                Licensee name:                            Any Authorised User"
"                Company                                  Meritech Engineering"
"                Date & Time last used:                5/20/2016 at 11:41:34 AM"
" 81           ADD COMMENT=========================================================="
"           2  Lines of comment"
"              SWM Analysis of 2-yr 24 hr post-development storm event "
"              for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"         5.000   Time Step"
"      1440.000   Max. Storm length"
"      7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"             1   Chicago storm"
"       583.440   Coefficient A"
"         3.561   Constant B"
"         0.783   Exponent C"
"         0.400   Fraction R"
"      1440.000   Duration"
"         1.000   Time step multiplier"
"              Maximum intensity           104.048    mm/hr"
"              Total depth                  47.029    mm"
"             4   2hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT=========================================================="
"           1  Lines of comment"
"              Area to SWM facility on west side"
" 33           CATCHMENT 701"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           701   Northwest corner - lots"
"        60.000   % Impervious"
"         7.666   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.066   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         4.600   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.875   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.110     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           3.066      4.600      7.666      hectare"
```

```
"             Time of concentration  12.659     1.298      3.067      minutes"
"             Time to Centroid       793.747    668.959    688.384    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        1442.11    2163.17    3605.28    c.m"
"             Rainfall losses        35.650     5.881      17.788     mm"
"             Runoff depth           11.380     41.149     29.241     mm"
"             Runoff volume          348.95     1892.68    2241.64    c.m"
"             Runoff coefficient     0.242      0.875      0.622      "
"             Maximum flow           0.087      1.087      1.110      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.110     1.110     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        1.322   Total Area"
"       90.000   Flow length"
"        3.000   Overland Slope"
"        0.925   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.397   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.242   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.878   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.078     1.110     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.925      0.397      1.322      hectare"
"             Time of concentration  37.094     3.803      16.844     minutes"
"             Time to Centroid       852.149    676.130    745.081    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        435.21     186.52     621.73     c.m"
"             Rainfall losses        35.629     5.722      26.657     mm"
"             Runoff depth           11.400     41.307     20.372     mm"
"             Runoff volume          105.50     163.82     269.32     c.m"
"             Runoff coefficient     0.242      0.878      0.433      "
"             Maximum flow           0.012      0.075      0.078      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.078     1.186     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.002   Total Area"
```

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"        80.000   Flow length"
"         3.000   Overland Slope"
"         0.902   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.100   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.877   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.022     1.186     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           0.902      0.100      1.002      hectare"
"              Time of concentration  34.563     3.544      25.667     minutes"
"              Time to Centroid       846.116    675.509    797.185    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        424.11     47.12      471.23     c.m"
"              Rainfall losses        35.632     5.779      32.646     mm"
"              Runoff depth           11.398     41.250     14.383     mm"
"              Runoff volume          102.78     41.33      144.12     c.m"
"              Runoff coefficient     0.242      0.877      0.306      "
"              Maximum flow           0.012      0.019      0.022      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.022     1.207     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         0.732   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.293   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.439   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.241   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.880   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.101     1.207     0.000     0.000 c.m/sec"
```

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"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.293      0.439      0.732      hectare"
"             Time of concentration  7.165      2.222      2.986      minutes"
"             Time to Centroid       781.076    671.334    688.286    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        137.70     206.55     344.26     c.m"
"             Rainfall losses        35.686     5.637      17.657     mm"
"             Runoff depth           11.343     41.393     29.373     mm"
"             Runoff volume          33.21      181.80     215.01     c.m"
"             Runoff coefficient     0.241      0.880      0.625      "
"             Maximum flow           0.012      0.097      0.101      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.101     1.308     0.000     0.000"
" 54          POND DESIGN"
"        1.308   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       2870.1   Hydrograph volume    c.m"
"           9.   Number of stages"
"      353.900   Minimum water level    metre"
"      356.200   Maximum water level    metre"
"      354.200   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.900     0.000     0.000"
"                354.200  1.00E-07   0.01000"
"                354.500   0.00616   780.000"
"                354.800   0.00914  1675.000"
"                355.100   0.01137  2799.000"
"                355.400    0.1897  4166.000"
"                355.700    0.5140  5653.000"
"                355.900    0.7844  6701.000"
"                356.200     1.256  8356.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                355.100     0.900     0.700     0.000     0.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                354.200     0.630    0.0750     1.000"
"             Peak outflow                  0.010    c.m/sec"
"             Maximum level               354.969    metre"
"             Maximum storage            2307.628    c.m"
"             Centroidal lag               57.972   hours"
"                  0.101     1.308     0.010     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.010    c.m/sec"
"             Hydrograph volume          2650.152    c.m"
"                    0.101     1.308     0.010     0.010"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501/507 are to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
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"                    0.101     0.000     0.010     0.010"
" 33          CATCHMENT 501"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           501   Northeast corner of subdivision"
"        60.000   % Impervious"
"         0.577   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.231   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.346   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.875   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.084     0.000     0.010     0.010 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.231      0.346      0.577      hectare"
"             Time of concentration  12.659     1.298      3.067      minutes"
"             Time to Centroid       793.747    668.958    688.384    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        108.54     162.82     271.36     c.m"
"             Rainfall losses        35.650     5.881      17.788     mm"
"             Runoff depth           11.380     41.149     29.241     mm"
"             Runoff volume          26.26      142.46     168.72     c.m"
"             Runoff coefficient     0.242      0.875      0.622      "
"             Maximum flow           0.007      0.082      0.084      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.084     0.084     0.010     0.010"
" 33          CATCHMENT 507"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           507   Trail block - east part"
"        50.000   % Impervious"
"         0.111   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.056   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.056   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
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"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.854   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.014     0.084     0.010     0.010 c.m/sec"
"              Catchment 507          Pervious   Impervious Total Area "
"              Surface Area           0.056      0.056      0.111      hectare"
"              Time of concentration  7.395      0.758      2.222      minutes"
"              Time to Centroid       781.366    668.863    693.675    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        26.10      26.10      52.20      c.m"
"              Rainfall losses        35.670     6.883      21.276     mm"
"              Runoff depth           11.360     40.146     25.753     mm"
"              Runoff volume          6.30       22.28      28.59      c.m"
"              Runoff coefficient     0.242      0.854      0.548      "
"              Maximum flow           0.002      0.013      0.014      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.014     0.098     0.010     0.010"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                      0.014     0.098     0.098     0.010"
" 40           HYDROGRAPH   Combine    507"
"             6   Combine "
"           507   Node #"
"                 To N and NE"
"              Maximum flow                  0.098    c.m/sec"
"              Hydrograph volume           197.308    c.m"
"                      0.014     0.098     0.098     0.098"
" 81           ADD COMMENT================================================="
"           4  Lines of comment"
"              Flows from 502 and 503 are to a proposed SWM facility "
"              south of Conservation Drive. Rooftop runoff from the "
"              school (502) up to 25mm rainfall depth to infiltration"
"              but conservatively ignored in this modeling."
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.014     0.000     0.098     0.098"
" 33           CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         1.557   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         0.779   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         0.779   Impervious Area"
"        30.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
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"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.881   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.179     0.000     0.098     0.098 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.779      0.779      1.557      hectare"
"              Time of concentration  19.188     1.967      5.678      minutes"
"              Time to Centroid       809.357    670.465    700.395    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        366.12     366.12     732.25     c.m"
"              Rainfall losses        35.643     5.578      20.611     mm"
"              Runoff depth           11.386     41.451     26.419     mm"
"              Runoff volume          88.64      322.70     411.34     c.m"
"              Runoff coefficient     0.242      0.881      0.562      "
"              Maximum flow           0.016      0.176      0.179      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.179     0.179     0.098     0.098"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        60.000   % Impervious"
"         8.765   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.506   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         5.259   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.875   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       1.269     0.179     0.098     0.098 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           3.506      5.259      8.765      hectare"
"              Time of concentration  12.659     1.298      3.067      minutes"
"              Time to Centroid       793.747    668.959    688.384    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        1648.85    2473.28    4122.13    c.m"
"              Rainfall losses        35.650     5.881      17.788     mm"
"              Runoff depth           11.380     41.149     29.241     mm"
"              Runoff volume          398.98     2164.02    2563.00    c.m"
"              Runoff coefficient     0.242      0.875      0.622      "
"              Maximum flow           0.100      1.243      1.269      c.m/sec"
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" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    1.269     1.448     0.098     0.098"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    1.269     1.448     1.448     0.098"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"               Maximum flow                  1.448    c.m/sec"
"               Hydrograph volume          2974.337    c.m"
"                    1.269     1.448     1.448     1.448"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 (townhouses "
"             at SW corner) are through an OGS (road runoff) and into "
"             infiltration"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    1.269     0.000     1.448     1.448"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       60.000   % Impervious"
"        0.760   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.304   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.456   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.242   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.875   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.110     0.000     1.448     1.448 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.304      0.456      0.760      hectare"
"             Time of concentration  12.659     1.298      3.067      minutes"
"             Time to Centroid       793.747    668.959    688.384    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        142.97     214.45     357.42     c.m"
"             Rainfall losses        35.650     5.881      17.788     mm"
"             Runoff depth           11.380     41.149     29.241     mm"
"             Runoff volume          34.59      187.64     222.23     c.m"
"             Runoff coefficient     0.242      0.875      0.622      "
"             Maximum flow           0.009      0.108      0.110      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
```

```
"            4   Add Runoff "
"                     0.110     0.110     1.448     1.448"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.110     0.110     0.110     1.448"
" 40          HYDROGRAPH   Combine    504"
"            6   Combine "
"          504   Node #"
"                Minor to infiltration"
"               Maximum flow                  0.110    c.m/sec"
"               Hydrograph volume           222.234    c.m"
"                     0.110     0.110     0.110     0.110"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Flows from catchment 505/506 are infiltrated (2-year "
"             and less) with overflows to the wetland finger, which "
"             then is combined with pond outflows towards Beaver Ck "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                     0.110     0.000     0.110     0.110"
" 33          CATCHMENT 505"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          505   Rear yards of lots at NW corner"
"       60.000   % Impervious"
"        0.562   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.225   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.337   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.242   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.875   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.081     0.000     0.110     0.110 c.m/sec"
"             Catchment 505          Pervious   Impervious Total Area "
"             Surface Area           0.225      0.337      0.562      hectare"
"             Time of concentration  12.659     1.298      3.067      minutes"
"             Time to Centroid       793.747    668.958    688.384    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        105.72     158.58     264.31     c.m"
"             Rainfall losses        35.650     5.881      17.788     mm"
"             Runoff depth           11.380     41.149     29.241     mm"
"             Runoff volume          25.58      138.75     164.34     c.m"
"             Runoff coefficient     0.242      0.875      0.622      "
"             Maximum flow           0.006      0.080      0.081      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
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"                    0.081     0.081     0.110     0.110"
" 33          CATCHMENT 506"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           506   Trail block - west part"
"        50.000   % Impervious"
"         0.203   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.101   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.101   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.854   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.026     0.081     0.110     0.110 c.m/sec"
"              Catchment 506          Pervious   Impervious Total Area "
"              Surface Area           0.101      0.101      0.203      hectare"
"              Time of concentration  7.395      0.758      2.222      minutes"
"              Time to Centroid       781.365    668.863    693.675    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        47.73      47.73      95.47      c.m"
"              Rainfall losses        35.670     6.883      21.276     mm"
"              Runoff depth           11.360     40.146     25.753     mm"
"              Runoff volume          11.53      40.75      52.28      c.m"
"              Runoff coefficient     0.242      0.854      0.548      "
"              Maximum flow           0.004      0.024      0.026      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.026     0.107     0.110     0.110"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                    0.026     0.107     0.107     0.110"
" 40           HYDROGRAPH   Combine    506"
"             6   Combine "
"           506   Node #"
"                 Minor to infiltration"
"              Maximum flow                 0.107    c.m/sec"
"              Hydrograph volume          216.615    c.m"
"                    0.026     0.107     0.107     0.107"
" 38           START/RE-START TOTALS 506"
"             3   Runoff Totals on EXIT"
"              Total Catchment area                    23.257    hectare"
"              Total Impervious area                   12.870    hectare"
"              Total % impervious                      55.336"
" 19           EXIT"
```

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"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                       Thursday, March 24, 2011"
"           10   Units used:                                          ie METRIC"
"                Job folder:                    K:\Projects\1279\60-Design\SWM"
"                Output filename:                    1279d5yr24hrMay202016.out"
"                Licensee name:                            Any Authorised User"
"                Company                                  Meritech Engineering"
"                Date & Time last used:              5/20/2016 at 11:56:40 AM"
" 81           ADD COMMENT=========================================================="
"           2  Lines of comment"
"              SWM Analysis of 5-yr 24 hr post-development storm event "
"              for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"         5.000   Time Step"
"      1440.000   Max. Storm length"
"      7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"             1   Chicago storm"
"       956.510   Coefficient A"
"         5.608   Constant B"
"         0.815   Exponent C"
"         0.400   Fraction R"
"      1440.000   Duration"
"         1.000   Time step multiplier"
"              Maximum intensity          133.887    mm/hr"
"              Total depth                 61.018    mm"
"             4   5hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT=========================================================="
"           1  Lines of comment"
"              Area to SWM facility on west side"
" 33           CATCHMENT 701"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           701   Northwest corner - lots"
"        60.000   % Impervious"
"         7.666   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.066   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         4.600   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.313   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.895   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.522     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           3.066      4.600      7.666      hectare"
```

```
"             Time of concentration  9.993      1.166      2.836      minutes"
"             Time to Centroid       756.254    656.264    675.184    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        1871.06    2806.59    4677.66    c.m"
"             Rainfall losses        41.904     6.416      20.611     mm"
"             Runoff depth           19.114     54.602     40.407     mm"
"             Runoff volume          586.11     2511.49    3097.61    c.m"
"             Runoff coefficient     0.313      0.895      0.662      "
"             Maximum flow           0.186      1.454      1.522      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    1.522     1.522     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        1.322   Total Area"
"       90.000   Flow length"
"        3.000   Overland Slope"
"        0.925   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.397   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.315   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.901   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.111     1.522     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.925      0.397      1.322      hectare"
"             Time of concentration  29.282     3.417      15.032     minutes"
"             Time to Centroid       801.541    662.410    724.887    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        564.66     242.00     806.66     c.m"
"             Rainfall losses        41.824     6.070      31.098     mm"
"             Runoff depth           19.194     54.948     29.920     mm"
"             Runoff volume          177.62     217.92     395.54     c.m"
"             Runoff coefficient     0.315      0.901      0.490      "
"             Maximum flow           0.028      0.107      0.111      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.111     1.633     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.002   Total Area"
```

```
"        80.000   Flow length"
"         3.000   Overland Slope"
"         0.902   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.100   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.315   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.902   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.034     1.633     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           0.902      0.100      1.002      hectare"
"              Time of concentration  27.284     3.184      21.461     minutes"
"              Time to Centroid       796.757    661.652    764.114    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        550.26     61.14      611.40     c.m"
"              Rainfall losses        41.821     5.973      38.236     mm"
"              Runoff depth           19.197     55.045     22.782     mm"
"              Runoff volume          173.12     55.16      228.28     c.m"
"              Runoff coefficient     0.315      0.902      0.373      "
"              Maximum flow           0.029      0.028      0.034      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.034     1.664     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         0.732   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.293   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.439   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.314   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.904   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.146     1.664     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.293      0.439      0.732      hectare"
"             Time of concentration  5.656      1.996      2.684      minutes"
"             Time to Centroid       745.655    658.155    674.589    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        178.66     267.99     446.65     c.m"
"             Rainfall losses        41.880     5.847      20.260     mm"
"             Runoff depth           19.138     55.171     40.758     mm"
"             Runoff volume          56.04      242.31     298.35     c.m"
"             Runoff coefficient     0.314      0.904      0.668      "
"             Maximum flow           0.024      0.132      0.146      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.146     1.810     0.000     0.000"
" 54          POND DESIGN"
"        1.810   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       4019.8   Hydrograph volume    c.m"
"           9.   Number of stages"
"      353.900   Minimum water level    metre"
"      356.200   Maximum water level    metre"
"      354.200   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.900     0.000     0.000"
"                354.200  1.00E-07   0.01000"
"                354.500   0.00616   780.000"
"                354.800   0.00914  1675.000"
"                355.100   0.01137  2799.000"
"                355.400    0.1897  4166.000"
"                355.700    0.5140  5653.000"
"                355.900    0.7844  6701.000"
"                356.200     1.256  8356.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                355.100     0.900     0.700     0.000     0.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                354.200     0.630    0.0750     1.000"
"             Peak outflow                  0.034    c.m/sec"
"             Maximum level               355.138    metre"
"             Maximum storage            2973.306    c.m"
"             Centroidal lag               55.037   hours"
"                  0.146     1.810     0.034     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.034    c.m/sec"
"             Hydrograph volume          3701.599    c.m"
"                    0.146     1.810     0.034     0.034"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501/507 are to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
```

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"                    0.146     0.000     0.034     0.034"
" 33          CATCHMENT 501"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           501   Northeast corner of subdivision"
"        60.000   % Impervious"
"         0.577   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.231   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.346   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.313   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.895   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.115     0.000     0.034     0.034 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.231      0.346      0.577      hectare"
"             Time of concentration  9.993      1.166      2.836      minutes"
"             Time to Centroid       756.254    656.264    675.183    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        140.83     211.25     352.08     c.m"
"             Rainfall losses        41.904     6.416      20.611     mm"
"             Runoff depth           19.114     54.602     40.407     mm"
"             Runoff volume          44.12      189.03     233.15     c.m"
"             Runoff coefficient     0.313      0.895      0.662      "
"             Maximum flow           0.014      0.109      0.115      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.115     0.115     0.034     0.034"
" 33          CATCHMENT 507"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           507   Trail block - east part"
"        50.000   % Impervious"
"         0.111   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.056   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.056   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.313   Pervious Runoff coefficient"
```

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"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.868   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.020     0.115     0.034     0.034 c.m/sec"
"              Catchment 507          Pervious   Impervious Total Area "
"              Surface Area           0.056      0.056      0.111      hectare"
"              Time of concentration  5.838      0.681      2.049      minutes"
"              Time to Centroid       746.213    656.853    680.551    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        33.87      33.87      67.73      c.m"
"              Rainfall losses        41.894     8.032      24.963     mm"
"              Runoff depth           19.124     52.986     36.055     mm"
"              Runoff volume          10.61      29.41      40.02      c.m"
"              Runoff coefficient     0.313      0.868      0.591      "
"              Maximum flow           0.004      0.017      0.020      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.020     0.135     0.034     0.034"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                       0.020     0.135     0.135     0.034"
" 40           HYDROGRAPH   Combine    507"
"             6   Combine "
"           507   Node #"
"                 To N and NE"
"              Maximum flow                  0.135    c.m/sec"
"              Hydrograph volume           273.170    c.m"
"                       0.020     0.135     0.135     0.135"
" 81           ADD COMMENT================================================="
"           4  Lines of comment"
"              Flows from 502 and 503 are to a proposed SWM facility "
"              south of Conservation Drive. Rooftop runoff from the "
"              school (502) up to 25mm rainfall depth to infiltration"
"              but conservatively ignored in this modeling."
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                       0.020     0.000     0.135     0.135"
" 33           CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         1.557   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         0.779   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         0.779   Impervious Area"
"        30.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.314   Pervious Runoff coefficient"
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"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.903   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.246     0.000     0.135     0.135 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.779      0.779      1.557      hectare"
"              Time of concentration  15.147     1.767      5.222      minutes"
"              Time to Centroid       767.984    657.510    686.036    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        475.03     475.03     950.05     c.m"
"              Rainfall losses        41.834     5.905      23.870     mm"
"              Runoff depth           19.185     55.113     37.149     mm"
"              Runoff volume          149.35     429.05     578.41     c.m"
"              Runoff coefficient     0.314      0.903      0.609      "
"              Maximum flow           0.040      0.237      0.246      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.246     0.246     0.135     0.135"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        60.000   % Impervious"
"         8.765   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.506   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         5.259   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.313   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.895   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.740     0.246     0.135     0.135 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           3.506      5.259      8.765      hectare"
"              Time of concentration  9.993      1.166      2.836      minutes"
"              Time to Centroid       756.254    656.264    675.184    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        2139.30    3208.95    5348.25    c.m"
"              Rainfall losses        41.904     6.416      20.611     mm"
"              Runoff depth           19.114     54.602     40.407     mm"
"              Runoff volume          670.14     2871.54    3541.68    c.m"
"              Runoff coefficient     0.313      0.895      0.662      "
"              Maximum flow           0.213      1.662      1.740      c.m/sec"
```

```
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    1.740     1.986     0.135     0.135"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    1.740     1.986     1.986     0.135"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"               Maximum flow                  1.986    c.m/sec"
"               Hydrograph volume          4120.089    c.m"
"                    1.740     1.986     1.986     1.986"
" 81          ADD COMMENT==================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 (townhouses "
"             at SW corner) are through an OGS (road runoff) and into "
"             infiltration (222m3)"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    1.740     0.000     1.986     1.986"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       60.000   % Impervious"
"        0.760   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.304   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.456   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.313   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.895   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.151     0.000     1.986     1.986 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.304      0.456      0.760      hectare"
"             Time of concentration  9.993      1.166      2.836      minutes"
"             Time to Centroid       756.254    656.264    675.184    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        185.50     278.24     463.74     c.m"
"             Rainfall losses        41.904     6.416      20.611     mm"
"             Runoff depth           19.114     54.602     40.407     mm"
"             Runoff volume          58.11      248.99     307.09     c.m"
"             Runoff coefficient     0.313      0.895      0.662      "
"             Maximum flow           0.018      0.144      0.151      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
```

```
"            4   Add Runoff "
"                     0.151     0.151     1.986     1.986"
" 54          POND DESIGN"
"         0.151   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         307.1   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.00E-04   222.000"
"                 102.000    10.000  1000.000"
"               Peak outflow                  0.006    c.m/sec"
"               Maximum level               101.001    metre"
"               Maximum storage             222.442    c.m"
"               Centroidal lag               30.921   hours"
"                    0.151     0.151     0.006     0.078 c.m/sec"
" 40            HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"               Maximum flow                  0.037    c.m/sec"
"               Hydrograph volume          3818.007    c.m"
"                       0.151     0.151     0.006     0.037"
" 81            ADD COMMENT================================================="
"           3  Lines of comment"
"              Flows from catchment 505/506 are infiltrated (2-year "
"              and less=216m3) with overflows to the wetland finger, "
"              which then is combined with outflows towards Beaver Ck "
" 40            HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                       0.151     0.000     0.006     0.037"
" 33            CATCHMENT 505"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           505   Rear yards of lots at NW corner"
"        60.000   % Impervious"
"         0.562   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.225   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.337   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.313   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.895   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
```

```
"         0.518   Impervious Initial abstraction"
"                       0.112     0.000     0.006     0.037 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.225      0.337      0.562      hectare"
"              Time of concentration  9.993      1.166      2.836      minutes"
"              Time to Centroid       756.254    656.263    675.183    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        137.17     205.75     342.92     c.m"
"              Rainfall losses        41.904     6.416      20.611     mm"
"              Runoff depth           19.114     54.602     40.407     mm"
"              Runoff volume          42.97      184.12     227.09     c.m"
"              Runoff coefficient     0.313      0.895      0.662      "
"              Maximum flow           0.014      0.107      0.112      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.112     0.112     0.006     0.037"
" 33           CATCHMENT 506"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           506   Trail block - west part"
"        50.000   % Impervious"
"         0.203   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.101   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.101   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.313   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.868   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.037     0.112     0.006     0.037 c.m/sec"
"              Catchment 506          Pervious   Impervious Total Area "
"              Surface Area           0.101      0.101      0.203      hectare"
"              Time of concentration  5.838      0.681      2.049      minutes"
"              Time to Centroid       746.214    656.852    680.551    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        61.93      61.93      123.87     c.m"
"              Rainfall losses        41.894     8.032      24.963     mm"
"              Runoff depth           19.124     52.986     36.055     mm"
"              Runoff volume          19.41      53.78      73.19      c.m"
"              Runoff coefficient     0.313      0.868      0.591      "
"              Maximum flow           0.008      0.032      0.037      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.037     0.148     0.006     0.037"
" 54           POND DESIGN"
"         0.148   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
```

```
"        300.3   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000   0.00100   216.000"
"                102.000    10.000  1000.000"
"             Peak outflow                  0.005    c.m/sec"
"             Maximum level               101.000    metre"
"             Maximum storage             216.295    c.m"
"             Centroidal lag               61.941   hours"
"                  0.037     0.148     0.005     0.037 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.039    c.m/sec"
"             Hydrograph volume          4074.700    c.m"
"                     0.037     0.148     0.005     0.039"
" 38          START/RE-START TOTALS 506"
"           3   Runoff Totals on EXIT"
"             Total Catchment area                     23.257    hectare"
"             Total Impervious area                    12.870    hectare"
"             Total % impervious                       55.336"
" 19          EXIT"
```

```
"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                        Thursday, March 24, 2011"
"           10   Units used:                                          ie METRIC"
"                Job folder:                    K:\Projects\1279\60-Design\SWM"
"                Output filename:                  1279d100yr24hrMay202016.out"
"                Licensee name:                           Any Authorised User"
"                Company                                 Meritech Engineering"
"                Date & Time last used:                5/20/2016 at 12:14:13 PM"
" 81           ADD COMMENT=================================================="
"           2  Lines of comment"
"              SWM Analysis of 100-yr 24 hr post-development storm event "
"              for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"         5.000   Time Step"
"      1440.000   Max. Storm length"
"      7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"             1   Chicago storm"
"      2221.210   Coefficient A"
"         9.093   Constant B"
"         0.866   Exponent C"
"         0.400   Fraction R"
"      1440.000   Duration"
"         1.000   Time step multiplier"
"              Maximum intensity           216.370    mm/hr"
"              Total depth                  97.564    mm"
"             6   100hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT=================================================="
"           1  Lines of comment"
"              Area to SWM facility on west side"
" 33           CATCHMENT 701"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           701   Northwest corner - lots"
"        60.000   % Impervious"
"         7.666   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.066   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         4.600   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.449   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.916   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      2.752     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           3.066      4.600      7.666      hectare"
```

```
"             Time of concentration  6.912      0.956      2.423      minutes"
"             Time to Centroid       704.754    637.792    654.288    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        2991.72    4487.57    7479.29    c.m"
"             Rainfall losses        53.747     8.194      26.415     mm"
"             Runoff depth           43.817     89.370     71.149     mm"
"             Runoff volume          1343.62    4110.68    5454.30    c.m"
"             Runoff coefficient     0.449      0.916      0.729      "
"             Maximum flow           0.675      2.421      2.752      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    2.752     2.752     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        1.322   Total Area"
"       90.000   Flow length"
"        3.000   Overland Slope"
"        0.925   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.397   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.453   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.929   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.215     2.752     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.925      0.397      1.322      hectare"
"             Time of concentration  20.254     2.802      12.085     minutes"
"             Time to Centroid       734.615    642.203    691.358    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        902.86     386.94     1289.80    c.m"
"             Rainfall losses        53.414     6.912      39.463     mm"
"             Runoff depth           44.151     90.652     58.101     mm"
"             Runoff volume          408.57     359.53     768.10     c.m"
"             Runoff coefficient     0.453      0.929      0.596      "
"             Maximum flow           0.107      0.194      0.215      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.215     2.967     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.002   Total Area"
```

```
"        80.000   Flow length"
"         3.000   Overland Slope"
"         0.902   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.100   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.452   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.930   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.118     2.967     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           0.902      0.100      1.002      hectare"
"              Time of concentration  18.872     2.611      15.847     minutes"
"              Time to Centroid       731.523    641.646    714.807    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        879.84     97.76      977.60     c.m"
"              Rainfall losses        53.445     6.836      48.784     mm"
"              Runoff depth           44.120     90.729     48.780     mm"
"              Runoff volume          397.87     90.91      488.78     c.m"
"              Runoff coefficient     0.452      0.930      0.500      "
"              Maximum flow           0.107      0.050      0.118      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.118     3.040     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         0.732   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.293   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.439   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.447   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.933   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.283     3.040     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.293      0.439      0.732      hectare"
"             Time of concentration  3.912      1.637      2.188      minutes"
"             Time to Centroid       698.123    638.842    653.198    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        285.67     428.50     714.17     c.m"
"             Rainfall losses        53.912     6.496      25.462     mm"
"             Runoff depth           43.653     91.069     72.102     mm"
"             Runoff volume          127.81     399.97     527.79     c.m"
"             Runoff coefficient     0.447      0.933      0.739      "
"             Maximum flow           0.065      0.228      0.283      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.283     3.324     0.000     0.000"
" 54          POND DESIGN"
"        3.324   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       7239.0   Hydrograph volume    c.m"
"           9.   Number of stages"
"      353.900   Minimum water level    metre"
"      356.200   Maximum water level    metre"
"      354.200   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.900     0.000     0.000"
"                354.200  1.00E-07   0.01000"
"                354.500   0.00616   780.000"
"                354.800   0.00914  1675.000"
"                355.100   0.01137  2799.000"
"                355.400    0.1897  4166.000"
"                355.700    0.5140  5653.000"
"                355.900    0.7844  6701.000"
"                356.200     1.256  8356.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                355.100     0.900     0.700     0.000     0.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                354.200     0.630    0.0750     1.000"
"             Peak outflow                 0.265    c.m/sec"
"             Maximum level              355.469    metre"
"             Maximum storage           4510.399    c.m"
"             Centroidal lag              31.553   hours"
"                  0.283     3.324     0.265     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                 0.265    c.m/sec"
"             Hydrograph volume         6913.561    c.m"
"                    0.283     3.324     0.265     0.265"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501/507 are to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
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```
"                    0.283     0.000     0.265     0.265"
" 33          CATCHMENT 501"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           501   Northeast corner of subdivision"
"        60.000   % Impervious"
"         0.577   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.231   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.346   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.449   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.916   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.207     0.000     0.265     0.265 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.231      0.346      0.577      hectare"
"             Time of concentration  6.912      0.956      2.423      minutes"
"             Time to Centroid       704.754    637.792    654.287    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        225.18     337.77     562.95     c.m"
"             Rainfall losses        53.747     8.194      26.415     mm"
"             Runoff depth           43.817     89.370     71.149     mm"
"             Runoff volume          101.13     309.40     410.53     c.m"
"             Runoff coefficient     0.449      0.916      0.729      "
"             Maximum flow           0.051      0.182      0.207      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.207     0.207     0.265     0.265"
" 33          CATCHMENT 507"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           507   Trail block - east part"
"        50.000   % Impervious"
"         0.111   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.056   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.056   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.448   Pervious Runoff coefficient"
```

```
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.878   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.039     0.207     0.265     0.265 c.m/sec"
"              Catchment 507          Pervious   Impervious Total Area "
"              Surface Area           0.056      0.056      0.111      hectare"
"              Time of concentration  4.038      0.559      1.734      minutes"
"              Time to Centroid       698.308    638.920    658.981    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        54.15      54.15      108.30     c.m"
"              Rainfall losses        53.867     11.905     32.886     mm"
"              Runoff depth           43.698     85.660     64.679     mm"
"              Runoff volume          24.25      47.54      71.79      c.m"
"              Runoff coefficient     0.448      0.878      0.663      "
"              Maximum flow           0.012      0.028      0.039      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.039     0.246     0.265     0.265"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                      0.039     0.246     0.246     0.265"
" 40           HYDROGRAPH   Combine    507"
"             6   Combine "
"           507   Node #"
"                 To N and NE"
"              Maximum flow                  0.246    c.m/sec"
"              Hydrograph volume           482.325    c.m"
"                      0.039     0.246     0.246     0.246"
" 81           ADD COMMENT================================================="
"           4  Lines of comment"
"              Flows from 502 and 503 are to a proposed SWM facility "
"              south of Conservation Drive. Rooftop runoff from the "
"              school (502) up to 25mm rainfall depth to infiltration"
"              but conservatively ignored in this modeling."
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.039     0.000     0.246     0.246"
" 33           CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         1.557   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         0.779   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         0.779   Impervious Area"
"        30.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.452   Pervious Runoff coefficient"
```

```
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.932   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.459     0.000     0.246     0.246 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.779      0.779      1.557      hectare"
"              Time of concentration  10.477     1.449      4.396      minutes"
"              Time to Centroid       712.370    638.454    662.584    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        759.54     759.54     1519.08    c.m"
"              Rainfall losses        53.511     6.668      30.090     mm"
"              Runoff depth           44.054     90.896     67.475     mm"
"              Runoff volume          342.96     707.63     1050.58    c.m"
"              Runoff coefficient     0.452      0.932      0.692      "
"              Maximum flow           0.130      0.408      0.459      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.459     0.459     0.246     0.246"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        60.000   % Impervious"
"         8.765   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.506   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         5.259   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.449   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.916   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       3.147     0.459     0.246     0.246 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           3.506      5.259      8.765      hectare"
"              Time of concentration  6.912      0.956      2.423      minutes"
"              Time to Centroid       704.754    637.792    654.288    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        3420.61    5130.92    8551.53    c.m"
"              Rainfall losses        53.747     8.194      26.415     mm"
"              Runoff depth           43.818     89.370     71.149     mm"
"              Runoff volume          1536.24    4699.99    6236.23    c.m"
"              Runoff coefficient     0.449      0.916      0.729      "
"              Maximum flow           0.771      2.768      3.147      c.m/sec"
```

```
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    3.147     3.606     0.246     0.246"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    3.147     3.606     3.606     0.246"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"               Maximum flow                  3.606    c.m/sec"
"               Hydrograph volume          7286.812    c.m"
"                    3.147     3.606     3.606     3.606"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 (townhouses "
"             at SW corner) are through an OGS (road runoff) and into "
"             infiltration (222m3)"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    3.147     0.000     3.606     3.606"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       60.000   % Impervious"
"        0.760   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.304   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.456   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.449   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.916   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.273     0.000     3.606     3.606 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.304      0.456      0.760      hectare"
"             Time of concentration  6.912      0.956      2.423      minutes"
"             Time to Centroid       704.755    637.792    654.288    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        296.60     444.89     741.49     c.m"
"             Rainfall losses        53.747     8.194      26.415     mm"
"             Runoff depth           43.817     89.370     71.149     mm"
"             Runoff volume          133.21     407.53     540.73     c.m"
"             Runoff coefficient     0.449      0.916      0.729      "
"             Maximum flow           0.067      0.240      0.273      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
```

```
"            4   Add Runoff "
"                     0.273     0.273     3.606     3.606"
" 54          POND DESIGN"
"         0.273   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         540.7   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.00E-04   222.000"
"                 102.000    10.000  1000.000"
"               Peak outflow                  0.143    c.m/sec"
"               Maximum level               101.017    metre"
"               Maximum storage             235.517    c.m"
"               Centroidal lag               17.524   hours"
"                    0.273     0.273     0.143     3.606 c.m/sec"
" 40            HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"               Maximum flow                  0.284    c.m/sec"
"               Hydrograph volume          7263.236    c.m"
"                       0.273     0.273     0.143     0.284"
" 81            ADD COMMENT================================================="
"           3  Lines of comment"
"              Flows from catchment 505/506 are infiltrated (2-year "
"              and less=216m3) with overflows to the wetland finger, "
"              which then is combined with outflows towards Beaver Ck "
" 40            HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                       0.273     0.000     0.143     0.284"
" 33            CATCHMENT 505"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           505   Rear yards of lots at NW corner"
"        60.000   % Impervious"
"         0.562   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.225   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.337   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.449   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.916   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
```

```
"         0.518   Impervious Initial abstraction"
"                       0.202     0.000     0.143     0.284 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.225      0.337      0.562      hectare"
"              Time of concentration  6.912      0.956      2.423      minutes"
"              Time to Centroid       704.754    637.792    654.288    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        219.32     328.99     548.31     c.m"
"              Rainfall losses        53.747     8.194      26.415     mm"
"              Runoff depth           43.817     89.370     71.149     mm"
"              Runoff volume          98.50      301.36     399.86     c.m"
"              Runoff coefficient     0.449      0.916      0.729      "
"              Maximum flow           0.049      0.177      0.202      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.202     0.202     0.143     0.284"
" 33           CATCHMENT 506"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           506   Trail block - west part"
"        50.000   % Impervious"
"         0.203   Total Area"
"         5.000   Flow length"
"         2.000   Overland Slope"
"         0.101   Pervious Area"
"         5.000   Pervious length"
"         2.000   Pervious slope"
"         0.101   Impervious Area"
"         5.000   Impervious length"
"         2.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.448   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.878   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.071     0.202     0.143     0.284 c.m/sec"
"              Catchment 506          Pervious   Impervious Total Area "
"              Surface Area           0.101      0.101      0.203      hectare"
"              Time of concentration  4.038      0.559      1.734      minutes"
"              Time to Centroid       698.309    638.920    658.982    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        99.03      99.03      198.06     c.m"
"              Rainfall losses        53.867     11.905     32.886     mm"
"              Runoff depth           43.698     85.660     64.679     mm"
"              Runoff volume          44.35      86.94      131.30     c.m"
"              Runoff coefficient     0.448      0.878      0.663      "
"              Maximum flow           0.023      0.052      0.071      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.071     0.273     0.143     0.284"
" 54           POND DESIGN"
"         0.273   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
```

```
"        531.2   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000   0.00100   216.000"
"                102.000    10.000  1000.000"
"             Peak outflow                  0.136    c.m/sec"
"             Maximum level               101.017    metre"
"             Maximum storage             229.015    c.m"
"             Centroidal lag               29.055   hours"
"                  0.071     0.273     0.136     0.284 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.372    c.m/sec"
"             Hydrograph volume          7750.701    c.m"
"                     0.071     0.273     0.136     0.372"
" 38          START/RE-START TOTALS 506"
"           3   Runoff Totals on EXIT"
"             Total Catchment area                     23.257    hectare"
"             Total Impervious area                    12.870    hectare"
"             Total % impervious                       55.336"
" 19          EXIT"
```

```
"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                            Version 2.25  rev. 473"
"                MIDUSS created                          Thursday, March 24, 2011"
"           10   Units used:                                            ie METRIC"
"                Job folder:                      K:\Projects\1279\60-Design\SWM"
"                Output filename:                        1279dHazelMay202016.out"
"                Licensee name:                              Any Authorised User"
"                Company                                   Meritech Engineering"
"                Date & Time last used:                 5/20/2016 at 12:19:56 PM"
" 81          ADD COMMENT==================================================="
"          2  Lines of comment"
"             SWM Analysis of Hurricane Hazel 48 hr post-development "
"             storm event for 556 and 576 Conservation Drive, Waterloo"
" 31          TIME PARAMETERS"
"        5.000   Time Step"
"     2880.000   Max. Storm length"
"     7200.000   Max. Hydrograph"
" 32          STORM Mass Curve"
"            3   Mass Curve"
"      285.000   Rainfall depth"
"     2880.000   Duration"
"           42   K:\Projects\1279\60-Design\SWM\Hazel48.mrd   Hurricane Hazel
(285mm, 48 hours)"
"              Maximum intensity            53.012    mm/hr"
"              Total depth                 285.000    mm"
"            8   Hazelhyd   Hydrograph extension used in this file"
" 81          ADD COMMENT==================================================="
"          1  Lines of comment"
"             Area to SWM facility on west side"
" 33          CATCHMENT 701"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          701   Northwest corner - lots"
"       60.000   % Impervious"
"        7.666   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        3.066   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.600   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.728   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.967   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    1.095     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
"             Surface Area           3.066      4.600      7.666      hectare"
"             Time of concentration  9.349      1.671      4.237      minutes"
"             Time to Centroid       2498.143   2270.257   2346.417   minutes"
```

```
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        0.8739     1.3109     2.1848     ha-m"
"             Rainfall losses        77.421     9.312      36.555     mm"
"             Runoff depth           207.579    275.688    248.445    mm"
"             Runoff volume          0.6365     1.2681     1.9046     ha-m"
"             Runoff coefficient     0.728      0.967      0.872      "
"             Maximum flow           0.423      0.672      1.095      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    1.095     1.095     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        1.322   Total Area"
"       90.000   Flow length"
"        3.000   Overland Slope"
"        0.925   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.397   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.732   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.977   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.190     1.095     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.925      0.397      1.322      hectare"
"             Time of concentration  27.395     4.896      19.209     minutes"
"             Time to Centroid       2524.451   2272.633   2432.829   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        2637.39    1130.31    3767.70    c.m"
"             Rainfall losses        76.459     6.694      55.529     mm"
"             Runoff depth           208.541    278.306    229.471    mm"
"             Runoff volume          1929.84    1103.76    3033.60    c.m"
"             Runoff coefficient     0.732      0.977      0.805      "
"             Maximum flow           0.131      0.060      0.190      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.190     1.268     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.002   Total Area"
"       80.000   Flow length"
"        3.000   Overland Slope"
```

```
"         0.902   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.100   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.731   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.975   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.143     1.268     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           0.902      0.100      1.002      hectare"
"              Time of concentration  25.525     4.562      22.819     minutes"
"              Time to Centroid       2521.583   2271.846   2489.346   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        2570.13    285.57     2855.70    c.m"
"              Rainfall losses        76.640     7.070      69.683     mm"
"              Runoff depth           208.360    277.930    215.317    mm"
"              Runoff volume          1878.99    278.49     2157.48    c.m"
"              Runoff coefficient     0.731      0.975      0.755      "
"              Maximum flow           0.128      0.015      0.143      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.143     1.410     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         0.732   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.293   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.439   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.728   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.965   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.103     1.410     0.000     0.000 c.m/sec"
"              Catchment 704          Pervious   Impervious Total Area "
"              Surface Area           0.293      0.439      0.732      hectare"
```

```
"             Time of concentration  5.292      2.860      3.673      minutes"
"             Time to Centroid       2492.836   2265.585   2341.595   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        834.48     1251.72    2086.20    c.m"
"             Rainfall losses        77.601     9.886      36.972     mm"
"             Runoff depth           207.399    275.114    248.028    mm"
"             Runoff volume          607.26     1208.30    1815.56    c.m"
"             Runoff coefficient     0.728      0.965      0.870      "
"             Maximum flow           0.040      0.066      0.103      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.103     1.512     0.000     0.000"
" 54          POND DESIGN"
"        1.512   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"      26052.4   Hydrograph volume    c.m"
"           9.   Number of stages"
"      353.900   Minimum water level    metre"
"      356.200   Maximum water level    metre"
"      354.200   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.900     0.000     0.000"
"                354.200  1.00E-07   0.01000"
"                354.500   0.00616   780.000"
"                354.800   0.00914  1675.000"
"                355.100   0.01137  2799.000"
"                355.400    0.1897  4166.000"
"                355.700    0.5140  5653.000"
"                355.900    0.7844  6701.000"
"                356.200     1.256  8356.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                355.100     0.900     0.700     0.000     0.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                354.200     0.630    0.0750     1.000"
"             Peak outflow                  1.077    c.m/sec"
"             Maximum level               356.086    metre"
"             Maximum storage            7728.490    c.m"
"             Centroidal lag               49.966   hours"
"                  0.103     1.512     1.077     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  1.077    c.m/sec"
"             Hydrograph volume         25291.607    c.m"
"                    0.103     1.512     1.077     1.077"
" 81          ADD COMMENT================================================="
"           2  Lines of comment"
"             501/507 are to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    0.103     0.000     1.077     1.077"
" 33          CATCHMENT 501"
```

```
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          501   Northeast corner of subdivision"
"       60.000   % Impervious"
"        0.577   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.231   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.346   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.728   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.967   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.082     0.000     1.077     1.077 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.231      0.346      0.577      hectare"
"             Time of concentration  9.349      1.671      4.237      minutes"
"             Time to Centroid       2498.142   2270.257   2346.417   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        657.78     986.67     1644.45    c.m"
"             Rainfall losses        77.420     9.312      36.555     mm"
"             Runoff depth           207.580    275.688    248.445    mm"
"             Runoff volume          479.09     954.43     1433.53    c.m"
"             Runoff coefficient     0.728      0.967      0.872      "
"             Maximum flow           0.032      0.051      0.082      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.082     0.082     1.077     1.077"
" 33          CATCHMENT 507"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          507   Trail block - east part"
"       50.000   % Impervious"
"        0.111   Total Area"
"        5.000   Flow length"
"        2.000   Overland Slope"
"        0.056   Pervious Area"
"        5.000   Pervious length"
"        2.000   Pervious slope"
"        0.056   Impervious Area"
"        5.000   Impervious length"
"        2.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.727   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
```

```
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.941   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.015     0.082     1.077     1.077 c.m/sec"
"             Catchment 507          Pervious   Impervious Total Area "
"             Surface Area           0.056      0.056      0.111      hectare"
"             Time of concentration  5.462      0.976      2.931      minutes"
"             Time to Centroid       2492.483   2270.942   2367.499   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        158.18     158.18     316.35     c.m"
"             Rainfall losses        77.901     16.931     47.416     mm"
"             Runoff depth           207.099    268.069    237.584    mm"
"             Runoff volume          114.94     148.78     263.72     c.m"
"             Runoff coefficient     0.727      0.941      0.834      "
"             Maximum flow           0.008      0.008      0.015      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.015     0.097     1.077     1.077"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.015     0.097     0.097     1.077"
" 40          HYDROGRAPH   Combine    507"
"            6   Combine "
"          507   Node #"
"                To N and NE"
"             Maximum flow                  0.097    c.m/sec"
"             Hydrograph volume          1697.244    c.m"
"                     0.015     0.097     0.097     0.097"
" 81          ADD COMMENT================================================="
"          4  Lines of comment"
"             Flows from 502 and 503 are to a proposed SWM facility "
"             south of Conservation Drive. Rooftop runoff from the "
"             school (502) up to 25mm rainfall depth to infiltration"
"             but conservatively ignored in this modeling."
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                     0.015     0.000     0.097     0.097"
" 33          CATCHMENT 502"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          502   Front half of school site"
"        50.000   % Impervious"
"         1.557   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         0.779   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         0.779   Impervious Area"
"        30.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.730   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
```

```
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.963   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.222     0.000     0.097     0.097 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.779      0.779      1.557      hectare"
"              Time of concentration  14.171     2.532      7.551      minutes"
"              Time to Centroid       2505.410   2267.788   2370.250   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        2218.73    2218.73    4437.45    c.m"
"              Rainfall losses        76.853     10.427     43.640     mm"
"              Runoff depth           208.147    274.573    241.360    mm"
"              Runoff volume          1620.43    2137.55    3757.97    c.m"
"              Runoff coefficient     0.730      0.963      0.847      "
"              Maximum flow           0.108      0.117      0.222      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.222     0.222     0.097     0.097"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        60.000   % Impervious"
"         8.765   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         3.506   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         5.259   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.728   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.967   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.251     0.222     0.097     0.097 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           3.506      5.259      8.765      hectare"
"              Time of concentration  9.349      1.671      4.237      minutes"
"              Time to Centroid       2498.143   2270.256   2346.417   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        0.9992     1.4988     2.4980     ha-m"
"              Rainfall losses        77.421     9.312      36.555     mm"
"              Runoff depth           207.579    275.688    248.445    mm"
"              Runoff volume          0.7278     1.4498     2.1776     ha-m"
"              Runoff coefficient     0.728      0.967      0.872      "
"              Maximum flow           0.484      0.768      1.251      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
```

```
"                    1.251     1.463     0.097     0.097"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    1.251     1.463     1.463     0.097"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"              Maximum flow                  1.463    c.m/sec"
"              Hydrograph volume         25534.148    c.m"
"                    1.251     1.463     1.463     1.463"
" 81          ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 504 (townhouses "
"              at SW corner) are through an OGS (road runoff) and into "
"              infiltration (222m3)"
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                    1.251     0.000     1.463     1.463"
" 33          CATCHMENT 504"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           504   Townhouse area at SW corner"
"        60.000   % Impervious"
"         0.760   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.304   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.456   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.728   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.967   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.109     0.000     1.463     1.463 c.m/sec"
"              Catchment 504          Pervious   Impervious Total Area "
"              Surface Area           0.304      0.456      0.760      hectare"
"              Time of concentration  9.349      1.671      4.237      minutes"
"              Time to Centroid       2498.141   2270.256   2346.417   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        866.40     1299.60    2166.00    c.m"
"              Rainfall losses        77.420     9.312      36.555     mm"
"              Runoff depth           207.580    275.688    248.445    mm"
"              Runoff volume          631.04     1257.14    1888.18    c.m"
"              Runoff coefficient     0.728      0.967      0.872      "
"              Maximum flow           0.042      0.067      0.109      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.109     0.109     1.463     1.463"
```

```
" 54          POND DESIGN"
"         0.109   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"        1888.2   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.00E-04   222.000"
"                 102.000    10.000  1000.000"
"               Peak outflow                  0.108    c.m/sec"
"               Maximum level               101.011    metre"
"               Maximum storage             230.408    c.m"
"               Centroidal lag               43.131   hours"
"                    0.109     0.109     0.108     1.463 c.m/sec"
" 40            HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"               Maximum flow                  1.155    c.m/sec"
"               Hydrograph volume         26982.219    c.m"
"                       0.109     0.109     0.108     1.155"
" 81            ADD COMMENT================================================="
"           3  Lines of comment"
"               Flows from catchment 505/506 are infiltrated (2-year "
"               and less=216m3) with overflows to the wetland finger, "
"               which then is combined with outflows towards Beaver Ck "
" 40            HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                       0.109     0.000     0.108     1.155"
" 33            CATCHMENT 505"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           505   Rear yards of lots at NW corner"
"        60.000   % Impervious"
"         0.562   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.225   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.337   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.728   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.967   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.080     0.000     0.108     1.155 c.m/sec"
```

```
"             Catchment 505          Pervious   Impervious Total Area "
"             Surface Area           0.225      0.337      0.562      hectare"
"             Time of concentration  9.349      1.671      4.237      minutes"
"             Time to Centroid       2498.142   2270.257   2346.417   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        640.68     961.02     1601.70    c.m"
"             Rainfall losses        77.421     9.312      36.555     mm"
"             Runoff depth           207.579    275.688    248.445    mm"
"             Runoff volume          466.64     929.62     1396.26    c.m"
"             Runoff coefficient     0.728      0.967      0.872      "
"             Maximum flow           0.031      0.049      0.080      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.080     0.080     0.108     1.155"
" 33          CATCHMENT 506"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          506   Trail block - west part"
"       50.000   % Impervious"
"        0.203   Total Area"
"        5.000   Flow length"
"        2.000   Overland Slope"
"        0.101   Pervious Area"
"        5.000   Pervious length"
"        2.000   Pervious slope"
"        0.101   Impervious Area"
"        5.000   Impervious length"
"        2.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.727   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.941   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.028     0.080     0.108     1.155 c.m/sec"
"             Catchment 506          Pervious   Impervious Total Area "
"             Surface Area           0.101      0.101      0.203      hectare"
"             Time of concentration  5.462      0.976      2.931      minutes"
"             Time to Centroid       2492.483   2270.941   2367.500   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        289.27     289.27     578.55     c.m"
"             Rainfall losses        77.901     16.931     47.416     mm"
"             Runoff depth           207.099    268.069    237.584    mm"
"             Runoff volume          210.21     272.09     482.30     c.m"
"             Runoff coefficient     0.727      0.941      0.834      "
"             Maximum flow           0.014      0.014      0.028      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.028     0.107     0.108     1.155"
" 54          POND DESIGN"
"        0.107   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"       1878.6   Hydrograph volume    c.m"
"           3.   Number of stages"
```

```
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000   0.00100   216.000"
"                102.000    10.000  1000.000"
"             Peak outflow                  0.107    c.m/sec"
"             Maximum level               101.011    metre"
"             Maximum storage             224.324    c.m"
"             Centroidal lag               49.303   hours"
"                  0.028     0.107     0.107     1.155 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  1.233    c.m/sec"
"             Hydrograph volume         28795.117    c.m"
"                    0.028     0.107     0.107     1.233"
" 38          START/RE-START TOTALS 506"
"           3   Runoff Totals on EXIT"
"             Total Catchment area                     23.257    hectare"
"             Total Impervious area                    12.870    hectare"
"             Total % impervious                       55.336"
" 19          EXIT"
```

Appendix E: Agency Correspondence

Grand River Conservation Authority
Resource Management Division
Kaitlyn Smith, Resource Planner

400 Clyde Road, P.O. Box 729
Cambridge, Ontario N1R 5W6
Phone: (519) 621-2761 ext. 2292
Fax: (519) 621-4945
E-mail: ksmith@grandriver.ca

PLAN REVIEW REPORT:	**Region of Waterloo** **Shiling Yip**

DATE:	**YOUR FILE:**	**GRCA FILE:**
September 14, 2015	Conservation Dr. at Beaver Creek Rd.	Presub 556, 560 & 576 Conservation Drive

RE: **Presubmission Draft Plan of Subdivision & Zone Change Application**
556, 560 and 576 Conservation Drive, City of Waterloo
2115881 Ontario Limited

GRCA COMMENT*:
A portion of the subject properties are regulated by the Grand River Conservation Authority (GRCA) under Ontario Regulation 150/06. GRCA request an opportunity to review the formal applications to ensure conformance with the relevant policies of the Provincial Policy Statement, the North Waterloo Scoped Subwatershed Study, and Ontario Regulation 150/06. Please see below for our detailed review requirements.

1. **Nature of the Application:**
   It is our understanding that the applicant is proposing to develop the vacant properties with a mix of low rise residential uses, including associated school, park, open space, and stormwater management blocks.

2. **GRCA Resource Issues:**
   Information currently available at this office indicates that the subject properties contain the following natural heritage and hazard features of interest to the GRCA:

   - Sunfish Lake – Laurel Creek Provincially Significant Wetland Complex and associated 120 metre allowance
   - Beaver Creek and associated 15 metre allowance
   - One Zone floodplain and associated 5 metre allowance

   Due to the presence of these resource features, a portion of the subject properties is regulated by the GRCA under Ontario Regulation 150/06 (Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation).

3. **Review of Application under the *Planning Act*:**
   For review of the Draft Plan of Subdivision and Zone Change applications, GRCA staff will require submission of the following materials:

   - Scoped Environmental Impact Study (EIS)
   - Stormwater Management (SWM) & Servicing Report
   - Hydrogeological Assessment
   - Pre-construction Monitoring Report (2 years)
   - Preliminary Grading and Erosion and Sediment Control Plans

   We note that the North Waterloo Scoped Subwatershed Study (NWSSS) recommends a 30 metre buffer for all Provincially Significant Wetlands in the subwatershed. The preliminary plan has incorporated this buffer, which also provides sufficient development setback from the creek and floodplain. GRCA staff support the Open Space zoning; however, a portion of the buffer (Block 35) is shown as Park. This is not the intent of the 30 metre buffer; therefore, GRCA staff request that this be revised to Open Space.

We also note that Stormwater Management Blocks 38 and 39 encroach into the wetland buffer. In accordance with the NWSSS, the Scoped EIS and SWM Report will need to demonstrate that there are no feasible locations outside of the buffer and that adverse impacts to the natural features can be avoided and/or mitigated appropriately. Please be advised that buffer encroachment shall only be permitted for *a portion* of stormwater management, not entire facilities.

Trail locations should also be shown on the Draft Plan of Subdivision and addressed in the supporting documentation (with attention paid to the requirements of the NWSSS).

4. **Review of Application under Ontario Regulation 150/06:**
Development proposed with GRCA regulated areas requires prior issuance of a GRCA permit pursuant to Ontario Regulation 150/06. GRCA staff will review the Draft Plan of Subdivision and Zone Change applications for conformance with Ontario Regulation 150/06 and advise of any specific permit requirements through that process.

5. **Plan Review Fees:**
The GRCA applies Plan Review Fees for *Planning Act* applications located within GRCA areas of interest. Given that the Draft Plan of Subdivision and Zone Change applications will be submitted concurrently, only the subdivision fee will be applied.

According to the 2015 Plan Review Fee Schedule, the fee for a Draft Plan of Subdivision application is $2,050 (base fee) plus $1,070 per net hectare (to a maximum of $25,000). Upon submission of the application, the GRCA will invoice for 70% of the total fee. The remaining 30% will be due prior to GRCA providing conditions for Draft Plan Approval. Additional fees are applied for providing clearance of Draft Plan Approval conditions for registration of the plan.

Please be advised that a separate fee is applied for a GRCA permit application. A 'minor' fee of $380 is typically applied in cases where GRCA staff have already reviewed the related Draft Plan of Subdivision.

We trust this information is of assistance. If you have any questions, or require additional information, please do not hesitate to contact the undersigned.

Sincerely,

Kaitlyn Smith
Resource Planner
Grand River Conservation Authority

cc: Kristen Barisdale – GSP Group (email)
Trevor Hawkins – City of Waterloo (email)
Robyn McMullen – City of Waterloo (email)

These comments are respectfully submitted as advice and reflect resource concerns within the scope and mandate of the Grand River Conservation Authority

Appendix F: Geotechnical Investigation

LVM

Soil and Materials Engineering
Environmental Engineering
Building Science
Supply Chain Quality

2115881 Ontario Limited

Proposed Residential Development
560-576 Conservation Drive
Waterloo, Ontario

Geotechnical Engineering Report

Date: March 20, 2015
Ref. N°: 160-P-0008077-0-01-100-GE-R-0001-00

LVM, a division of EnGlobe Corp.



LVM

2115881 Ontario Limited

Proposed Residential Development
560-576 Conservation Drive
Waterloo, Ontario

Geotechnical Engineering Report |160-P-0008077-0-01-100



Prepared by:

Montana Wilson, M.Eng., P.Eng., PMP
Geotechnical Group Leader



Prepared by:

Vanessa Marshall, M.Eng., P.Eng.
Team Leader, Engineering Group

TABLE OF CONTENTS

1 INTRODUCTION 1

2 PREVIOUS WORK 1

3 INVESTIGATION PROCEDURE 2

3.1 Field Program 2
3.2 Laboratory Testing 3

4 SUMMARIZED CONDITIONS 3

4.1 Site Description 3
4.2 Subsoil Conditions 4
4.2.1 Topsoil 4
4.2.2 Sand 4
4.2.3 Silt 5
4.2.4 Glacial Till 5
4.3 Groundwater 6

5 DISCUSSIONS AND RECOMMENDATIONS 6

5.1 General 6
5.2 Site Grading 7
5.3 Site Servicing 8
5.3.1 Excavations and Dewatering 8
5.3.2 Pipe Bedding 9
5.3.3 Trench Backfilling 10
5.4 Pavements 11
5.4.1 Pavement Design 11
5.4.2 Subdrains 12
5.4.3 Curbs and Sidewalks 12
5.5 Residential Buildings 13
5.5.1 Foundations 13
5.5.2 Basements 13
5.6 At Source Stormwater Infiltration 14

6 STATEMENT OF LIMITATIONS 16

TABLE OF CONTENTS

Tables

Table 1: Sand Particle Size Distribution Analyses....4
Table 2: Silt Particle Size Distribution Analyses Results....5
Table 3: Groundwater Level Measurements....6
Table 4: Compaction Specifications....7
Table 5: Pavement Designs....11

Appendices

Appendix 1 Drawings
Appendix 2 Borehole Logs
Appendix 3 Figures

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Test results mentioned herein are only valid for the sample(s) stated in this report.

LVM's subcontractors who may have accomplished work either on site or in laboratory are duly qualified as stated in our Quality Manual's procurement procedure. Should you require any further information, please contact your Project Manager."

2115881 Ontario Limited
c/o Ian Cook Construction Limited
169 Lexington Court, Unit B-1
Waterloo, ON N2J 4R3
Attention: Ms. Nicole Simas

REVISION AND PUBLICATION REGISTER		
Revision N°	Date	Modification And/Or Publication Details
00	2015-03-20	Report Issued

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1 INTRODUCTION

LVM, a division of EnGlobe Corp. (LVM) was retained by 2115881 Ontario Limited, c/o Ian Cook Construction Limited, to carry out a geotechnical investigation at the site of a proposed residential development in Waterloo, Ontario. This work was authorized by Ms. Nicole Simas of Ian Cook Construction Limited on February 12, 2015 following submission of a detailed proposal.

The project involves the proposed construction of a new 21.8 hectare residential development to be situated on a parcel of land located north of Conservation Drive in Waterloo, Ontario at the location shown on Drawing 1, in Appendix 1. It is understood the lands are designated for residential streets and houses. The lots will be serviced with municipal water and sewer. A preliminary site plan was unavailable at the time of this report. No details were available regarding placement of proposed stormwater management structures.

The purpose of the investigation was to determine the subsurface soil and groundwater conditions at the site and, based on that information, prepare this engineering report with geotechnical recommendations pertaining to the development including site grading, site servicing, pavement construction, house construction, excavations and dewatering, and stormwater infiltration.

2 PREVIOUS WORK

In 2003, LVM (formerly Naylor Engineering Associates Ltd. prior to 2009) carried out a geotechnical investigation for the land on the east side of the site. The fieldwork for this investigation comprised of drilling of twenty-one boreholes (Boreholes 1 to 21) and excavation of thirty-four test pits (Test Pits 1 through 34). The results of this investigation were provided in our Geotechnical Engineering Report No. 4500G1.R01.

In 2005, LVM carried out a geotechnical investigation on Roy Schmidt Road adjacent to the site. The fieldwork for this investigation comprised the drilling of six boreholes (Boreholes 1 through 6). The results of this investigation were provided in our Geotechnical Engineering Report No. 4500G4.R01.

The relevant geotechnical information from the above noted reports have been incorporated into this report.

3 INVESTIGATION PROCEDURE

3.1 FIELD PROGRAM

The fieldwork for this investigation was carried out between February 26 and 27, 2015 and involved the drilling of ten boreholes (Boreholes BH-01-15 to BH-10-15) to depths of 5.0 to 8.1 m. The locations of the boreholes are shown on the Site Plan, Drawing 2 in Appendix 1.

Local utility companies were contacted prior to the start of drilling activities in order to demarcate underground utilities near the boring locations.

The boreholes were advanced with a CME-75 track mounted drillrig equipped with continuous flight hollow stem augers supplied and operated by a specialist drilling contractor.

In the boreholes, representative samples of the overburden were recovered at regular intervals throughout the depths explored. Standard Penetration Tests (SPT) were carried out during sampling operations in the boreholes using conventional split spoon equipment. The SPT N-values recorded are plotted on the borehole logs in Appendix 2.

Samples of the cohesive soils were tested using a hand-held pocket penetrometer to determine approximate shear strengths. The pocket penetrometer test results are plotted on the borehole logs in Appendix 2.

Standpipes were installed in Boreholes BH-01-15, BH 04-15, BH 05-15 and BH 07-15, to allow measurement of groundwater levels and the collection of groundwater samples. The standpipes installation comprises 19 mm diameter pipes with slotted screens, as well as bentonite seals near the ground surface. Details of the installations and groundwater observations and measurements are provided on the borehole logs in Appendix 2.

The standpipes were installed in accordance with Ontario Regulation 468/10 which provides requirements for wells in the Province of Ontario. The regulation encompasses test holes, and provides detailed requirements for monitoring well construction, test hole sealing, well record submission, drilling contractor licensing, well tagging, protective covers, and decommissioning.

A completed well record was submitted to the property owner and the Ministry of Environment for Ontario as per Ontario Regulation 468/10. A licensed well technician must properly decommission all standpipes before construction according to Regulation 903 of the Ontario Water Resources Act.

Upon completion of drilling, the remaining boreholes were backfilled with bentonite in accordance with the Ontario Regulation 468/10 (formerly Ontario Regulation 903) under the province's Water Resources Act.

The fieldwork was monitored throughout by a member of our geotechnical engineering staff, who documented the drilling procedures; recorded the results of the SPT and pocket penetrometer tests; documented the soil stratigraphies; monitored the groundwater conditions; documented the installation of the standpipes and, cared for the recovered soil samples.

The borehole locations and ground surface elevations were surveyed by LVM using Sokkia Model GXR 1 Global Navigation Satellite System (GNSS) rover. The borehole locations were referenced to Universal Trans Mercator North American Datum of 1983 (UTM NAD83) coordinates; the zone referenced (17T) has been excluded for presentation purposes. The ground surface elevations are geodetic, based on GNSS and local base station telemetry with a vertical root mean square error of less than 20 mm.

3.2 LABORATORY TESTING

All soil samples secured during this investigation were returned to our laboratory for visual examination, as well as moisture content tests. The moisture content test results are plotted on the borehole logs in Appendix 2. The geotechnical laboratory tests carried out on selected samples of the major subsurface soils from the investigation comprised the following:

- five particle size distribution analyses with results plotted on Figure 1 in Appendix 3; and,
- two standard Proctor moisture-density tests with results plotted on Figures 2 and 3 in Appendix 3.

The soil samples will be stored for a period of three months from the date of sampling. After this time, they will be discarded unless prior arrangements have been made for longer storage.

4 SUMMARIZED CONDITIONS

4.1 SITE DESCRIPTION

The subject property is located on the north side of Conservation Drive at the northwest corner of Waterloo, Ontario. The property is bordered on the east by an existing residential development and Roy Schmidt Road; on the south by Conservation Drive; on the west by a natural area and Beaver Creek; and on the north by agricultural land. There are two houses at 570 and 576 Conservation Drive.

The property currently comprises mostly agricultural land. The ground surface at the site slopes down from east to west (Elevation 363.1 m to Elevation 354.8 m) and from north to south (Elevation 357.6 m to Elevation 351.9 m).

4.2 SUBSOIL CONDITIONS

We refer to the appended borehole logs for detailed soil descriptions and stratigraphies; results of SPT and pocket penetrometer testing; moisture content profiles; and, groundwater observations and measurements.

In general, the subsurface stratigraphy contacted at the site comprise topsoil, overlying sand, silt and glacial till. Descriptions of the various soil deposits encountered are provided in the following subsections.

4.2.1 Topsoil

Topsoil was encountered surficially at all of the boreholes and is 150 to 1070 mm thick (average 475 mm). The topsoil comprises dark brown silt with trace sand and was frozen at the time of the fieldwork.

4.2.2 Sand

Sand was encountered beneath the topsoil in all boreholes. The sand is 2.7 and 5.0 m thick and extends below the termination depth of Boreholes BH 01-15, BH 03-15, BH 05-15, BH 07-15, BH 09-15 and BH 10-15. The sand ranges in composition from brown sand and silt with trace gravel to sand with some silt and trace gravel. The results of three grain size distribution analyses conducted on samples of sand are plotted on Figure 1 in Appendix 3 and are summarized on the following table:

Table 1: Sand Particle Size Distribution Analyses

BOREHOLE NUMBER	SAMPLE DEPTH (m)	GRAVEL (%)	SAND (%)	FINES (%)
BH-04-15	2.29 – 2.74	6	85	9
BH-05-15	1.52 – 1.98	21	65	14
BH-07-15	2.29 – 2.74	1	95	4

SPT N-values measured in the sand deposits typically range from 6 to 33 blows per 300 mm penetration of the split spoon sampler indicating a loose to dense relative density. Insitu moisture contents in the sand range from 4 to 29% indicating moist to saturated conditions.

The results of a standard Procter moisture-density test conducted on a sample of sand are provided on Figure 2 in Appendix 3 and indicates a maximum dry density of 1.771 t/m^3 at an optimum moisture content 13.4%

4.2.3 Silt

Silt was encountered beneath the sand in Boreholes BH-01-15, BH-02-15 and BH-08-15; and beneath the till at Borehole BH-04-15. The silt is 4.6 m thick in Borehole BH-01-15, and extends below the termination depths of the remaining boreholes. The silt ranges in composition from silt and sand with trace gravel and clay to clay and silt with trace sand. The results of two particle size distribution analyses conducted on samples of silt are plotted on Figure 1 in Appendix 3 and summarized in the following table:

Table 2: Silt Particle Size Distribution Analyses Results

BOREHOLE NUMBER	SAMPLE DEPTH (m)	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)
BH-01-15	3.05 – 3.51	0	9	44	47
BH-08-15	4.57 – 5.03	0	22	57	21

SPT N-values measured in the silt generally increase with depth and range from 14 to above 50 blows per 300 mm penetration of the split spoon sampler indicating a compact to very dense relative density. In-situ moisture contents of the silt range from 12 to 23% indicating very moist to wet conditions.

The results of a standard Proctor moisture-density test conducted on a sample of silt are provided on Figure 3 in Appendix 3 and indicate a maximum dry density of 1.968 t/m^3 at an optimum moisture content 11.8%.

4.2.4 Glacial Till

Glacial till was encountered at a depth of 3.0 m in Borehole BH-04-15 and at a depth of 4.6 in Borehole BH-06-15. The till is 2.1 m thick in Borehole BH-04-15 and extends below the termination depth of Borehole BH-06-15. The till ranges in composition from brown silt with some sand and trace clay and gravel to clayey silt with some sand and trace gravel.
SPT N-values measured in the till range from 14 to 30 blows per 300 mm penetration of the split spoon sampler indicating a compact to dense relative density. The till was moist or about the plastic limit at the time of fieldwork.

4.3 GROUNDWATER

Groundwater observations and measurements carried out in the open boreholes are provided on the appended borehole logs. Standpipes were installed in four boreholes drilled in various locations on the property. The groundwater level measurements are summarized in the following table:

Table 3: Groundwater Level Measurements

BOREHOLE NUMBER	GROUND SURFACE ELEVATION (m)	MEASURED MARCH 9, 2015	
		GROUNDWATER DEPTH (m)	GROUNDWATER ELEVATION (m)
BH-01-15	361.21	6.99	354.22
BH-04-15	351.86	0.95	350.91
BH-05-15	353.74	1.53	352.21
BH-07-15	354.85	2.78	352.07

Free groundwater was also encountered at a depth of 0.8 to 1.5 m in Boreholes BH-04-15 and BH-05-15; and at depths ranging from 3.0 to 6.1 m Boreholes BH-01-15, BH-02-15, BH-03-15, BH-07-15 and BH-08-15. No free groundwater was encountered in Boreholes BH-06-15, BH-09-15, and BH-10-15. The groundwater occurs in unconfined water table conditions.

Local variations and seasonal fluctuations in the groundwater levels would be expected.

5 DISCUSSIONS AND RECOMMENDATIONS

5.1 GENERAL

The project involves the proposed construction of a residential subdivision on a 21.8 hectare parcel of land located north of Conservation Drive in Waterloo, Ontario at the location shown on Drawing 1, in Appendix 1. The lands are designated for residential streets and houses. The house lots will be serviced with municipal water and sewer.

Based on the results of the geotechnical investigation, the subsurface stratigraphy comprises topsoil overlying sand, silt and glacial till. The stabilized groundwater level generally occurs between Elevation 350.9 m and 354.2 m.

Based on the results of this geotechnical investigation, there are shallow groundwater levels at the south and east portions of the property; however, the site is suitable for the proposed residential development. The following subsections of this report contain geotechnical recommendations pertaining to development of the property including site grading, site servicing, pavements, residential buildings, and stormwater infiltration.

5.2 SITE GRADING

Area grading of the property will likely be required to prepare the land for the construction of the proposed residential subdivision. A proposed grading plan was unavailable at the time this report was issued.

Prior to carrying out any cutting and engineered fill placement, the surficial topsoil and loose native deposits should be removed from cuts and critical fill areas. In calculating the approximate quantity of soil to be removed, we recommend that the thicknesses on the individual borehole logs be increased by 50 mm to account for variations and some stripping of the mineral soil below. The topsoil material could be used for landscaping fill to raise grades in the rear yards of the house lots or in park areas. The topsoil ranges in thickness from 0.2 to 1.1 m at the borehole locations (average 475 mm).

The existing houses located off Conservation Drive will likely be demolished. The floor slabs, foundations, and foundation wall backfill should be removed prior to grading of this area.

Within the low-lying areas of the site where the groundwater table is quite close to the existing ground surface (west side of site) it will likely be necessary to remove the organic deposits with a tracked hydraulic excavator.

Following removal of the topsoil, the exposed subgrade should be inspected by LVM. Any fill required at the site should be placed in maximum 300 mm thick lifts and compacted to the following minimum percentages of standard Proctor maximum dry density (SPMDD):

Table 4: Compaction Specifications

FILL USE	MINIMUM COMPACTION REQUIRED
Structural fill to support houses.	98% SPMDD
Subgrade fill beneath streets or beneath services.	95% SPMDD
Bulk fill in landscaped areas.	90% SPMDD

The silty nature of the subgrade soils, as well as shallow perched groundwater table, renders the subgrade material highly susceptible to pumping/disturbance from heavy construction equipment. It is recommended that construction traffic (particularly earth scrapers) be minimized on the finished subgrade, and the subgrade be sloped to promote rainwater drainage.

The major soils likely to be generated from cut areas at the site are silt and sand. Based on the results of insitu moisture content and standard Proctor moisture-density tests, the majority of the on-site excavated soils from above the groundwater table will be suited for reuse as road subgrade fill and structural fill if the grading work is carried out during relatively dry weather. The silt is generally very moist and will require drying or blending with dry sand prior to use as structural fill. If time is not available for drying, then this material should be used as pavement subgrade fill and in landscaped area.

Also, if structural fill operations are carried out in the fall, winter or spring, imported granular material is recommended.

Where structural fill is placed on a wet subgrade, we suggest that only a coarse sand and gravel material be used for the bottom few lifts. Also, the initial lift may be up to 750 mm thick in order to ensure trafficability and minimize compaction problems associated with instability of the subgrade caused by vibratory equipment.

The structural fill pads should extend at least 1.0 m beyond the footing edge of any building and down to the subgrade level at a slope of 45° to the horizontal. A typical detail for structural fill placement beneath house foundations is shown on Drawing 3, in Appendix 1.

Full-time testing by experienced geotechnical personnel should be carried out during fill placement and compaction to examine and approve potential sources of fill material, and to carefully monitor the placement and verify the compaction by in-situ density testing (ASTM D2167 or ASTM 2922).

5.3 SITE SERVICING

5.3.1 Excavations and Dewatering

Following site grading operations, the subdivision will be serviced to provide the individual lots with water and sewer services. It is anticipated that the invert levels for the watermain and sewers will be at conventional depths, some 2 to 4 m below finished grade through most of the site. We recommend that LVM be allowed to check the final site grading and servicing plans for the subdivision to ensure that the exploratory boreholes extend below the design invert elevations. It is noted additional boreholes may be required.

If imported fill is required onsite, we recommend structural fill used below buildings consisting of clean granular material such as OPSS Granular ‘B’. Any imported fill material should be tested and approved by a geotechnical engineer prior to use.

Temporary excavations to conventional depths for installation of underground pipes at this site must comply with the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The predominant soils encountered in the boreholes would be classified as Type 3 soils (O. Reg. 213/91, s. 226(4)). Temporary side slopes must be cut at an inclination of 1.0 horizontal to 1.0 vertical or less above the base of excavation as per O. Reg. 213/91, s. 234(2) (exclusive of groundwater effects).

Significant seepage was noted at a depth of 0.8 to 1.5 m at Boreholes BH-04-15 and BH-05-15. A positive dewatering system installed by a specialist dewatering contractor may be required if excavations extend below Elevation 354 m in the east portion of the site and below Elevation 352 m in the west portion of the site. It will be necessary to flatten the excavation side slopes where groundwater seepage is occurring to ensure stability. Every excavation that a worker may be required to enter shall be kept reasonably free of water (O. Reg. 213/91, s. 230).

A Permit to Take Water (PTTW) is required by the Ministry of Environment in the event that the daily taking of groundwater exceeds 50,000 L per day. If the contractor carefully plans and stages his work so that only short sections of trench are open at a given time, it may be possible to complete this project without the need for a PTTW.

The contractor should evaluate this latter recommendation to ensure that he is in agreement, and he should notify the prime consultant in the event that he feels that a PTTW will be needed on the basis of his excavation and pipe laying schedule.

The design of the dewatering system should be left to the contractor's discretion, and the system should meet a performance specification to maintain and control the groundwater at least 0.30 m below the invert level in order to provide a stable excavation base. Successful dewatering operations will depend on the contractor's own experience, construction techniques, sequencing, and efficiency of work force and plant. Also the dewatering must be in compliance with the Ontario Water Resources Act (OWRA) and the Water Taking and Transfer Regulation (O.Reg. 451/07).

It is recommended that several test pits be dug during the tendering stage of the project in order that prospective contractors may familiarize themselves with the soil and groundwater conditions to be contacted.

5.3.2 Pipe Bedding

The subgrade soils beneath the watermain and sewers will comprise native mineral soils or compacted fill placed during the site grading operations. No support problems are anticipated for flexible or rigid pipes founded in the native deposits or compacted on-site soils.

Pipe bedding for water and sewer services should be conventional Class 'B' pipe bedding comprising a minimum 150 mm thick layer of OPSS Granular 'A' aggregate below the pipe invert. The bedding course may be thickened if portions of the subgrade become unduly wet during excavation. Granular 'A' type aggregate should be provided around the pipe to at least 300 mm above the pipe. The bedding aggregate should be compacted to a minimum 95% standard Proctor maximum dry density (SPMDD). Water and sewer lines installed outside of heated areas should be provided with a minimum 1.2 m of soil cover or equivalent insulation for frost protection.

A well-graded clear stone such as Coarse Aggregate for HL4 Asphaltic Concrete (OPSS 1003) could be used in the sewer trenches as bedding below the spring line of the pipe to facilitate sump pump dewatering, if necessary. The clear stone should be compacted with a plate tamper.

The proposed sewers could create hydraulic connections between groundwater regimes that are not presently connected. To stop the movement of groundwater along the pipe bedding, it is recommended that concrete or clay collars be installed around the pipe. The collars should be at least 1.0 m long and in place of the standard bedding material. Clay seals shall be compacted to 95% standard Proctor maximum dry density (SPMDD) as per OPSS 410.07.18. (Also OPSD 802.095 and OPSS 1205).

Thrust blocks for the watermain should be designed using current OPSS Standards and shall conform to OPSD 1103.010 and 1103.020. The following soil parameters may be used for thrust restraint design:

- Angle of internal friction (ϕ) = 30°
- Soil cohesion (c) = 0 kPa
- Soil unit weight (γ) = 20 kN/m^3

The interface friction coefficient for granular bedding and smooth ductile iron pipe or PVC pipe would be 0.60. An appropriate factor of safety should be employed.

5.3.3 Trench Backfilling

The trenches above the specified pipe bedding should be backfilled with inorganic on-site soils placed in 300 mm thick lifts and compacted to at least 95% SPMDD.

Based on the results of insitu moisture content and standard Proctor moisture-density tests carried out on the native overburden deposits, the majority of the on-site excavated materials will be compactable to the required density. If imported fill is required we recommend OPSS Granular ‘B’ be used.

If necessary, compensation for wet trench backfill conditions can be made with additional Granular 'B' in the pavement structure.

To minimize potential problems, backfilling operations should follow closely after excavation so that only a minimal length of trench is exposed. Care should be taken to protect side slopes of excavations by diverting surface run-off away from the excavations.

If construction extends into the winter, then the backfilling operations should be planned so that exposure of the backfill material to frost is kept to a minimum and to ensure that frozen material is not used as backfill.

Frequent compaction testing by experienced geotechnical personnel should be carried out to examine and approve backfill materials, and to verify that the specified degree of compaction has been achieved.

5.4 PAVEMENTS

5.4.1 Pavement Design

Following site grading and servicing operations, the pavement subgrade will comprise native and recompacted sand and silt soils or imported granular fill.

The following pavement component thicknesses are recommended based on the City of Waterloo Development Manual 2013, the proposed pavement usage, and the frost-susceptibility and strength of the subgrade soils:

Table 5: Pavement Designs

PAVEMENT COMPONENT	COLLECTOR STREETS	LOCAL STREETS
Asphalt Hot Mix	90 mm	90 mm
OPSS 1010 Granular 'A' Base	150 mm	150 mm
OPSS 1010 Granular 'B' Type 1 Subbase	500 mm	300 mm

The pavement designs meet City of Waterloo Standard Drawings Numbers W-201 and W-203 requirements.

The pavement design is based on the assumption that construction will be carried out during the drier time of the year and that the subgrade soil is stable as determined by proof-rolling inspected by a Geotechnical Engineer. If the subgrade is wet and unstable, additional granular subbase will be required.

Samples of both the Granular 'A' and Granular 'B' aggregates should be checked for conformance to OPSS 1010 prior to utilization on site and during construction. The Granular 'B' subbase and Granular 'A' base courses must be compacted to 100% SPMDD, as verified by insitu density testing.

The asphaltic concrete should comprise a binder layer of HL8 and a surface layer of HL3. It is recommended that the compacted thicknesses be 50 mm of HL8 binder and 40 mm of HL3 surface for both collector and local streets.

The asphaltic concrete paving materials should conform to the requirements of OPSS 1150. The asphalt should be placed and compacted in accordance with OPSS 310. The Performance Graded Asphalt Cement designation for the asphaltic concrete is 58-28.

The need for continuous paving supervision by a qualified pavement technician, and quality control testing during pavement construction cannot be over emphasized.

All materials and construction services required for the work should be in accordance with the applicable sections of the Ontario Provincial Standard Specifications.

5.4.2 Subdrains

Portions of he native subgrade soils have poor natural drainage therefore we recommend that where silt is encountered at the subgrade, subdrains be installed continuously along both sides of the street and connected to the catch basins. Where sand deposits are encountered at the subgrade level it is recommended that subdrain stubs be installed at the catchbasins. This should be confirmed by a geotechnical engineer at the time of subgrade preparation.

The purpose of the subdrains is to remove excess subsurface water in order to improve pavement serviceability and increase the pavement life. A detail for a typical pavement subdrain is provided on Drawing 4, in Appendix 1.

The work of subdrain installation shall be in accordance with OPSS 405 and OPSD 216.021. The subdrain shall be 100 or 150 mm diameter perforated pipe conforming to OPSS 1801 or 1840, and wrapped with geotextile conforming to OPSS 1860.

5.4.3 Curbs and Sidewalks

The concrete for curb and gutter should be proportioned, mixed, placed, and cured in accordance with the requirements of OPSS 353 and OPSS.MUNI 1350, and shall meet the following specific requirements (OPSS 353.05.01):

- minimum 28-day compressive strength = 30 MPa
- coarse aggregate = 19.0 mm nominal max. size
- maximum slump = 60 mm
- air entrainment = 7.0 ± 1.5%

During cold weather (when the air temperature is at or is likely to fall below 5°C within 96 hours of concrete placement) the freshly placed concrete must be covered with insulating blankets to protect against freezing, as per OPSS 904. Ice and snow must be removed from

the area where concrete is to be placed and the concrete must not be placed against frozen ground. All cold weather protection material shall be on site prior to each concrete placement.

The subgrade for the concrete sidewalks should comprise undisturbed native mineral soil or well-compacted fill. A minimum 150 mm thick layer of compacted Granular 'A' type aggregate should be placed beneath the sidewalk slabs. The subgrade and granular base should be prepared in accordance with the requirements of OPSS 315.

5.5 RESIDENTIAL BUILDINGS

5.5.1 Foundations

In general, the undisturbed native mineral soils are considered suitable to support residential house foundations. Where the footing levels will be above the existing native mineral soil grade, structural fill will probably be used. House footings constructed on the compact native mineral soil or approved structural fill may be designed using the minimum footing sizes provided in the Ontario Building Code.

All founding surfaces for residential dwellings on structural fill or native soils should be inspected by LVM personnel prior to placing concrete. The purpose of the inspection is to ensure that the founding conditions are consistent with the design bearing intended by the geotechnical engineer. The on-site review of the condition of the foundation soil as foundations are constructed is an integral part of the geotechnical design function and cannot be over emphasized. These reviews are required by Section 4.2.2.2 of the Ontario Building Code.

Further geotechnical investigation will be necessary for large structures such as schools, plazas or apartment buildings to provide specific recommendations for design of these structures. The preliminary Site Classification for Seismic Site Response is 'D'.

The subgrade soils are considered to be frost susceptible and must be protected from freezing at all times including during construction. The exterior footings or footings in unheated areas should be provided with a minimum 1.20 m of earth cover upon final grading for frost protection.

5.5.2 Basements

It is recommended basement floor slabs be installed above the groundwater levels and LVM review grading plans once complete.

House basements at this site must be provided with perimeter weeping tile systems as per the Ontario Building Code (Section 9.14). The drain tile or pipe should be laid on undisturbed or well-compacted soil so that the top of the tile or pipe (minimum 100 mm diameter) is below the bottom of the basement floor slab.

The top and sides of the drain tile or pipe shall be surrounded with not less than 150 mm of crushed stone or other clean coarse granular material containing no more than 10% of material that will pass the 4 mm sieve. The pipe bedding should be wrapped with geotextile filter fabric. The weeping tile must drain to a suitable frost-free outlet or sump.

The portion of the exterior basement wall below finished ground level must be damp-proofed as per Section 9.13.2 of the Ontario Building Code (2012). The basement wall backfill should be graded to prevent drainage towards the foundation after settling as per OBC 9.12.3.

The basement walls should be designed to resist the lateral earth pressure. For calculating the lateral earth pressure, the coefficient of earth pressure (K) may be assumed as 0.5 for cohesionless sand soils and 1.0 for silt and clay. The bulk unit weight of the retained backfill may be taken as 21 kN/m^3 for well-compacted soil. An appropriate factor of safety should be employed.

The subgrade for the basement floor slabs should comprise undisturbed native soil or well-compacted fill. A minimum 100 mm thick layer of coarse clean granular material containing not more than 10% material that will pass a 4 mm sieve shall be placed beneath slabs in houses as per Section 9.16.2 of the Ontario Building Code. If the subgrade soil is wet, we recommend that LVM be notified and subfloor weeping tiles be placed and connected to the sump pit.

To prevent the migration of moisture vapour into the houses from beneath basement floor slabs, particularly where moisture sensitive floor coverings are placed, a vapour retarder shall be placed directly beneath the floor slab that meets the requirements of the designer and flooring manufacturer. Prior to installing moisture sensitive floor coverings, the moisture content of the concrete slab must be determined at operational conditions by internal relative humidity testing to ensure an acceptable slab moisture level. It should be noted that it typically takes more than ninety days at operational conditions to lower the slabs internal relative humidity to 85%. Different flooring systems have different responses to slab moisture (i.e. some systems can tolerate more moisture than others), and the flooring contractor must assess the floor moisture levels with respect to their flooring components.

5.6 AT SOURCE STORMWATER INFILTRATION

At source infiltration of water from house roof leaders into dry wells may be feasible in areas where the natural groundwater level is below the bottom of the dry well and the native soils are relatively free-draining.

Based on the results of this investigation, the general soil profile existing at the site comprises surficial topsoil overlying major native deposits of sand with interbeds of silt. The hydraulic conductivity of the sand is in the order of 10^{-5} cm/sec, indicating that water infiltration would be feasible in this soil. The silt deposit has a hydraulic conductivity of 10^{-4} cm/sec or less, and therefore is not suitable for infiltration. The inferred groundwater table within most of the proposed residential lots is at least 3 m below existing grade.

The soak-away pits should be more than 5 m from the building foundations and located so that drainage is away from the buildings as per the Ontario Building Code.

Although the sand is prevalent across the site, it is anticipated that much of the sand will be stripped from the higher areas during site grading. For this reason, it will be necessary to identify potential infiltration lots during area grading. We would be pleased to provide preliminary information on which lots would be suitable for infiltration after reviewing the Site Grading Plan.

6 STATEMENT OF LIMITATIONS

The geotechnical recommendations provided in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known at the time of report preparation, we recommend that we be retained during the final design stage to verify that the geotechnical recommendations have been correctly interpreted in the design. We also recommend that we be retained during construction to confirm that the subsurface conditions do not deviate materially from those encountered in the boreholes and to ensure that our recommendations are properly understood.

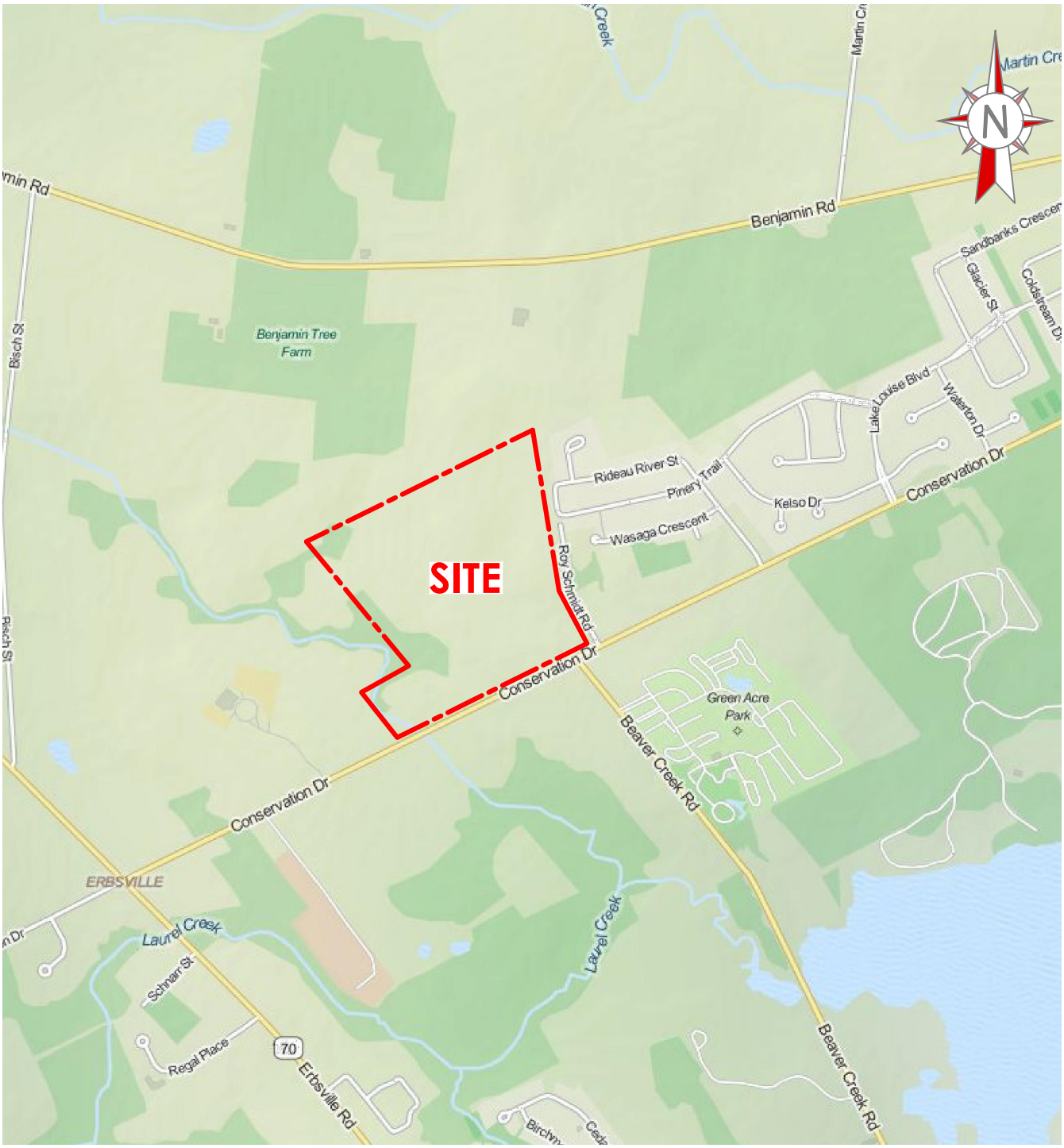
The geotechnical recommendations provided in this report are applicable only to the project described in the text and are intended for the use of the project designer. They are not intended as specifications or instructions to contractors. Any use which a contractor makes of this report, or decisions made based on it, are the responsibility of the contractor. The contractor must also accept the responsibility for means and methods of construction, seek additional information if required, and draw their own conclusions as to how the subsurface conditions may affect their work.

It is important to note that the geotechnical investigation involves a limited sampling of the site gathered at specific test hole locations and the conclusions in this report are based on this information gathered. The subsurface conditions between and beyond the boreholes will differ from those encountered at the test holes. Should subsurface conditions be encountered which differ materially from those indicated at the test holes, we request that we be notified in order to assess the additional information and determine whether or not changes should be made as a result of the conditions.

It must be recognized that the passage of time, natural occurrences and direct or indirect human intervention at or near the site have potential to alter the subsurface conditions. If during construction the soil or groundwater is found not to be of the type or in the condition used in design and as indicated on the drawings, the design shall be reassessed by the designer. If during construction, climatic (i.e. rain, frost etc.) or any other conditions (i.e. seepage, excavations etc.) have changed the properties of the soil or groundwater, the design shall be reassessed by the designer as per Section 4.2.2.3 of the Ontario Building Code.

Appendix 1 Drawings

Drawing 1: Location Plan
Drawing 2: Site Plan
Drawing 3: Typical Structural Fill Detail
Drawing 4: Typical Pavement Subdrain Detail



NOTES :
1-REFERENCES : © OpenStreetMap contributors (2013).

0 100 200 300 400 500 m
SCALE 1:15000

10 cm 0 1 2 3 4 5

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Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

LOCATION PLAN

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Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
Drawn	E.Ciochon	Scale	1 : 15000	Sequence no.	01 of 04
Checked	M.Wilson	Date	2015-03-03		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0008077-0-01-100	GE	001	00



LEGEND :

- SITE BOUNDARY LINE
- BOREHOLE LOCATION
- BOREHOLE/TEST PIT LOCATION (Previous NEA Investigation Project 4500G1. Feb 2003)
- BOREHOLE (Previous NEA Investigation Project 4500G4. July 2005)
- EL. 351.86 — GROUND SURFACE ELEVATION (m)
- 252.30 — GROUND WATER ELEVATION (m)

0 20 40 60 80 100 m

SCALE 1:3000

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, 2015.

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

3-Groundwater measured on March 9, 2015.

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

SITE PLAN

LVM

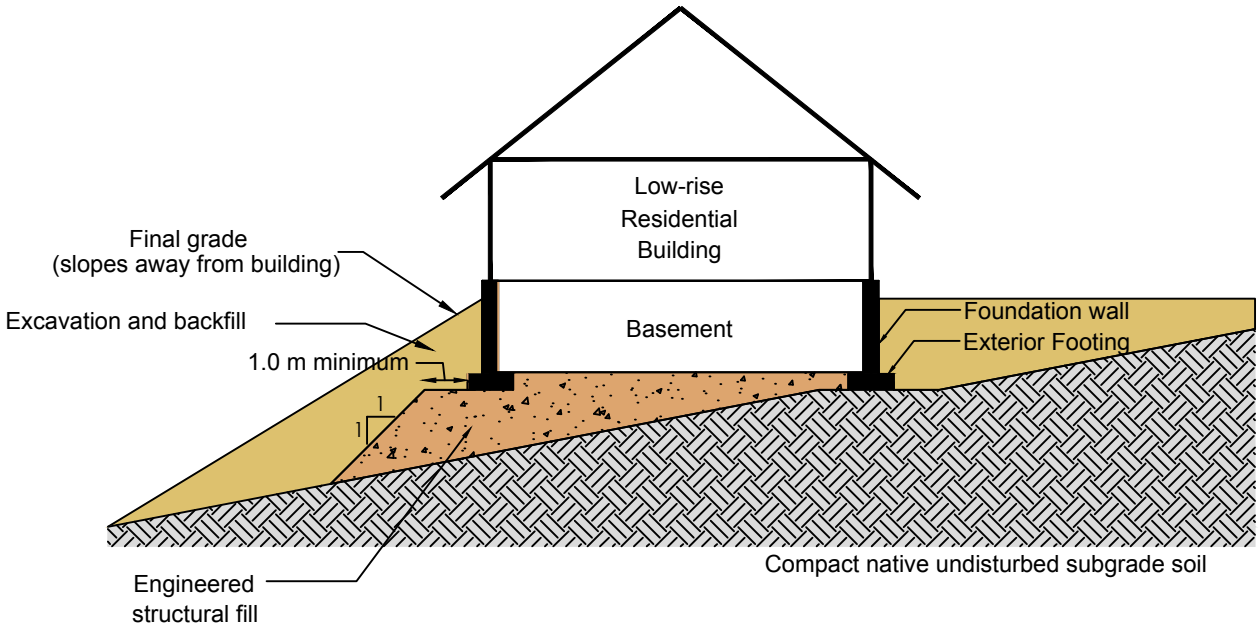
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	S.Meteer	Discipline	GEOTECHNICAL
Drawn	S.Meteer	Scale	1:3000
Checked	D.Gonser	Date	2015-02-17
Project manager	D.Gonser	Sequence no.	02 of 04

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0008077-0-01-100	GE	02	00

10 cm 0 1 2 3 4 5

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GENERAL REQUIREMENTS FOR ENGINEERED STRUCTURAL FILL

1. The area must be excavated of all pre-existing, topsoil and/or organic soil until compact native undisturbed soil is reached.

2. The excavation should allow for the structural fill to extend 1.0 m beyond the outside edge of the building footings and down to the approved subgrade soil at a slope of 1 horizontal to 1 vertical (45 °).

3. The subgrade below the engineered fill should be inspected and approved by a geotechnical engineer prior to fill construction. Fill placement and compaction operations to be carried out under full-time geotechnical supervision.

4. The structural fill should comprise sand and gravel aggregate placed in 300 mm thick lifts and compacted to at least 98 % Standard Proctor Maximum Dry Density (SPMDD). The exterior backfill should consist of approved inorganic soil also placed in 300 mm thick lifts and compacted to minimum 95 % SPMDD.

5. Exterior footings should be provided with minimum 1.2 m of soil cover for frost protection.

6. All excavations must be carried out in conformance with the current Ontario Occupational Health and Safety Act and Regulations 213/91 for construction projects.

7. This is not a design drawing or contract specification.

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Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

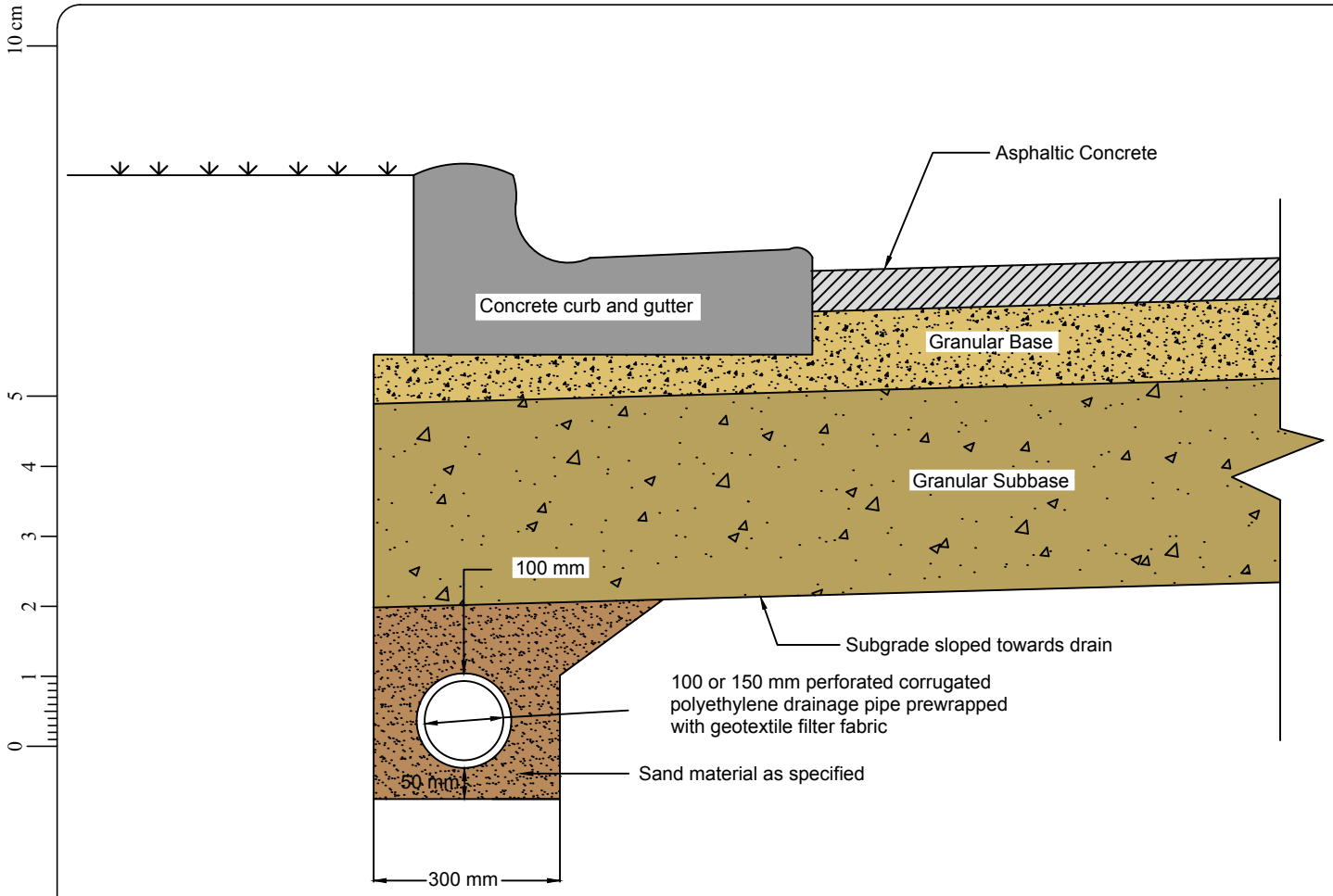
Title

TYPICAL STRUCTURAL FILL DETAIL

LVM
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
Drawn	E.Ciochon	Scale	NTS	Sequence no.	03 of 04
Checked	M.Wilson	Date	2015-03-03		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0008077-0-01-100	GE	003	00



GENERAL REQUIREMENTS FOR PAVEMENT SUBDRAINS

1. Perforated corrugated polyethylene drainage pipe shall meet the requirements of OPSS 1840.
2. Pipe filter fabric conforming to OPSS 1860 for geotextile Class 1 with a filtration opening size of 150 to 450 microns shall be supplied on all sections of perforated pipe.
3. The open upstream ends of pipes should be capped.
4. Subdrain pipes to be set on at least 1% grade draining to a positive frost-free outlet. If the subdrains are outletted to a ditch then the last 1.5 m of the outlet pipe should consist of a corrugated galvanized steel pipe equipped with a rodent gate.
5. Bedding and backfill material shall be concrete sand meeting the gradation requirements of OPSS 1002 (Fine Aggregate for Concrete).
6. This is not a design drawing or contract specification.

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Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

TYPICAL PAVEMENT SUBDRAIN DETAIL

LVM
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
Drawn	E.Ciochon	Scale	NTS	Sequence no.	04 of 04
Checked	M.Wilson	Date	2015-03-03		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0008077-0-01-100	GE	004	00

Appendix 2 Borehole and Test Pit Logs

List of Abbreviations

Current Investigation: Boreholes BH-01-15 to BH-12-15

Previous Investigation: Boreholes BH1 and BH2, Test Pits TP29 and TP31 (LVM Report No.4500G1)

Previous Investigation Boreholes BH1 to BH5 (LVM Report No.4500G4)

LIST OF ABBREVIATIONS

The abbreviations commonly employed on the borehole logs, on the figures, and in the text of the report, are as follows:

Sample Types		Soil Tests and Properties	
AS	Auger Sample	SPT	Standard Penetration Test
CS	Core Sample	UC	Unconfined Compression
RC	Rock Core	FV	Field Vane Test
SS	Split Spoon	ø	Angle of internal friction
TW	Thinwall, Open	γ	Unit weight
WS	Wash Sample	w_p	Plastic limit
BS	Bulk Sample	w	Water content
GS	Grab Sample	w_L	Liquid limit
WC	Water Content Sample	I_L	Liquidity index
TP	Thinwall, Piston	I_p	Plasticity index
		PP	Pocket penetrometer

Penetration Resistances	
Dynamic Penetration Resistance	The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) diameter 60º cone a distance 300 mm (12 in.). The cone is attached to 'A' size drill rods and casing is not used.
Standard Penetration Resistance, N (ASTM D1586)	The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a standard split spoon sampler 300 mm (12 in.)
WH	sampler advanced by static weight of hammer
PH	sampler advanced by hydraulic pressure
PM	sampler advanced by manual pressure

Soil Description			
Cohesionless Soils		**SPT N-Value**	**Relative Density (D_r)**
Compactness Condition		(blows per 0.3 m)	(%)
Very Loose		0 to 4	0 to 20
Loose		4 to 10	20 to 40
Compact		10 to 30	40 to 60
Dense		30 to 50	60 to 80
Very Dense		over 50	80 to 100
Cohesive Soils		**Undrained Shear Strength (C_u)**	
Consistency		**kPa**	**psf**
Very Soft		less than 12	less than 250
Soft		12 to 25	250 to 500
Firm		25 to 50	500 to 1000
Stiff		50 to 100	1000 to 2000
Very Stiff		100 to 200	2000 to 4000
Hard		over 200	over 4000
DTPL	Drier than plastic limit	Low Plasticity, W_L <30	
APL	About plastic limit	Medium Plasticity, 30 < W_L < 50	
WTPL	Wetter than plastic limit	High Plasticity, W_L > 50	

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Ground Elevation:	*361.21 m*	**Borehole Number:**	**BH-01-15**
Northing:	*4815267 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532899 m*	**Drill Date:**	*2015-02-27*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE								
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Shear Strength (FV) kPa	Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		361.21							
	TOPSOIL: dark brown silt, trace sand, frozen		0.00 / 360.90							
	SAND: compact brown silty sand, trace gravel, frozen to moist		0.30 / 360.45							
1	very moist		0.76 / 359.69	SS-1	6-8 10	18				
	SILT: compact brown silt, some sand, trace clay and gravel, moist		1.52 / 358.92	SS-2	6-8 14	22				
2	some sand and clay, moist to very moist		2.29 / 358.16	SS-3	6-9 10	19				
3	hard grey/brown clay and silt, trace sand and gravel, DTPL		3.05	SS-4	10-13 15	28		> ▲.		bentonite seal
4										
				SS-5	11-15 18	33				
5										
6			355.11							
	SAND: very dense brown silty sand, wet		6.10	SS-6	7-24 27	51				sand pack
7										19 mm pipe 1.52 m slotted screen
	dense, saturated		7.62 / 353.59	SS-7	8-14 17	31				native cave
8	Borehole terminated at 8.08 m		353.13 / 8.08							

Dynamic Cone: 20 40 60 80 — Std Penetration: 20 40 60 80

Shear Strength (PP) kPa: 50 100 150 200 — ■ Initial, □ Remold — Shear Strength (FV) kPa: 50 100 150 200

WP WL — Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details: ▽ el. 354.22 m 2015-03-15

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulk sample AS-1A taken from 0.61 to 1.52 m and AS-5A from 3.05 to 4.57 m.*

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Ground Elevation:	*358.14 m*	**Borehole Number:**	**BH-02-15**
Northing:	*4815128 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532872 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE								
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	WP WL / Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		358.14				20 40 60 80	50 100 150 200	10 20 30	
	TOPSOIL: dark brown silt, trace sand, frozen		0.00							
			357.38							
1	loose, moist		0.76	SS-1	3-3 3	6				
	SAND: loose brown sand, some silt, trace topsoil, moist		357.07 1.07							
				SS-2	2-3 3	6				
2			355.85							bentonite seal
	silty sand, very moist		2.29	SS-3	3-3 3	6				
3				SS-4	1-3 7	10				
			354.33							
	wet		3.81	SS-5	3-5 6	11				
4			353.57							
	saturated		4.57	SS-6	1-3 4	7				
5										
6			352.04							native cave
	SILT: compact grey/brown silt, some clay, sand and gravel, very moist, some wet sand seams		6.10	SS-7	6-12 15	27				
7										
			350.52							
	hard, trace sand and gravel, DTPL		7.62	SS-8	10-13 17	30		>▲.		
8			350.06							
	Borehole terminated at 8.08 m		8.08							At drilling completion, wet cave at 4.27 m.

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulk sample taken from 2.13 to 3.05 m.*

Ground Elevation:	*356.21 m*	**Borehole Number:**	**BH-03-15**
Northing:	*4815019 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532995 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration (20 40 60 80)	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa (50 100 150 200)	Water Content (%) WP WL (10 20 30)	Groundwater Observations and Standpipe Details
	Ground Elevation		356.21							
	TOPSOIL: dark brown sandy silt, frozen		0.00 / 356.06							
			0.15							
	SAND: compact brown sand, some silt, trace gravel, frozen			SS-1	5-6 7	13				
			354.69							
	trace silt and gravel, moist		1.52	SS-2	7-9 10	19				bentonite seal
				SS-3	6-11 13	24				
				SS-4	4-6 8	14				
			351.64							
	wet to saturated		4.57	SS-5	6-6 8	14				native cave
				SS-6	10-8 11	19				
			349.66							
	Borehole terminated at 6.55 m		6.55							At drilling completion, wet cave at 3.96 m.

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

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Ground Elevation: *351.86 m* | **Borehole Number:** **BH-04-15**

Northing: *4814862 m* | **Job N°:** *P-0008077-0-01-100*

Easting: *532751 m* | **Drill Date:** *2015-02-26*

Project: *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** *D.Souter*

Location: *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** *Hollow Stem Auger*

Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		351.86			
	TOPSOIL: dark brown silt, some sand, frozen		0.00 / 351.50			
	SAND: loose brown silty sand, trace gravel, wet		0.36 / 350.34	SS-1	2-3 3	6
	compact brown sand, trace gravel and silt, saturated		1.52 / 348.81	SS-2	5-5 6	11
				SS-3	7-8 6	14
	SILT TILL: hard grey clayey silt, some sand, trace gravel, APL		3.05 / 347.29	SS-4	4-6 10	16
	very stiff, trace sand and gravel, APL to WTPL		4.57 / 346.68	SS-5	3-6 7	13
	SILT: compact grey silt, some clay and fine sand, saturated		5.18 / 343.78	SS-6	6-7 9	16
				SS-7	5-7 7	14
	Borehole terminated at 8.08 m		8.08			

Dynamic Cone: 20 40 60 80 | Std Penetration: 20 40 60 80

Shear Strength (PP) kPa: 50 100 150 200 | Initial | Remold | Shear Strength (FV) kPa: 50 100 150 200

WP WL | Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details

el. 350.91 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
3.05 m slotted screen

native cave

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* | **Drafted by:** *E.Ciochon* | **Sheet:** *1 of 1*

Notes:

EQ-09-Ge-72 R.1 18.02.2011

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Ground Elevation:	*353.74 m*	**Borehole Number:**	**BH-05-15**
Northing:	*4814992 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532711 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration (20 40 60 80)	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa (50 100 150 200)	Water Content (%) WP WL (10 20 30)	Groundwater Observations and Standpipe Details
	Ground Elevation		353.74							
	TOPSOIL: dark brown silt, trace sand, frozen		0.00							
			352.90							
1	***SAND:*** compact brown sand, some silt, trace gravel, frozen to moist		0.84	SS-1	7-7 7	14				
			352.22							
	compact brown gravelly sand, some silt, trace gravel, saturated		1.52	SS-2	7-7 6	13				
2										
				SS-3	5-7 10	17				
			350.69							
3	some gravel		3.05	SS-4	3-7 12	19				
4										
			349.17							
	trace gravel		4.57	SS-5	7-10 10	20				
5										
6										
				SS-6	15-9 8	17				
			347.19							
	Borehole terminated at 6.55 m		6.55							
7										
8										

el. 352.21 m 2015-03-15

bentonite seal

19 mm pipe
1.52 m slotted screen

native cave

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

Ground Elevation:	*356.92 m*	**Borehole Number:**	**BH-06-15**
Northing:	*4815119 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532711 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		356.92			
	TOPSOIL: dark brown silt, trace sand and gravel, frozen		0.00 / 356.51			
	SAND: loose to compact brown sand, some silt, trace gravel, frozen		0.41 / 356.01			
1	moist		0.91 / 355.40	SS-1	3-4 5	9
	loose silty sand, very moist to wet		1.52 / 354.63	SS-2	3-3 4	7
2						
	compact, trace gravel, moist		2.29 / 352.35	SS-3	6-10 11	21
3				SS-4	5-12 16	28
4						
	SILT TILL: dense grey/brown silt, some sand, trace clay and gravel, moist		4.57 / 351.89	SS-5	10-12 18	30
5	Borehole terminated at 5.03 m		5.03			
6						
7						
8						

Dynamic Cone: 20 40 60 80
Std Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Initial
Remold
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details

bentonite seal

At drilling completion, borehole open and dry.

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulk sample taken from 2.44 to 3.66 m.*

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Ground Elevation:	*354.85 m*	**Borehole Number:**	**BH-07-15**
Northing:	*4815131 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532578 m*	**Drill Date:**	*2015-02-27*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE		SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration (20 40 60 80)	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa (50 100 150 200)	Water Content (%) WP WL (10 20 30)	Groundwater Observations and Standpipe Details
	Ground Elevation		354.85							
	TOPSOIL: dark brown silt, trace sand, frozen		0.00 / 354.44							
	SAND: loose brown sand, some silt, frozen to moist		0.41 / 354.09							
1	moist		0.76 / 353.33	SS-1	2-3 3	6				
	trace silt and gravel		1.52	SS-2	1-1 3	4				
2				SS-3	2-3 3	6				
3			351.80							
	some silt and gravel, saturated		3.05	SS-4	8-10 12	22				
4										
	dense		350.28 / 4.57	SS-5	8-14 19	33				
5	Borehole terminated at 5.03 m		349.82 / 5.03							
6										
7										
8										

el. 352.07 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
1.52 m slotted screen

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

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Ground Elevation:	*357.56 m*	**Borehole Number:**	**BH-08-15**
Northing:	*4815292 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532630 m*	**Drill Date:**	*2015-02-27*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	WP WL / Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		357.56				20 40 60 80	50 100 150 200	10 20 30	
	TOPSOIL: dark brown silt, some sand, frozen		0.00 357.41 0.15							
	SAND: brown sand, some silt and topsoil, frozen		356.80 0.76							
1	compact, some silt, trace gravel, moist			SS-1	4-6 5	11				
			356.04							
	compact brown silty sand, trace gravel, wet		1.52	SS-2	5-5 8	13				
2										
				SS-3	4-6 7	13				bentonite seal
3										
				SS-4	7-18 20	38				
4										
			352.99							
	SILT: dense grey/brown sandy clayey silt, trace gravel, very moist		4.57	SS-5	8-19 16	35				
5										
6			351.46							native cave
	compact		6.10	SS-6	9-10 16	26				
			351.01							At drilling completion, wet cave at 5.79 m.
	Borehole terminated at 6.55 m		6.55							
7										
8										

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Ground Elevation:	*361.96 m*	**Borehole Number:**	**BH-09-15**
Northing:	*4815237 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532778 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	WP WL / Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		361.96							
	TOPSOIL: dark brown silt, trace sand, frozen		0.00							
			361.05							
1	***SAND:*** loose brown fine sand, some silt, moist		0.91	SS-1	2-3 3	6				
			360.44							
	compact		1.52	SS-2	4-6 9	15				
2										
				SS-3	5-10 10	20				bentonite seal
3			358.91							
	dense		3.05	SS-4	10-16 17	33				
4										
			357.24							
	sand, trace silt		4.72	SS-5	15-18 25	43				
5			356.93							
	Borehole terminated at 5.03 m		5.03							At drilling completion, borehole open and dry.
6										
7										
8										

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 — Initial, Remold

WP WL / Water Content (%): 10 20 30

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulk sample taken from 1.52 to 3.05 m.*

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

Ground Elevation:	*363.11 m*	**Borehole Number:**	**BH-10-15**
Northing:	*4815398 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532842 m*	**Drill Date:**	*2015-02-27*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		363.11			
	TOPSOIL: dark brown silt, trace sand, frozen		0.00 362.96 0.15			
	SAND: compact brown silty fine sand, frozen		362.50 0.61			
1	moist			SS-1	3-5 6	11
	some silt		361.59 1.52	SS-2	3-5 7	12
2				SS-3	3-7 7	14
3	some silty sand seams		360.06 3.05	SS-4	7-12 14	26
4						
5				SS-5	7-7 10	17
6				SS-6	7-9 13	22
	Borehole terminated at 6.55 m		356.56 6.55			
7						
8						

Dynamic Cone: 20 40 60 80
Std Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Initial
Remold
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details

benonite seal

native cave

At drillig completion, borehole open and dry.

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulksample AS-4A taken from 3.05 to 4.57 m.*

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

BOREHOLE: 1
Sheet 1 of 1

PROJECT Proposed Residential Subdivision
DATE 6 December 2002
JOB NO. 4500G01
LOCATION Activa Conservation Lands, Waterloo, Ontario
FIELD ENG/TECH RM

DEPTH (m)	DESCRIPTION	LEGEND	ELEV.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES N-VALUE
	GROUND ELEVATION: 364.23					
0	0.20 TOPSOIL: dark brown silt, moist		364			
	SILT: compact brown silt, some sand, trace clay, wet			1	SS	16
1	1.50 compact to dense		363			
				2	SS	43
2			362	3	SS	20
3			361	4	SS	29
4	3.95 SILT TILL: very stiff grey clayey silt, trace sand, APL		360			
				5	SS	17
5	5.05 Borehole terminated at 5.05 m.					

SHEAR STRENGTH. kPa(ksf)
FV. NAT. ■ REM. □
UC ✕ PP ▲
50(1)100(2)150(3)200(4)
PENETRATION RESISTANCE
DYNAMIC CONE ✕
STANDARD PENETRATION ●
20 40 60 80

150 mm

WATER CONTENT (%)
Wp W Wl
10 20 30

GROUNDWATER OBSERVATIONS & PIEZOMETER DETAILS

bentonite seal

13 mm pipe

native backfill

1.2 m slotted filter

At drilling completion, dry cave at 4.6 m.

December 12, 2002
Water level at 4.28 m
(Elev. 359.95)

NOTES:

DRILLING METHOD: Solid Stem Augers

ENGINEER: JD

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

BOREHOLE: 2
Sheet 1 of 1

PROJECT Proposed Residential Subdivision
DATE 6 December 2002
JOB NO. 4500G01
LOCATION Activa Conservation Lands, Waterloo, Ontario
FIELD ENG/TECH RM

DEPTH (m)	DESCRIPTION	ELEV.	NUMBER	TYPE	N-VALUE
	GROUND ELEVATION: 362.60				
0	TOPSOIL: dark brown silt, moist				
0.30	SILT: compact to dense brown silt, trace sand and clay, wet	362	1	SS	12
1		361	2	SS	32
2					
2.45					
2.60	SILT TILL: dense brown silt, some clay, wet	360	3	SS	44
3	hard grey clayey silt, trace sand, APL	359	4	SS	22
3.95	brown; some silt layers, wet	358	5	SS	45
4					
5.05	Borehole terminated at 5.05 m.				
5					

SHEAR STRENGTH, kPa(ksf)
FV. NAT. ■ REM. □
UC ✜ PP ▲
50(1)100(2)150(3)200(4)
PENETRATION RESISTANCE
DYNAMIC CONE ×
STANDARD PENETRATION ●
20 40 60 80

WATER CONTENT (%)
Wp W Wl
10 20 30

GROUNDWATER OBSERVATIONS & PIEZOMETER DETAILS

bentonite seal

13 mm pipe

native backfill

1.2 m slotted filter

At drilling completion, dry cave at 4.6 m.

December 12, 2002
Water level at 4.74 m
(Elev. 357.86)

NOTES: Bulk sample taken at 2.4 to 3.4 m.

DRILLING METHOD: Solid Stem Augers

ENGINEER: JD

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

TEST PIT: 29

LOCATION Proposed Residential Subdivision DATE 10 December 2002 JOB NO. 4500G01

PROJECT Activa Conservation Lands, Waterloo, Ontario FIELD ENG/TECH RM

SOIL PROFILE					WATER CONTENT (%) Wp W Wl	GROUNDWATER OBSERVATIONS AND HEADSPACE READINGS (ppm)
DEPTH m	DESCRIPTION	LEGEND	ELEV.	SAMPLE	10 20 30	
	GROUND ELEVATION: 363.73					
0	TOPSOIL: dark brown silt, moist					
0.55	SILT: rusty brown silt, trace sand, wet		363			
0.80	brown				⊙	
1.10	Test pit terminated at 1.10 m.					Upon completion of excavation, test pit sidewalls stable. No free groundwater encountered during excavation.

NOTES:

ENGINEER:

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

TEST PIT: 31

LOCATION Proposed Residential Subdivision DATE 10 December 2002 JOB NO. 4500G01

PROJECT Activa Conservation Lands, Waterloo, Ontario FIELD ENG/TECH RM

SOIL PROFILE					WATER CONTENT (%) Wp W Wl	GROUNDWATER OBSERVATIONS AND HEADSPACE READINGS (ppm)
DEPTH m	DESCRIPTION	LEGEND	ELEV.	SAMPLE	10 20 30	
	GROUND ELEVATION: 362.62					
0	TOPSOIL: dark brown silt, moist					
0.35	SAND: rusty brown fine to medium sand, some silt, moist		362			
0.85	brown, trace silt					
1.00	Test pit terminated at 1.00 m.					Test pit sidewalls caving below 0.4 m. No free groundwater encountered during excavation.

NOTES:

ENGINEER: JD

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 1

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Symbol	Elevation (m)	Sample Number	Sample Type	N-Value
	Ground Elevation		0.00			
0.00	***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 50 mm; Granular 'A': 150 mm					
	SAND: compact fine brown sand, trace silt, damp			1	SS	14
1.00			-1.00	2	SS	10
	compact light brown fine sand, some silt, wet			3	SS	17
2.00	Borehole terminated at 1.98 m.		-2.00			

Dynamic Cone: X 20 40 60 80 X
Standard Penetration: ● 20 40 60 80 ●
Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲
Shear Strength (FV) kPa: ■ 50 100 150 200 ■
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details

dry-pack asphalt seal

native backfill

native cave

At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 2

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Elevation (m)	Number	Type	N-Value
	Ground Elevation	0.00			
0.00	***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 40 mm; Granular 'A': 125 mm				
	FILL: loose dark brown silt, some clay and gravel, trace sand, very moist		1	SS	7
1.00	***SAND:*** very loose brown sand, some silt, moist	-1.00	2	SS	4
	SAND AND GRAVEL: compact brown medium to coarse sand and gravel, trace silt, moist		3	SS	13
2.00	Borehole terminated at 1.98 m.	-2.00			

Dynamic Cone: 20 40 60 80
Standard Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details:
- dry-pack asphalt seal
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 3

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Elevation (m)	Number	Type	N-Value
	Ground Elevation	0.00			
0.00	***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 40 mm; Granular 'A': 205 mm				
	FILL: firm dark brown clayey silt, some gravel, trace sand, damp		1	SS	8
	SILT: light brown silt, some sand, trace gravel, moist				
	silt, trace sand, trace gravel, very moist		2	SS	10
1.00		-1.00			
	SAND: dense light brown silty fine sand, very moist to wet		3	SS	39
2.00	Borehole terminated at 1.98 m.	-2.00			

Dynamic Cone: 20 40 60 80
Standard Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details:
- dry-pack asphalt seal
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 4

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Elevation (m)	Sample Number	Sample Type	N-Value
	Ground Elevation	0.00			
0.00	***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 50 mm; Granular 'A': 100 mm				
	FILL: firm dark brown clayey silt, some gravel, trace sand, damp				
	SAND: compact rusty brown sand, some silt, moist		1	SS	11
	compact light brown fine sand, some silt, moist		2	SS	18
1.00		-1.00			
	wet		3	SS	22
2.00	Borehole terminated at 1.98 m.	-2.00			

Dynamic Cone: X 20 40 60 80 X
Standard Penetration: ● 20 40 60 80 ●
Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲
Shear Strength (FV) kPa: ■ 50 100 150 200 ■
Water Content (%): WP WL; 10 20 30

Groundwater Observations and Standpipe Details:
- dry-pack asphalt seal
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 5

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Elevation (m)	Sample Number	Sample Type	N-Value
0.00	Ground Elevation	0.00			
	FILL: Topsoil Fill: 50 mm; Granular 'A': 150 mm				
	SAND: compact brown sand, trace silt, moist		1	SS	10
1.00	***SILT:*** very loose mottled brown/rusty silt, some sand, very moist	-1.00	2	SS	4
	compact light brown silt, trace sand, very moist		3	SS	12
2.00	Borehole terminated at 1.98 m.	-2.00			

Dynamic Cone: X 20 40 60 80 X
Standard Penetration: ● 20 40 60 80 ●
Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲
Shear Strength (FV) kPa: ■ 50 100 150 200 ■
Water Content (%): WP — WL; 10 20 30

Groundwater Observations and Standpipe Details:
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

Appendix 3 Figures

Figures 1 and 2: Particle Size Distribution Analyses
Figures 3 and 4: Standard Proctor Moisture-Density Test Results

Z:\Style_LVM_Ontario\Lab Lab_Particle_Size_LVM_Ontario.STY - Printed: 2015-03-16T09:40:16

PARTICLE SIZE ANALYSIS

Project: **Geotechnical Investigation, Proposed Residential Development**

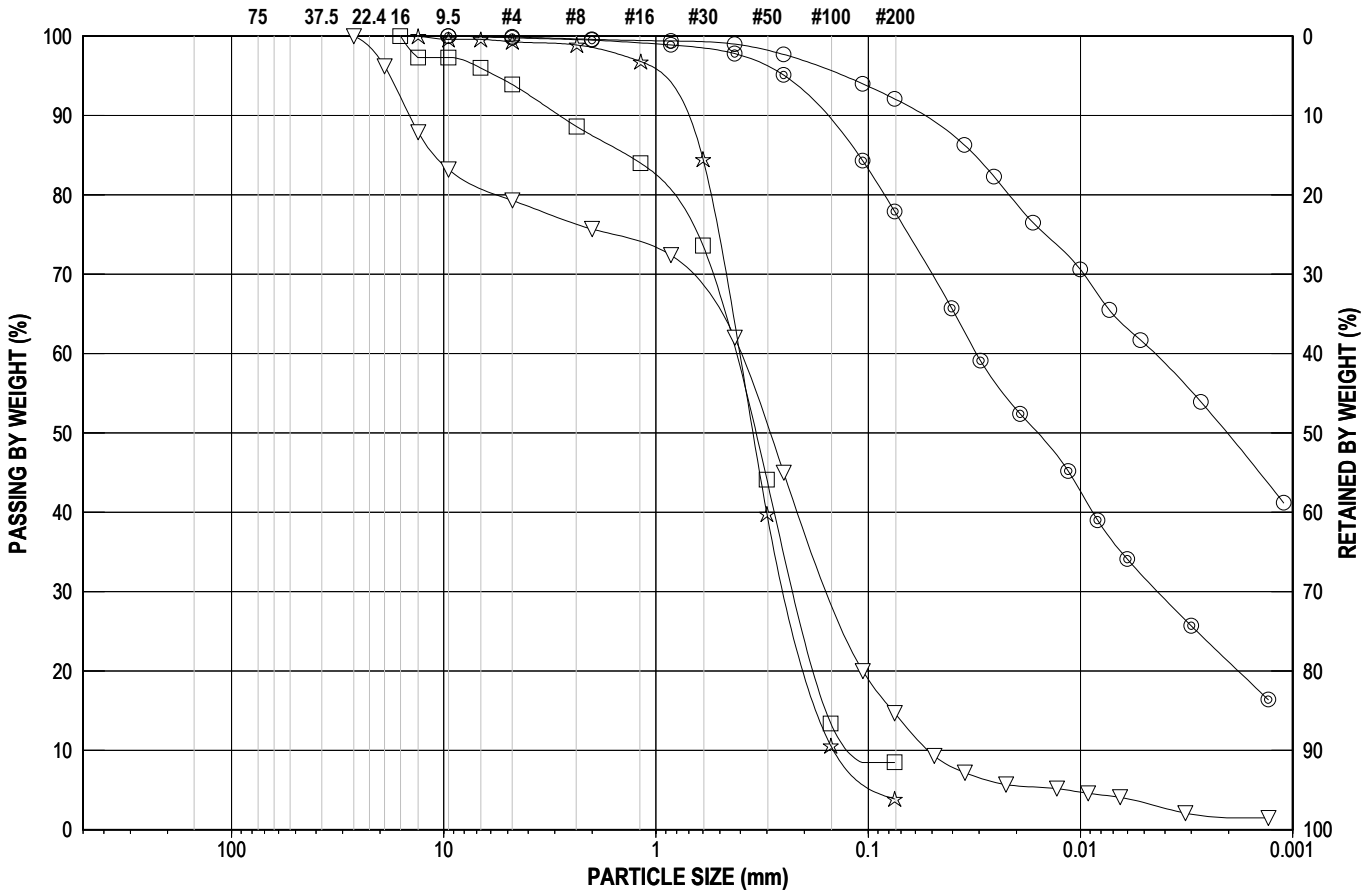
Figure No : **1**

Location: **560/576 Conservation Drive, Waterloo, Ontario**

File No : **P-0008077-0-01-100**

UNIFIED SOIL CLASSIFICATION

COBBLES	*GRAVEL*		*SAND*			*SILT OR CLAY*
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN MILLIMETRES			*U.S. STANDARD SIEVE No.*			*HYDROMETER*



Symbol	Borehole n°	Sample n°	Depth (m)	Description
○	BH-01-15	SS-4	3.05 - 3.51	SILT and CLAY, trace Sand
□	BH-04-15	SS-3	2.29 - 2.74	SAND, trace Gravel and Silt
▽	BH-05-15	SS-2	1.52 - 1.98	Gravelly SAND, some Silt, trace Clay
☆	BH-07-15	SS-3	2.29 - 2.74	SAND, trace Gravel and Silt
◎	BH-08-15	SS-5	4.57 - 5.03	Sandy, Clayey SILT

FIGURE NO. 2

LABORATORY PROCTOR MOISTURE–DENSITY TEST

PROJECT Proposed Residential Development

LOCATION 560 / 576 Conservation Drive, □aterloo, Ontario JOB NO. P-0008077-0-01-100

BOREHOLE NO. BH-09-15 Bulk Sample DATE TESTED March, 2015

SAMPLE DEPTH 1.52 m - 3.05 m TESTED BY M.D

SOIL TYPE SA□D MOISTURE CONTENT 9.5 %

REMARKS

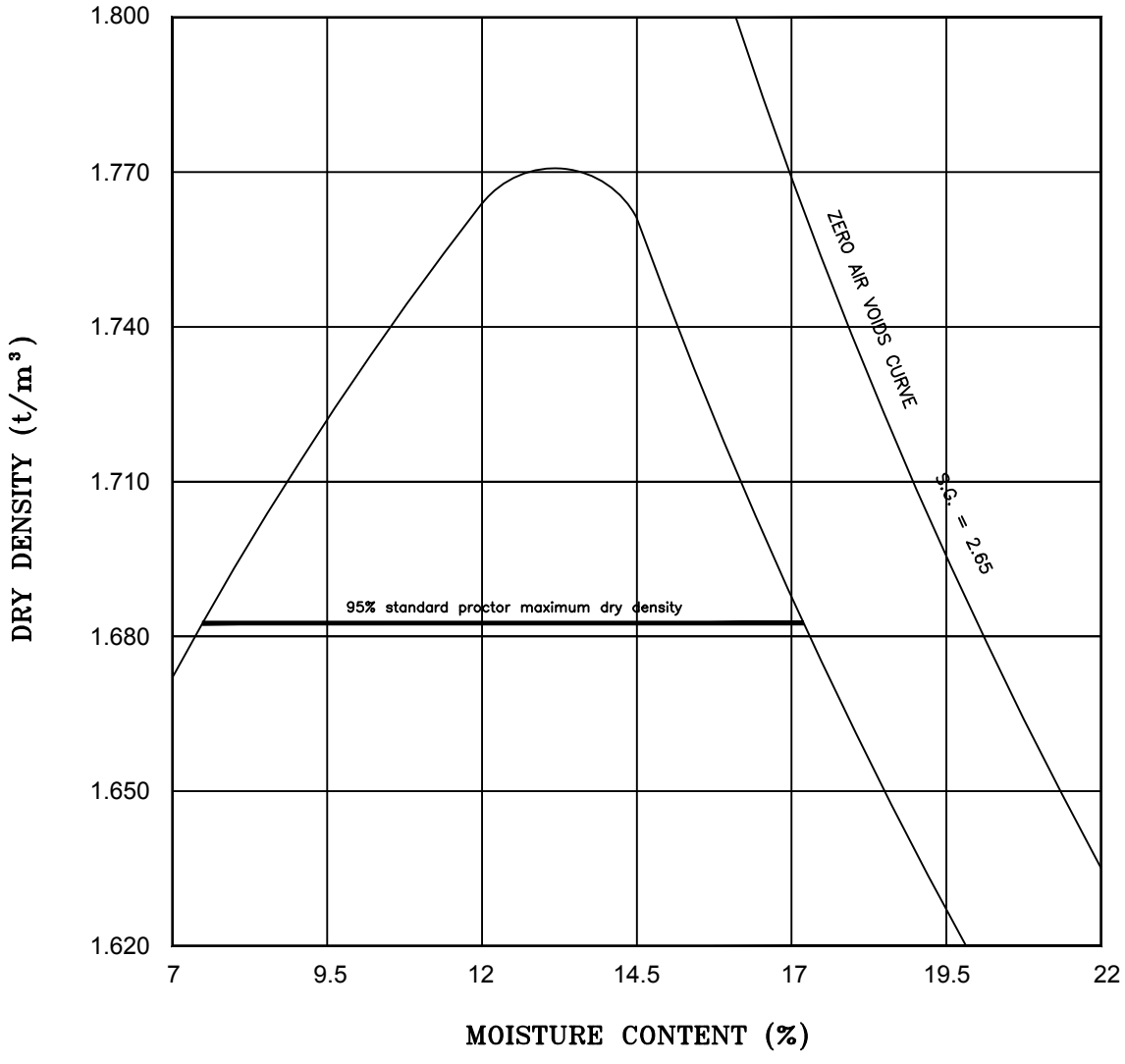
METHOD LS – 706

PROCEDURE: 1☒ 2☐ 3☐

Procedure 1 (Mold ø – 101.6 mm)
Procedure 2 (Mold ø – 101.6 mm)
Procedure 3 (Mold ø – 152.4 mm)

MAXIMUM DRY DENSITY 1.771 t/m³

OPTIMUM MOISTURE 13.4 %



G:\160\P0008077\z5_CAD\WP100\P-0008077-0-01-100_Fig002.dwg

FIGURE NO. 3

LABORATORY PROCTOR MOISTURE–DENSITY TEST

PROJECT Proposed Residential Development

LOCATION 560 / 576 Conservation Drive, □aterloo, Ontario JOB NO. P-0008077-0-01-100

BOREHOLE NO. BH-01-15 Auger Sample □6 DATE TESTED March 4, 2015

SAMPLE DEPTH 3.05 - 4.57 m TESTED BY M.Dalgliesh

SOIL TYPE S□LT MOISTURE CONTENT 18.9 %

REMARKS

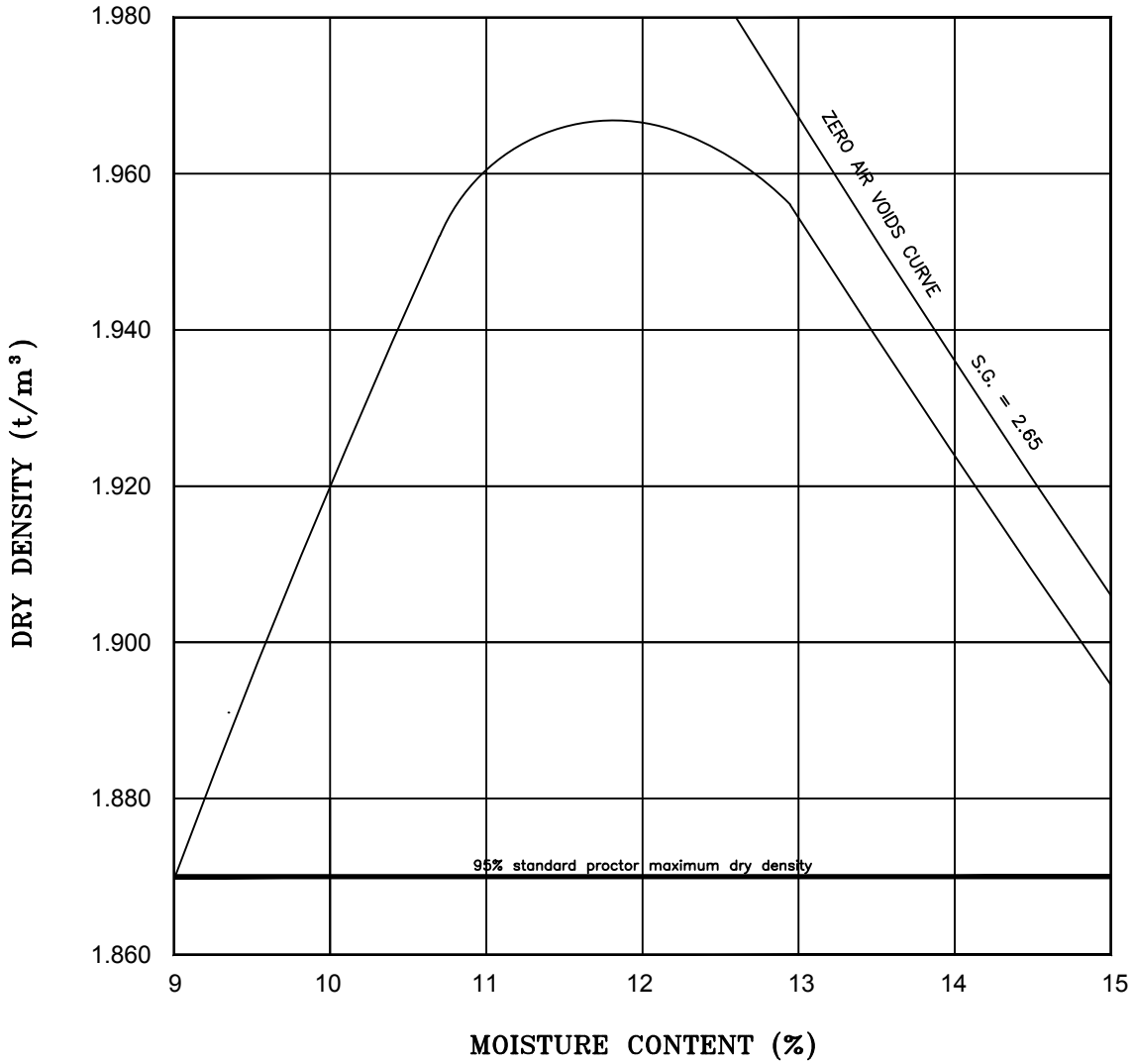
METHOD LS – 706

PROCEDURE: 1☒ 2☐ 3☐

Procedure 1 (Mold ø – 101.6 mm)
Procedure 2 (Mold ø – 101.6 mm)
Procedure 3 (Mold ø – 152.4 mm)

MAXIMUM DRY DENSITY 1.968 t/m³

OPTIMUM MOISTURE 11.8 %



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North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

DRAFT

Prepared for:
Northgate Corporation,
2115881 Ontario Ltd.,
Activa Holdings, and
Erbsville Kartway

Prepared by:
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1603-10875

April 15, 2016

Sign-off Sheet

This document entitled North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program was prepared by Stantec Consulting Ltd. ("Stantec") for the account of Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway (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.

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DRAFT

Table of Contents

ABBREVIATIONS ..... **III**

1.0 INTRODUCTION **1.1**

2.0 BACKGROUND **2.1**
2.1 NWSSS HYDROGEOLOGIC INVESTIGATION 2.1
2.2 NWSSS SURFACE WATER INVESTIGATION 2.2
2.3 NORTH WATERLOO MONITORING PROGRAM 2.2

3.0 METHODOLOGY **3.1**
3.1.1 Water Level Monitoring 3.1
3.1.2 Surface Water Flow Monitoring 3.2
3.1.3 Surface Water Quality 3.2
3.1.4 Groundwater Sampling and Water Quality Testing 3.3
3.1.5 Climatic Data 3.4

4.0 MONITORING RESULTS **4.1**
4.1 LOW PRECIPITATION - SUMMER 2012 ..... 4.1
4.2 GROUNDWATER LEVELS – SPRING 2013/2014 ..... 4.2
4.3 GROUNDWATER CHEMISTRY 2014 AND 2015 ..... 4.3
4.4 SURFACE WATER FLOW AND WATER LEVEL ANALYSIS 4.4
4.5 SURFACE WATER QUALITY RESULTS 4.4

5.0 CONCLUSIONS AND RECOMMENDATIONS **5.1**

6.0 REFERENCES **6.1**

DRAFT

LIST OF APPENDIX

Appendix A Figures
Appendix B Tables
Appendix C Phase I Monitoring Program
Appendix D Surface Water Flow Data
Appendix E Laboratory Certificate of Analysis

LIST OF FIGURES

Figure 1 Site Location
Figure 2 Water Level Hydrographs
Figure 3 Water Level Hydrographs – Northwestern Monitoring Locations
Figure 4 Water Level Hydrographs – Southwestern Monitoring Locations
Figure 5 Water Level Hydrographs – Central/Northeastern Monitoring Locations
Figure 6 Water Level Hydrographs – Southeastern Monitoring Locations
Figure 7 Trends in Total Precipitation

LIST OF TABLES

Table 1 Well Installation Details
Table 2 Surface Water Flow Measurements
Table 3 Summary of Groundwater Analytical Results

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Abbreviations

BGS	below ground surface
BTOC	below top of casing
City	City of Waterloo
the Client	Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway
HDPE	high density polyethylene
KWCS	Kitchener-Waterloo Climate Station
LCWS	Laurel Creek Watershed Study
NWSSS	North Waterloo Scoped Subwatershed Study
MNR	Ministry of Natural Resources
RCS	Roseville Climate Station
Region	Regional Municipality of Waterloo
the Site	proposed development, generally bounded by Erbsville Road, Beaver Creek Road, Laurel Creek Conservation lands and City limits
Stantec	Stantec Consulting Ltd.
SWMF	storm water management facility
TSS	total suspended solids
UWWS	University of Waterloo Weather Station

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1.0 INTRODUCTION

Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway (the client) are proposing future development within properties located in the northwestern portion of the City of Waterloo (City), within the Regional Municipality of Waterloo (Region). The City of Waterloo formally refers to this area as the Beaver Creek Meadows District. The proposed development is generally bounded by Erbsville Road to the west, Beaver Creek Road to the east, the Laurel Creek Conservation lands to the south and the City limits to the north (the Site). This Site is located within the study boundary of the North Waterloo Scoped Subwatershed Study (NWSSS).

In support of development, the City requires that monitoring programs be completed by the developer and must include Stage I, II and III monitoring per the Laurel Creek Watershed Development Monitoring Program. Stage I consists of 2 years of pre-development monitoring, Stage II represents during construction conditions, and Stage III extends for 24 months following substantial completion of the development (i.e., 90% stabilization of the catchment area).

The NWSSS presented initial groundwater and surface water monitoring results from 2009 and 2010 (Ecoplans, MHBC, Stantec, 2013). Stantec Consulting Ltd. (Stantec) was retained to complete the 2011 to 2015 surface water and groundwater monitoring and to prepare the 2014 and 2015 monitoring report in support of proposed development of the Site. Natural Resource Solutions Inc. was retained to complete the terrestrial monitoring components, which are provided under separate cover. The following report presents the surface water and groundwater monitoring data collected from 2011 to 2015 along with the historical data for reference.

This report is arranged in six sections, including this introduction. Section 2 presents a background of the previous investigations. Section 3 presents the methodology while the 2009 to 2015 monitoring results are presented in Section 4. Section 5 provides conclusions and recommendations based on the 2011 to 2015 monitoring program results while Section 6 provides a list of references.

All figures and tables referenced in the report are presented in Appendices A and B, respectively. Appendices C to E present the approved Phase I Monitoring Program, surface water flow data and analysis and laboratory certificates of analysis, respectively.

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2.0 BACKGROUND

The NWSSS focused on lands located in the northwestern portion of the City including the current Site. The overall goal of the NWSSS was to assess existing characteristics within the study area and develop a management strategy for the study area that protected, maintained and enhanced the ecological function and significant natural features.

2.1 NWSSS HYDROGEOLOGIC INVESTIGATION

The following section presents a summary of the findings from the NWSSS (2013) hydrogeologic investigation with respect to the current Site. Full details of the investigation and reports are included in the subwatershed report (Ecoplans, MHBC, Stantec, 2013).

The Site is located within the Waterloo Moraine, a complex deposit of ice contact and glacial outwash sands and gravels separated by silt and clay tills. The conceptual hydrogeologic model for the moraine consists of four (4) overburden aquifers (Aquifers 1 to 4), separated by four aquitards (Aquitards 1 to 4). The upper portion of the bedrock aquifer in the area was classified as being part of the fourth aquifer unit. The overburden in the vicinity of the Site is approximately 70 m thick and overlies dolostone and shale bedrock of the Salina Formation.

The surficial geology within the Site consists predominately of sandy glaciofluvial deposits associated with Aquifer 1 overlain by discontinuous deposits of clay to silt-textured till associated with Aquitard 1. Modern alluvial deposits were found in low lying areas associated with Beaver Creek and Laurel Creek.

Aquitards 2/3 are generally continuous within the Waterloo Moraine; however, within the Site, Aquitards 2/3 were eroded by a glacial meltwater channel that extends in a general northwest to southeast direction. Aquitard 2 was absent within select areas of the Site and within the meltwater channel, Aquitard 3 was eroded to only 6 m. The erosion of Aquitard 2/3 created hydraulic connections with the underlying aquifer.

Groundwater flow within the shallow deposits of Aquifer 1 is predominantly towards Beaver Creek and Laurel Creek from areas of topographic highs. The local groundwater flow contours are consistent with regional groundwater flow direction. Groundwater level data from monitoring wells within the Site and available topography suggest that groundwater discharge to Laurel Creek may be occurring.

Based on surface water flow rate data and groundwater / surface water hydraulic gradients, groundwater discharge conditions are interpreted along Laurel Creek during both low and high groundwater levels. Minimal groundwater discharge/recharge is interpreted along the majority of Beaver Creek with the exception of seasonal groundwater discharge conditions interpreted at the southern extent of the creek. Groundwater recharge conditions may be occurring within Beaver Creek to the northwest of the Site during low groundwater conditions.

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Water quality results within deposits of Aquifer 1 within the northeastern portion of the Site were characterized by aerobic groundwater with nitrate present suggesting influence from local agricultural fields. Within the western portion of the property, shallow water quality results indicated slightly anaerobic water with both manganese and nitrate present and typically low dissolved oxygen levels. Water quality results within the deep monitoring wells at the western extent of the Site including MW8-10D and MW12-10D indicated elevated sulphate concentrations of up to 370 mg/L, suggesting a hydraulic connection with the deeper hydrostratigraphic units, likely a result of the eroded deposits of Aquitards 2/3 within the glacial meltwater channel.

2.2 NWSSS SURFACE WATER INVESTIGATION

The following section presents a summary of the findings from the NWSSS (2013) surface water investigation with respect to the current Site. Full details of the investigation and reports are included in the subwatershed report (Ecoplans, MHBC, Stantec, 2013).

Laurel Creek and its associated tributaries represent the main surface water feature near the Site. Laurel Creek flows immediately south of the Site discharging into the Laurel Creek Reservoir. Beaver Creek, a tributary of Laurel Creek, flows from the northwest of the Site, meanders through the Site before discharging to Laurel Creek just upstream of the Laurel Creek Reservoir.

Laurel Creek is a headwater tributary of the Grand River that flows in a southeasterly direction through the Site and discharges to the Grand River south of the Site. The reach immediately downstream of the Site (and upstream of the reservoir) has been classified as an existing coldwater system as well as an important source for groundwater discharge, possibly supplying baseflow to the creek and its associated wetland features (GRCA 1993). In addition, the portion of Laurel Creek within the Site is considered by the Ministry of Natural Resources (MNR) to be 'a trout stream containing a naturally reproducing population of Brown Trout and possibly Brook Trout.

Beaver Creek is a headwater tributary of Laurel Creek and flows in a southerly direction through the Site, discharging into Laurel Creek at the southern end of the Site. According to the Laurel Creek Watershed Study (LCWS) (GRCA 1993), this tributary was classified as a potential coldwater stream, although portions of the watercourse have been degraded by intensive agricultural activities through the years.

2.3 NORTH WATERLOO MONITORING PROGRAM

The NWSSS included groundwater and surface water monitoring data for the Site from 2009 and 2010. The groundwater and surface water monitoring has been on-going since 2011. The Phase 1 Monitoring Program for the Site was approved in mid-2014, which included a reduced monitoring program within the Site itself and eliminated monitoring of adjacent wells. The monitoring wells and current status are detailed in Table 1. A copy of the approved monitoring program is included in Appendix C.

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3.0 METHODOLOGY

The following section details the methodology for monitoring from 2011 to 2015, including groundwater and surface water level monitoring, surface water flow monitoring, groundwater quality sampling and analysis, and climate data.

3.1.1 Water Level Monitoring

In 2011, the groundwater and surface water level monitoring was continued at the Site for all locations included in the original monitoring program for the NWSSS. The monitoring locations are presented on Figure 1 with well construction details and monitoring status presented in Table 1. Since 2011, the following modifications were completed to the program:

- Groundwater level monitoring was completed at WN1-91-1/2/3/4 until September 2013. The loggers were removed to allow well upgrades by the Region. Stantec indicated that no additional monitoring was required at this location
- Groundwater level monitoring was completed at WN2-91-1/4 until April 2014. Stantec indicated that no additional monitoring was required at this location and the Region was planning to abandon this well
- Groundwater level monitoring was completed at WN3-91-1/2 until September 2013. Stantec indicated that no additional monitoring was required at this location and the Region abandoned this well
- Groundwater level monitoring was attempted at MW9-10S/D; however, due to on-going issues with artesian conditions, the wells were abandoned in December 2013
- With the approval of the 2014 monitoring program, groundwater level monitoring requirement was removed for the majority of locations outside of the Site. The following locations were removed from the monitoring program between Spring and Fall 2014:
    - Monitoring wells MW1-05, MW8-05, WN-TW2-06, MW1-10, MW4-10 and MW5-10
    - Drivepoint Piezometers DP2-09, DP4-09, DP6-09 and DP8-09
- Groundwater and surface water level monitoring was completed at DP7-09 until September 2014. The surface water characteristics at the drivepoint had changed over the monitoring period and accurate stream flow data could no longer be recorded. Drivepoint Piezometer DP10-14 was installed in September 2014 downstream of DP7-09, as a replacement. This location was considered the closest suitable monitoring location based on stream conditions

Groundwater and surface water level monitoring was completed using a combination of manual and automated techniques. Monitoring wells and drivepoint piezometers were instrumented with Solinst® LT Leveloggers® and were set to record at 15-minute intervals (in September 2015, the interval was increased to 60-min). The Leveloggers® are not vented to the atmosphere and therefore record total pressure. As a result, data obtained from the

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Leveloggers® was corrected for atmospheric pressure to obtain the actual height of water above the sensor. The atmospheric corrections were made using data collected from a Solinst Barologger®, which was initially located at MW1-05 and later moved to MW7-10.

Manual measurements were collected at all wells using a battery operated probe and calibrated tape. Water depths were recorded in meters below the top of the well casing (BTOC).

The surface water level data and groundwater level data from the drivepoint monitoring locations were reviewed. Surface water data were omitted when temperatures as recorded by the logger decreased below 0°C. Groundwater data were reviewed and omitted if clearly impacted by freezing conditions. It is expected that some of the groundwater and surface water level data from the drivepoints are still impacted by freezing conditions, and care should be given when interpreting winter data.

Groundwater and surface water level hydrographs are presented in Figures 2 to 6 for all monitoring locations.

3.1.2 Surface Water Flow Monitoring

The locations of the drivepoint piezometers established along Laurel Creek (DP6-09, DP7-09, DP9-09, and DP10-14) and Beaver Creek (DP1-09 to DP5-09 and DP8-09) are shown on Figure 1.

Stream flow at each drivepoint location was calculated using the velocity-area method (Dingman, 1994). Measurements were obtained by placing a measuring tape across the width of the stream and dividing the distance into equal sections. At each point, the depth of water was measured and the flow rate recorded using a Marsh-McBirney Inc. Model 201 portable water flow meter. Total discharge through the section was then calculated using the U.S. Geological Survey approved mid-section method as discussed in Hipolito and Loureiro (1988) and Dingman (1994).

Stream flows were measured at DP1-09 to DP9-09 on eight (8) select dates between May 2012 and August 2014. Stream flows were measured at DP1-09, DP3-09, DP5-09 and DP9-09 on at least three (3) occasions between August and December 2014, and three (3) occasions in 2015. Monitoring was also completed at DP7-09 in 2014 before this location was replaced be DP10-14 for the 2015 monitoring. Table 2 presents a summary of manual stream flow measurements at each location with detailed stream flow data and calculations included in Appendix D.

3.1.3 Surface Water Quality

Water quality sampling for City of Waterloo Monitoring Station 17 - Beaver Creek at Conservation Drive (DP3-09) was completed by the City of Waterloo. Beaver Creek converges with Laurel Creek just upstream of the Laurel Creek Reservoir. Since the watercourse is part of the Laurel Creek Watershed, it is governed by in-stream water quality targets established in the LCWS (GRCA, 1993). The in-stream quality targets are summarized below:

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- **Temperature** – Target in-stream surface water temperatures to protect the coldwater fish species upstream of the Laurel Creek reservoir are:
    - Laurel Creek (cold water) - 22°C from April 1 to October 31 and between 4°C and 14°C from November 1 to March 31
    - Beaver Creek (warm water) - 29 °C from May 31 to October 31 and 26°C from June 1 to August
- **Dissolved Oxygen** – Target in-stream dissolved oxygen concentrations upstream of Laurel Creek Reservoir are:
    - Laurel Creek (cold water) – 6 mg/L
    - Beaver Creek (warm water) – 5 mg/L
- **Total Phosphorous** – Target instream phosphorous concentrations upstream of the Laurel Creek Reservoir are:
    - Laurel Creek (cold water) – 0.03 mg/L
    - Beaver Creek (warm water) – 0.08 mg/L
- **Total Suspended Solids (TSS)** – Maintain a concentration of less than 25 mg/L TSS for the effluent from storm water management facility (SWMF)
- **Bacteria** – Specific targets have not been established for new development, other than "maximizing bacteria removal." The LCWS target for *E.Coli* is based on Provincial Water Quality Guidelines for bathing beaches. The instream target for *E.Coli* is 100 CFU/100 mL for areas tributary to the Laurel Creek Reservoir

3.1.4 Groundwater Sampling and Water Quality Testing

Stantec completed groundwater water quality sampling within the shallow and deep monitoring wells at MW2-10, MW3-10, MW4-10, MW6-10, MW7-10, MW8-10S/D, and MW10-10 through MW13-10 in August 2014 and September 2015. The sampling was completed to document water quality prior to construction activity.

Groundwater samples were primarily collected using dedicated inertial-lift Waterra™ sampling pumps. The use of dedicated equipment reduced the possibility of cross contamination of samples between sampling locations. The Waterra™ sampling pumps were constructed of 16 mm diameter high density polyethylene (HDPE) tubing connected to a Waterra™ Delrin foot valve. For deep monitoring wells including MW3-10D, MW8-10D, and MW12-10D, a 38 mm Waterra™ submersible pump attached to 16 mm diameter HDPE tubing was employed to facilitate sample collection. Efforts were made to remove at least three (3) casing volumes from each well prior to sampling to remove stagnant water from the well casing. In cases where the well was purged dry, the well was allowed to fully recover prior to sampling. Prior to sample collection, the sampling system was lowered to within or just above the top of the well screen.

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Field measurements of conductivity, temperature and pH were made using a Hanna Instruments model HI 991300 multiparameter water quality meter. This meter was calibrated prior to use according to the manufacturers' specifications with the appropriate calibration standards. Field parameters were monitored and allowed to stabilize prior to sampling.

Following purging, groundwater samples were collected directly from the HDPE tubing into the appropriate pre-labeled sample containers. Groundwater samples for metals analysis were field-filtered using disposable, in-line, 0.45 µm filters attached to the HDPE tubing and as such the results for metal parameters represent dissolved concentrations.

All groundwater samples collected were packed into sample coolers, which were refrigerated using ice packs, and delivered to Maxxam Analytics Inc. for laboratory analyses. All groundwater samples were analyzed for general inorganic, metals and nutrient analysis. Chain of custody forms were completed and included with the samples. The results of the groundwater quality testing are presented in Table 3 with a copy of the Laboratory Certificates of Analysis being provided in Appendix E.

3.1.5 Climatic Data

The University of Waterloo Weather Station (UWWS) is located approximately 4 km southeast of the Site. Except in 2015 when issues arose with UWWS data, daily precipitation and temperature data were collected from the UWWS. The 2015 data were obtained from the Environment Canada for the Kitchener-Waterloo Climate Station (KWCS) (located at the Region of Waterloo International Airport) and Roseville Climate Station (RCS). The KWCS and RCS are located approximately 24 km to the southeast and 20 km to the south of the Site, respectively. Historical precipitation data were obtained from RCS. Recent and historical precipitation data are presented on Figure 7.

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4.0 MONITORING RESULTS

The 2011 to 2015 monitoring data was summarized with hydrographs presented in Figures 2 to 6, well construction details in Table 1, surface water flow data in Table 2 and groundwater analytical data in Table 3. In general, groundwater and surface water observations from 2011 to 2015 were consistent with the overall results and interpretations as presented in the NWSSS with respect to groundwater flow, levels and chemistry and surface water conditions. The following sections detail additional observations, clarifications or changes to the understanding of Site conditions since the NWSSS.

4.1 LOW PRECIPITATION - SUMMER 2012

Historical precipitation data for the RCS and from the UWWS was reviewed with a graph of the historical data presented on Figure 7. Over the 17 year monitoring period at UWWS (1998-2014), the average annual precipitation was 909 mm, and over the 30 year monitoring period at the RCS (1996-2015), the annual average precipitation was 899 mm.

The 2011 to 2015 data generally indicated above or near annual average precipitation over the monitoring period, with the exception of 2012, where below average precipitation was generally noted from February to August 2012. The annual precipitation in 2012 was recorded as 754 mm from the RCS, which is 16% below the 30-year average and 789 mm from the UWWS, which is 13% below the 17-year average.

Groundwater hydrographs from the monitoring wells and drivepoint piezometers within and adjacent to the Site are presented in Figures 2 to 6. The below average precipitation in summer 2012 resulted in groundwater level decrease at all shallow monitoring wells, with many monitoring wells reaching their lowest observed levels from 2009 to 2015. Precipitation and recharge in Fall 2012, resulted in groundwater level recovery at all locations.

The NWSSS indicated variable vertical hydraulic gradients along both Beaver Creek and Laurel Creek and did not consistently indicate areas of groundwater recharge or discharge. During the summer of 2012, gradients along Beaver Creek remained upward at DP1-09, DP2-09 and DP5-09 but became downward at DP8-09, DP3-09 and DP4-09, while along Laurel Creek gradients remained upward at DP7-09 and neutral at DP9-09 but became downward at DP6-09. Vertical gradients returned to previous conditions in Fall 2012, following precipitation events.

Stream flows along Beaver Creek and Laurel Creek measured during August 2012 ranged from 6 L/s to 10 L/s and 16 L/s to 21 L/s, respectively. Stream flow data were generally at their lowest historical levels. Surface water flow rates indicated some variation along the flow path but did not indicate a consistent increase or decrease in flow rate, suggesting the streams are not gaining or losing within the Site during this period.

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This period of below average precipitation in summer 2012 indicated the potential for lower groundwater levels than previously presented in the NWSSS and also indicated that groundwater discharge conditions may not be occurring within Laurel Creek during periods of low groundwater conditions.

4.2 GROUNDWATER LEVELS – SPRING 2013/2014

As previously stated, the 2011 to 2015 data generally indicated above or near average annual precipitation over the monitoring period, with the exception of 2012 as discussed above. The annual precipitation in 2013 was recorded at 1231 mm from the UWWS, which is 35% above average. Above average monthly precipitation was measured in nine months in 2013, with peak precipitation occurring in July and October 2013. The annual precipitation in 2014 was recorded at 946 mm from the UWWS, which is 4% above average, with above average monthly precipitation primarily occurring in July and September 2014.

Within the shallow monitoring wells installed within Aquitard 1, the hydrographs indicated rapid response to individual precipitation events as the ground became saturated and water slowly infiltrated as noted at MW8-10S (Figure 4). Monitoring wells installed within deposits of Aquifer 1, with a larger unsaturated zone, such as MW7-10 (Figure 5) indicated a steady response to overall precipitation and recharge, but did not respond to individual events. These trends and responses to precipitation are consistent with the NWSSS.

However, the periods of above average precipitation and groundwater recharge in 2013 and 2014, resulted in higher shallow groundwater levels observed at all monitoring wells than suggested by the 2009/2010 data. The spring groundwater levels were compared to those originally presented in the NWSSS to evaluate the difference in levels. Levels were compared after a period of minimal precipitation in order to represent steady state levels. Within the Site, peak spring water levels increased at the following locations:

- At MW8-10S, located at the western extent of the Site, spring levels increased by 0.9 m compared to data from May 2012. This monitoring well is located adjacent to a swale area south of Conservation Drive, and is likely influenced by surface water / recharge occurring within the swale.
- At MW12-10S and MW13-10, located at the southern extent of the Site, spring groundwater levels increased by 0.6 m to 0.2 m, respectively.
- At MW10-10, within the western portion of the Site, spring groundwater levels did not significantly change as they were already at or near ground surface.
- Within the northeastern portion of the Site, spring groundwater levels increased by 0.9 m at MW3-10S and MW7-10, 0.4 m at MW2-10 and 0.5 m at MW6-10.

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In general, these data indicate the potential for shallower groundwater conditions across the Site than previously expected. Within the northeastern portion of the Site, where an increase in spring groundwater levels of up to 0.9 m was predicted, there is a thick unsaturated zone and minimal impact to proposed construction is expected due to this change in peak spring levels.

Within the southern portion of the property, spring groundwater levels are generally expected to increase 0.2 m to 0.6 m from previous levels presented in the NWSSS. The NWSSS indicated that spring groundwater levels within the developable portion of the southern portion of the Site were generally expected at greater than 3 m below ground surface (BGS). The higher spring groundwater levels could impact some areas depending on proposed construction. The proposed development should take these revised levels into consideration.

4.3 GROUNDWATER CHEMISTRY 2014 AND 2015

Stantec completed groundwater water quality sampling at MW2-10, MW3-10S/D, MW4-10, MW6-10, MW7-10, MW8-10S/D, MW10-10, MW12-10S/D and MW13-10 in August 2014 and September 2015. MW11-10 was sampled in August 2014 but could not be sampled in September 2015 as the well had been damaged. Stantec is currently organizing well replacement. Water quality results are presented in Table 3 with copies of the laboratory certificates of analysis included in Appendix E. In general, the results are consistent with the data presented in the NWSSS, with the exception of:

- A decrease in chloride concentration at MW8-10S from 800 mg/L and 970 mg/L in 2010 to 500 mg/L in 2014 and 550 mg/L in 2015. This monitoring well is located near a swale adjacent to Conservation Drive and is influenced by winter road salting activities. It is interpreted that chloride concentration may fluctuate at this location, but remain elevated
- At MW3-10S, MW6-10 and MW11-10, water chemistry has changed since initial monitoring

At MW3-10S, the following changes were noted:

  - chloride decreasing from 28 and 23 mg/L in 2010 to 15 mg/L in 2014 and 17 mg/L in 2015
  - nitrate decreasing from 37 and 28 mg/L in 2010 to 22 mg/L in 2014 and 24 mg/L in 2015

At MW6-10, the following changes were noted:

  - nitrate decreasing from 23 mg/L in 2010 to 20 mg/L in 2014 and 16 mg/L in 2015

At MW11-10, the following changes were noted (monitoring could not be completed in 2015 as mentioned previously):

  - sulphate decreasing from 32 and 55 mg/L in 2010 to 18 mg/L in 2014
  - sodium decreasing from 46 and 85 mg/L in 2010 to 13 mg/L in 2014

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- nitrate increasing from 11 and 13 mg/L in 2010 to 16 mg/L in 2014

These changes in shallow groundwater chemistry may be a function of changes in agricultural activity within the Site.

4.4 SURFACE WATER FLOW AND WATER LEVEL ANALYSIS

Historical flow and manual water level measurements were used to develop a rating curve for each of the flow monitoring sites. The rating curve was then applied to the continuous water level measurements derived from the deployed leveloggers to produce a hydrograph. Rating curves and associated hydrographs are presented in Appendix D.

A rating curve and hydrograph has not been produced for DP10-14 as it was installed in 2014 and does not have enough data to develop a rating curve at this time. This monitoring location was installed to replace DP7-10 as flow at this location is too disperse for accurate measurement.

In general, flow measurements during low flow and base flow events have produced consistent values, resulting in a well-defined rating curve for flow conditions at or near baseflow. Only a few flow measurements have been completed during periods of high flow, resulting in a rating curve producing significant increases in flow for marginal increases in water surface elevation. Future surface water flow measurements should be attempted during larger monitoring events in order to supplement the missing data within the presented rating curves.

4.5 SURFACE WATER QUALITY RESULTS

Surface water quality results for Beaver Creek at Conservation Drive – Station 17 were provided by the City of Waterloo, and are included in Appendix D. Water quality results were compared to targets established in the LCWS. The results of the analysis are listed below:

- TSS targets were met in 54% of the samples
- Dissolved oxygen targets were met in 90% of the samples
- Total phosphorous concentration targets were met in 790% of the samples
- Temperature targets were met in all samples
- Bacteria was not monitored by the City of Waterloo

Flow measurements completed by the City of Waterloo at Station 17 were cross referenced with estimated flows established using the rating curves developed as part of this study. Estimated flows were similar to those measured, however did not match up exactly. Further development of the rating curves should allow for estimated flow rates and flow rates measured by others to converge as more data is incorporated.

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5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the Phase 1 monitoring completed following the NWSSS, the following conclusions are provided:

- The NWSSS indicated that groundwater discharge conditions were expected within Laurel Creek, south of the Site, during both low and high groundwater conditions. Data during summer 2012 indicated that during prolonged periods of below average precipitation, groundwater levels will decrease and groundwater discharge to Laurel Creek may not be occurring

- Spring groundwater levels from 2013 and 2014 indicated an increase in peak groundwater levels throughout the Site of up to 0.9 m depending on the location. It is interpreted that this increase will have minimal impact on the northeastern portion of the Site due to the thick unsaturated zone. Groundwater levels within the developable portion of the southern portion of the Site were generally expected to be greater than 3 m BGS and the higher spring groundwater levels could impact some areas depending on proposed construction

- Groundwater quality results throughout the Site were generally consistent with historical data. Minor water quality changes at MW3-10S, MW6-10 and MW11-10 observed in 2014/2015 may be a function of changes in agricultural activity in the area

- Surface water hydrographs were created through the use of continuous water level loggers and manual flow measurements to develop a rating curve at each monitoring site

- Water quality monitoring at Station 17 (Beaver Creek at Conservation Drive) was completed by the City of Waterloo. In general LCWS targets were met for dissolved oxygen and temperature, however targets were not met for TSS and total phosphorous on a regular basis

Based on the results of the Phase 1 monitoring, the following recommendations are provided:

- The proposed grading and development within the Site should be reviewed with respect to the updated peak spring groundwater levels to confirm development design and grading

- Surface water levels and manual flow measurements should continue to be collected to gain further confidence in the rating curves. Monitoring should be focused on larger storm events to further refine the rating curve at higher water level elevations. Pre-development rating curves will provide a basis for comparison of during and post-construction monitoring results as development commences and SWM systems are installed

- Water quality monitoring at Station 17 should continue to be used to establish background water quality characteristics

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6.0 REFERENCES

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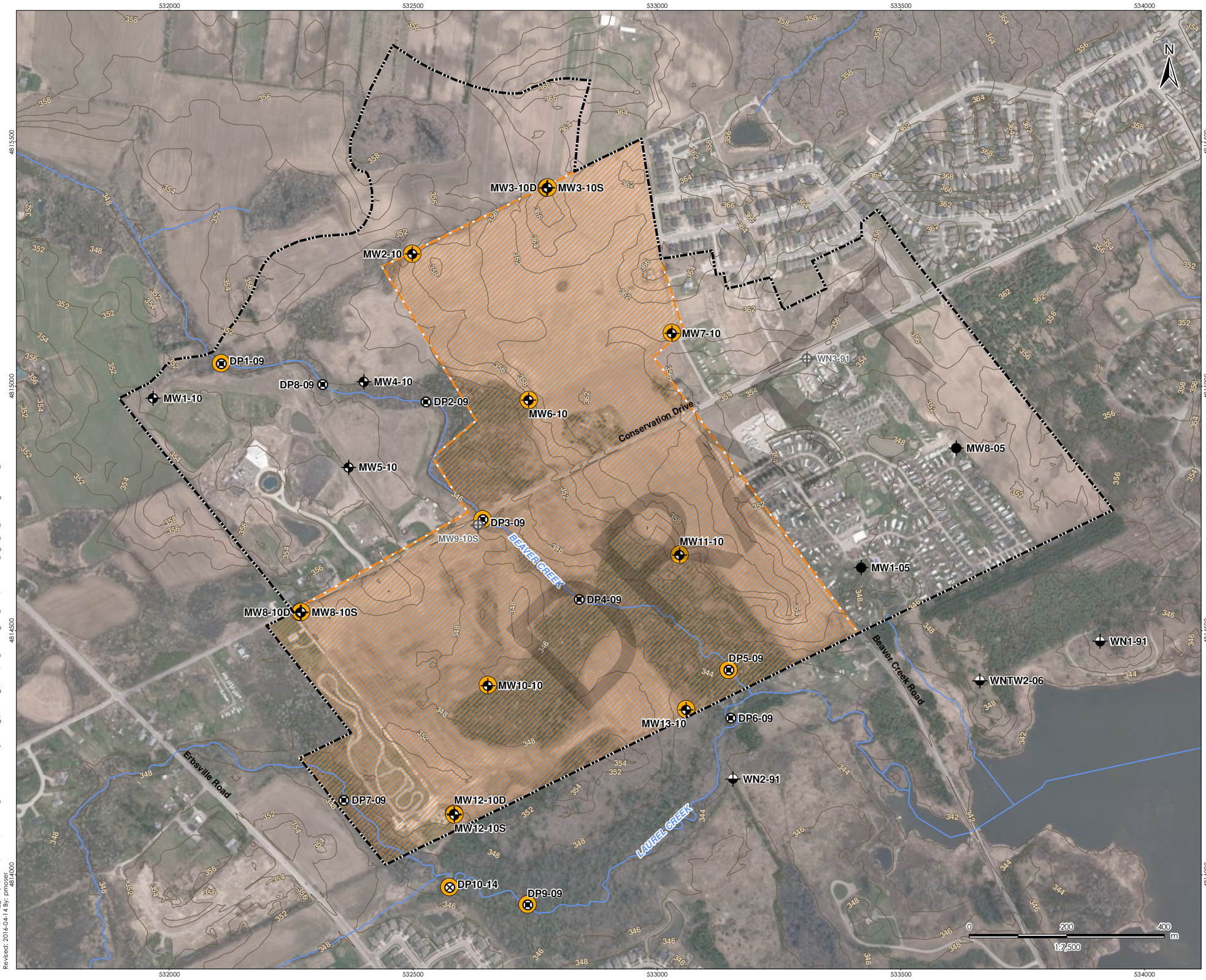
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APPENDIX A
FIGURES



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Legend

- North Waterloo Scoped Subwatershed Study area
- Monitoring Well (Stantec, 2010)
- Monitoring Well (Stantec, 2005)
- Monitoring Well (Other)
- Drive-Point Piezometer (Stantec, 2010)
- Drive Point Piezometer (Stantec, 2014)
- Abandoned Monitoring Well (Other)
- Phase 1 Monitoring Location
- Watercourse
- Topographic Contour - 2m Inerval
- Proposed Development Area



Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.
3. Orthoimagery © First Base Solutions, 2014.
4. Topogrpahic Contours © Region of Waterloo, 2008

April 2016
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Client/Project

North Waterloo Scoped Watershed Study
Phase I - Groundwater and
Surface Water Monitoring Program

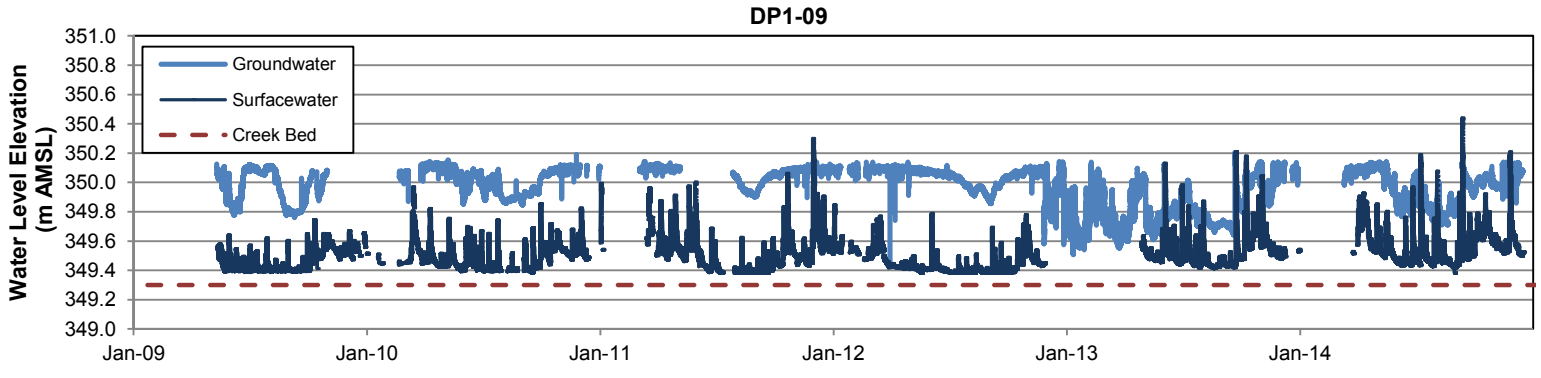
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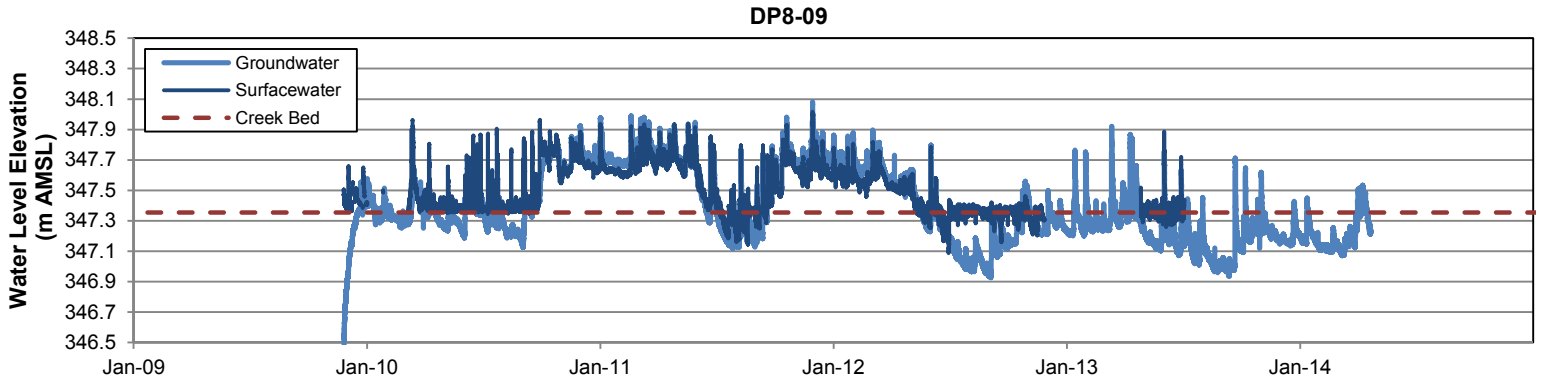
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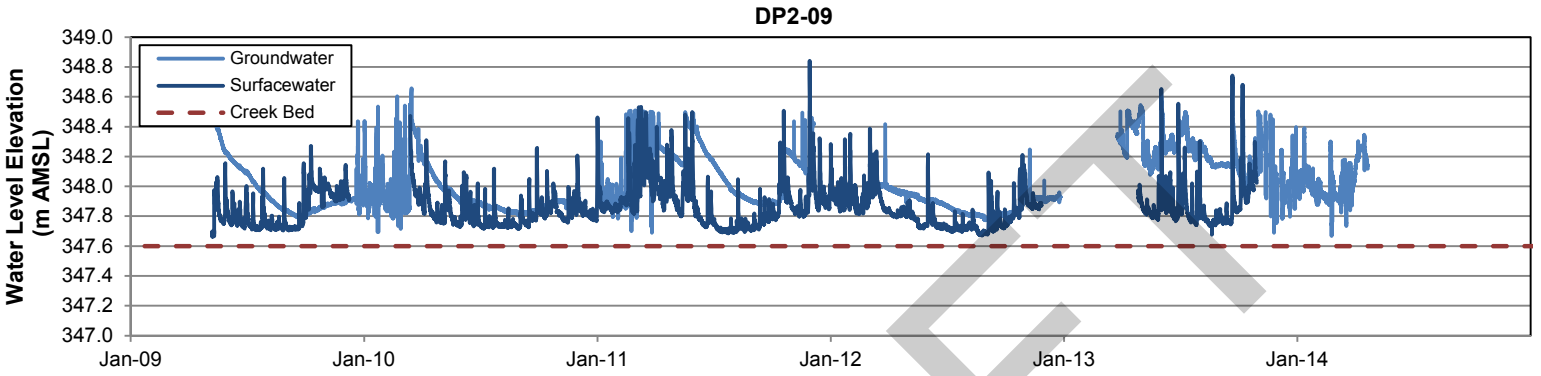
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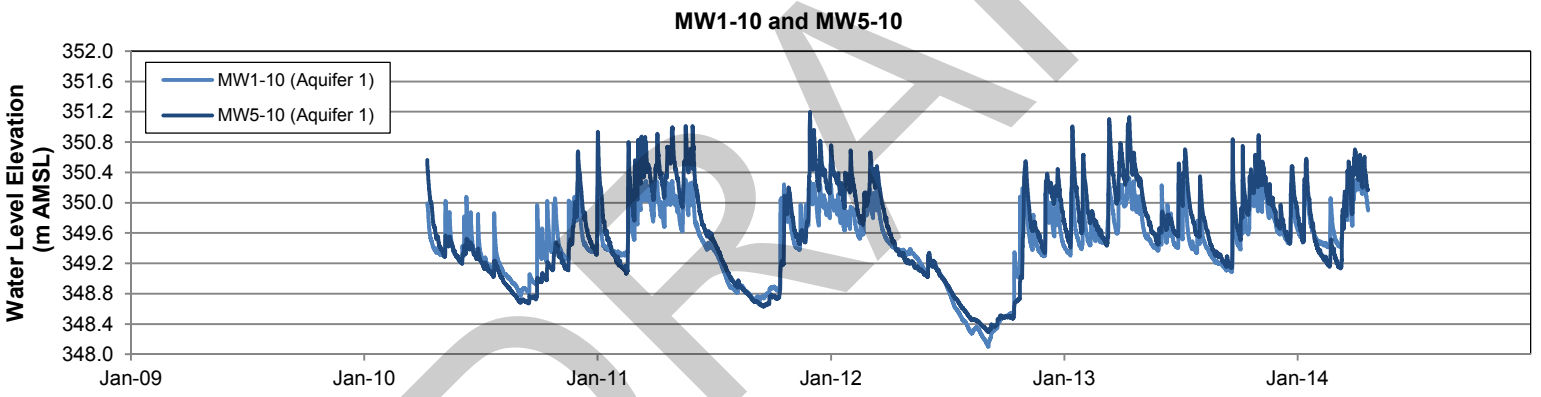
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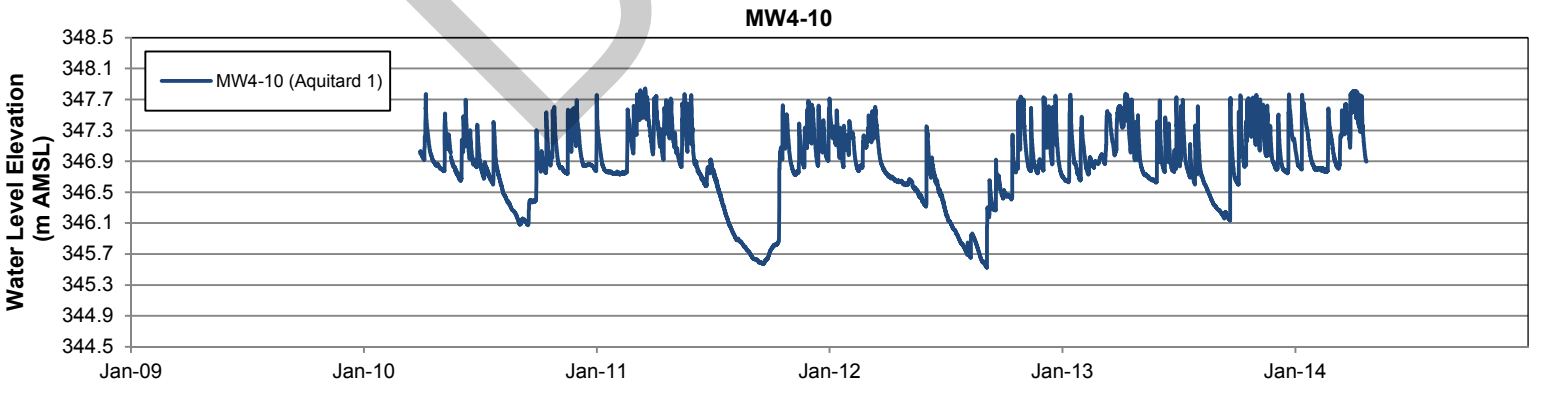
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Revised: 2016-04-14 By: pmoser

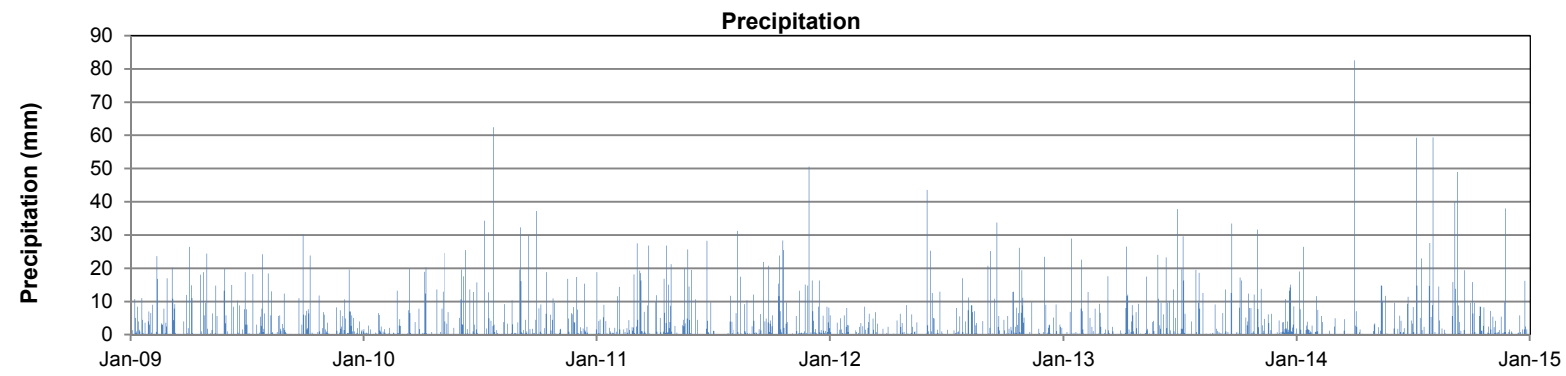












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Figure to be updated to be consistent with Figures 4 to 6. Only DP1-09 was monitored in 2015.

Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

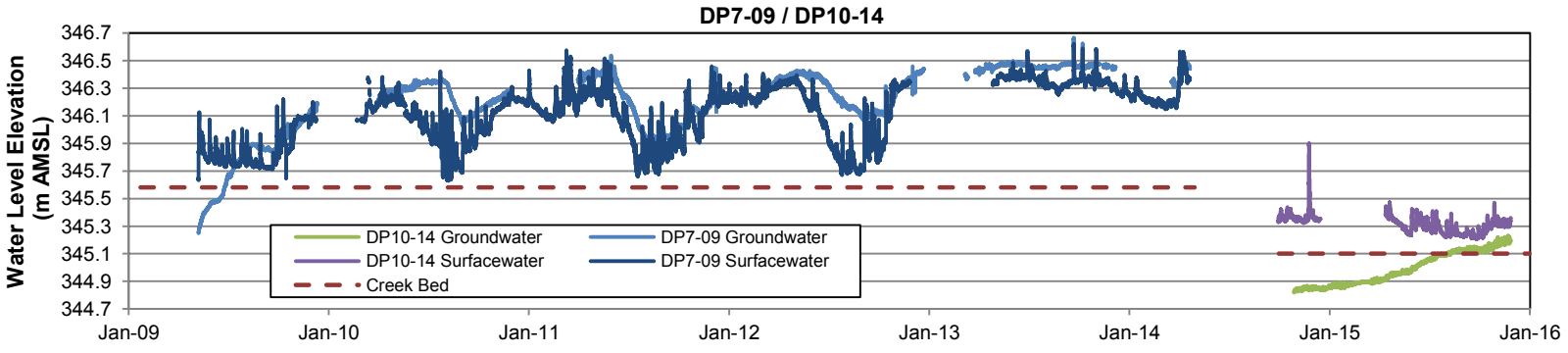
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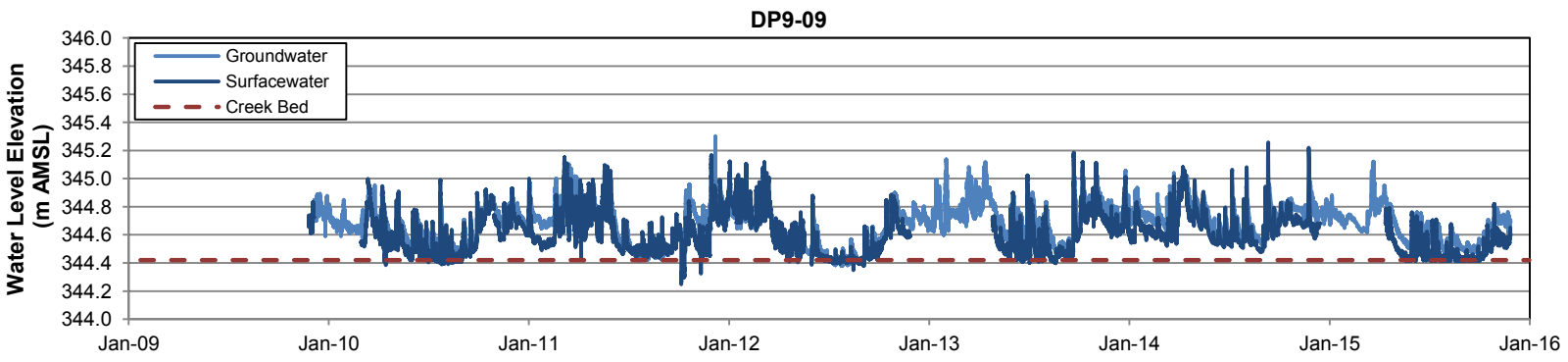
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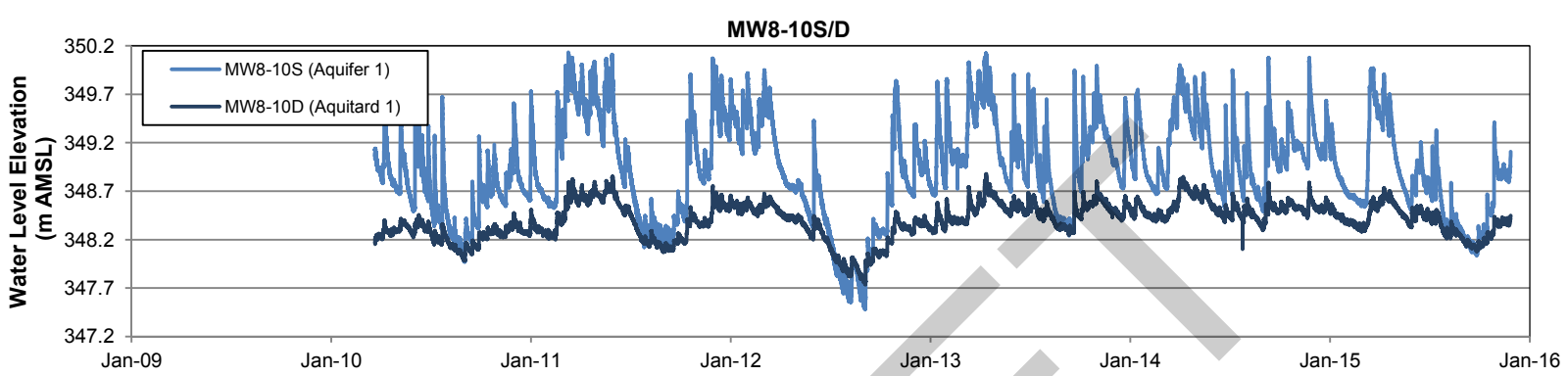
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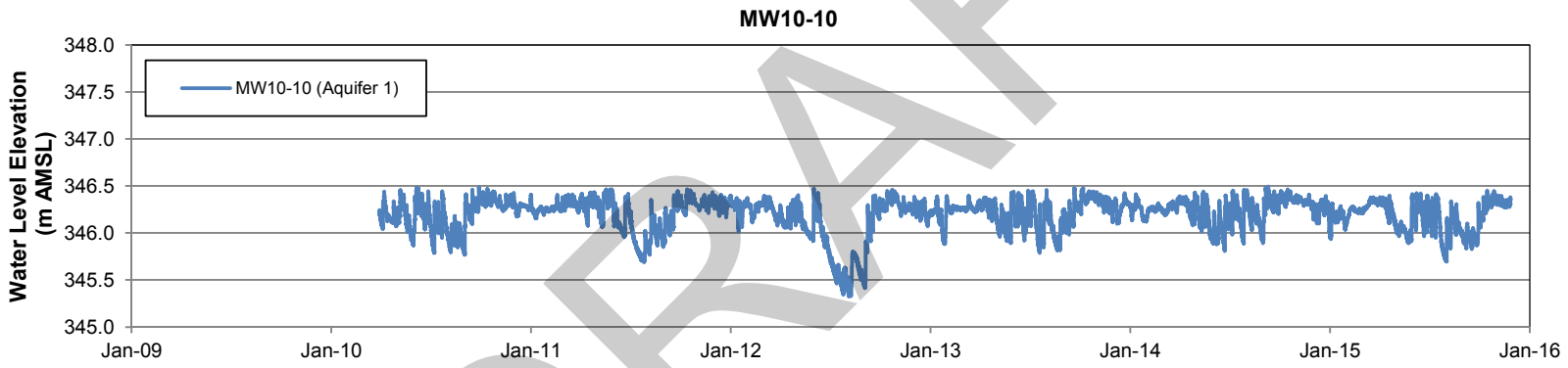
Water Level Hydrographs
Northwestern Monitoring Locations

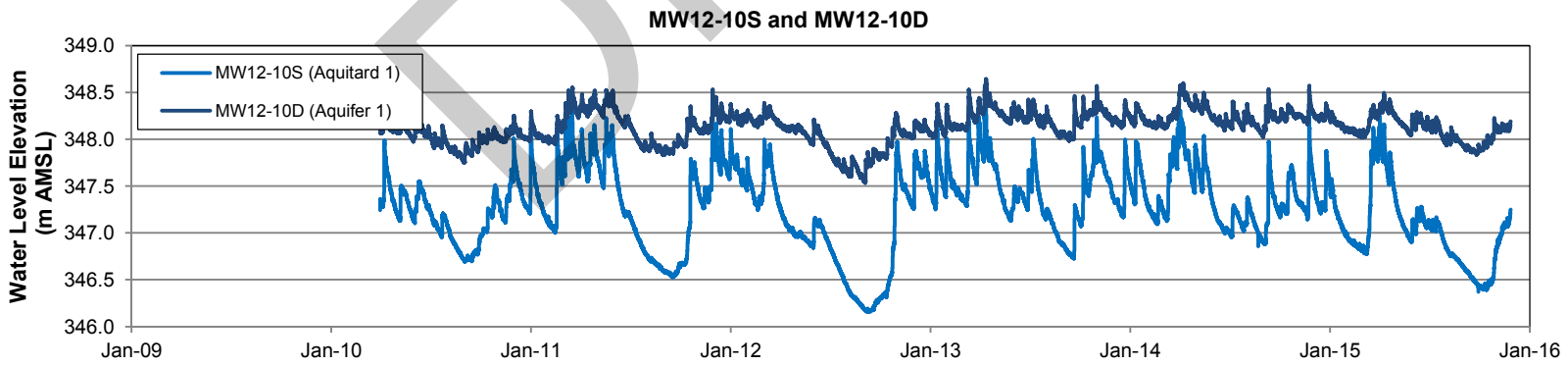
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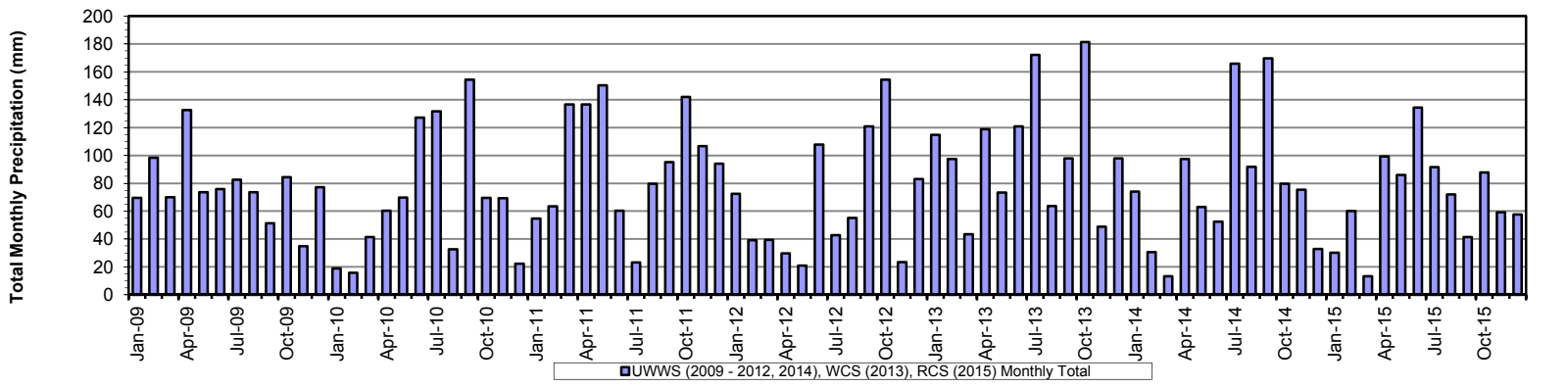












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Top of casing and streambed elevations at DP10-14 are estimated based on topographic mapping and DP7-09 and DP9-09.

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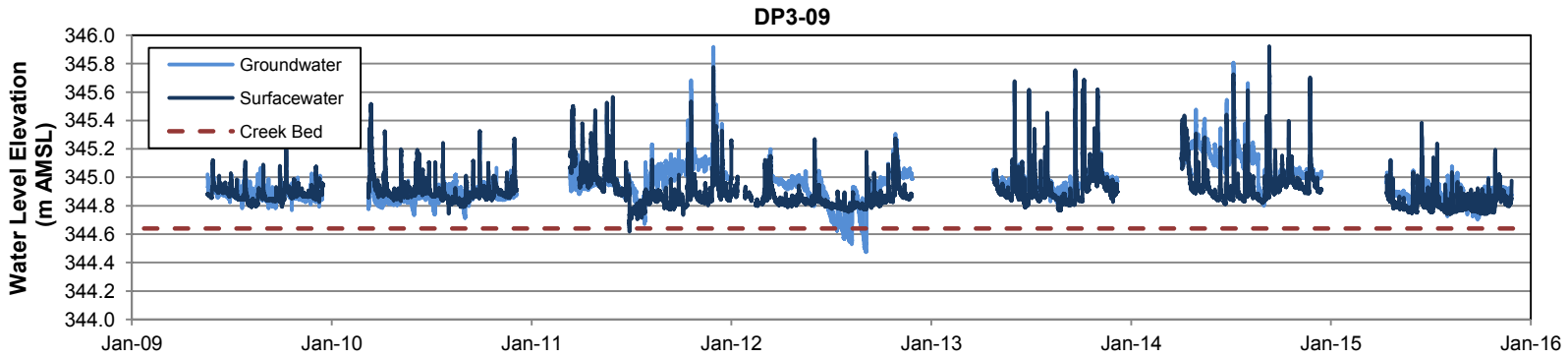
NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

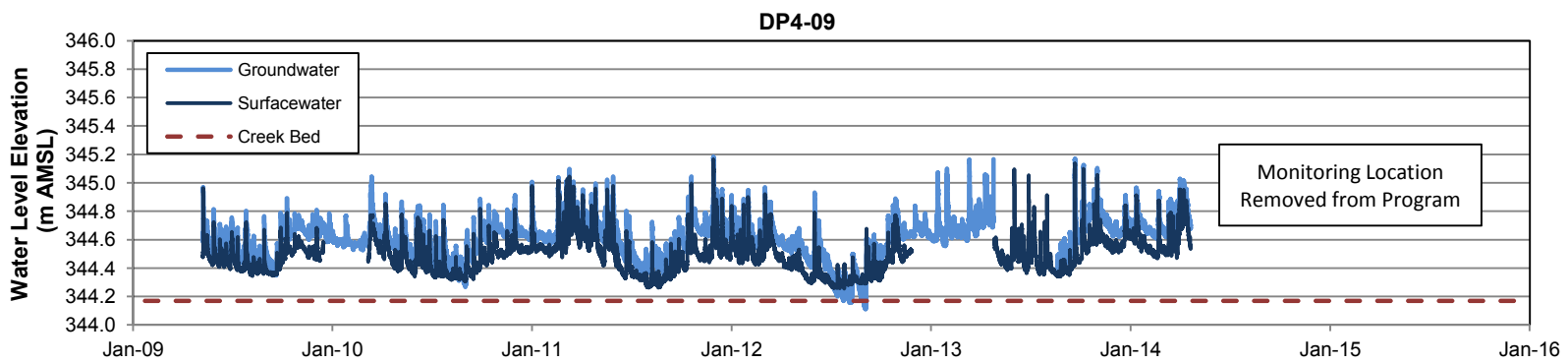
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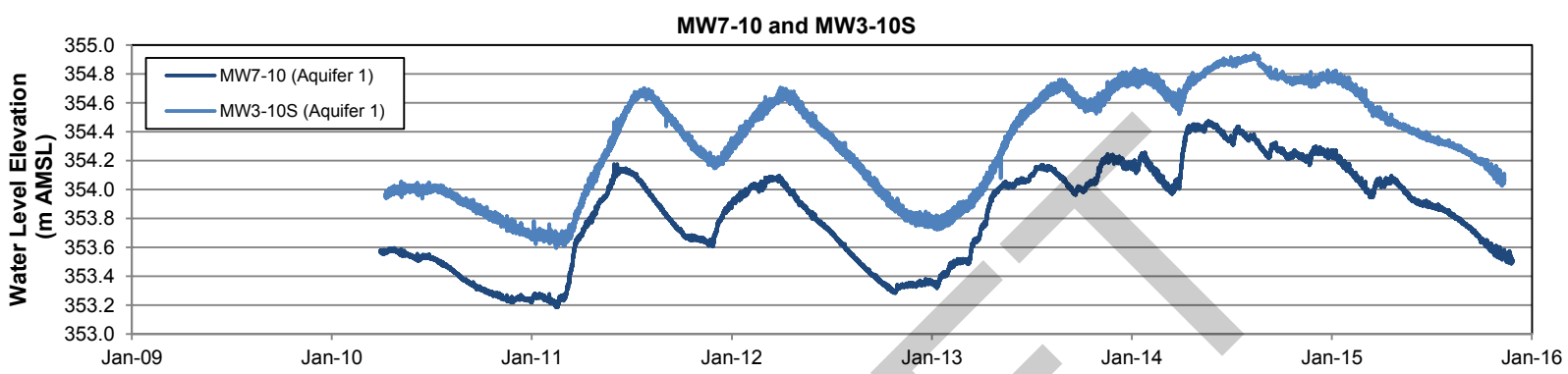
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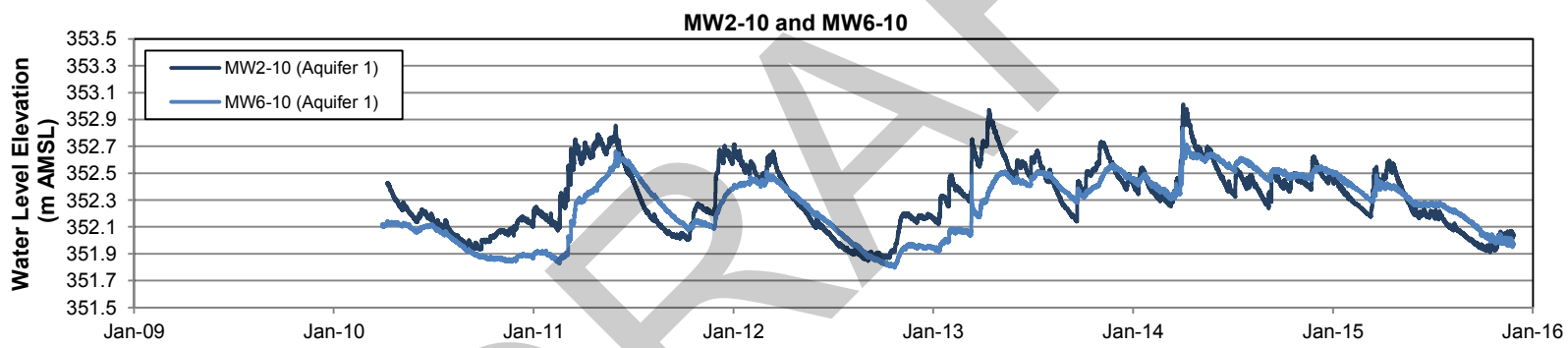
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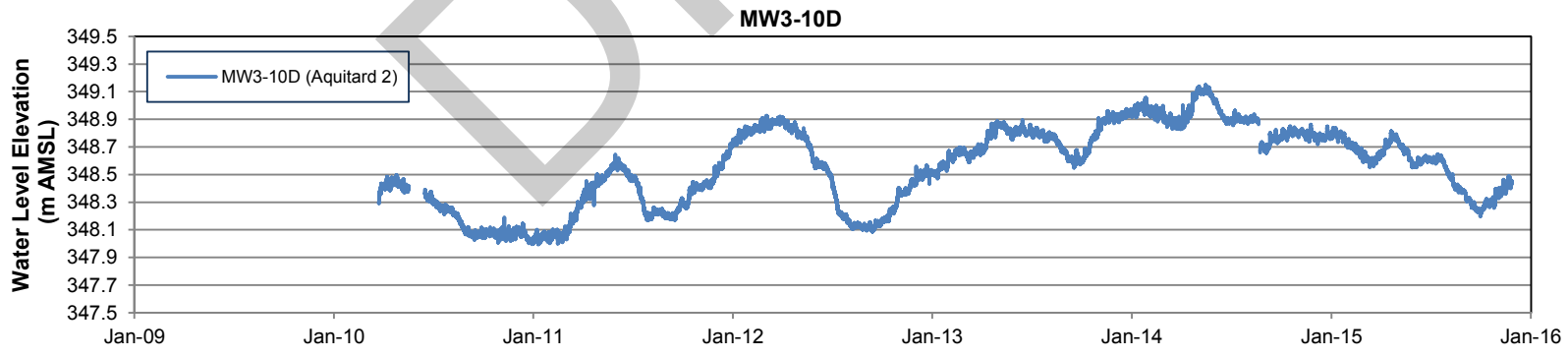
Water Level Hydrographs
Southwestern Monitoring Locations

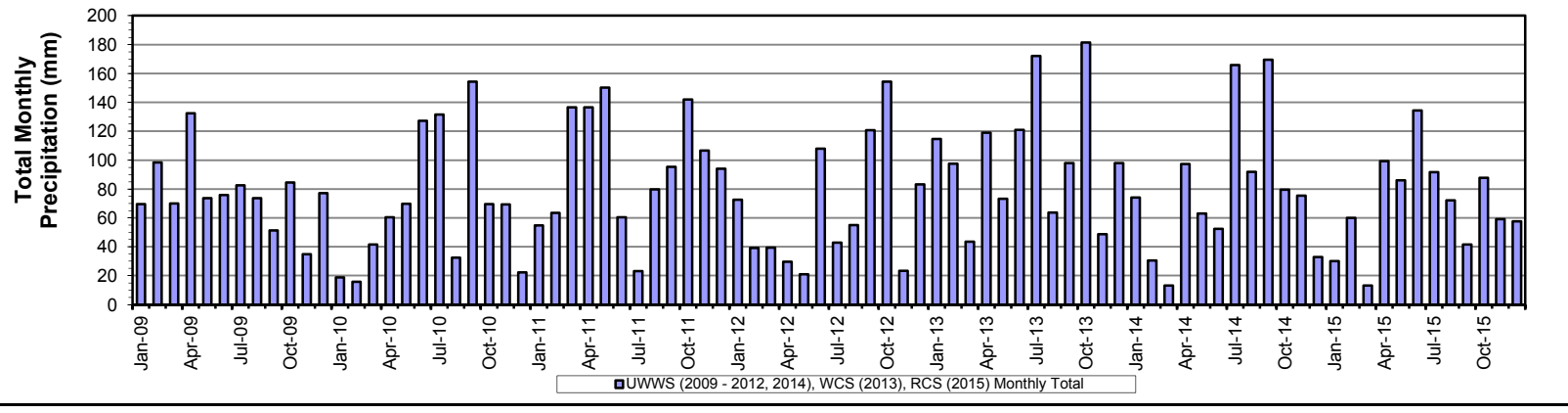












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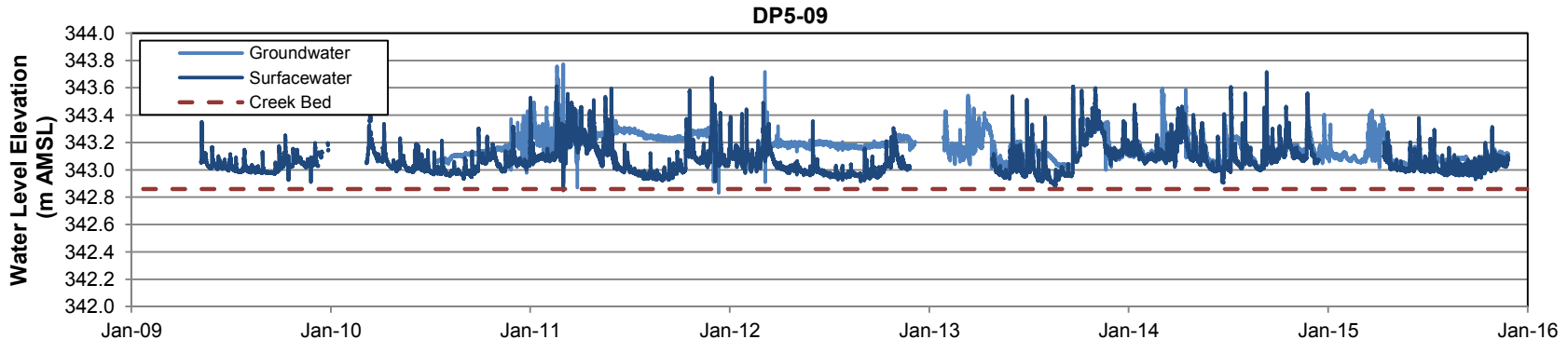
NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

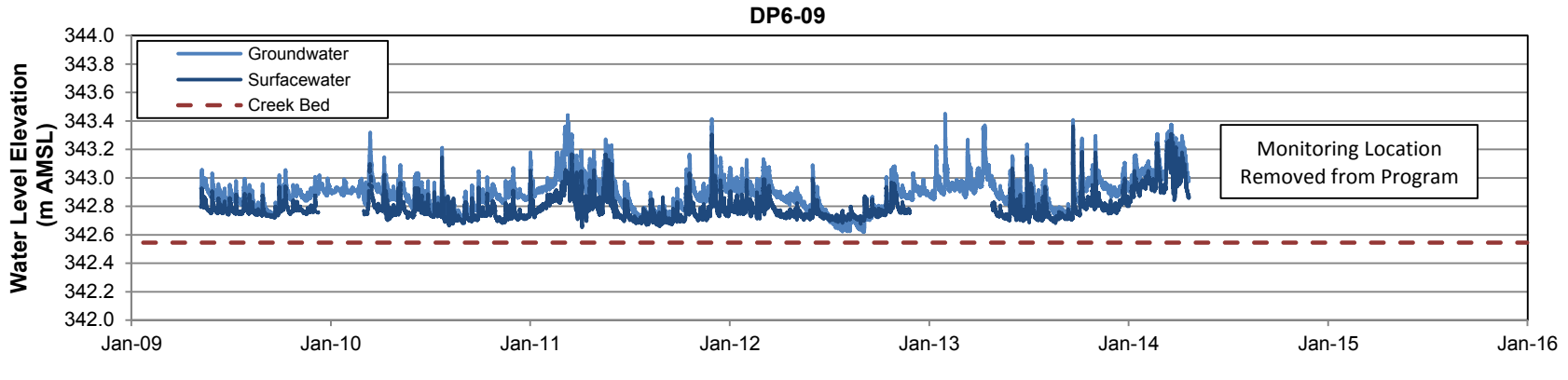
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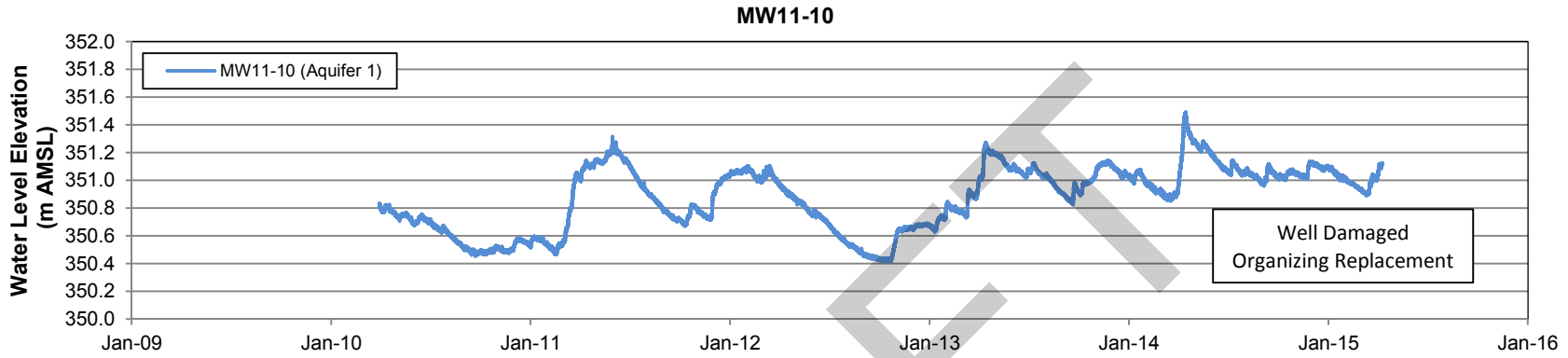
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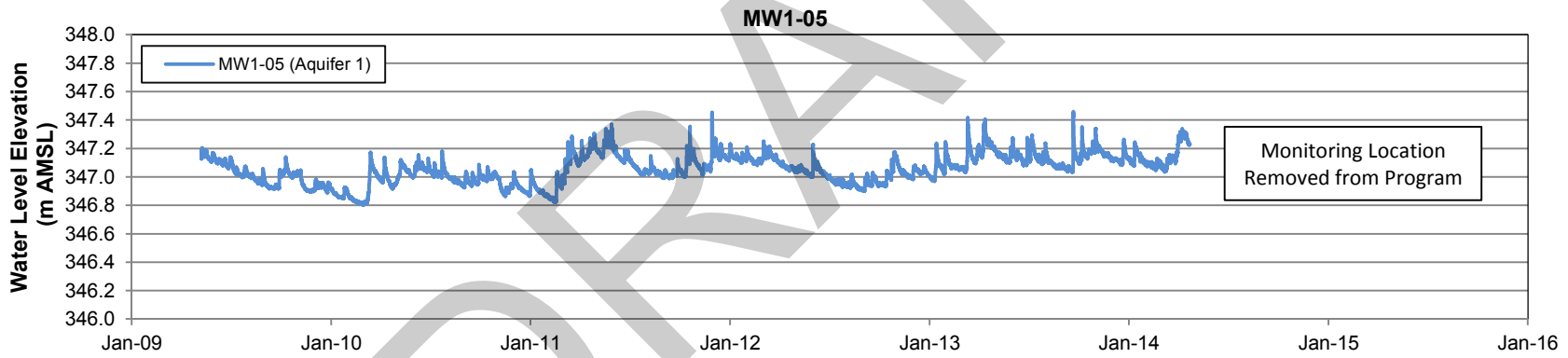
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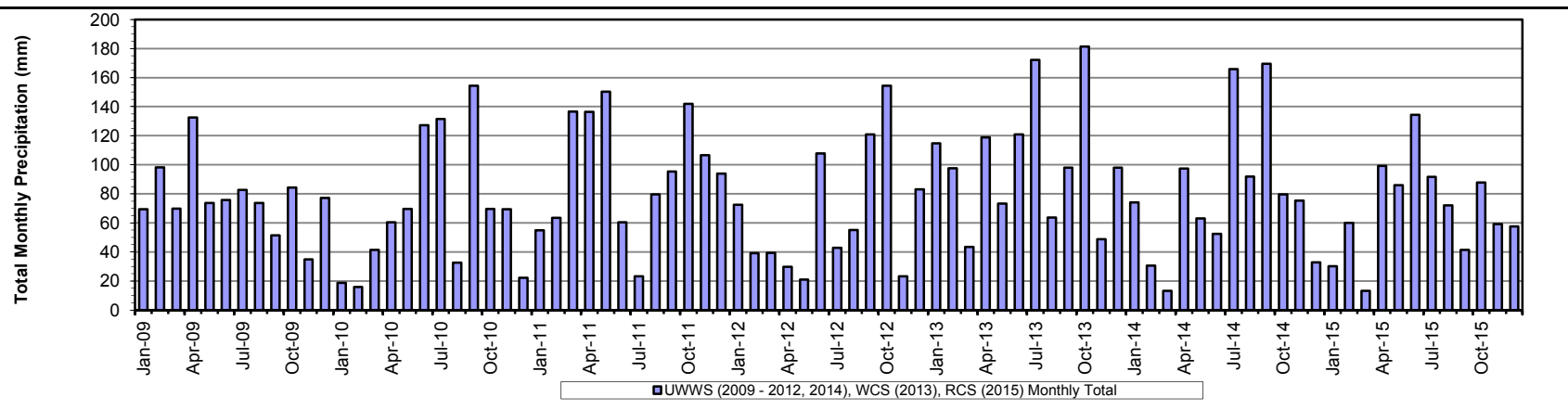
Water Level Hydrographs
Central/Northeastern Monitoring Locations











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NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

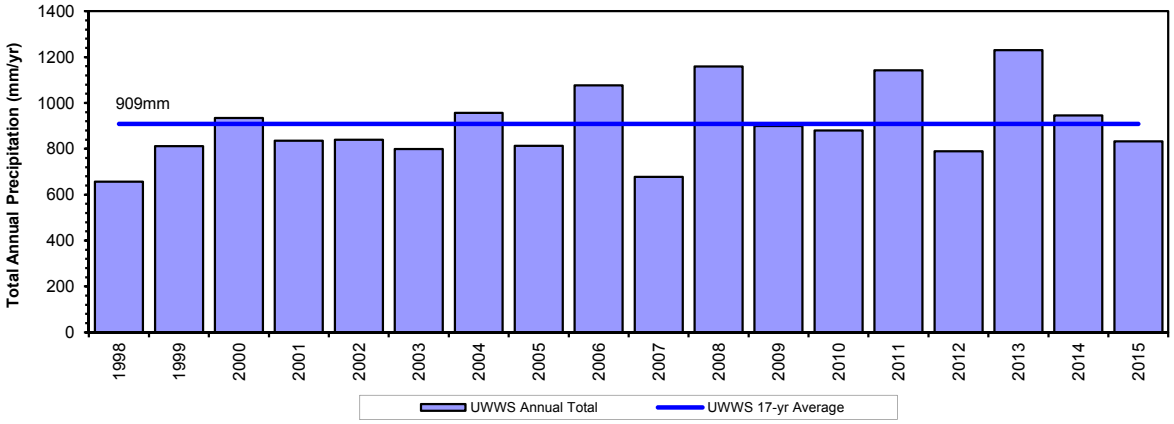
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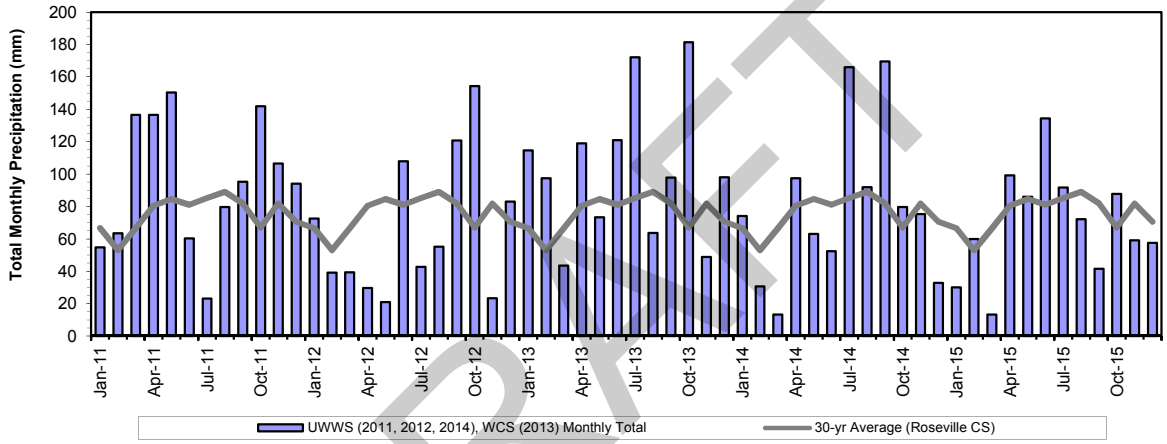
Water Level Hydrographs
Southeastern Monitoring Locations

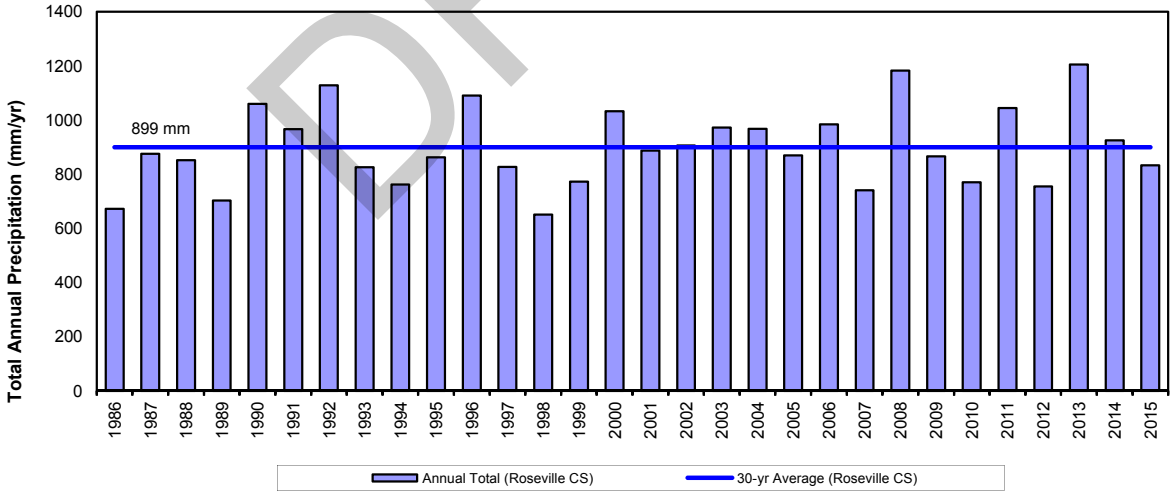
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Notes:

Precipitation data obtained from University of Waterloo Climate Station (UWWS), except for 2015 data which was obtained from Roseville Climate Station (RCS). The UWWS and RCS are located approximately 4 km to the southeast and 20 km to the south of the Site, respectively.





Notes:

Precipitation data obtained from Roseville Climate Station (RCS). For 2014, missing values from RCS in September (7 days), November (7 days) and December (3 days) supplemented with data from Waterloo-Wellington Climate Station.

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Stantec	NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING	
	TRENDS IN TOTAL PRECIPITATION	
DATE: 12-Apr-15	SCALE: not to scale	PROJECT No. 1603-10875 / FIGURE No. FIGURE 7

APPENDIX C
PHASE I MONITORING PROGRAM

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NORTH WATERLOO
PROPOSED PHASE 1 MONITORING PROGRAM
2014

1.0 STUDY AREA AND CONTEXT

The subject properties comprise a large portion of the Primary Study Area from the North Waterloo Scoped Subwatershed Study. The lands are located in the northwest portion of the City Urban Area and are generally bounded by City limits to the north, Beaver Creek Road / Roy Schmidt Road to the east and Laurel Creek Nature Centre to the south.

The subject properties and adjacent lands are representative of a typical southern Ontario landscape mosaic, consisting of urban, rural residential, institutional (church), natural, agricultural, educational (Laurel Creek Nature Centre), and recreational (Erbsville Kartway) uses.

The broader landscape is predominantly agricultural, with large blocks of natural heritage features. The agricultural areas were generally cleared for agriculture in the early 1800s and have been generally unchanged (notwithstanding year-to-year variations in plough limits and some tree cutting). Rural residential properties have been present on the landscape for many decades; urban residential development is relatively recent and progressing from the south and east toward the north / northwest limits of the City.

The Laurel Creek Forest (ESPA 80) encompasses the forest features south of Conservation Drive and extends beyond the subject properties along Laurel Creek and adjacent features. The Sunfish Lake - Laurel Creek PSW encompasses wetlands north and south of Conservation Drive on the subject properties as part of a large complex of wetlands across the landscape. These designations overlap on the subject properties with additional designations including significant woodlands and natural hazards (i.e., floodplain).

Lands to the north and west of the subject properties, outside the City, are comprised of extensive farmlands designated as Prime Agricultural Areas in the Regional Official Polices Plan (ROPP). Features located on the subject properties extend beyond the City into Woolwich and Wellesley Townships along the Beaver Creek Corridor, providing an ecological link from Laurel Creek (and associated features) to the south and the Laurel Creek Headwaters Environmentally Sensitive Landscape (ESL) in the townships. South and east of the subject properties is the Laurel Creek Conservation Area (CA) and Laurel Creek ESPA 18.

The Study Team is very familiar with the area through extensive surveys and preparation of the North Waterloo Scoped Subwatershed Study for these lands.

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2.0 MONITORING STUDY APPROACH

The City of Waterloo requires that monitoring programs be completed for new development applications. These monitoring programs are the responsibility of the developer, and include Stage I, II and III monitoring per the Laurel Creek Watershed Development Monitoring Program. Stage I consists of 2 years of pre-development monitoring, Stage II represents during construction conditions, and Stage III extends for 24 months following substantial completion of the development (i.e., 90% stabilization of the catchment area). Recommended Stage I monitoring components are discussed below. The Stage II and III monitoring programs are to be verified at the draft plan of subdivision application and final engineering design stages (respectively). Monitoring programs will be undertaken by the developer.

2.1 SURFACE WATER MONITORING

Surface water monitoring components prior to development/construction are generally addressed through the City's System Monitoring Program. Monitoring includes water quality (chemistry) and flows (hydrology) where Beaver Creek crosses Conservation Drive (Station #17), and this data will be summarized and discussed in the context of the North Waterloo area monitoring program. Surface water monitoring will be undertaken by Stantec with the monitoring locations shown on Figure 1. Additional monitoring will include:

2.1.1 Surface Water Flow Monitoring

Location. Surface water flow measurements will be completed along Beaver Creek at three (3) drivepoint piezometers (DP1-09, DP3-09 and DP5-09) and along Laurel Creek at two (2) drivepoint piezometers (DP7-09 and DP9-09). The monitoring locations along Laurel Creek will be reviewed in 2014. Sections of Laurel Creek do not exhibit channel flow and there is ponding in the area. The monitoring locations may be modified/replaced based on site conditions to obtain representative flow data. The drivepoint locations are shown on Figure 1.

Timing. Flow measurement will be completed three (3) times annually at the same time as manual water level monitoring is conducted.

Methodology. Surface water flow measurements will be completed using the velocity-area method. Measurements will be obtained at regular intervals across the creek and will include the depth of the tributary and the flow rate recorded using a Marsh-McBirney Inc. Model 201 portable water flow meter.

2.1.2 Water Level Monitoring

Location. Surface water level monitoring will be completed along Beaver Creek at three (3) drivepoint piezometers (DP1-09, DP3-09 and DP5-09) and along Laurel Creek at two (2)

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drivepoint piezometers (DP7-09 and DP9-09, or as modified). The drivepoint locations are shown on Figure 1.

Timing. Manual measurements will be collected three (3) times per year and the continuous loggers will be downloaded during each monitoring event.

Methodology. Water level measurements would be collected using a combination of manual and automated techniques.

2.2 GROUNDWATER MONITORING

Groundwater monitoring within the subject properties should include water level measurements and water chemistry analysis under Stage I, II and III conditions.

Due to the expected staged development of the property, it is anticipated that several years may pass between Draft Plan Approval and construction of all stages of the development. The following groundwater monitoring program is recommended for the Stage I monitoring. It is expected that the future monitoring may be reduced in scope based on timing and location of development. Groundwater monitoring will be undertaken by Stantec.

2.2.1 Water Level Monitoring

Location. Groundwater level monitoring will be completed at the 2010 monitoring wells located within the subject lands and within drivepoint piezometers located along Beaver Creek and Laurel Creek including:

- Twelve (12) monitoring wells (MW2-10, MW3-10S, MW3-10D, MW6-10, MW7-10, MW8-10S, MW8-10D, MW10-10, MW11-10, MW12-10S, MW12-10D, MW13-10) including shallow and deep monitoring locations; and
- Three (3) drivepoint piezometers along Beaver Creek (DP1-09, DP3-09 and DP5-09).
- Two (2) drivepoint piezometers along Laurel Creek (DP7-09 and DP9-09, or as modified).

Timing. Manual measurements will be collected three (3) times per year and the loggers will be downloaded during each monitoring event.

Methodology. Water level measurements would be collected using a combination of manual and automated techniques.

2.2.2 Water Chemistry Monitoring

Location. Groundwater quality sampling will be completed at the 2010 monitoring wells located within the subject lands including:

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- Twelve (12) monitoring wells (MW2-10, MW3-10S, MW3-10D, MW6-10, MW7-10, MW8-10S, MW8-10D, MW10-10, MW11-10, MW12-10S, MW12-10D, MW13-10) including shallow and deep monitoring locations.

Timing. Water quality samples will be collected once per year in the spring. The 2014 sampling will be completed in August 2014.

Methodology. Groundwater samples will be collected using foot valve / tubing or submersible pump depending on the location. Each well will be purged of three (3) casing volumes prior to sampling. Groundwater samples for metals analysis will be field filtered. Water quality samples would be analyzed for metals, nutrients and general chemistry.

3.0 REPORTING

Results from groundwater and surface water monitoring for Stage I monitoring will be presented in brief annual reports that include an assessment of results, integration of other monitoring data (as relevant) and recommendations for management or changes to future monitoring protocols, as required. Data sheets and representative photographs will be appended.

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