SUNNYBROOK FARM WINERY
1425 LAKESHORE ROAD, NIAGARA-ON-THE-LAKE, ON

STORM WATER MANAGEMENT DESIGN BRIEF

REV 0 – May 04, 2026

PREPARED BY:

HALLEX PROJECT #260201

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1. PRE-DEVELOPMENT CONDITIONS

1.1 LOCATION

The proposed Sunnybrook Farm Winery development is located at 1425 Lakeshore Road, which is east of the Lakeshore Road and Four Mile Creek Road intersection in town of Niagara-on-the-Lake, ON.

1.2 DRAINAGE PATTERN

The current drainage path for the site consists partly of overland sheet flow and existing culverts to the existing 400mm culvert located on the adjacent westerly property and partially of overland sheet flow to other areas of the adjacent properties. This includes an existing stormwater management dry pond and an existing infiltration trench which discharge to the existing 400mm culvert located on the adjacent westerly property, as per the Stormwater Management Report by Quartek Group Inc., dated February 2017 (Refer to Appendix 'A' at the end of the design brief). Hallex Engineering report is limited to the northern portion of the site draining to the westerly property, as the southern portion flows to adjacent lands and will not be impacted by the proposed works.

Given the SWM dry pond will be redeveloped as part of the new development, the pre-development site condition will consider the pre-2017 condition. The proposed stormwater management controls will ensure the storm flows are controlled to the pre-2015 pre-development flow rate to the existing culvert at the westerly property.

2. PROPOSED WORK

2.1 GRADING

The objective of the design is to utilize the existing natural slope and achieve the minimum and maximum slopes in the grading of the granular and paved surfaces. This will ensure the surface not only drains as per the design, but is not too steep. The grading of the site also ensures that the storm water flow will mostly drain through the onsite drainage system for storm water quantity and quality controls. The proposed drainage system onsite has been designed according to the five-year storm event as per the Town of Niagara-on-the-Lake intensity-duration-frequency curve.

2.2 DRAINAGE

The proposed design requires 6.0 metres of storm sewer piping and 28.1 meters of flat bottom swale, in addition to the 24.4 meters of storm sewer piping, 59.6 meters of flat bottom swale, 58.9 meters of V-swale, the infiltration trench and the stormwater management pond currently in place. The existing pond is proposed to be modified to accommodate the flows from the additional impervious areas.

3. DESIGN CONSIDERATIONS

3.1 PRE-DEVELOPMENT SITE DRAINAGE

3.1.1 Peak Runoff

The total drainage area for the development in the pre-2017 condition is 1.410 hectares with an existing flow of 41.0 L/s for the five-year storm, as per the Stormwater Management Report by Quartek Group Inc., dated February 2017 (Refer to Appendix 'A' at the end of the design brief).

Subcatchment	Draining to	Imperviousness converted to C	Area, ha	Q, L/s
Area.1	West Prpty	0.39±	0.150	8.0
Area.2	West Prpty	0.26±	0.990	13.0
Area.3	West Prpty	0.49±	0.270	20.0
TOTAL		**0.32**±	**1.410**	**41.0**

* Minimum runoff coefficient is 0.25 for grassed areas as per the Town of NOTL standards.

Therefore, the total pre-development flow for the subject site is 41.0 L/s for the five-year storm. The flows and other design information are contained in Appendix 'A' at the end of the design brief.

3.1.2 Quantity

There is no known storm quantity control measure in place for the pre-2017 site condition.

3.1.3 Quality

There is no known storm quality control measure in place for the pre-2017 site condition.

3.2 POST-DEVELOPMENT SITE DRAINAGE

3.2.1 Peak Runoff

The proposed Sunnybrook Farm Winery development consists of the construction of the new concrete pads, a concrete walkway and extending the existing asphalt parking area. A new building with adjacent concrete areas was included in the flow calculations and is proposed to be constructed at a later date. The total drainage area in the post-development condition will increase to 1.482 hectares with a resulting runoff coefficient of 0.49.

The proposed development will drain via overland sheet flow and through the existing and proposed swales and pond onsite and shall discharge to the existing 400mm culvert located on the adjacent westerly property, as per the existing site condition.

Utilizing the minimum recommended time of concentration of 10 minutes, the time for storm water to flow from the farthest drainage area to the adjacent westerly property, as outlined in Exhibit #1, is calculated to be 10.00 minutes.

Using the Rational Method, the peak flow rates for the five-year storm are as follows:

Subcatchment	Draining to	C	Area, ha	*i*,mm/h	Q, L/s
Area.1	West Prpty	0.54	0.176	90	23.7
Pond.1	West Prpty	0.48	1.306	90	156.1
TOTAL		**0.49**	**1.482**	**90**	**179.9**

Therefore, the total post-development flow for the subject site is 179.9 L/s for the five-year storm. The flows and other design information are contained in Exhibit #1 at the end of the design brief.

3.2.2 Quantity

The post-development storm water runoff for Area.1 will decrease as a result of the development. As such, no stormwater quantity controls are proposed in addition to the existing culverts for this drainage area.

The post-development storm water runoff from Pond.1 is higher than the pre-development runoff. As such, storm water detention is required to ensure that the existing downstream infrastructure does not surcharge as a result of the proposed development.

Stormwater quantity controls for the site will be achieved by utilizing a 135mm diameter orifice installed at the outlet pipe of the stormwater management pond. The orifice will ensure the post-development runoff is controlled to the pre-development runoff rate for the five-year storm event. The resulting 156m^3 volume generated from the five-year storm will be contained within the proposed stormwater management pond. The pond has a total active storage capacity of 157m^3 with a 150mm freeboard for the five-year storm event.

The storage volume for the five-year storm is calculated using EPA SWMM v5.1 software (Refer to Appendix 'B' for EPA SWMM v5.1 – Output Files).

The following table summarizes the pre-development flow rates, the post-development uncontrolled flow rates and the post-development controlled flow rates for the subject site:

	Pre- Development Flow Rate (L/s)	Post- Development Uncontrolled Flow Rate (L/s)	Post- Development Controlled Flow Rate (L/s)
5-year Storm			
Area.1	28.0	23.7	23.7
Pond.1	13.0	156.1	16.8
TOTAL	**41.0**	**179.9**	**40.5**

The orifice sizing and subsequent storage volume for the detained flow are indicated in Exhibit #2 for the five-year storm at the end of the design brief.

3.2.3 Quality

The storm water collected in the proposed development passes through the dry detention pond and the enhanced grass swales to achieve a treatment train approach for water quality control. Typical total suspended solids removal efficiencies for dry detention ponds are 60% TSSR and enhanced swales is 40% TSSR. These default values have been vetted with both the MOECC and Greater Toronto Area Conservation Authorities Technical Review Managers. The removal efficiencies provided only consider removal from filtration and do not represent total removal by an LID/BMP which would also consider pollutant removal due to volume reduction. The combined removal efficiencies from the dry detention pond and the enhanced swale exceed the required 'Enhanced' treatment of 80% as indicated in the MOE Stormwater Management Planning and Design Manual, dated March 2003 (refer to Chapter 3: Environmental Design Criteria, Section 3.3.1.1. Level of Protection).

Furthermore, the enhanced grass swale has been designed for water quality control in accordance with the MOE Stormwater Management Planning and Design Manual, dated March 2003 (refer to Chapter 4: Stormwater Management Plan and SWMP Design, Section 4.5.9 – Grassed Swale). To ensure pollutant removal the following design constraints are utilized: trapezoidal channel, grassed lined (n = 0.035), 2.5:1 sideslopes. Also, the design velocity for each storm event does not exceed 0.5m/s based on the controlled flow from the dry detention pond.

Additionally, the infiltration trench located within the catchment Area.1 will aid to improve the quality of the water collected from the asphalt parking area, as per the Stormwater Management Report by Quartek Group Inc., dated February 2017 (Refer to Appendix 'A' at the end of the design brief).

3.2.4 Maintenance Recommendations

The storm sewer system includes swales and a stormwater management pond. It is important to regularly inspect the elements to ensure that storm water is flowing as originally designed. Debris and sediment commonly clog the system and reduce the overall effectiveness.

The following maintenance and inspection tasks should be done:

1. Inspect the culverts for structural integrity. (Annually) Check culvert pipes for structural integrity to ensure they aren't crumbling or broken.
2. Conduct routine inspections for trash or other debris that may be blocking the culvert pipes, swales and stormwater management pond. (Monthly and after rain events) Remove all trash and debris.
3. Conduct routine inspections for erosion of the stormwater management pond and swales. (Annually and after rain events). Any erosion shall be corrected by sodding the area. There may be a need to provide further erosion control (ie rip-rap) to prevent the re-occurrence of erosion.

4. If there is a visible accumulation of sediment in the bottom of the pond or around the high-water line of the pond, then removal of sediment accumulation is required.
5. Conduct routine maintenance of swales and pond including grass cutting.
6. The frequency of grass cutting correlates on the surrounding land uses, and ultimately local municipal by - laws. Grass cutting should be done as infrequently as possible recognizing the aesthetic concerns of nearby residents. Grass around wet facilities should not be cut to the edge of the permanent pool.
7. As a safety precaution, grass cutting should be done parallel to the shoreline with grass clippings being ejected upland to reduce the potential for organic loadings to the pond.
8. Inspect for sediment accumulation at pipes (Semi-annually and after rain events). It is important to clean out sediment that might be restricting water flow.
9. Do not dump any materials in the storm system.

4. CONCLUSION

The aforementioned calculations and recommendations for the storm drainage system are based on the current design for the site as of writing this report.

We trust this report meets your approval. Please contact the undersigned should you have any questions or comments.

Yours truly,
HALLEX CIVIL ENGINEERING LTD

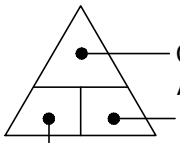


Jim Halucha P.Eng
Civil/Structural Engineer



Mustafa Abdullaiev, B.Eng
Civil Designer

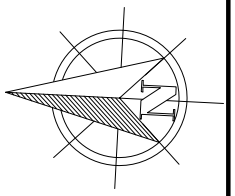
LEGEND

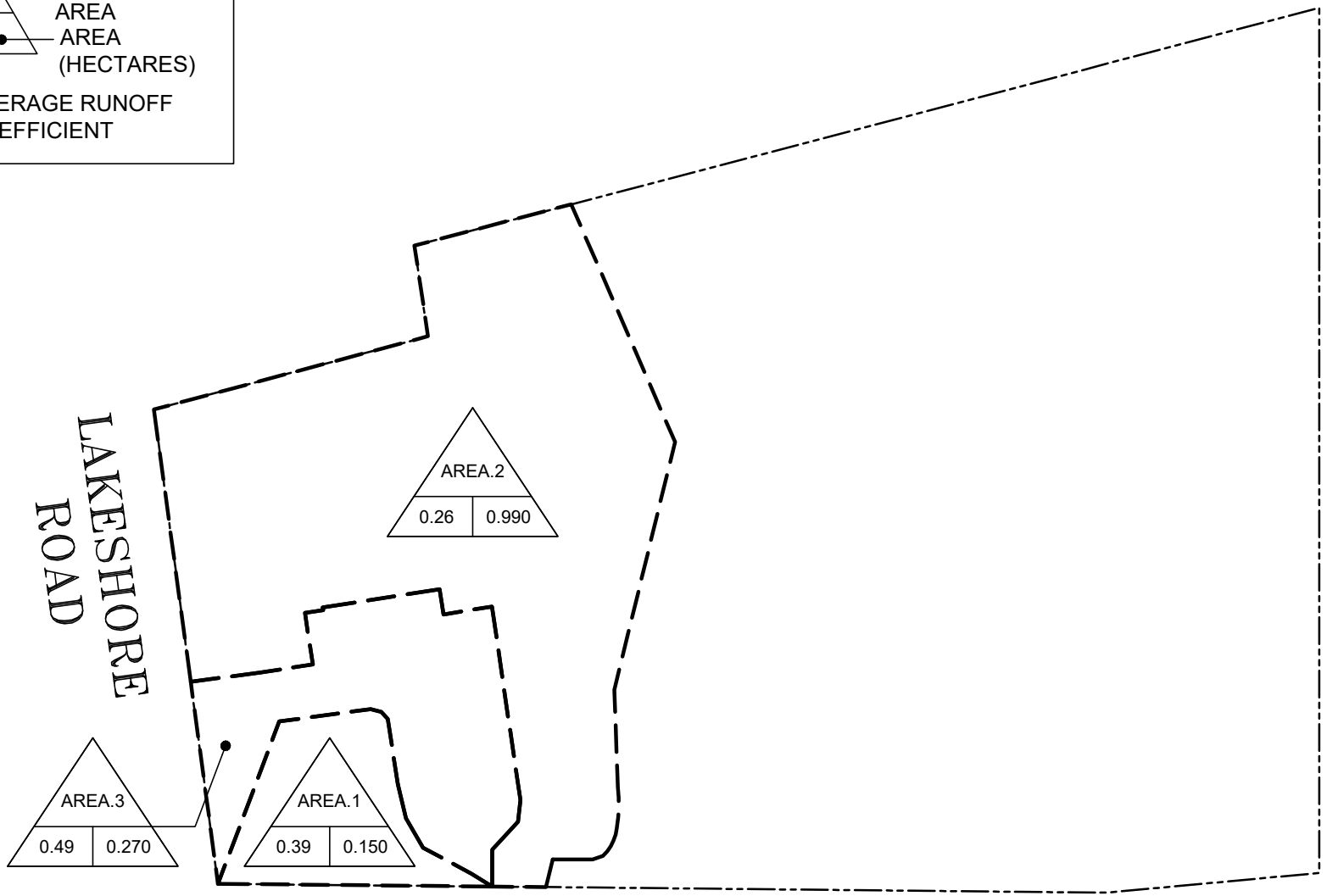


CATCHMENT AREA

AREA (HECTARES)

AVERAGE RUNOFF COEFFICIENT





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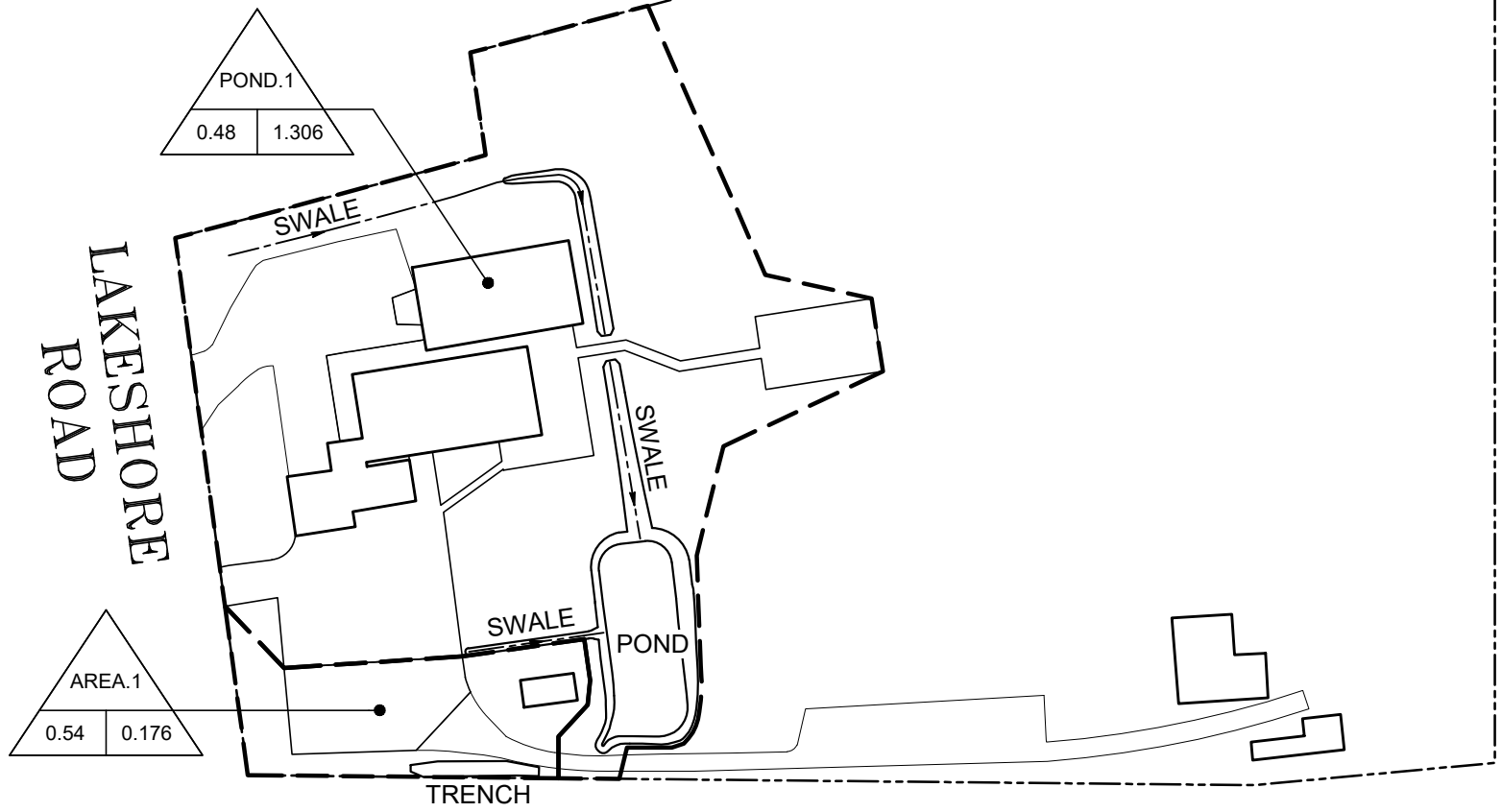
PROJECT:
SUNNYBROOK FARM WINERY
1425 LAKESHORE ROAD, NOTL, ON

SHEET TITLE:
PRE-DEVELOPMENT
CATCHMENT AREA PLAN

SCALE: 1:1500	JOB NUMBER: 260201
DATE: 2026/05/04	ISSUED FOR: ZBA / SPA
DRAWN BY: MA	DWG CSK1 REV. 0
DESIGNED BY: MA	
CHECKED BY: AI	

LEGEND

CATCHMENT AREA
AREA (HECTARES)
AVERAGE RUNOFF COEFFICIENT



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PROJECT:
SUNNYBROOK FARM WINERY
1425 LAKESHORE ROAD, NOTL, ON

SHEET TITLE:
POST-DEVELOPMENT
CATCHMENT AREA PLAN

SCALE: 1:1500	JOB NUMBER: 260201
DATE: 2026/05/04	ISSUED FOR: ZBA / SPA
DRAWN BY: MA	DWG CSK2 REV. 0
DESIGNED BY: MA	
CHECKED BY: AI	

1425 Lakeshore Road, Niagara-on-the-Lake, ON
Exhibit #1 - 5 Year Post - Development Calculations

2026-05-04
Job: 260201

MUNICIPALITY: **NOTL**

Rainfall Intensity Values = A= 664.000, B= 4.700, C= 0.744

manning's n = 0.013 PVC Pipe; 0.013 Conc Pipe; 0.024 Corr. Stl Pipe; 0.035 Grass Swale

Location			Length of Pipe	Area		Flow Time		Rainfall Intensity	Unit rate of Runoff	Design Flows		Flow Control	Sewer/Channel Design				Invert Elevations	
Pipe	From Node	To Node		Incre-ment	Cum Total	To Upper	In Section			Cum Flow	Cum Flow		Slope	Capacity Full	Velocity Full	*Dia/ Depth	Up-stream	Down-stream
			(m)	(ha)	(ha)	(min)	(min)	mm/hr	m^3/ha*day	(m^3/d)	(m^3/s)	(m^3/s)	(m/m)	(m^3/s)	(m/s)	(m)	(m)	(m)
1	**Area 1**	**Prpty 1**	**N/A**	**0.176**	**0.176**	**10.00**	**N/A**	**90**	**58245**	**2051.5**	**0.0237**	**0.0237**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Roof	-	-	-	0.006	-	-	-	-	20493.6	123.0	-	-	-	-	-	-	-	-
Paved	-	-	-	0.063	-	-	-	-	19415.0	1223.1	-	-	-	-	-	-	-	-
Gravel	-	-	-	0.017	-	-	-	-	12943.3	220.0	-	-	-	-	-	-	-	-
Grass	-	-	-	0.090	-	-	-	-	5393.1	485.4	-	-	-	-	-	-	-	-
2	**Pond 1**	**Prpty 1**	**11**	**1.306**	**1.306**	**10.00**	**0.58**	**90**	**58245**	**13489.1**	**0.1561**	**0.0168**	**0.0055**	**0.0046**	**0.3214**	**0.135**	**80.00**	**79.94**
Roof	-	-	-	0.156	-	-	-	-	20493.6	3197.0	-	-	-	-	-	-	-	-
Paved	-	-	-	0.226	-	-	-	-	19415.0	4387.8	-	-	-	-	-	-	-	-
Gravel	-	-	-	0.122	-	-	-	-	12943.3	1579.1	-	-	-	-	-	-	-	-
Grass	-	-	-	0.802	-	-	-	-	5393.1	4325.2	-	-	-	-	-	-	-	-

* Swale/Ditch geometry based on the following assumptions: trapezoidal channel, grassed lined (n = 0.035), 2.5:1 sideslopes, 0.75 m bottom width.
* Grassed swale Flow Velocity for Water Quality Enhancement to be maximum 0.5 m/s for the 4 hour 25mm Chicago Storm.

Run-off Coefficients Used:

Roof Structure C = 0.95
Paved Surface C = 0.90
Gravel Surface C = 0.60
Grass Surface C = 0.25

Velocity Range:

Minimum Velocity = 0.75 m/s
Maximum Velocity = 6.00 m/s

Time of Concentration:

Time of Concentration = 10 min

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745 South Service Road, Unit 205
Stoney Creek, ON L8E 5Z2

1425 Lakeshore Road, Niagara-on-the-Lake, ON
Exhibit #2 - 5 Year Orifice Plate and Storage Volume Calcs

2026-05-04
Job: 260201

Site Data

Site Discharge	Flow to West Property	Adj. Flow (w/o Area.1)	Total Storm Volume
	(m^3/s)	(m^3/s)	(m^3)
Pre - Develop.*	0.0410	0.0173	
Post - Develop.	0.1799	0.1561	156.0

Control Node Data

Outlet Pipe	Storm Control Node	Outlet Pipe Size	Outlet Invert Elev.	Elev. @ Orifice
		(m)	(m)	(m)
2	Pond 1	0.135	80.00	80.07

* Pre-development site condition prior to 2017, as per the SWM report by Quartek Group Inc., dated February 2017.
** Volume calculated using SWMM 5.1 modelling software in accordance with the flow rate for actual size of the orifice.

Head Height 0.18 m **Storm Retention Elev. Check** **80.25 m**

Infiltration Trench / Pond Storage

Pond Sections	Pond Dimensions		Storage Volume
	Depth	Avg Area	
	(m)	(m)	(m^3)
Pond	0.250	628.09	157.02
Total			**157.02**

Total Storage = 157.0 m^3 Required Storage Achieved

Orifice Diameter Calculation (A=Q/(Cd*sqrt(2*g*h)))

Coefficient of Discharge	Cd =	0.62	(sharp)	0.62	Sharp Orifice coefficient of discharge
Allowable Flow Rate	Q =	0.0173	m^3/s	0.80	Tube coefficient of discharge
Force of Gravity	g =	9.81	m/s/s		
Head Height	h =	0.18	m		
Dia of Max. Orifice	dia =	136.88	mm	Use - 135	mm

Flow Rate for Actual Size of Hole (Q=Cd*A*sqrt(2*g*h))

Area of Orifice	A =	0.0143	m^2
Flow Rate through Orifice	Q =	0.0168	m^3/s

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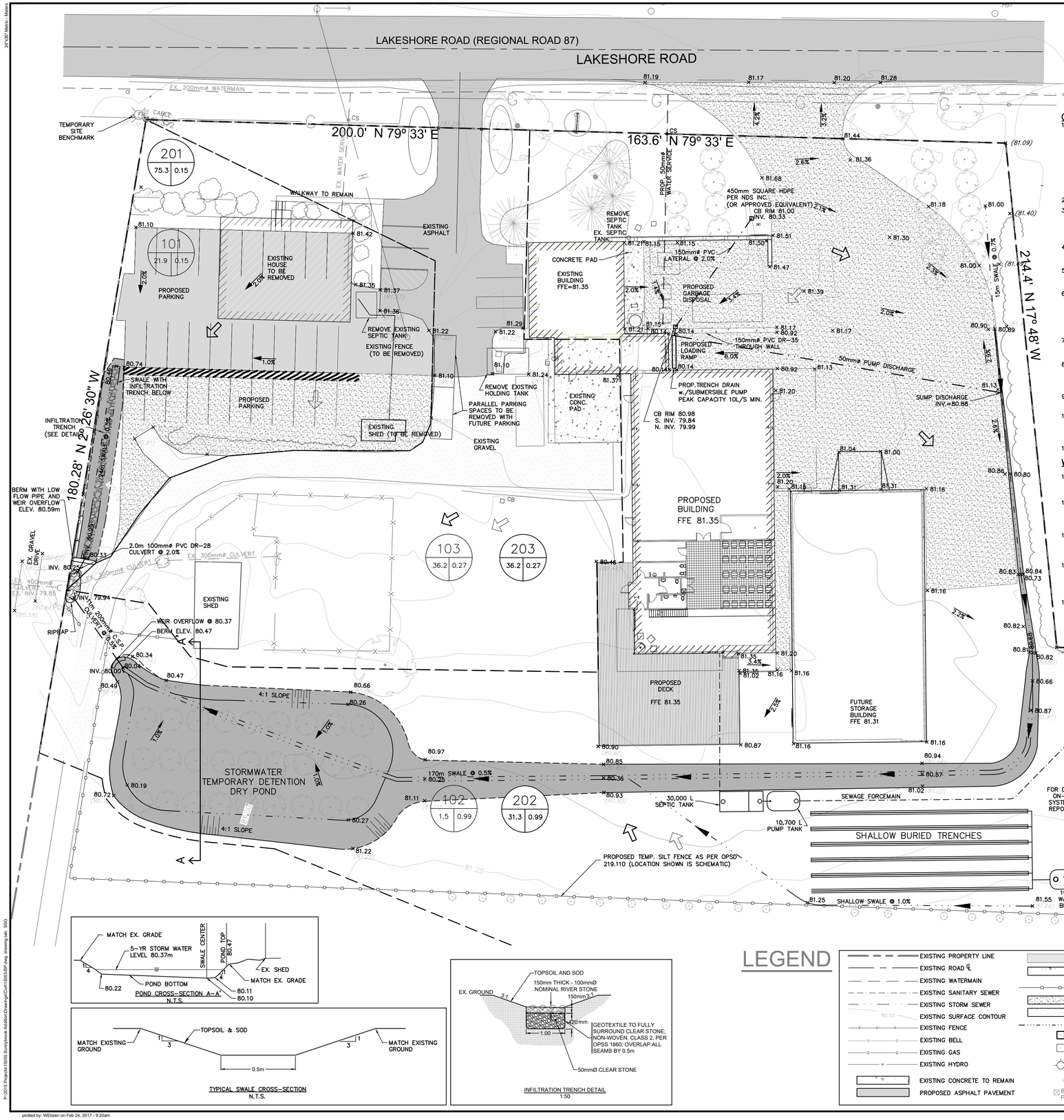
745 South Service Road, Unit 205
Stoney Creek, ON L8E 5Z2

APPENDIX 'A'

Current Condition
Stormwater Management Report

by Quartek Group Inc.

24"x36" Metric - Meters



LEGEND

- EXISTING PROPERTY LINE
- EXISTING ROAD ℄
- EXISTING WATERMAIN
- EXISTING SANITARY SEWER
- EXISTING STORM SEWER
- EXISTING SURFACE CONTOUR
- EXISTING FENCE
- EXISTING BELL
- EXISTING GAS
- EXISTING HYDRO
- EXISTING CONCRETE TO REMAIN
- PROPOSED ASPHALT PAVEMENT
- EXISTING ASPHALT
- PROPOSED CONCRETE
- SILT FENCE DURING CONSTRUCTION
- PROPOSED GRAVEL
- EXISTING GRAVEL
- DITCH CENTRE LINE
- CB PROP. CATCHBASIN
- CB EX. CATCHBASIN
- FH EXISTING HYDRANT
- HP EXISTING HYDRO POLE
- BELL PED EXISTING BELL PEDESTAL
- FIB EXISTING FOUND IRON BAR
- SIB EXISTING STANDARD IRON BAR
- EXISTING TREES
- CS EXISTING CURBSTOP
- CS PROPOSED CURBSTOP
- 2.0% PROPOSED SURFACE GRADE
- TEMPORARY BENCHMARK
- 93.09 (93.45) PROPOSED SURFACE ELEVATION / EXISTING SURFACE ELEVATION
- DIRECTION OF EX. MAJOR STORM OVERLAND FLOW
- DIRECTION OF PROP. MAJOR STORM OVERLAND FLOW
- STORM CATCHMENT BOUNDARY

GENERAL

1. LOCATION AND SIZE OF EXISTING UTILITIES WAS DERIVED FROM VARIOUS DRAWINGS FROM OTHERS. THE POSITION OF ALL POLE LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND UTILITIES AND STRUCTURES ARE NOT NECESSARILY SHOWN AND, WHERE SHOWN, THE ACCURACY OF THE LOCATION SHOWN OF SUCH UTILITIES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL CONTACT ALL SUCH UTILITIES INVOLVED AND INFORM HIMSELF AS TO THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES AND SHALL ASSUME LIABILITY FOR DAMAGE TO THEM. CONTRACTOR TO REPORT ANY CONFLICTS OR DISCREPANCIES WITH THIS DRAWING TO THE ENGINEER IMMEDIATELY.
2. ALL MEASUREMENTS ARE IN METRES UNLESS OTHERWISE NOTED.
3. ALL WORK SHALL BE IN ACCORDANCE WITH THE RELEVANT SECTIONS OF THE ONTARIO PROVINCIAL STANDARD SPECIFICATIONS AND DRAWINGS, AND THE NIAGARA PENINSULA STANDARD CONTRACT DOCUMENT (NPSCD) UNLESS OTHERWISE NOTED ON THE DRAWINGS OR IN THE SPECIFICATIONS.
4. COMPUTER DRAWING FILE CO-ORDINATES FOR THIS DRAWING SHALL NOT BE USED FOR CONSTRUCTION LAYOUT UNLESS SPECIFICALLY DIRECTED BY THE ENGINEER.
5. ALL GRANULAR MATERIAL SHALL BE COMPACTED TO 100% STANDARD PROCTOR DENSITY AND ALL NATIVE BACKFILL SHALL BE COMPACTED TO 95% STANDARD PROCTOR DENSITY UNLESS OTHERWISE NOTED.
6. ALL CONSTRUCTION SHALL BE CARRIED OUT IN SUCH A WAY THAT SILTATION OR OTHER DAMAGE TO WATER COURSES DOES NOT OCCUR. THE REQUIREMENTS OF THE MINISTRY OF NATURAL RESOURCES ARE TO BE ADHERED TO IN THIS RESPECT. AT A MINIMUM, PROVIDE SILT FENCE AND STABILIZED CONSTRUCTION ACCESS AND MAINTAIN SAME FOR DURATION OF CONSTRUCTION.
7. ALL EXCAVATION IN EXISTING ROADWAYS OR OTHER PAVED SURFACES SHALL BE BACKFILLED WITH GRANULAR 'A' COMPACTED TO 100% SPD. MINIMUM
8. CONTRACTOR TO OBTAIN EXACT LOCATION AND ELEVATION OF EXISTING UTILITIES PRIOR TO COMMENCEMENT OF WORK AND REPORT ANY CONFLICTS OR DISCREPANCIES WITH THESE DRAWINGS TO THE ENGINEER IMMEDIATELY
9. PROPOSED GRADES SHALL NOT ADVERSELY AFFECT ADJACENT PROPERTIES.
10. PRIOR TO COMMENCEMENT OF CONSTRUCTION, CONTRACTOR TO OBTAIN ENCROACHMENT PERMIT FROM NIAGARA REGION FOR WORKS WITHIN REG. RD. R.O.W. AND TO COMPLY WITH ALL REQUIREMENTS OF SUCH PERMIT.
11. REFER TO SITE PLAN FOR SITE DIMENSIONS.

WATER SUPPLY

12. CONTRACTOR SHALL OBTAIN EXPLICIT APPROVAL FROM TOWN OF NIAGARA-ON-THE-LAKE WATER DEPARTMENT PRIOR TO MAKING A CONNECTION TO THE EXISTING TOWN WATERMAIN.
13. A MINIMUM CLEAR HORIZONTAL SEPARATION OF 2.5m SHALL BE MAINTAINED BETWEEN ANY SEWER & ANY PARALLEL WATERMAIN. A MINIMUM CLEAR VERTICAL SEPARATION OF 0.5m SHALL BE MAINTAINED AT SEWER CROSSINGS.
14. WATERMAINS & SERVICES SMALLER THAN 150mmø SHALL BE TYPE 'K' SOFT COPPER OR MUNICIPEX OR APPROVED EQUIVALENT. MINIMUM FINISHED COVER OVER WATERMAINS & SERVICES SHALL BE 1.5m UNLESS OTHERWISE INDICATED.
15. ALL WATER SUPPLY PIPING SHALL BE FLUSHED, PRESSURE TESTED & DISINFECTED IN ACCORDANCE WITH OPSS 441 & NPSCD SPC-D13 UNDER THE DIRECTION OF THE TOWN'S ENGINEERING PERSONNEL & TO THE SATISFACTION OF THE TOWN DIRECTOR OF PUBLIC WORKS.
16. FOR ALL NON-METALLIC WATERMAINS AND SERVICES, 8-GAUGE COPPER TRACING WIRE SHALL BE INSTALLED ALONG THE SPRING-LINE ALONG ITS ENTIRE LENGTH, ALONG HYDRANT LEAD AND EXTENDED ABOVE EXPOSED FLANGE AT HYDRANT.

ROADS AND EARTHWORKS

17. FILL FOR ROADWAY AND PARKING AREAS TO BE CONSTRUCTED IN ACCORDANCE WITH OPSS 201 IN 200mm THICK LIFTS, USING SUITABLE NATIVE EXCAVATED OR IMPORTED MATERIAL APPROVED BY CONTRACT ADMINISTRATOR AND GEOTECHNICAL ENGINEER. THE SUBSOIL BELOW ANY ROADWAY OR PARKING AREA SHALL BE COMPACTED, PROOF ROLLED AND INSPECTED BY THE GEOTECHNICAL ENGINEER OR HIS DESIGNATE PRIOR TO THE PLACEMENT OF ANY GRANULAR MATERIAL.THE UPPER 0.6m BELOW ANY RIGID OR PAVED SURFACE SHALL BE COMPACTED TO 98% SPD MIN.
18. WHERE DISTURBED OR DAMAGED, REINSTATEMENT OF EXISTING ROADS SHALL COMPLY WITH THE REQUIREMENT OF THE ROAD AUTHORITY. PAVEMENT REINSTATEMENT SHALL COMPLY WITH OPSD 509.010 AND OPSS 310.
19. SUBDRAIN TO BE 100mmø OR 150mmø HDPE PERFORATED FILTER-WRAPPED TILE PER OPSD 216.021, DISCHARGING TO AN EXISTING DITCH OR OTHER DRAINAGE OUTLET.
20. MINIMUM ASPHALT AND GRANULAR THICKNESS FOR DRIVEWAY AND PARKING AREA PER OPSS 310 & 314 AS FOLLOWS:

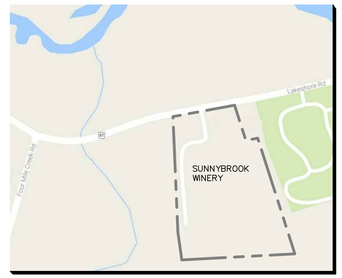
	HEAVY DUTY	LIGHT DUTY
SURFACE COURSE	40mm HL3	40mm HL3
BINDER COURSE	65mm HL8	50mm HL8
GRANULAR BASE	150mm GRAN. 'A'	150mm GRAN. 'A'
GRANULAR SUBBASE	350mm GRAN. 'B'	200mm GRAN. 'B'
TOTAL THICKNESS	605mm	440mm

21. AREAS TO BE SODDED SHALL INCLUDE MINIMUM 75mm TOPSOIL PER OPSS 802 AND NPSCD SPC-B21. SOD TO BE IN ACCORDANCE WITH OPSS 803 AND NPSCD SPC-B21. NATIVE BACKFILLED AREAS TO BE SODDED SHALL BE FREE OF GRANULAR PARTICLES OR OTHER MATERIALS DELETERIOUS TO PLANT GROWTH.

SEWERS

22. ALL SEWERS, LEADS AND LATERALS SHALL HAVE CLASS 'B' BEDDING PER OPSD 802.010, GRANULAR 'A' COVER MATERIAL AND SELECT NATIVE BACKFILL UNLESS OTHERWISE NOTED.
23. ALL STORM SEWERS AND CATCHBASIN LEADS TO BE CONCRETE, CLASS III PER CSA A257.2 WITH CLASS 'B' BEDDING TO OPSD 802.030 OR PVC DR-35 PER CSA 182.1 WITH GRANULAR 'A' BEDDING TO OPSD 802.010 UNLESS OTHERWISE NOTED.
24. FOR DETAILS OF ON-SITE SEWAGE SYSTEM SEE ENGINEERING REPORT PREPARED BY RIVERCOURT ENGINEERING INC.

KEYPLAN



OPERATIONS DEPARTMENT APPROVAL

SIGNATURE	DATE
JEFFREY VYSE (NAME)	MANAGER OF PUBLIC WORKS (POSITION)

FIRE DEPARTMENT APPROVAL

SIGNATURE	DATE
ALEX BURBIDGE (NAME)	FIRE CHIEF (POSITION)

TEMPORARY BENCHMARK INFORMATION

TOP OF TOP-NUT OF FIRE HYDRANT LOCATED 1.72m WEST OF NORTHWEST PROPERTY BAR (# 1425 LAKESHORE ROAD) WITHIN THE LAKESHORE ROAD RIGHT-OF-WAY
ELEVATION = 82.411

PRE-DEVELOPMENT STORM CATCHMENT AREAS

101 — AREA NUMBER
21.9 — % IMPERVIOUS
0.15 — AREA (Ha)

POST-DEVELOPMENT STORM CATCHMENT AREAS

201 — AREA NUMBER
75.3 — % IMPERVIOUS
0.15 — AREA (Ha)

issue	issued for	date	init.
B	SITE PLAN APPLICATION	23 FEB 2017	WE
A	FOR REVIEW	14 FEB 2017	WE

seal

LICENSED PROFESSIONAL ENGINEER — H. E. KLASSEN — 23 Feb 2017 — PROVINCE OF ONTARIO

Do not scale drawings. Report any discrepancies to Quartek Group Inc. before proceeding.

Drawings must be sealed by the Architect and / or Engineer prior to the use for any building permit applications and / or government approval. Seals must be signed by the Architect and / or Engineer before drawings are used for any construction.

All construction to be in accordance with the current Ontario Building Code and all applicable Ontario regulations.

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Niagara-on-the-Lake EST.1781

SUNNYBROOK

project title

SUNNYBROOK BUILDING ADDITION
1425 LAKESHORE ROAD, NIAGARA-ON-THE-LAKE

drawing title

SITE SERVICES AND GRADING PLAN

drawn by	designed by
JTB/BRHJ	HEK

scale	date
1:250	16 Jun 2016

job number	issue
15055	B

drawing number
15055-SSG

P:\2015 Projects\15055 Sunnybrook Addition\Drawings\Civil\15055-ASP.dwg drawing tab: SSG

plotted by: WEitzen on Feb 24, 2017 - 9:20am

STORMWATER MANAGEMENT REPORT

Sunnybrook Building Addition

1425 Lakeshore Road
Niagara-on-the-Lake, Ontario

Submitted on behalf of ***Sunnybrook Wine Co.***

Prepared by: ***Quartek Group Inc.***
Engineers, Architects and Planners
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Quartek
Architects • Engineers • Planners • Project Managers

February 2017

Sunnybrook Building Addition
1425 Lakeshore Road, Niagara-on-the-Lake, Ontario

STORMWATER MANAGEMENT REPORT

1. Background Information and Design Criteria

1.1 Site Conditions

Site Address: 1425 Lakeshore Road, Niagara-on-the-Lake, Ontario

Site Area: 1.41 ha. within stormwater management catchment areas (SWM Site area), 4.30 ha. within property lines

Land Use:

Existing: winery, detached house, two sheds, asphalt driveway, gravel driveway, agricultural land,

Proposed: winery with building addition, future storage building and parking lot, agricultural land

Receiving Watercourse: Small tributary to Four Mile Creek, eventually to Lake Ontario

Site Drainage: A small portion of the site drains northerly to the Lakeshore Road roadside ditch, while most of the site drains westerly to a culvert adjacent to the property that drains for approximately 150 m through an adjacent wooded lot to a tributary of Four Mile Creek.

1.2 Background

This report summarizes the stormwater management design for the proposed development at 1425 Lakeshore Road in Niagara-on-the-Lake. It is submitted with the Site Plan Application and assumes full development of the site in accordance with the proposed site plan included in Appendix 'A'. An aerial view of the site is provided in Figure 1-1.

The subject site is located on the south side of Lakeshore Road just east of Four Mile Creek Road. The site comprises a total area of 4.30 hectares; 1.41 hectares (the northern part of the site) will be addressed in this report with respect to stormwater management. The remaining 2.89 hectares of land drains to a separate location on site and remains unaffected by the proposed work.

The existing features on the site are a building functioning as a winery, an existing detached house, an asphalt driveway, a gravel driveway, two sheds, a septic tank, an orchard, and surrounding trees.



Figure 1-1: Aerial View of Site

1.3 Development Proposal

The first phase of development will be a building addition of approximately 7200 ft^2, a gravel driveway with parking, a paved parking lot, a new on-site sewage system, and removal of the existing house. The next phase will include a storage building.

The stormwater management provided in this report will accommodate both phases of the development. The proposed building addition and storage building will require a portion of the overland flow to be redirected to a proposed swale along the east and south sides of the developed area. The paved parking area will require an infiltration trench and swale along the west side of the property.

1.4 Runoff Characteristics and Criteria

The runoff characteristics and design criteria for the site can be summarized as follows:

- the area of existing impervious surfaces is 0.14 hectares, or approximately 10.0% of the SWM site area.
- the proposed impervious area, consisting of roof, driveway, and asphalt surfaces will total approximately 0.53 hectares, which is approximately 37.6% of the SWM site area
- it is understood that Town Policy requires that peak post-development runoff flow is not to exceed peak pre-development flow for the 5-year return period storm discharging onto the adjacent property; accordingly, quantity stormwater management will be required as there exists a discernible increase in impervious area
- the site is relatively level throughout and drains via sheetflow and infiltration. Existing topography suggests that the majority of the SWM site area drains to a 400 mmø culvert west of the site on the adjacent property.

1.5 Design Storm Characteristics

The design storm is defined as a Chicago Storm Hyetograph, 3-hour duration. The defining parameters for the intensity-duration-frequency relationship are taken from the Engineering Standards for the Town of Niagara-on-the-Lake, which reference the City of St. Catharines IDF curves. These parameters are summarized in Table 1-1 below and are incorporated in our computerized modelling.

Table 1-1: Design Storm Parameters

Storm Return Period	3-hr IDF Curve Parameters		
	a	b	c
5 year	664	0.744	4.7

**rainfall intensity, $I = a/(t+c)^b$, where t = time of concentration (min.)*
Ratio of time to peak = 0.375

2. Minor Storm Drainage System and Quantity Management

The design of the stormwater collection system will detain and release the minor system runoff generated from the proposed development within two separate catchment areas. The outlet for both catchments will converge at the discharge location of the existing 300 mmø culvert. A portion of the pervious SWM site area, identified as catchment area 3, will continue to drain to the existing 300 mmø culvert. Since this catchment will be unaltered with the proposed work, it will not have a change in post-development peak flow. Storage will be provided in the catchment areas 1 and 2 by means of a swale above an infiltration trench and a stormwater management dry pond respectively.

The design of the swale above the infiltration trench will meet the requirements for the 5-year return period storm parameters using the storage available above the clear stone and river stone in the swale. The swale will be designed with a 1m bottom width, 3:1 side slopes, a 0.5% grade and a maximum depth of 0.3 m. The infiltration trench below the swale will act primarily as a quality control measure.

The stormwater management dry pond will also detain enough stormwater to meet the requirements for the 5-year return period storm parameters. The pond will have a bottom area of 500 m^2 with 4:1 side slopes surrounding the pond and 3:1 side slopes along the swale portion. The pond bottom will generally slope at 1% towards the swale. A freeboard of 0.1 m to the top of pond will be provided above the 5-year return period storm water level.

Both storage areas will detain flows by restricting the outlet with appropriately sized pipes. Drawing 15055-SSG shows the proposed storm drainage works, site grading as it will convey runoff from the development areas into the grassed swales, and the drainage boundaries of the three catchment areas. Figure 2-1 shows the full extent of the catchment areas including the portion extending into the orchard that will remain unaltered with this development, as well as 1m contour lines provided by the Niagara Peninsula Conservation Authority.

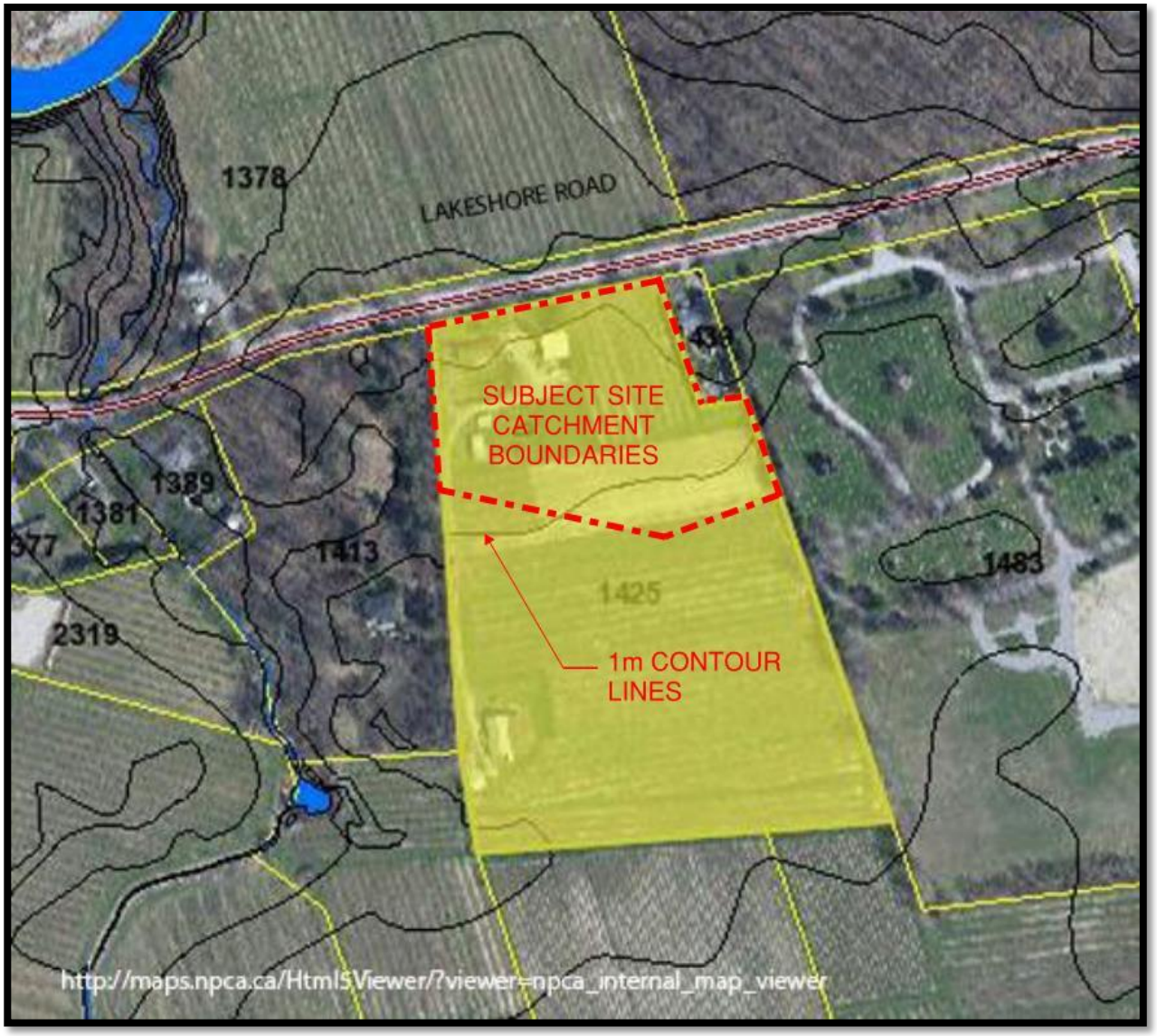


Figure 2-1: Aerial View of Site

Software modelling for the 5-year return period storm was performed using MIDUSS (Micro Interactive Design of Urban Storm Sewers) software. Details of the parameter calculations can be seen in Appendix B and the MIDUSS output can be viewed in Appendix C. Peak pre-development and post-development flows for the 5-year return period storm and corresponding storage output is shown in Table 2-1 below.

Table 2-1: 5-Year Peak Flow Stormwater Detention Summary

	Pre-Development	Post-Development			
Catchment Area	Peak Outflow (m^3/s)	Peak Inflow (m^3/s)	Peak Outflow (m^3/s)	Storage Volume (m^3)	Water Elev. (m)
1	0.008	0.022	0.008	12.7	80.55
2	0.013	0.072	0.012	94.9	80.37*
3	0.020	N/A	0.020	N/A	N/A

**80.37m is the actual pond water elevation with a sloped bottom and at least 94.9m^3 of storage volume. MIDUSS calculates the elevation based on a flat bottom.*

The storage volumes provided above the infiltration trench in the swale conveying runoff from catchment area 1 and in the stormwater management pond in catchment area 2 are adequate to restrict the peak post-development flows to their peak pre-development flows for the 5-Year return period storm.

3. Major Storm Drainage System

For storms greater than the 5-year return period, overland flow is generally directed westerly towards the adjacent wooded lot, as indicated by overland flow arrows on drawing 15055-SSG. Overflow from the storage areas will be conveyed through weirs placed at elevations higher than the 5-Year Return Period maximum storage elevations.

4. Stormwater Quality

This development will discharge into the Four Mile Creek watershed and will require that stormwater controls be in place to treat stormwater runoff to a 'Normal' (Level 2) protection level. With the additional roof runoff and asphalt and gravel surfaces, stormwater quality enhancements will be incorporated into the design in order to maintain this protection. The stormwater quality onsite will be addressed using an infiltration trench for catchment area 1 and a grassed swale for catchment area 2.

Catchment 1 contains the majority of the proposed asphalt. According to the Ministry of Environment and Climate Change Stormwater Management Planning and Design Manual (SWMPD), an infiltration trench with a Normal protection level should provide 25 m^3/ha storage volume for an Impervious Level of 70% and 30 m^3/ha storage volume for an Impervious Level of 85%. Since the catchment area draining to the infiltration trench

contains an impervious level of 75.3%, SWMPD suggests to use an interpolated value, which is 26.8 m^3/ha storage volume. With a catchment area of 0.15 ha, catchment area 1 requires 4.02 m^3 of water quality storage. The 25 m infiltration trench design in the proposed development allows for 4.2 m^3 of storage, exceeding the suggested amount for a Normal level of protection. Calculations can be seen in Appendix B. It is also suggested in the SWMPD that the base of the trench be at least 1 m above the groundwater level. According to the Geotechnical Investigation performed by Soil-Mat dated September 9, 2016 for this development, their observations indicated a groundwater level estimated between 2 to 3 m beneath the existing ground surface. The infiltration trench bottom is expected to be less than 1 m below existing ground, leaving 1 to 2 m between the trench bottom and the estimated groundwater level.

Catchment 2 will convey the majority of the runoff from the proposed gravel driveway and roof runoff through a lengthy (75+ m) grassed swale with a 0.5 m width, 3:1 sideslopes and 0.5% shallow grade. Note that the SWMPD considers grassed swales to be a significant quality enhancement where, under a 25 mm quality storm condition, velocity and flow rate are under 0.5 m/s and 0.15 m^3/s respectively. MIDUSS modelling (found in Appendix C) under the 4-hour Chicago 25 mm storm condition yielded a velocity of 0.32 m/s and a flow rate of 0.039 m^3/s in the grassed swale, which suggests the grassed swale will significantly enhance the stormwater quality before entering the stormwater management pond.

5. Maintenance

The proposed detention basins should be inspected semi-annually and cleaned as needed. By design, the invert elevation of the outflow control pipe shall indicate the approximate design elevation of the detention pond floor. Sedimentation significantly above this point should prompt immediate removal of sediment.

Drainage channels should be mowed regularly and kept under 150 mm in height but taller than 75 mm for the purpose of quality treatment.

Attachments

1. Drawing 15055-SSG Site Services and Grading Plan
2. Appendix A: 15055-SP1 Site Plan
3. Appendix B: Design Calculations
4. Appendix C: MIDUSS Model Output



Stormwater Management Report prepared by: *W. Eitzen, EIT, Quartek Group Inc.*
H. Klassen, P.Eng., Quartek Group Inc.

STORMWATER MANAGEMENT REPORT

Sunnybrook Building Addition

1425 Lakeshore Road,
Niagara-on-the-Lake, Ontario

APPENDIX A

15055-SP1 Site Plan

STORMWATER MANAGEMENT REPORT

Sunnybrook Building Addition

1425 Lakeshore Road,
Niagara-on-the-Lake, Ontario

APPENDIX B

Design Calculations

Infiltration Trench Design

$A = \frac{(1{,}000)(\mathrm{V})}{\mathrm{P}\cdot\mathrm{n}\cdot\Delta\mathrm{t}}$ $[MOEcc\ Stormwater\ Management\ Planning\ and\ Design\ Manual, 2003]$ (SWMPD)

Where:

A = trench bottom footprint in m^2 (computed by length· width)
Δt = 48 hrs
n = 0.4 (50mm clear stone void ratio, unitless)
Geotechnical Investigation performed by Soil-Mat dated September 9, 2016 for this development recommends using a conservative T value (percolation time) of 20 min/cm, which is a percolation rate of
P = 30 mm/hr > 15mm/hr MOEcc minimum →OK
V = volume of runoff (m^3) from Table 3.2 in (SWMPD) for 75.3% Impervious recommends 26.8 m^3/ha.
Catchment area = 0.15 ha, V = 4.02 m^3

Area Calculation

Based on a perforated trench length of 25m, solving for area,'A', for the infiltration trench:

$$\mathrm{A} = \frac{(1{,}000)(4.02m^3)}{\frac{30\mathrm{mm}}{\mathrm{hr}}\cdot 0.40\cdot 48\mathrm{hr}}$$

A_{req} = 6.98 m^2 →

using a prop. trench W = 1.0 m wide infiltration trench with 25 m length A_{prop} = 25 m^2 > A_{req}

Thus, the proposed infiltration trench is proposed sufficient at **25 m long x 1.0 m wide**.

Underground Storage Calculation

The available storage within the clear stone is based on the following:

Width of Infiltration Trench	1.0 m	Open Cross Sectional Area	0.168 m^2
Total Height of Granular Surround	0.42 m	Length of Trench	25 m
Void Ratio	0.4	Total Underground Storage	**4.2 m^3**

$$\mathrm{V} = (0.168m^2)(25m) = 4.2m^3$$

Thus, the **4.2m^3** of underground storage will be available in the clear stone gallery to provide for quality management and is sufficient for the volume of runoff suggested from Table 3.2 in SWMPD. The entire quantity control of the 5-year storm runoff will be stored aboveground.

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Composite Curve Numbers

$$CN_c = \frac{\mathrm{CN}_1\ \mathrm{A}_1 + \mathrm{CN}_2\ \mathrm{A}_2 \ldots\ \mathrm{CN}_n\ \mathrm{A}_n}{\mathrm{A}_1 + \mathrm{A}_2 \ldots\ \mathrm{A}_n} \quad [HydroCAD\ Owner's\ Manual, 2011]$$

Where:

CN_c = Composite CN Value
$CN_1 – CN_n$ = Individual CN Values
$A_1 – A_n$ = Area associated with each CN value

CN Calculation

A SCS Soil Type C is used based on Niagara-on-the-Lake typical loamy texture over heavy clay. This is confirmed in the Geotechnical Investigation performed by Soil-Mat dated September 9, 2016 for this development, which describes the soil as native silty sand/sandy silt below the topsoil.

Pervious CN Values:

CN 74 = Pasture in good condition
CN 74 = Parkland > 75% grass
CN 88 = Cultivated Land

Impervious CN Values:

CN 98 = Roof, Concrete, Asphalt
CN 93 = Gravel

Pre-Development Catchment 101					
Impervious			Pervious		
Surface	Area m^2	CN	Surface	Area	CN
Asphalt	63	98	Grass	1200	74
Gravel	30	93			
Shed, house, walkway	243	98			

Impervious CN_c = 97.6 Pervious CN_c = 74

$$Impervious\ CN_c = \frac{(63\ \mathrm{m}^2)\ (98) + (30\ \mathrm{m}^2)\ (93) + (243\ \mathrm{m}^2)\ (98)}{(63\ \mathrm{m}^2) + (30\ \mathrm{m}^2) + (243\ \mathrm{m}^2)} = 97.6$$

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Pre-Development Catchment 102					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Building	150	98	Grass	7515	74
			Cultivated	2195	88

Impervious CN_c = 98 Pervious CN_c = 77

Pre-Development Catchment 103					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Asphalt	320	98	Grass	1705	74
Gravel	455	93			
Concrete, building	192	98			

Impervious CN_c = 95.6 Pervious CN_c = 74

Post-Development Catchment 201					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Asphalt	687	98	Grass	380	74
Gravel	470	93			

Impervious CN_c = 96.0 Pervious CN_c = 74

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Post-Development Catchment 202					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Asphalt	1400	98	Grass	4923	74
Gravel	266	93	Cultivated	1844	88
Buildings	1422	98			

**Note: The proposed driveway shows gravel and conservative efforts have been made to account for future paving.*

Impervious CN_c = 97.5 Pervious CN_c = 77.8

Post-Development Catchment 203					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Asphalt	320	98	Grass	1705	74
Gravel	455	93			
Concrete, building	192	98			

Impervious CN_c = 95.6 Pervious CN_c = 74

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STORMWATER MANAGEMENT REPORT

Sunnybrook Building Addition

1425 Lakeshore Road,
Niagara-on-the-Lake, Ontario

APPENDIX C

MIDUSS Model Output

5-YR Storm – Catchment 1 Pre-Development Condition

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"       4.700   Constant B"
"       0.744   Exponent C"
"       0.375   Fraction R"
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"       1.500  Pervious slope"
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"       0.100  Pervious Ia/S coefficient"
"       7.587  Pervious Initial abstraction"
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"         8   Copy to Outflow"
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```
"            MIDUSS Output ------------------------------------------------>"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10 Units used:                              ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 3"
"            Output filename:                    5-YR_PRE_3A.out"
"            Licensee name:                          Quartek"
"            Company                          Quartek Group Inc."
"            Date & Time last used:           2/14/2017 at 11:10:23 AM"
" 31        TIME PARAMETERS"
"       5.000 Time Step"
"     180.000 Max. Storm length"
"    1500.000 Max. Hydrograph"
" 32        STORM Chicago storm"
"          1 Chicago storm"
"     664.000 Coefficient A"
"       4.700 Constant B"
"       0.744 Exponent C"
"       0.375 Fraction R"
"     180.000 Duration"
"       1.000 Time step multiplier"
"           Maximum intensity        120.814    mm/hr"
"           Total depth              41.024    mm"
"          6 005hyd Hydrograph extension used in this file"
" 33        CATCHMENT 103"
"          1 Triangular SCS"
"          1 Equal length"
"          1 SCS method"
"        103 Pre Development Site"
"      36.200 % Impervious"
"       0.270 Total Area"
"      62.000 Flow length"
"       2.000 Overland Slope"
"       0.172 Pervious Area"
"      62.000 Pervious length"
"       2.000 Pervious slope"
"       0.098 Impervious Area"
"      62.000 Impervious length"
"       2.000 Impervious slope"
"       0.250 Pervious Manning 'n'"
"      74.000 Pervious SCS Curve No."
"       0.207 Pervious Runoff coefficient"
"       0.100 Pervious Ia/S coefficient"
"       8.924 Pervious Initial abstraction"
"       0.015 Impervious Manning 'n'"
"      95.600 Impervious SCS Curve No."
"       0.736 Impervious Runoff coefficient"
```

```
"      0.100   Impervious Ia/S coefficient"
"      1.169   Impervious Initial abstraction"
"              0.020     0.000     0.000     0.000 c.m/sec"
"         Catchment 103         Pervious   Impervious Total Area "
"         Surface Area          0.172      0.098      0.270      hectare"
"         Time of concentration  38.078     3.482     14.942     minutes"
"         Time to Centroid       147.455    94.466    112.018    minutes"
"         Rainfall depth         41.024     41.024     41.024     mm"
"         Rainfall volume        70.67      40.10      110.76     c.m"
"         Rainfall losses        32.537     10.825     24.677     mm"
"         Runoff depth           8.487      30.199     16.347     mm"
"         Runoff volume          14.62      29.52      44.14      c.m"
"         Runoff coefficient     0.207      0.736      0.398      "
"         Maximum flow           0.003      0.020      0.020      c.m/sec"
" 40        HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"              0.020     0.020     0.000     0.000"
" 51        PIPE DESIGN"
"      0.020   Current peak flow    c.m/sec"
"      0.024   Manning 'n'"
"      0.300   Diameter    metre"
"      0.070   Gradient   %"
"         Surcharged HGL             0.147    %"
"         Velocity                   0.285    m/sec"
"         Pipe capacity              0.014    c.m/sec"
"         Critical depth             0.000    metre"
" 53        ROUTE    Pipe Route 26"
"      25.80      Pipe Route 26 Reach length   ( metre)"
"      0.000   X-factor <= 0.5"
"      0.000   K-lag   ( seconds)"
"      0.000   Default(0) or user spec.(1) values used"
"      0.500   X-factor <= 0.5"
"     30.000   K-lag   ( seconds)"
"      0.000   Beta weighting factor"
"      0.000   Routing time step   ( seconds)"
"         0   No. of sub-reaches"
"         Peak outflow               0.020    c.m/sec"
"              0.020     0.020     0.020     0.000 c.m/sec"
" 38        START/RE-START TOTALS 103"
"         3   Runoff Totals on EXIT"
"         Total Catchment area                 0.270    hectare"
"         Total Impervious area                0.098    hectare"
"         Total % impervious                  36.200"
" 19        EXIT"
```

5-YR Storm – Catchment 1 Post-Development Condition

```
"            MIDUSS Output ------------------------------------------------>"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                    Tuesday, February 05, 2008"
"         10 Units used:                                ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 1"
"            Output filename:                    5-YR_POST_1C.out"
"            Licensee name:                            Quartek"
"            Company                           Quartek Group Inc."
"            Date & Time last used:             2/15/2017 at 11:37:04 AM"
" 31        TIME PARAMETERS"
"       5.000 Time Step"
"     180.000 Max. Storm length"
"    1500.000 Max. Hydrograph"
" 32         STORM Chicago storm"
"          1 Chicago storm"
"     664.000 Coefficient A"
"       4.700 Constant B"
"       0.744 Exponent C"
"       0.375 Fraction R"
"     180.000 Duration"
"       1.000 Time step multiplier"
"           Maximum intensity         120.814    mm/hr"
"           Total depth               41.024    mm"
"          6 005hyd Hydrograph extension used in this file"
" 33         CATCHMENT 201"
"          1 Triangular SCS"
"          1 Equal length"
"          1 SCS method"
"        201 Post Development Site"
"      75.300 % Impervious"
"       0.150 Total Area"
"      31.000 Flow length"
"       1.700 Overland Slope"
"       0.037 Pervious Area"
"      31.000 Pervious length"
"       1.700 Pervious slope"
"       0.113 Impervious Area"
"      31.000 Impervious length"
"       1.700 Impervious slope"
"       0.250 Pervious Manning 'n'"
"      74.000 Pervious SCS Curve No."
"       0.207 Pervious Runoff coefficient"
"       0.100 Pervious Ia/S coefficient"
"       8.924 Pervious Initial abstraction"
"       0.015 Impervious Manning 'n'"
"      96.000 Impervious SCS Curve No."
"       0.760 Impervious Runoff coefficient"
```

```
"       0.100   Impervious Ia/S coefficient"
"       1.058   Impervious Initial abstraction"
"                0.022     0.000     0.000     0.000 c.m/sec"
"          Catchment 201         Pervious   Impervious Total Area "
"          Surface Area          0.037      0.113      0.150      hectare"
"          Time of concentration  26.378     2.385      4.353      minutes"
"          Time to Centroid       133.706    92.277     95.674     minutes"
"          Rainfall depth         41.024     41.024     41.024     mm"
"          Rainfall volume        15.20      46.34      61.54      c.m"
"          Rainfall losses        32.537     9.858      15.460     mm"
"          Runoff depth           8.487      31.166     25.564     mm"
"          Runoff volume          3.14       35.20      38.35      c.m"
"          Runoff coefficient     0.207      0.760      0.623      "
"          Maximum flow           0.001      0.022      0.022      c.m/sec"
" 40         HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"                0.022     0.022     0.000     0.000"
" 52         CHANNEL DESIGN"
"       0.022   Current peak flow    c.m/sec"
"       0.045   Manning 'n'"
"         0.   Cross-section type: 0=trapezoidal; 1=general"
"       1.000   Basewidth    metre"
"       3.000   Left bank slope"
"       3.000   Right bank slope"
"       0.500   Channel depth    metre"
"       0.500   Gradient   %"
"          Depth of flow              0.074    metre"
"          Velocity                   0.244    m/sec"
"          Channel capacity           0.881    c.m/sec"
"          Critical depth             0.035    metre"
" 53         ROUTE    Channel Route 25"
"       25.00      Channel Route 25 Reach length   ( metre)"
"       0.332   X-factor <= 0.5"
"      76.688   K-lag   ( seconds)"
"       0.000   Default(0) or user spec.(1) values used"
"       0.500   X-factor <= 0.5"
"      30.000   K-lag   ( seconds)"
"       0.500   Beta weighting factor"
"     100.000   Routing time step   ( seconds)"
"          1   No. of sub-reaches"
"          Peak outflow               0.022    c.m/sec"
"                0.022     0.022     0.022     0.000 c.m/sec"
" 40         HYDROGRAPH Next link "
"          5   Next link "
"                0.022     0.022     0.022     0.000"
" 58         CULVERT"
"       0.022   Culvert Q    c.m/sec"
"        2.00   Length    metre"
```

" 0.013 Manning 'n'"
" 80.330 Upstream IL metre"
" 80.290 Downstream IL metre"
" 80.550 Weir Elev. metre"
" 1.000 Weir Breadth. metre"
" 20.000 Weir Left slope to 1"
" 20.000 Weir Right slope to 1"
" 80.150 Tail water elevation"
" 1 Barrel Option (Pipe/Box/CSPA/HE/VE)"
" 0.100 Barrel Height/Diameter"
" 0.100 Barrel Width"
" 0.500 Cc 001 CSP thin walled projecting"
" 0.900 Ke 012 Project from fill"
" 1. Number of Barrels"
" 39 Number of stages"
" Level Discharge Volume"
" 80.330 0.000 0.0"
" 80.386 0.001 1.1"
" 80.412 0.002 1.8"
" 80.435 0.003 2.6"
" 80.456 0.004 3.4"
" 80.477 0.005 4.3"
" 80.564 0.007 8.5"
" 80.625 0.008 12.1"
" 80.696 0.009 16.9"
" 80.778 0.010 23.3"
" 80.869 0.011 31.6"
" 80.971 0.012 43.4"
" 81.082 0.013 62.1"
" 81.204 0.014 89.4"
" 81.335 0.015 127.3"
" 81.476 0.016 177.7"
" 81.627 0.018 242.6"
" 81.788 0.019 324.2"
" 81.959 0.020 424.9"
" 82.139 0.021 547.1"
" 82.329 0.022 693.6"
" 82.529 0.023 867.0"
" 82.738 0.024 1070.4"
" 82.958 0.025 1306.7"
" 83.187 0.026 1579.1"
" 83.425 0.027 1891.1"
" 83.674 0.029 2246.1"
" 83.932 0.030 2647.7"
" 84.200 0.031 3099.7"
" 84.478 0.032 3606.0"
" 84.765 0.033 4170.8"
" 85.062 0.034 4798.1"

```
"            85.369    0.035   5492.3"
"            85.686    0.036   6258.0"
"            86.013    0.037   7099.7"
"            86.349    0.038   8022.3"
"            86.695    0.039   9030.6"
"            87.050    0.041  10129.6"
"            87.416    0.042  11324.7"
"      1.000   Channel Basewidth"
"      0.500   Channel Depth"
"      4.000   Channel Topwidth"
"     10.000   Grade Left"
"     10.000   Grade Right"
"      0.500   Grade %"
"     25.000   Length"
"          Barrel Yo                0.100    metre"
"          Barrel Ycr               0.088    metre"
"          Exit Velocity            1.061    m/sec"
"          Barrel Peak Outflow      0.008    c.m/sec"
"          Weir Peak Flow           0.000    c.m/sec"
"          Total Peak Outflow       0.008    c.m/sec"
"          Maximum level           80.550    metre"
"          Maximum storage         12.615    c.m"
"          Centroidal lag           1.944   hours"
"            0.022    0.022    0.008    0.000 c.m/sec"
" 38       START/RE-START TOTALS 201"
"          3   Runoff Totals on EXIT"
"          Total Catchment area              0.150    hectare"
"          Total Impervious area             0.113    hectare"
"          Total % impervious               75.300"
" 19       EXIT"
```

```
"            MIDUSS Output ---------------------------------------------->"
"            MIDUSS version                  Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10 Units used:                            ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 2"
"            Output filename:                  5-YR_POST_2C.out"
"            Licensee name:                          Quartek"
"            Company                         Quartek Group Inc."
"            Date & Time last used:            2/15/2017 at 9:13:00 AM"
" 31        TIME PARAMETERS"
"       5.000 Time Step"
"     180.000 Max. Storm length"
"    1500.000 Max. Hydrograph"
" 32         STORM Chicago storm"
"          1 Chicago storm"
"     664.000 Coefficient A"
"       4.700 Constant B"
"       0.744 Exponent C"
"       0.375 Fraction R"
"     180.000 Duration"
"       1.000 Time step multiplier"
"           Maximum intensity         120.814    mm/hr"
"           Total depth               41.024    mm"
"          6 005hyd Hydrograph extension used in this file"
" 33         CATCHMENT 202"
"          1 Triangular SCS"
"          1 Equal length"
"          1 SCS method"
"        202 Post area to swale"
"      31.300 % Impervious"
"       0.986 Total Area"
"      60.000 Flow length"
"       1.500 Overland Slope"
"       0.677 Pervious Area"
"      60.000 Pervious length"
"       1.500 Pervious slope"
"       0.309 Impervious Area"
"      60.000 Impervious length"
"       1.500 Impervious slope"
"       0.250 Pervious Manning 'n'"
"      77.800 Pervious SCS Curve No."
"       0.262 Pervious Runoff coefficient"
"       0.100 Pervious Ia/S coefficient"
"       7.248 Pervious Initial abstraction"
"       0.015 Impervious Manning 'n'"
"      97.500 Impervious SCS Curve No."
"       0.830 Impervious Runoff coefficient"
```

```
"       0.100   Impervious Ia/S coefficient"
"       0.651   Impervious Initial abstraction"
"               0.072     0.000     0.000     0.000 c.m/sec"
"          Catchment 202         Pervious   Impervious Total Area "
"          Surface Area          0.677      0.309      0.986     hectare"
"          Time of concentration 35.099     3.537      16.439    minutes"
"          Time to Centroid      144.063    92.274     113.446   minutes"
"          Rainfall depth        41.024     41.024     41.024    mm"
"          Rainfall volume       277.89     126.61     404.50    c.m"
"          Rainfall losses       30.294     6.964      22.991    mm"
"          Runoff depth          10.730     34.060     18.033    mm"
"          Runoff volume         72.68      105.12     177.80    c.m"
"          Runoff coefficient    0.262      0.830      0.440     "
"          Maximum flow          0.014      0.069      0.072     c.m/sec"
" 40         HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"               0.072     0.072     0.000     0.000"
" 52         CHANNEL DESIGN"
"       0.072   Current peak flow    c.m/sec"
"       0.045   Manning 'n'"
"         0.   Cross-section type: 0=trapezoidal; 1=general"
"       0.500   Basewidth    metre"
"       3.000   Left bank slope"
"       3.000   Right bank slope"
"       0.300   Channel depth    metre"
"       0.500   Gradient   %"
"          Depth of flow              0.183    metre"
"          Velocity                   0.374    m/sec"
"          Channel capacity           0.207    c.m/sec"
"          Critical depth             0.104    metre"
" 40         HYDROGRAPH Copy to Outflow"
"          8   Copy to Outflow"
"               0.072     0.072     0.072     0.000"
" 40         HYDROGRAPH Next link "
"          5   Next link "
"               0.072     0.072     0.072     0.000"
" 54         POND DESIGN"
"       0.072   Current peak flow    c.m/sec"
"       0.013   Target outflow    c.m/sec"
"       177.8   Hydrograph volume    c.m"
"        42.   Number of stages"
"       0.000   Minimum water level    metre"
"       0.500   Maximum water level    metre"
"       0.040   Starting water level    metre"
"          0   Keep Design Data: 1 = True; 0 = False"
"              Level Discharge    Volume"
"              0.000     0.000     0.000"
"             0.01220  1.01E-05  1.00E-07"
```

" 0.02439 1.01E-05 1.00E-07"
" 0.03659 1.01E-05 1.00E-07"
" 0.04878 4.92E-05 4.405"
" 0.06098 0.00025 10.574"
" 0.07317 0.00062 16.795"
" 0.08537 0.00115 23.078"
" 0.09756 0.00183 29.413"
" 0.1098 0.00264 35.832"
" 0.1220 0.00358 42.288"
" 0.1341 0.00461 48.748"
" 0.1463 0.00573 55.320"
" 0.1585 0.00690 61.950"
" 0.1707 0.00811 68.639"
" 0.1829 0.00933 75.387"
" 0.1951 0.01051 82.194"
" 0.2073 0.01160 89.061"
" 0.2195 0.01255 95.987"
" 0.2317 0.02621 102.973"
" 0.2439 0.02703 110.019"
" 0.2561 0.02783 117.126"
" 0.2683 0.02860 124.293"
" 0.2805 0.02935 131.521"
" 0.2927 0.03009 138.810"
" 0.3049 0.03081 146.161"
" 0.3171 0.03151 153.573"
" 0.3293 0.03219 161.046"
" 0.3415 0.03287 168.582"
" 0.3537 0.03352 176.180"
" 0.3659 0.03417 183.840"
" 0.3780 0.03480 191.500"
" 0.3902 0.03542 199.286"
" 0.4024 0.03603 207.134"
" 0.4146 0.03663 215.046"
" 0.4268 0.03723 223.022"
" 0.4390 0.03781 231.061"
" 0.4512 0.03838 239.165"
" 0.4634 0.03895 247.333"
" 0.4756 0.03950 255.565"
" 0.4878 0.04005 263.862"
" 0.5000 0.04059 272.225"
" 1. LAYERS"
" Bottom Aspect Bottom Top Average"
" area ratio elevation elevation sideslope"
" 500.000 2.000 0.040 0.500 4.000"
" 1. OUTFLOW PIPE"
" Upstream Downstr'm Pipe Pipe Manning Entry"
" invert invert Length Diameter 'n' loss Ke"
" 0.040 0.000 8.000 0.200 0.024 0.500"

5-YR Storm – Catchment 2 Post-Development Condition

" Peak outflow 0.012 c.m/sec"
" Maximum level 0.218 metre"
" Maximum storage 94.906 c.m"
" Centroidal lag 4.491 hours"
" 0.072 0.072 0.012 0.000 c.m/sec"
" 38 START/RE-START TOTALS 202"
" 3 Runoff Totals on EXIT"
" Total Catchment area 0.986 hectare"
" Total Impervious area 0.309 hectare"
" Total % impervious 31.300"
" 19 EXIT"

5-YR Storm – Catchment 3 Post-Development Condition

```
"            MIDUSS Output ---------------------------------------------->"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10   Units used:                           ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 3"
"            Output filename:                    5-YR_POST_3A.out"
"            Licensee name:                          Quartek"
"            Company                          Quartek Group Inc."
"            Date & Time last used:            2/14/2017 at 11:15:39 AM"
" 31         TIME PARAMETERS"
"       5.000   Time Step"
"     180.000   Max. Storm length"
"    1500.000   Max. Hydrograph"
" 32         STORM Chicago storm"
"          1   Chicago storm"
"     664.000   Coefficient A"
"       4.700   Constant B"
"       0.744   Exponent C"
"       0.375   Fraction R"
"     180.000   Duration"
"       1.000   Time step multiplier"
"            Maximum intensity         120.814    mm/hr"
"            Total depth               41.024    mm"
"          6   005hyd   Hydrograph extension used in this file"
" 33         CATCHMENT 103"
"          1   Triangular SCS"
"          1   Equal length"
"          1   SCS method"
"        103   Pre Development Site"
"      36.200   % Impervious"
"       0.270   Total Area"
"      62.000   Flow length"
"       2.000   Overland Slope"
"       0.172   Pervious Area"
"      62.000   Pervious length"
"       2.000   Pervious slope"
"       0.098   Impervious Area"
"      62.000   Impervious length"
"       2.000   Impervious slope"
"       0.250   Pervious Manning 'n'"
"      74.000   Pervious SCS Curve No."
"       0.207   Pervious Runoff coefficient"
"       0.100   Pervious Ia/S coefficient"
"       8.924   Pervious Initial abstraction"
"       0.015   Impervious Manning 'n'"
"      95.600   Impervious SCS Curve No."
"       0.736   Impervious Runoff coefficient"
```

```
"       0.100   Impervious Ia/S coefficient"
"       1.169   Impervious Initial abstraction"
"               0.020     0.000     0.000     0.000 c.m/sec"
"          Catchment 103         Pervious   Impervious Total Area "
"          Surface Area          0.172      0.098      0.270      hectare"
"          Time of concentration 38.078     3.482      14.942     minutes"
"          Time to Centroid      147.455    94.466     112.018    minutes"
"          Rainfall depth        41.024     41.024     41.024     mm"
"          Rainfall volume       70.67      40.10      110.76     c.m"
"          Rainfall losses       32.537     10.825     24.677     mm"
"          Runoff depth          8.487      30.199     16.347     mm"
"          Runoff volume         14.62      29.52      44.14      c.m"
"          Runoff coefficient    0.207      0.736      0.398      "
"          Maximum flow          0.003      0.020      0.020      c.m/sec"
" 40         HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"               0.020     0.020     0.000     0.000"
" 51         PIPE DESIGN"
"       0.020   Current peak flow    c.m/sec"
"       0.024   Manning 'n'"
"       0.300   Diameter    metre"
"       0.070   Gradient   %"
"          Surcharged HGL             0.147    %"
"          Velocity                   0.285    m/sec"
"          Pipe capacity              0.014    c.m/sec"
"          Critical depth             0.000    metre"
" 53         ROUTE    Pipe Route 26"
"       25.80     Pipe Route 26 Reach length   ( metre)"
"       0.000   X-factor <= 0.5"
"       0.000   K-lag   ( seconds)"
"       0.000   Default(0) or user spec.(1) values used"
"       0.500   X-factor <= 0.5"
"      30.000   K-lag   ( seconds)"
"       0.000   Beta weighting factor"
"       0.000   Routing time step   ( seconds)"
"          0   No. of sub-reaches"
"          Peak outflow               0.020    c.m/sec"
"               0.020     0.020     0.020     0.000 c.m/sec"
" 38         START/RE-START TOTALS 103"
"          3   Runoff Totals on EXIT"
"          Total Catchment area                 0.270    hectare"
"          Total Impervious area                0.098    hectare"
"          Total % impervious                   36.200"
" 19         EXIT"
```

25 mm Storm – Catchment 2 Post-Development Condition

```
"            MIDUSS Output ---------------------------------------------->"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10   Units used:                              ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 2"
"            Output filename:                      25mm_POST_2A.out"
"            Licensee name:                             Quartek"
"            Company                           Quartek Group Inc."
"            Date & Time last used:             2/15/2017 at 11:34:55 AM"
" 31         TIME PARAMETERS"
"       5.000   Time Step"
"     240.000   Max. Storm length"
"    1500.000   Max. Hydrograph"
" 32         STORM Chicago storm"
"          1   Chicago storm"
"     483.850   Coefficient A"
"       6.000   Constant B"
"       0.790   Exponent C"
"       0.400   Fraction R"
"     240.000   Duration"
"       1.000   Time step multiplier"
"            Maximum intensity          69.927    mm/hr"
"            Total depth               25.000    mm"
"          6   025hyd   Hydrograph extension used in this file"
" 33         CATCHMENT 202"
"          1   Triangular SCS"
"          1   Equal length"
"          1   SCS method"
"        202   Post area to swale"
"      31.300   % Impervious"
"       0.986   Total Area"
"      60.000   Flow length"
"       1.500   Overland Slope"
"       0.677   Pervious Area"
"      60.000   Pervious length"
"       1.500   Pervious slope"
"       0.309   Impervious Area"
"      60.000   Impervious length"
"       1.500   Impervious slope"
"       0.250   Pervious Manning 'n'"
"      77.800   Pervious SCS Curve No."
"       0.140   Pervious Runoff coefficient"
"       0.100   Pervious Ia/S coefficient"
"       7.248   Pervious Initial abstraction"
"       0.015   Impervious Manning 'n'"
"      97.500   Impervious SCS Curve No."
"       0.761   Impervious Runoff coefficient"
```

```
"       0.100   Impervious Ia/S coefficient"
"       0.651   Impervious Initial abstraction"
"                0.039     0.000     0.000     0.000 c.m/sec"
"          Catchment 202         Pervious   Impervious Total Area "
"          Surface Area          0.677      0.309      0.986     hectare"
"          Time of concentration  56.404    4.505     19.406    minutes"
"          Time to Centroid       212.479   125.820   150.701   minutes"
"          Rainfall depth         25.000    25.000    25.000    mm"
"          Rainfall volume        169.34    77.15     246.50    c.m"
"          Rainfall losses        21.508    5.971     16.645    mm"
"          Runoff depth           3.492     19.029    8.355     mm"
"          Runoff volume          23.65     58.73     82.38     c.m"
"          Runoff coefficient     0.140     0.761     0.334     "
"          Maximum flow           0.003     0.038     0.039     c.m/sec"
" 40         HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"                0.039     0.039     0.000     0.000"
" 52         CHANNEL DESIGN"
"       0.039   Current peak flow    c.m/sec"
"       0.045   Manning 'n'"
"         0.   Cross-section type: 0=trapezoidal; 1=general"
"       0.500   Basewidth    metre"
"       3.000   Left bank slope"
"       3.000   Right bank slope"
"       0.300   Channel depth    metre"
"       0.500   Gradient   %"
"          Depth of flow              0.136    metre"
"          Velocity                   0.317    m/sec"
"          Channel capacity           0.207    c.m/sec"
"          Critical depth             0.073    metre"
" 53         ROUTE    Channel Route 75"
"       75.00      Channel Route 75 Reach length   ( metre)"
"       0.409   X-factor <= 0.5"
"     177.455   K-lag   ( seconds)"
"       0.000   Default(0) or user spec.(1) values used"
"       0.500   X-factor <= 0.5"
"      30.000   K-lag   ( seconds)"
"       0.500   Beta weighting factor"
"     150.000   Routing time step   ( seconds)"
"          1   No. of sub-reaches"
"          Peak outflow               0.035    c.m/sec"
"                0.039     0.039     0.035     0.000 c.m/sec"
" 40         HYDROGRAPH Next link "
"          5   Next link "
"                0.039     0.035     0.035     0.000"
" 54         POND DESIGN"
"       0.035   Current peak flow    c.m/sec"
"       0.013   Target outflow    c.m/sec"
```

" 82.4 Hydrograph volume c.m"
" 42. Number of stages"
" 0.000 Minimum water level metre"
" 0.500 Maximum water level metre"
" 0.040 Starting water level metre"
" 0 Keep Design Data: 1 = True; 0 = False"
" Level Discharge Volume"
" 0.000 0.000 0.000"
" 0.01220 1.01E-05 1.00E-07"
" 0.02439 1.01E-05 1.00E-07"
" 0.03659 1.01E-05 1.00E-07"
" 0.04878 4.92E-05 4.405"
" 0.06098 0.00025 10.574"
" 0.07317 0.00062 16.795"
" 0.08537 0.00115 23.078"
" 0.09756 0.00183 29.413"
" 0.1098 0.00264 35.832"
" 0.1220 0.00358 42.288"
" 0.1341 0.00461 48.748"
" 0.1463 0.00573 55.320"
" 0.1585 0.00690 61.950"
" 0.1707 0.00811 68.639"
" 0.1829 0.00933 75.387"
" 0.1951 0.01051 82.194"
" 0.2073 0.01160 89.061"
" 0.2195 0.01255 95.987"
" 0.2317 0.02621 102.973"
" 0.2439 0.02703 110.019"
" 0.2561 0.02783 117.126"
" 0.2683 0.02860 124.293"
" 0.2805 0.02935 131.521"
" 0.2927 0.03009 138.810"
" 0.3049 0.03081 146.161"
" 0.3171 0.03151 153.573"
" 0.3293 0.03219 161.046"
" 0.3415 0.03287 168.582"
" 0.3537 0.03352 176.180"
" 0.3659 0.03417 183.840"
" 0.3780 0.03480 191.500"
" 0.3902 0.03542 199.286"
" 0.4024 0.03603 207.134"
" 0.4146 0.03663 215.046"
" 0.4268 0.03723 223.022"
" 0.4390 0.03781 231.061"
" 0.4512 0.03838 239.165"
" 0.4634 0.03895 247.333"
" 0.4756 0.03950 255.565"
" 0.4878 0.04005 263.862"

" 0.5000 0.04059 272.225"
" 1. LAYERS"
" Bottom Aspect Bottom Top Average"
" area ratio elevation elevation sideslope"
" 500.000 2.000 0.040 0.500 4.000"
" 1. OUTFLOW PIPE"
" Upstream Downstr'm Pipe Pipe Manning Entry"
" invert invert Length Diameter 'n' loss Ke"
" 0.040 0.000 8.000 0.200 0.024 0.500"
" Peak outflow 0.004 c.m/sec"
" Maximum level 0.130 metre"
" Maximum storage 46.789 c.m"
" Centroidal lag 7.449 hours"
" 0.039 0.035 0.004 0.000 c.m/sec"
" 38 START/RE-START TOTALS 202"
" 3 Runoff Totals on EXIT"
" Total Catchment area 0.986 hectare"
" Total Impervious area 0.309 hectare"
" Total % impervious 31.300"
" 19 EXIT"

Infiltration Trench Design

$A = \frac{(1{,}000)(\mathrm{V})}{\mathrm{P}\cdot\mathrm{n}\cdot\Delta\mathrm{t}}$ $[MOEcc\ Stormwater\ Management\ Planning\ and\ Design\ Manual, 2003]$ (SWMPD)

Where:

A = trench bottom footprint in m^2 (computed by length· width)
Δt = 48 hrs
n = 0.4 (50mm clear stone void ratio, unitless)
Geotechnical Investigation performed by Soil-Mat dated September 9, 2016 for this development recommends using a conservative T value (percolation time) of 20 min/cm, which is a percolation rate of
P = 30 mm/hr > 15mm/hr MOEcc minimum →OK
V = volume of runoff (m^3) from Table 3.2 in (SWMPD) for 75.3% Impervious recommends 26.8 m^3/ha.
Catchment area = 0.15 ha, V = 4.02 m^3

Area Calculation

Based on a perforated trench length of 25m, solving for area,'A', for the infiltration trench:

$$\mathrm{A} = \frac{(1{,}000)(4.02m^3)}{\frac{30\mathrm{mm}}{\mathrm{hr}}\cdot 0.40\cdot 48\mathrm{hr}}$$

A_{req} = 6.98 m^2 →

using a prop. trench W = 1.0 m wide infiltration trench with 25 m length A_{prop} = 25 m^2 > A_{req}

Thus, the proposed infiltration trench is proposed sufficient at **25 m long x 1.0 m wide**.

Underground Storage Calculation

The available storage within the clear stone is based on the following:

Width of Infiltration Trench	1.0 m	Open Cross Sectional Area	0.168 m^2
Total Height of Granular Surround	0.42 m	Length of Trench	25 m
Void Ratio	0.4	Total Underground Storage	**4.2 m^3**

$$\mathrm{V} = (0.168m^2)(25m) = 4.2m^3$$

Thus, the **4.2m^3** of underground storage will be available in the clear stone gallery to provide for quality management and is sufficient for the volume of runoff suggested from Table 3.2 in SWMPD. The entire quantity control of the 5-year storm runoff will be stored aboveground.

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Composite Curve Numbers

$$CN_c = \frac{\mathrm{CN}_1\ \mathrm{A}_1 + \mathrm{CN}_2\ \mathrm{A}_2 \ldots\ \mathrm{CN}_n\ \mathrm{A}_n}{\mathrm{A}_1 + \mathrm{A}_2 \ldots\ \mathrm{A}_n} \quad [HydroCAD\ Owner's\ Manual, 2011]$$

Where:

CN_c = Composite CN Value
$CN_1 – CN_n$ = Individual CN Values
$A_1 – A_n$ = Area associated with each CN value

CN Calculation

A SCS Soil Type C is used based on Niagara-on-the-Lake typical loamy texture over heavy clay. This is confirmed in the Geotechnical Investigation performed by Soil-Mat dated September 9, 2016 for this development, which describes the soil as native silty sand/sandy silt below the topsoil.

Pervious CN Values:

CN 74 = Pasture in good condition
CN 74 = Parkland > 75% grass
CN 88 = Cultivated Land

Impervious CN Values:

CN 98 = Roof, Concrete, Asphalt
CN 93 = Gravel

Pre-Development Catchment 101					
Impervious			Pervious		
Surface	Area m^2	CN	Surface	Area	CN
Asphalt	63	98	Grass	1200	74
Gravel	30	93			
Shed, house, walkway	243	98			

Impervious CN_c = 97.6 Pervious CN_c = 74

$$Impervious\ CN_c = \frac{(63\ \mathrm{m}^2)\ (98) + (30\ \mathrm{m}^2)\ (93) + (243\ \mathrm{m}^2)\ (98)}{(63\ \mathrm{m}^2) + (30\ \mathrm{m}^2) + (243\ \mathrm{m}^2)} = 97.6$$

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Pre-Development Catchment 102					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Building	150	98	Grass	7515	74
			Cultivated	2195	88

Impervious CN_c = 98 Pervious CN_c = 77

Pre-Development Catchment 103					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Asphalt	320	98	Grass	1705	74
Gravel	455	93			
Concrete, building	192	98			

Impervious CN_c = 95.6 Pervious CN_c = 74

Post-Development Catchment 201					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Asphalt	687	98	Grass	380	74
Gravel	470	93			

Impervious CN_c = 96.0 Pervious CN_c = 74

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Post-Development Catchment 202					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Asphalt	1400	98	Grass	4923	74
Gravel	266	93	Cultivated	1844	88
Buildings	1422	98			

**Note: The proposed driveway shows gravel and conservative efforts have been made to account for future paving.*

Impervious CN_c = 97.5 Pervious CN_c = 77.8

Post-Development Catchment 203					
Impervious			**Pervious**		
Surface	**Area m^2**	**CN**	**Surface**	**Area**	**CN**
Asphalt	320	98	Grass	1705	74
Gravel	455	93			
Concrete, building	192	98			

Impervious CN_c = 95.6 Pervious CN_c = 74

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5-YR Storm – Catchment 1 Pre-Development Condition

```
"            MIDUSS Output ---------------------------------------------->"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10   Units used:                              ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 1"
"            Output filename:                      5-YR_PRE_1C.out"
"            Licensee name:                            Quartek"
"            Company                           Quartek Group Inc."
"            Date & Time last used:            2/14/2017 at 10:33:42 AM"
" 31         TIME PARAMETERS"
"       5.000   Time Step"
"     180.000   Max. Storm length"
"    1500.000   Max. Hydrograph"
" 32         STORM Chicago storm"
"          1   Chicago storm"
"     664.000   Coefficient A"
"       4.700   Constant B"
"       0.744   Exponent C"
"       0.375   Fraction R"
"     180.000   Duration"
"       1.000   Time step multiplier"
"           Maximum intensity         120.814    mm/hr"
"           Total depth               41.024    mm"
"          6   005hyd   Hydrograph extension used in this file"
" 33         CATCHMENT 101"
"          1   Triangular SCS"
"          1   Equal length"
"          1   SCS method"
"        101   Pre Development Site"
"      21.900   % Impervious"
"       0.150   Total Area"
"      31.000   Flow length"
"       1.500   Overland Slope"
"       0.117   Pervious Area"
"      31.000   Pervious length"
"       1.500   Pervious slope"
"       0.033   Impervious Area"
"      31.000   Impervious length"
"       1.500   Impervious slope"
"       0.250   Pervious Manning 'n'"
"      74.000   Pervious SCS Curve No."
"       0.207   Pervious Runoff coefficient"
"       0.100   Pervious Ia/S coefficient"
"       8.924   Pervious Initial abstraction"
"       0.015   Impervious Manning 'n'"
"      97.600   Impervious SCS Curve No."
"       0.841   Impervious Runoff coefficient"
```

" 0.100 Impervious Ia/S coefficient"
" 0.625 Impervious Initial abstraction"
" 0.008 0.000 0.000 0.000 c.m/sec"
" Catchment 101 Pervious Impervious Total Area "
" Surface Area 0.117 0.033 0.150 hectare"
" Time of concentration 27.387 2.374 14.061 minutes"
" Time to Centroid 134.888 90.266 111.115 minutes"
" Rainfall depth 41.024 41.024 41.024 mm"
" Rainfall volume 48.06 13.48 61.54 c.m"
" Rainfall losses 32.539 6.522 26.841 mm"
" Runoff depth 8.485 34.502 14.183 mm"
" Runoff volume 9.94 11.33 21.27 c.m"
" Runoff coefficient 0.207 0.841 0.346 "
" Maximum flow 0.002 0.007 0.008 c.m/sec"
" 40 HYDROGRAPH Add Runoff "
" 4 Add Runoff "
" 0.008 0.008 0.000 0.000"
" 40 HYDROGRAPH Copy to Outflow"
" 8 Copy to Outflow"
" 0.008 0.008 0.008 0.000"
" 38 START/RE-START TOTALS 101"
" 3 Runoff Totals on EXIT"
" Total Catchment area 0.150 hectare"
" Total Impervious area 0.033 hectare"
" Total % impervious 21.900"
" 19 EXIT"

```
"            MIDUSS Output ---------------------------------------------->"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10 Units used:                              ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 2"
"            Output filename:                    5-YR_PRE_2A.out"
"            Licensee name:                          Quartek"
"            Company                          Quartek Group Inc."
"            Date & Time last used:           12/19/2016 at 11:39:18 AM"
" 31        TIME PARAMETERS"
"       5.000  Time Step"
"     180.000  Max. Storm length"
"    1500.000  Max. Hydrograph"
" 32        STORM Chicago storm"
"          1  Chicago storm"
"     664.000  Coefficient A"
"       4.700  Constant B"
"       0.744  Exponent C"
"       0.375  Fraction R"
"     180.000  Duration"
"       1.000  Time step multiplier"
"           Maximum intensity         120.814    mm/hr"
"           Total depth               41.024    mm"
"          6  005hyd  Hydrograph extension used in this file"
" 40        HYDROGRAPH Start - New Tributary"
"          2  Start - New Tributary"
"               0.000     0.000     0.000     0.000"
" 33        CATCHMENT 102"
"          1  Triangular SCS"
"          1  Equal length"
"          1  SCS method"
"        102  Pre Development Site"
"       1.500  % Impervious"
"       0.986  Total Area"
"     149.000  Flow length"
"       1.500  Overland Slope"
"       0.971  Pervious Area"
"     149.000  Pervious length"
"       1.500  Pervious slope"
"       0.015  Impervious Area"
"     149.000  Impervious length"
"       1.500  Impervious slope"
"       0.250  Pervious Manning 'n'"
"      77.000  Pervious SCS Curve No."
"       0.249  Pervious Runoff coefficient"
"       0.100  Pervious Ia/S coefficient"
"       7.587  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"
"              0.013     0.000     0.000     0.000 c.m/sec"
"         Catchment 102         Pervious   Impervious Total Area "
"         Surface Area          0.971     0.015     0.986     hectare"
"         Time of concentration  62.376    6.032     59.533    minutes"
"         Time to Centroid       177.413   95.217    173.266   minutes"
"         Rainfall depth         41.024    41.024    41.024    mm"
"         Rainfall volume        398.43    6.07      404.50    c.m"
"         Rainfall losses        30.797    5.344     30.415    mm"
"         Runoff depth           10.227    35.680    10.609    mm"
"         Runoff volume          99.33     5.28      104.60    c.m"
"         Runoff coefficient     0.249     0.870     0.259     "
"         Maximum flow           0.013     0.003     0.013     c.m/sec"
" 40        HYDROGRAPH Add Runoff "
"         4   Add Runoff "
"              0.013     0.013     0.000     0.000"
" 40        HYDROGRAPH Copy to Outflow"
"         8   Copy to Outflow"
"              0.013     0.013     0.013     0.000"
" 38        START/RE-START TOTALS 102"
"         3   Runoff Totals on EXIT"
"         Total Catchment area                  0.986    hectare"
"         Total Impervious area                 0.015    hectare"
"         Total % impervious                    1.500"
" 19        EXIT"
```

```
"            MIDUSS Output ------------------------------------------------>"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10 Units used:                              ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 3"
"            Output filename:                    5-YR_PRE_3A.out"
"            Licensee name:                          Quartek"
"            Company                          Quartek Group Inc."
"            Date & Time last used:           2/14/2017 at 11:10:23 AM"
" 31        TIME PARAMETERS"
"       5.000 Time Step"
"     180.000 Max. Storm length"
"    1500.000 Max. Hydrograph"
" 32        STORM Chicago storm"
"          1 Chicago storm"
"     664.000 Coefficient A"
"       4.700 Constant B"
"       0.744 Exponent C"
"       0.375 Fraction R"
"     180.000 Duration"
"       1.000 Time step multiplier"
"           Maximum intensity        120.814    mm/hr"
"           Total depth              41.024    mm"
"          6 005hyd Hydrograph extension used in this file"
" 33        CATCHMENT 103"
"          1 Triangular SCS"
"          1 Equal length"
"          1 SCS method"
"        103 Pre Development Site"
"      36.200 % Impervious"
"       0.270 Total Area"
"      62.000 Flow length"
"       2.000 Overland Slope"
"       0.172 Pervious Area"
"      62.000 Pervious length"
"       2.000 Pervious slope"
"       0.098 Impervious Area"
"      62.000 Impervious length"
"       2.000 Impervious slope"
"       0.250 Pervious Manning 'n'"
"      74.000 Pervious SCS Curve No."
"       0.207 Pervious Runoff coefficient"
"       0.100 Pervious Ia/S coefficient"
"       8.924 Pervious Initial abstraction"
"       0.015 Impervious Manning 'n'"
"      95.600 Impervious SCS Curve No."
"       0.736 Impervious Runoff coefficient"
```

```
"      0.100   Impervious Ia/S coefficient"
"      1.169   Impervious Initial abstraction"
"              0.020     0.000     0.000     0.000 c.m/sec"
"         Catchment 103         Pervious   Impervious Total Area "
"         Surface Area          0.172      0.098      0.270      hectare"
"         Time of concentration  38.078     3.482     14.942     minutes"
"         Time to Centroid       147.455    94.466    112.018    minutes"
"         Rainfall depth         41.024     41.024     41.024     mm"
"         Rainfall volume        70.67      40.10      110.76     c.m"
"         Rainfall losses        32.537     10.825     24.677     mm"
"         Runoff depth           8.487      30.199     16.347     mm"
"         Runoff volume          14.62      29.52      44.14      c.m"
"         Runoff coefficient     0.207      0.736      0.398      "
"         Maximum flow           0.003      0.020      0.020      c.m/sec"
" 40        HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"              0.020     0.020     0.000     0.000"
" 51        PIPE DESIGN"
"      0.020   Current peak flow    c.m/sec"
"      0.024   Manning 'n'"
"      0.300   Diameter    metre"
"      0.070   Gradient   %"
"         Surcharged HGL             0.147    %"
"         Velocity                   0.285    m/sec"
"         Pipe capacity              0.014    c.m/sec"
"         Critical depth             0.000    metre"
" 53        ROUTE    Pipe Route 26"
"      25.80      Pipe Route 26 Reach length   ( metre)"
"      0.000   X-factor <= 0.5"
"      0.000   K-lag   ( seconds)"
"      0.000   Default(0) or user spec.(1) values used"
"      0.500   X-factor <= 0.5"
"     30.000   K-lag   ( seconds)"
"      0.000   Beta weighting factor"
"      0.000   Routing time step   ( seconds)"
"         0   No. of sub-reaches"
"         Peak outflow               0.020    c.m/sec"
"              0.020     0.020     0.020     0.000 c.m/sec"
" 38        START/RE-START TOTALS 103"
"         3   Runoff Totals on EXIT"
"         Total Catchment area                 0.270    hectare"
"         Total Impervious area                0.098    hectare"
"         Total % impervious                  36.200"
" 19        EXIT"
```

5-YR Storm – Catchment 1 Post-Development Condition

```
"            MIDUSS Output ------------------------------------------------>"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                    Tuesday, February 05, 2008"
"         10 Units used:                                ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 1"
"            Output filename:                    5-YR_POST_1C.out"
"            Licensee name:                            Quartek"
"            Company                           Quartek Group Inc."
"            Date & Time last used:             2/15/2017 at 11:37:04 AM"
" 31        TIME PARAMETERS"
"       5.000 Time Step"
"     180.000 Max. Storm length"
"    1500.000 Max. Hydrograph"
" 32         STORM Chicago storm"
"          1 Chicago storm"
"     664.000 Coefficient A"
"       4.700 Constant B"
"       0.744 Exponent C"
"       0.375 Fraction R"
"     180.000 Duration"
"       1.000 Time step multiplier"
"           Maximum intensity         120.814    mm/hr"
"           Total depth               41.024    mm"
"          6 005hyd Hydrograph extension used in this file"
" 33         CATCHMENT 201"
"          1 Triangular SCS"
"          1 Equal length"
"          1 SCS method"
"        201 Post Development Site"
"      75.300 % Impervious"
"       0.150 Total Area"
"      31.000 Flow length"
"       1.700 Overland Slope"
"       0.037 Pervious Area"
"      31.000 Pervious length"
"       1.700 Pervious slope"
"       0.113 Impervious Area"
"      31.000 Impervious length"
"       1.700 Impervious slope"
"       0.250 Pervious Manning 'n'"
"      74.000 Pervious SCS Curve No."
"       0.207 Pervious Runoff coefficient"
"       0.100 Pervious Ia/S coefficient"
"       8.924 Pervious Initial abstraction"
"       0.015 Impervious Manning 'n'"
"      96.000 Impervious SCS Curve No."
"       0.760 Impervious Runoff coefficient"
```

```
"       0.100   Impervious Ia/S coefficient"
"       1.058   Impervious Initial abstraction"
"                0.022     0.000     0.000     0.000 c.m/sec"
"          Catchment 201         Pervious   Impervious Total Area "
"          Surface Area          0.037      0.113      0.150      hectare"
"          Time of concentration  26.378     2.385      4.353      minutes"
"          Time to Centroid       133.706    92.277     95.674     minutes"
"          Rainfall depth         41.024     41.024     41.024     mm"
"          Rainfall volume        15.20      46.34      61.54      c.m"
"          Rainfall losses        32.537     9.858      15.460     mm"
"          Runoff depth           8.487      31.166     25.564     mm"
"          Runoff volume          3.14       35.20      38.35      c.m"
"          Runoff coefficient     0.207      0.760      0.623      "
"          Maximum flow           0.001      0.022      0.022      c.m/sec"
" 40         HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"                0.022     0.022     0.000     0.000"
" 52         CHANNEL DESIGN"
"       0.022   Current peak flow    c.m/sec"
"       0.045   Manning 'n'"
"         0.   Cross-section type: 0=trapezoidal; 1=general"
"       1.000   Basewidth    metre"
"       3.000   Left bank slope"
"       3.000   Right bank slope"
"       0.500   Channel depth    metre"
"       0.500   Gradient   %"
"          Depth of flow              0.074    metre"
"          Velocity                   0.244    m/sec"
"          Channel capacity           0.881    c.m/sec"
"          Critical depth             0.035    metre"
" 53         ROUTE    Channel Route 25"
"       25.00      Channel Route 25 Reach length   ( metre)"
"       0.332   X-factor <= 0.5"
"      76.688   K-lag   ( seconds)"
"       0.000   Default(0) or user spec.(1) values used"
"       0.500   X-factor <= 0.5"
"      30.000   K-lag   ( seconds)"
"       0.500   Beta weighting factor"
"     100.000   Routing time step   ( seconds)"
"          1   No. of sub-reaches"
"          Peak outflow               0.022    c.m/sec"
"                0.022     0.022     0.022     0.000 c.m/sec"
" 40         HYDROGRAPH Next link "
"          5   Next link "
"                0.022     0.022     0.022     0.000"
" 58         CULVERT"
"       0.022   Culvert Q    c.m/sec"
"        2.00   Length    metre"
```

" 0.013 Manning 'n'"
" 80.330 Upstream IL metre"
" 80.290 Downstream IL metre"
" 80.550 Weir Elev. metre"
" 1.000 Weir Breadth. metre"
" 20.000 Weir Left slope to 1"
" 20.000 Weir Right slope to 1"
" 80.150 Tail water elevation"
" 1 Barrel Option (Pipe/Box/CSPA/HE/VE)"
" 0.100 Barrel Height/Diameter"
" 0.100 Barrel Width"
" 0.500 Cc 001 CSP thin walled projecting"
" 0.900 Ke 012 Project from fill"
" 1. Number of Barrels"
" 39 Number of stages"
" Level Discharge Volume"
" 80.330 0.000 0.0"
" 80.386 0.001 1.1"
" 80.412 0.002 1.8"
" 80.435 0.003 2.6"
" 80.456 0.004 3.4"
" 80.477 0.005 4.3"
" 80.564 0.007 8.5"
" 80.625 0.008 12.1"
" 80.696 0.009 16.9"
" 80.778 0.010 23.3"
" 80.869 0.011 31.6"
" 80.971 0.012 43.4"
" 81.082 0.013 62.1"
" 81.204 0.014 89.4"
" 81.335 0.015 127.3"
" 81.476 0.016 177.7"
" 81.627 0.018 242.6"
" 81.788 0.019 324.2"
" 81.959 0.020 424.9"
" 82.139 0.021 547.1"
" 82.329 0.022 693.6"
" 82.529 0.023 867.0"
" 82.738 0.024 1070.4"
" 82.958 0.025 1306.7"
" 83.187 0.026 1579.1"
" 83.425 0.027 1891.1"
" 83.674 0.029 2246.1"
" 83.932 0.030 2647.7"
" 84.200 0.031 3099.7"
" 84.478 0.032 3606.0"
" 84.765 0.033 4170.8"
" 85.062 0.034 4798.1"

```
"            85.369    0.035   5492.3"
"            85.686    0.036   6258.0"
"            86.013    0.037   7099.7"
"            86.349    0.038   8022.3"
"            86.695    0.039   9030.6"
"            87.050    0.041  10129.6"
"            87.416    0.042  11324.7"
"      1.000   Channel Basewidth"
"      0.500   Channel Depth"
"      4.000   Channel Topwidth"
"     10.000   Grade Left"
"     10.000   Grade Right"
"      0.500   Grade %"
"     25.000   Length"
"          Barrel Yo                0.100    metre"
"          Barrel Ycr               0.088    metre"
"          Exit Velocity            1.061    m/sec"
"          Barrel Peak Outflow      0.008    c.m/sec"
"          Weir Peak Flow           0.000    c.m/sec"
"          Total Peak Outflow       0.008    c.m/sec"
"          Maximum level           80.550    metre"
"          Maximum storage         12.615    c.m"
"          Centroidal lag           1.944   hours"
"            0.022    0.022    0.008    0.000 c.m/sec"
" 38       START/RE-START TOTALS 201"
"          3   Runoff Totals on EXIT"
"          Total Catchment area              0.150    hectare"
"          Total Impervious area             0.113    hectare"
"          Total % impervious               75.300"
" 19       EXIT"
```

```
"            MIDUSS Output ---------------------------------------------->"
"            MIDUSS version                  Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10 Units used:                            ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 2"
"            Output filename:                  5-YR_POST_2C.out"
"            Licensee name:                          Quartek"
"            Company                         Quartek Group Inc."
"            Date & Time last used:            2/15/2017 at 9:13:00 AM"
" 31        TIME PARAMETERS"
"       5.000 Time Step"
"     180.000 Max. Storm length"
"    1500.000 Max. Hydrograph"
" 32         STORM Chicago storm"
"          1 Chicago storm"
"     664.000 Coefficient A"
"       4.700 Constant B"
"       0.744 Exponent C"
"       0.375 Fraction R"
"     180.000 Duration"
"       1.000 Time step multiplier"
"           Maximum intensity         120.814    mm/hr"
"           Total depth               41.024    mm"
"          6 005hyd Hydrograph extension used in this file"
" 33         CATCHMENT 202"
"          1 Triangular SCS"
"          1 Equal length"
"          1 SCS method"
"        202 Post area to swale"
"      31.300 % Impervious"
"       0.986 Total Area"
"      60.000 Flow length"
"       1.500 Overland Slope"
"       0.677 Pervious Area"
"      60.000 Pervious length"
"       1.500 Pervious slope"
"       0.309 Impervious Area"
"      60.000 Impervious length"
"       1.500 Impervious slope"
"       0.250 Pervious Manning 'n'"
"      77.800 Pervious SCS Curve No."
"       0.262 Pervious Runoff coefficient"
"       0.100 Pervious Ia/S coefficient"
"       7.248 Pervious Initial abstraction"
"       0.015 Impervious Manning 'n'"
"      97.500 Impervious SCS Curve No."
"       0.830 Impervious Runoff coefficient"
```

```
"       0.100   Impervious Ia/S coefficient"
"       0.651   Impervious Initial abstraction"
"               0.072     0.000     0.000     0.000 c.m/sec"
"          Catchment 202         Pervious   Impervious Total Area "
"          Surface Area          0.677      0.309      0.986     hectare"
"          Time of concentration 35.099     3.537      16.439    minutes"
"          Time to Centroid      144.063    92.274     113.446   minutes"
"          Rainfall depth        41.024     41.024     41.024    mm"
"          Rainfall volume       277.89     126.61     404.50    c.m"
"          Rainfall losses       30.294     6.964      22.991    mm"
"          Runoff depth          10.730     34.060     18.033    mm"
"          Runoff volume         72.68      105.12     177.80    c.m"
"          Runoff coefficient    0.262      0.830      0.440     "
"          Maximum flow          0.014      0.069      0.072     c.m/sec"
" 40         HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"               0.072     0.072     0.000     0.000"
" 52         CHANNEL DESIGN"
"       0.072   Current peak flow    c.m/sec"
"       0.045   Manning 'n'"
"         0.   Cross-section type: 0=trapezoidal; 1=general"
"       0.500   Basewidth    metre"
"       3.000   Left bank slope"
"       3.000   Right bank slope"
"       0.300   Channel depth    metre"
"       0.500   Gradient   %"
"          Depth of flow              0.183    metre"
"          Velocity                   0.374    m/sec"
"          Channel capacity           0.207    c.m/sec"
"          Critical depth             0.104    metre"
" 40         HYDROGRAPH Copy to Outflow"
"          8   Copy to Outflow"
"               0.072     0.072     0.072     0.000"
" 40         HYDROGRAPH Next link "
"          5   Next link "
"               0.072     0.072     0.072     0.000"
" 54         POND DESIGN"
"       0.072   Current peak flow    c.m/sec"
"       0.013   Target outflow    c.m/sec"
"       177.8   Hydrograph volume    c.m"
"        42.   Number of stages"
"       0.000   Minimum water level    metre"
"       0.500   Maximum water level    metre"
"       0.040   Starting water level    metre"
"          0   Keep Design Data: 1 = True; 0 = False"
"              Level Discharge    Volume"
"              0.000     0.000     0.000"
"             0.01220  1.01E-05  1.00E-07"
```

" 0.02439 1.01E-05 1.00E-07"
" 0.03659 1.01E-05 1.00E-07"
" 0.04878 4.92E-05 4.405"
" 0.06098 0.00025 10.574"
" 0.07317 0.00062 16.795"
" 0.08537 0.00115 23.078"
" 0.09756 0.00183 29.413"
" 0.1098 0.00264 35.832"
" 0.1220 0.00358 42.288"
" 0.1341 0.00461 48.748"
" 0.1463 0.00573 55.320"
" 0.1585 0.00690 61.950"
" 0.1707 0.00811 68.639"
" 0.1829 0.00933 75.387"
" 0.1951 0.01051 82.194"
" 0.2073 0.01160 89.061"
" 0.2195 0.01255 95.987"
" 0.2317 0.02621 102.973"
" 0.2439 0.02703 110.019"
" 0.2561 0.02783 117.126"
" 0.2683 0.02860 124.293"
" 0.2805 0.02935 131.521"
" 0.2927 0.03009 138.810"
" 0.3049 0.03081 146.161"
" 0.3171 0.03151 153.573"
" 0.3293 0.03219 161.046"
" 0.3415 0.03287 168.582"
" 0.3537 0.03352 176.180"
" 0.3659 0.03417 183.840"
" 0.3780 0.03480 191.500"
" 0.3902 0.03542 199.286"
" 0.4024 0.03603 207.134"
" 0.4146 0.03663 215.046"
" 0.4268 0.03723 223.022"
" 0.4390 0.03781 231.061"
" 0.4512 0.03838 239.165"
" 0.4634 0.03895 247.333"
" 0.4756 0.03950 255.565"
" 0.4878 0.04005 263.862"
" 0.5000 0.04059 272.225"
" 1. LAYERS"
" Bottom Aspect Bottom Top Average"
" area ratio elevation elevation sideslope"
" 500.000 2.000 0.040 0.500 4.000"
" 1. OUTFLOW PIPE"
" Upstream Downstr'm Pipe Pipe Manning Entry"
" invert invert Length Diameter 'n' loss Ke"
" 0.040 0.000 8.000 0.200 0.024 0.500"

5-YR Storm – Catchment 2 Post-Development Condition

" Peak outflow 0.012 c.m/sec"
" Maximum level 0.218 metre"
" Maximum storage 94.906 c.m"
" Centroidal lag 4.491 hours"
" 0.072 0.072 0.012 0.000 c.m/sec"
" 38 START/RE-START TOTALS 202"
" 3 Runoff Totals on EXIT"
" Total Catchment area 0.986 hectare"
" Total Impervious area 0.309 hectare"
" Total % impervious 31.300"
" 19 EXIT"

5-YR Storm – Catchment 3 Post-Development Condition

```
"            MIDUSS Output ---------------------------------------------->"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10   Units used:                           ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 3"
"            Output filename:                    5-YR_POST_3A.out"
"            Licensee name:                          Quartek"
"            Company                          Quartek Group Inc."
"            Date & Time last used:            2/14/2017 at 11:15:39 AM"
" 31         TIME PARAMETERS"
"       5.000   Time Step"
"     180.000   Max. Storm length"
"    1500.000   Max. Hydrograph"
" 32         STORM Chicago storm"
"          1   Chicago storm"
"     664.000   Coefficient A"
"       4.700   Constant B"
"       0.744   Exponent C"
"       0.375   Fraction R"
"     180.000   Duration"
"       1.000   Time step multiplier"
"            Maximum intensity         120.814    mm/hr"
"            Total depth               41.024    mm"
"          6   005hyd   Hydrograph extension used in this file"
" 33         CATCHMENT 103"
"          1   Triangular SCS"
"          1   Equal length"
"          1   SCS method"
"        103   Pre Development Site"
"      36.200   % Impervious"
"       0.270   Total Area"
"      62.000   Flow length"
"       2.000   Overland Slope"
"       0.172   Pervious Area"
"      62.000   Pervious length"
"       2.000   Pervious slope"
"       0.098   Impervious Area"
"      62.000   Impervious length"
"       2.000   Impervious slope"
"       0.250   Pervious Manning 'n'"
"      74.000   Pervious SCS Curve No."
"       0.207   Pervious Runoff coefficient"
"       0.100   Pervious Ia/S coefficient"
"       8.924   Pervious Initial abstraction"
"       0.015   Impervious Manning 'n'"
"      95.600   Impervious SCS Curve No."
"       0.736   Impervious Runoff coefficient"
```

```
"       0.100   Impervious Ia/S coefficient"
"       1.169   Impervious Initial abstraction"
"               0.020     0.000     0.000     0.000 c.m/sec"
"          Catchment 103         Pervious   Impervious Total Area "
"          Surface Area          0.172      0.098      0.270      hectare"
"          Time of concentration 38.078     3.482      14.942     minutes"
"          Time to Centroid      147.455    94.466     112.018    minutes"
"          Rainfall depth        41.024     41.024     41.024     mm"
"          Rainfall volume       70.67      40.10      110.76     c.m"
"          Rainfall losses       32.537     10.825     24.677     mm"
"          Runoff depth          8.487      30.199     16.347     mm"
"          Runoff volume         14.62      29.52      44.14      c.m"
"          Runoff coefficient    0.207      0.736      0.398      "
"          Maximum flow          0.003      0.020      0.020      c.m/sec"
" 40         HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"               0.020     0.020     0.000     0.000"
" 51         PIPE DESIGN"
"       0.020   Current peak flow    c.m/sec"
"       0.024   Manning 'n'"
"       0.300   Diameter    metre"
"       0.070   Gradient   %"
"          Surcharged HGL             0.147    %"
"          Velocity                   0.285    m/sec"
"          Pipe capacity              0.014    c.m/sec"
"          Critical depth             0.000    metre"
" 53         ROUTE    Pipe Route 26"
"       25.80     Pipe Route 26 Reach length   ( metre)"
"       0.000   X-factor <= 0.5"
"       0.000   K-lag   ( seconds)"
"       0.000   Default(0) or user spec.(1) values used"
"       0.500   X-factor <= 0.5"
"      30.000   K-lag   ( seconds)"
"       0.000   Beta weighting factor"
"       0.000   Routing time step   ( seconds)"
"          0   No. of sub-reaches"
"          Peak outflow               0.020    c.m/sec"
"               0.020     0.020     0.020     0.000 c.m/sec"
" 38         START/RE-START TOTALS 103"
"          3   Runoff Totals on EXIT"
"          Total Catchment area                 0.270    hectare"
"          Total Impervious area                0.098    hectare"
"          Total % impervious                   36.200"
" 19         EXIT"
```

25 mm Storm – Catchment 2 Post-Development Condition

```
"            MIDUSS Output ---------------------------------------------->"
"            MIDUSS version                    Version 2.25  rev. 465"
"            MIDUSS created                  Tuesday, February 05, 2008"
"         10   Units used:                              ie METRIC"
"            Job folder:       P:\2015 Projects\15055 Sunnybrook Addition\"
"                                    Design\Detailed\MIDUSS\Area 2"
"            Output filename:                      25mm_POST_2A.out"
"            Licensee name:                             Quartek"
"            Company                           Quartek Group Inc."
"            Date & Time last used:             2/15/2017 at 11:34:55 AM"
" 31         TIME PARAMETERS"
"       5.000   Time Step"
"     240.000   Max. Storm length"
"    1500.000   Max. Hydrograph"
" 32         STORM Chicago storm"
"          1   Chicago storm"
"     483.850   Coefficient A"
"       6.000   Constant B"
"       0.790   Exponent C"
"       0.400   Fraction R"
"     240.000   Duration"
"       1.000   Time step multiplier"
"            Maximum intensity          69.927    mm/hr"
"            Total depth               25.000    mm"
"          6   025hyd   Hydrograph extension used in this file"
" 33         CATCHMENT 202"
"          1   Triangular SCS"
"          1   Equal length"
"          1   SCS method"
"        202   Post area to swale"
"      31.300   % Impervious"
"       0.986   Total Area"
"      60.000   Flow length"
"       1.500   Overland Slope"
"       0.677   Pervious Area"
"      60.000   Pervious length"
"       1.500   Pervious slope"
"       0.309   Impervious Area"
"      60.000   Impervious length"
"       1.500   Impervious slope"
"       0.250   Pervious Manning 'n'"
"      77.800   Pervious SCS Curve No."
"       0.140   Pervious Runoff coefficient"
"       0.100   Pervious Ia/S coefficient"
"       7.248   Pervious Initial abstraction"
"       0.015   Impervious Manning 'n'"
"      97.500   Impervious SCS Curve No."
"       0.761   Impervious Runoff coefficient"
```

```
"       0.100   Impervious Ia/S coefficient"
"       0.651   Impervious Initial abstraction"
"                0.039     0.000     0.000     0.000 c.m/sec"
"          Catchment 202         Pervious   Impervious Total Area "
"          Surface Area          0.677      0.309      0.986     hectare"
"          Time of concentration  56.404    4.505     19.406    minutes"
"          Time to Centroid       212.479   125.820   150.701   minutes"
"          Rainfall depth         25.000    25.000    25.000    mm"
"          Rainfall volume        169.34    77.15     246.50    c.m"
"          Rainfall losses        21.508    5.971     16.645    mm"
"          Runoff depth           3.492     19.029    8.355     mm"
"          Runoff volume          23.65     58.73     82.38     c.m"
"          Runoff coefficient     0.140     0.761     0.334     "
"          Maximum flow           0.003     0.038     0.039     c.m/sec"
" 40         HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"                0.039     0.039     0.000     0.000"
" 52         CHANNEL DESIGN"
"       0.039   Current peak flow    c.m/sec"
"       0.045   Manning 'n'"
"         0.   Cross-section type: 0=trapezoidal; 1=general"
"       0.500   Basewidth    metre"
"       3.000   Left bank slope"
"       3.000   Right bank slope"
"       0.300   Channel depth    metre"
"       0.500   Gradient   %"
"          Depth of flow              0.136    metre"
"          Velocity                   0.317    m/sec"
"          Channel capacity           0.207    c.m/sec"
"          Critical depth             0.073    metre"
" 53         ROUTE    Channel Route 75"
"       75.00      Channel Route 75 Reach length   ( metre)"
"       0.409   X-factor <= 0.5"
"     177.455   K-lag   ( seconds)"
"       0.000   Default(0) or user spec.(1) values used"
"       0.500   X-factor <= 0.5"
"      30.000   K-lag   ( seconds)"
"       0.500   Beta weighting factor"
"     150.000   Routing time step   ( seconds)"
"          1   No. of sub-reaches"
"          Peak outflow               0.035    c.m/sec"
"                0.039     0.039     0.035     0.000 c.m/sec"
" 40         HYDROGRAPH Next link "
"          5   Next link "
"                0.039     0.035     0.035     0.000"
" 54         POND DESIGN"
"       0.035   Current peak flow    c.m/sec"
"       0.013   Target outflow    c.m/sec"
```

" 82.4 Hydrograph volume c.m"
" 42. Number of stages"
" 0.000 Minimum water level metre"
" 0.500 Maximum water level metre"
" 0.040 Starting water level metre"
" 0 Keep Design Data: 1 = True; 0 = False"
" Level Discharge Volume"
" 0.000 0.000 0.000"
" 0.01220 1.01E-05 1.00E-07"
" 0.02439 1.01E-05 1.00E-07"
" 0.03659 1.01E-05 1.00E-07"
" 0.04878 4.92E-05 4.405"
" 0.06098 0.00025 10.574"
" 0.07317 0.00062 16.795"
" 0.08537 0.00115 23.078"
" 0.09756 0.00183 29.413"
" 0.1098 0.00264 35.832"
" 0.1220 0.00358 42.288"
" 0.1341 0.00461 48.748"
" 0.1463 0.00573 55.320"
" 0.1585 0.00690 61.950"
" 0.1707 0.00811 68.639"
" 0.1829 0.00933 75.387"
" 0.1951 0.01051 82.194"
" 0.2073 0.01160 89.061"
" 0.2195 0.01255 95.987"
" 0.2317 0.02621 102.973"
" 0.2439 0.02703 110.019"
" 0.2561 0.02783 117.126"
" 0.2683 0.02860 124.293"
" 0.2805 0.02935 131.521"
" 0.2927 0.03009 138.810"
" 0.3049 0.03081 146.161"
" 0.3171 0.03151 153.573"
" 0.3293 0.03219 161.046"
" 0.3415 0.03287 168.582"
" 0.3537 0.03352 176.180"
" 0.3659 0.03417 183.840"
" 0.3780 0.03480 191.500"
" 0.3902 0.03542 199.286"
" 0.4024 0.03603 207.134"
" 0.4146 0.03663 215.046"
" 0.4268 0.03723 223.022"
" 0.4390 0.03781 231.061"
" 0.4512 0.03838 239.165"
" 0.4634 0.03895 247.333"
" 0.4756 0.03950 255.565"
" 0.4878 0.04005 263.862"

" 0.5000 0.04059 272.225"
" 1. LAYERS"
" Bottom Aspect Bottom Top Average"
" area ratio elevation elevation sideslope"
" 500.000 2.000 0.040 0.500 4.000"
" 1. OUTFLOW PIPE"
" Upstream Downstr'm Pipe Pipe Manning Entry"
" invert invert Length Diameter 'n' loss Ke"
" 0.040 0.000 8.000 0.200 0.024 0.500"
" Peak outflow 0.004 c.m/sec"
" Maximum level 0.130 metre"
" Maximum storage 46.789 c.m"
" Centroidal lag 7.449 hours"
" 0.039 0.035 0.004 0.000 c.m/sec"
" 38 START/RE-START TOTALS 202"
" 3 Runoff Totals on EXIT"
" Total Catchment area 0.986 hectare"
" Total Impervious area 0.309 hectare"
" Total % impervious 31.300"
" 19 EXIT"

APPENDIX 'B'

EPA SWMM v5.1

Output File

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.015)

1425 Lakeshore Rd, 5yr Storm

****
Element Count
****
Number of rain gages 1
Number of subcatchments ... 1
Number of nodes 2
Number of links 1
Number of pollutants 0
Number of land uses 0

****
Raingage Summary
****

Name	Data Source	Data Type	Recording Interval
1	3hrChicago5yr_R0.46	INTENSITY	5 min.

****
Subcatchment Summary
****

Name	Area	Width	%Imperv	%Slope	Rain Gage	Outlet
5yr_POST	1.31	141.00	47.90	1.5000	1	Pond

****
Node Summary
****

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
Prpty_POST	OUTFALL	100.00	0.00	0.0	
Pond	STORAGE	101.00	1.00	0.0	

****
Link Summary
****

Name	From Node	To Node	Type	Length	%Slope	Roughness
Outlet	Pond	Prpty_POST	ORIFICE			

****
Cross Section Summary
****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow

****
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
****

****
Analysis Options
****
Flow Units ..... LPS
Process Models:
  Rainfall/Runoff ..... YES
  RDII ..... NO
  Snowmelt ..... NO
  Groundwater ..... NO
  Flow Routing ..... YES
  Ponding Allowed ..... NO
  Water Quality ..... NO
Infiltration Method ..... CURVE_NUMBER
Flow Routing Method ..... DYNWAVE
Surcharge Method ..... EXTRAN
Starting Date 08/08/2014 00:00:00
Ending Date 08/08/2014 06:00:00
Antecedent Dry Days 0.0
Report Time Step 00:05:00
Wet Time Step 00:05:00
Dry Time Step 01:00:00

Routing Time Step ..... 30.00 sec
Variable Time Step ..... YES
Maximum Trials 8
Number of Threads 1
Head Tolerance ..... 0.001524 m

Runoff Quantity Continuity	Volume hectare-m	Depth mm
Total Precipitation	0.050	38.537
Evaporation Loss	0.000	0.000
Infiltration Loss	0.026	19.745
Surface Runoff	0.024	18.068
Final Storage	0.001	0.805
Continuity Error (%)	-0.210	

Flow Routing Continuity	Volume hectare-m	Volume 10^6 ltr
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.024	0.236
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.019	0.191
Flooding Loss	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.005	0.045
Continuity Error (%)	0.000	

Time-Step Critical Elements

None

Highest Flow Instability Indexes

All links are stable.

Routing Time Step Summary

Minimum Time Step	:	29.50 sec
Average Time Step	:	29.96 sec
Maximum Time Step	:	30.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.00
Percent Not Converging	:	0.00
Time Step Frequencies	:	
30.000 - 13.228 sec	:	100.00 %
13.228 - 5.833 sec	:	0.00 %
5.833 - 2.572 sec	:	0.00 %
2.572 - 1.134 sec	:	0.00 %
1.134 - 0.500 sec	:	0.00 %

Subcatchment Runoff Summary

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Imperv Runoff mm	Perv Runoff mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff LPS	Runoff Coeff
5yr_POST	38.54	0.00	0.00	19.74	18.07	0.00	18.07	0.24	148.36	0.469

Node Depth Summary

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min	Reported Max Depth Meters
Prpty_POST	OUTFALL	0.00	0.00	100.00	0 00:00	0.00
Pond	STORAGE	0.12	0.22	101.22	0 02:01	0.22

Node Inflow Summary

Node	Type	Maximum Lateral Inflow LPS	Maximum Total Inflow LPS	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Flow Balance Error Percent
Prpty_POST	OUTFALL	0.00	16.80	0 02:01	0	0.191	0.000
Pond	STORAGE	148.36	148.36	0 01:30	0.236	0.236	-0.004

Node Surcharge Summary

No nodes were surcharged.

Node Flooding Summary

No nodes were flooded.

Storage Volume Summary

Storage Unit	Average Volume 1000 m3	Avg Pcnt Full	Evap Pcnt Loss	Exfil Pcnt Loss	Maximum Volume 1000 m3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow LPS
Pond	0.082	12	0	0	0.156	22	0 02:01	16.80

Outfall Loading Summary

Outfall Node	Flow Freq Pcnt	Avg Flow LPS	Max Flow LPS	Total Volume 10^6 ltr
Prpty_POST	92.23	9.55	16.80	0.191
System	92.23	9.55	16.80	0.191

Link Flow Summary

Link	Type	Maximum |Flow| LPS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
Outlet	ORIFICE	16.80	0 02:01			1.00

Flow Classification Summary

Conduit	Adjusted /Actual Length	Fraction of Time in Flow Class: Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl

Conduit Surcharge Summary

No conduits were surcharged.

Analysis begun on: Mon May 4 09:10:55 2026
Analysis ended on: Mon May 4 09:10:55 2026
Total elapsed time: < 1 sec