Hydrology Update Report
Carruthers Creek Watershed

Carruthers Creek Flood Management & Analysis

Municipal Class EA

Project No. W10-288

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COLE ENGINEERING
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1.0 Introduction

This report summarizes the analysis carried out by Cole Engineering Group Ltd. (Cole Engineering) for the Town (Town, "Owner") and the Toronto and Region Conservation Authority (TRCA) to prepare a hydrology update for the Carruthers Creek Watershed. This report includes an update to the hydrologic model for Carruthers Creek, using Visual OTTHYMO V.2.3 (VO2). The work undertaken was used to validate the flows established in the previous watershed model update, prepared by Philips Engineering in 2007, and will subsequently be used to define the flood elevations throughout the subwatershed as part of the Carruthers Creek Flood Management and Analysis Municipal Class Environmental Assessment for flood remediation within the Pickering Beach area of the Town.

This report will discuss the review of previous modelling work, recommended updates to the model and subsequent flows, as well as establish recommendations for stormwater management criteria for development planned within the approved Official Plan Amendment (OPA), and evaluate the impacts of future potential development within the headwaters of the Carruthers Creek Watershed.

1.1. Study Background

Carruthers Creek conveys runoff to Lake Ontario from an approximate drainage area of 36 km^2 within the City of Pickering (Pickering) and the Town. The Carruthers Creek Watershed extends north from Lake Ontario to north of 8th Concession in Pickering between Westney Road and Audley Road. The map of the watershed is presented in **Figure 1-1**.

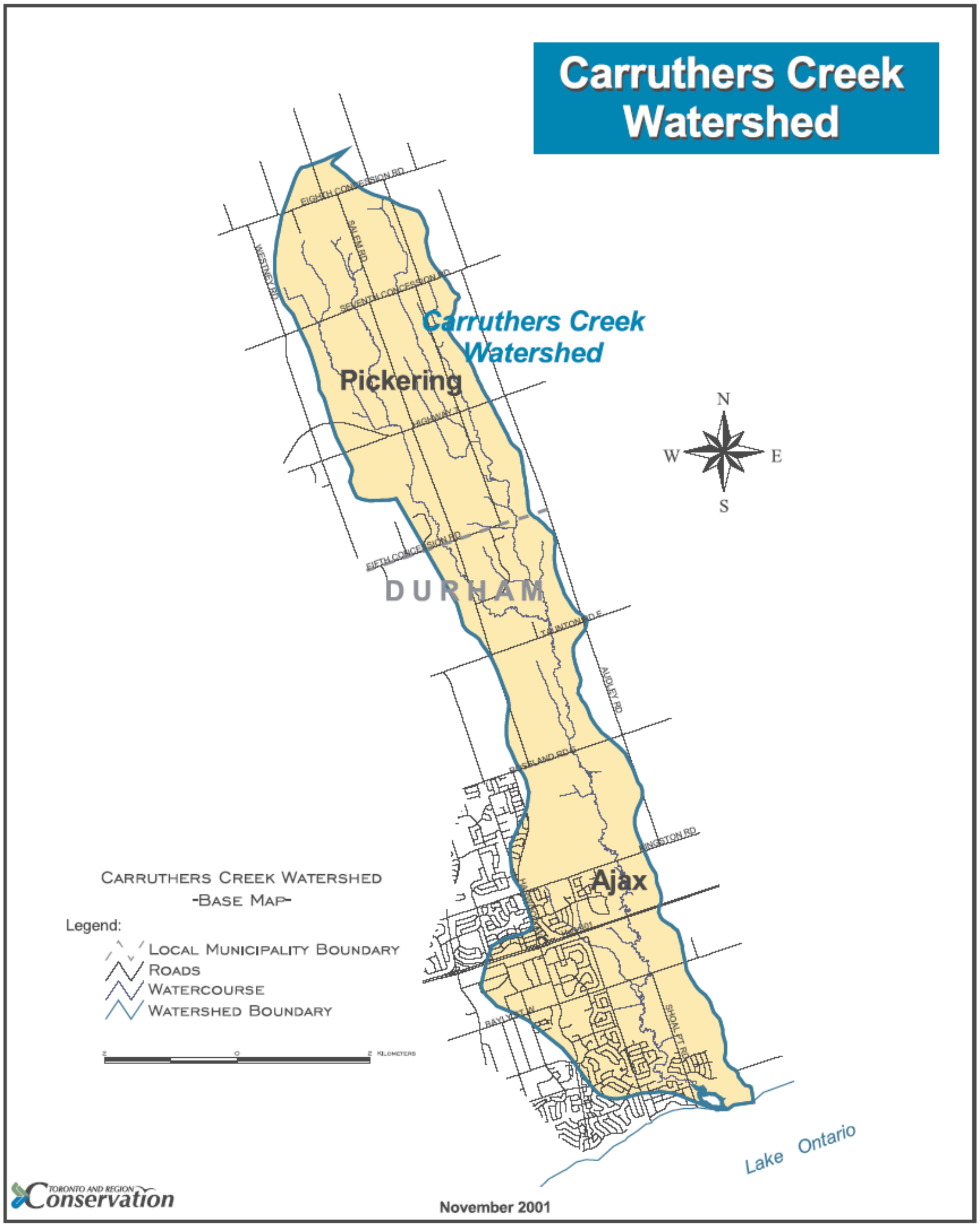

Figure 1-1 – Carruthers Creek Watershed

In 2010, the Town initiated a Schedule 'C' Municipal Class Environmental Assessment (Class EA) of the Carruthers Creek Watershed, with a specific emphasis on flood remediation for the Pickering Beach area. Floodplain mapping updates prepared by R.J. Burnside & Associates Ltd. (Burnside) for the TRCA had identified a spill point at Seabreeze Road. Initial mapping had not delineated the extent of potential flood risk to the Pickering Beach area until the update was completed in 2009. The progression of flood mapping in this area from 1986, 2007, and 2009 is presented below in **Figure 1-2**. As can be seen through this mapping, flooding risk associated with the regulatory regional storm event seems to have increased with time.


1986 Flood Plain / Floodway
FILL REGULATION LINE
Photo Source: 1983 Aerial - Kenting
2007 Flood Plain / Floodway
INSUFFICIENT MAPPING
Photo Source: 2008 Ortho - FBS
2009 Flood Plain / Floodway
SPILL
Photo Source: 2008 Ortho - FBS

Figure 1-2 – Carruthers Creek Flood Plain
(Source: Town of Ajax Carruthers Creek Watershed Environmental Assessment Report to General Government Committee, 2010)

1.2. Purpose

The purpose of Cole Engineering's hydrology update was to review the methodology and hydrology model update for the watershed prepared by Philips and summarized in the 2007 report Carruthers Creek Hydrology Update for Toronto and Region Conservation Authority (2007 hydrology update report). This model was updated to the 2008 condition to allow for calibration to precipitation and stream flow data available mainly between 2008 and 2009. Along with updating the model to the 2008 condition, any discrepancies identified through the review of the 2007 hydrology model were also noted and updated.

Once the model was updated to the 2008 existing condition it was calibrated using stream flow data provided by the TRCA and precipitation data provided by the TRCA and Central Lake Ontario Conservation Authority (CLOCA).

The calibrated model was then used to evaluate two (2) future conditions:

1. The approved OPAs for the Town and for Pickering; as well as,
2. A future watershed build-out based on the proposed Regional Official Plan Amendment 128 (ROPA 128).

The stormwater management criteria for Carruthers Creek recommended in the Philips 2007 update was considered and further recommendations associated with the future approved development and future potential development were provided. This included recommendations regarding the necessity of Regional controls within this watershed.

1.3. Background Information

Appendix A lists the background information used for the hydrology model update.

2.0 Previous Hydrology Model Review and Update

The Carruthers Creek Watershed was modelled using VO2 and was last updated by Philips Engineering as summarized in the report titled: Carruthers Creek Hydrology Update for Toronto and Region Conservation Authority, dated March 2007. The hydrology model and supporting report for the Carruthers Creek Watershed was provided to Cole Engineering by the TRCA. Cole Engineering used VO2 to review and validate the model. The various input parameters in the VO2 model were reviewed, as was the overall layout and connectivity of the sub-catchments within the model. The following sections describe the methodology that Philips Engineering used for their modelling and the updates made by Cole Engineering. In general it was concluded that, aside from the noted recommended changes, the approach applied by Philips was acceptable based on information available at the time.

For Cole Engineering's update of the hydrology model, the majority of the stream flow and precipitation data available from the TRCA was for the time period between the years 2008 and 2009, with sporadic data available for portions of the years 2006 and 2007. Given the timeline that the stream flow and precipitation data were available for, it was decided it was necessary to update the 2005 condition model to the 2008 condition. This would better represent the developed form of the watershed when compared with the available stream flow and precipitation data. Information was gathered from the Town regarding developments that occurred between the years 2005 and 2008. This was used to update the model to the 2008 condition. Through the review, any errors, omissions, and/or modifications to the previous watershed model were made.

2.1. Watershed Boundary

Philips Engineering had verified, where possible, the base sub-catchment delineation of the watershed and modified as necessary through review of drainage plans and maps, contours, and sewer mapping.

Similarly, Cole Engineering has reviewed the watershed boundary using one (1) m contour information provided by the TRCA to compare the catchment delineation. For any boundaries within development areas that appeared to deviate from what the contour information indicated, the Town was contacted to obtain further information on developments infrastructure. The Town provided stormwater management reports and/or drainage area plans for the developments in question.

Generally the watershed boundary appeared accurate and was altered only slightly, as shown in **Figure 2-1**, based on the Audley Road Lands subdivision drainage plan, provided by the Town.

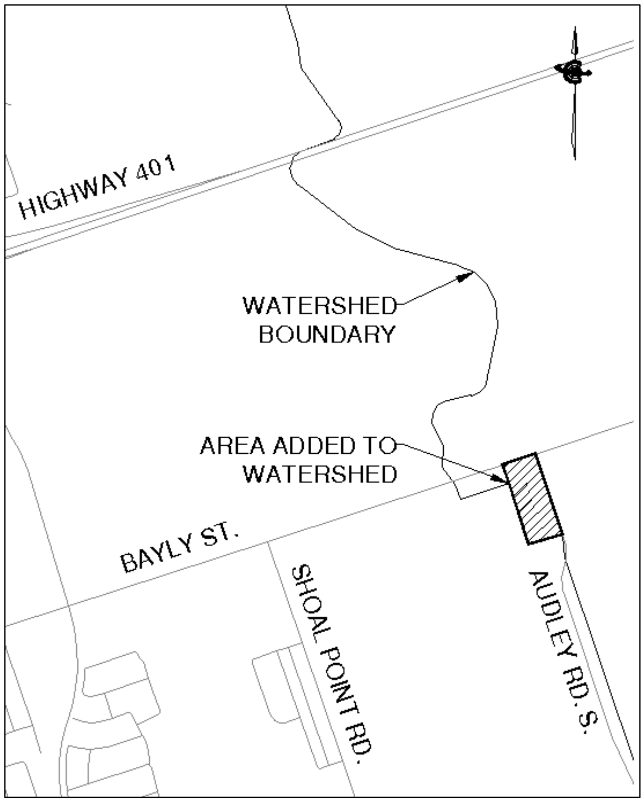

Figure 2-1 – Change in Watershed Boundary

2.2. Sub-catchment Layout

The sub-catchment layout in the VO2 model was reviewed in conjunction with the 2007 hydrology update report. The 2007 hydrology update included 16 model scenarios:

1. 2002 Existing Condition;
2. 2002 Existing Condition – Regional Storm;
3. 2005 Existing Condition;
4. 2005 Existing Condition – Regional Storm;
5. 2005 Existing Condition without Stormwater Management Ponds built since 2002 ;
6. Future Condition with Committed Stormwater Management Ponds;
7. Future Condition with Committed Stormwater Management Ponds – Regional Storm;
8. Future Condition with Greenbelt;
9. Future Condition with Greenbelt – Regional Storm;
10. Future Condition with Greenbelt and Natural Heritage System;
11. Future Condition with Greenbelt and Natural Heritage System – Regional Storm;
12. Future Condition without Stormwater Management Ponds;
13. Future Condition with the Proposed Stormwater Management for Alternative 2;
14. Future Condition with the Proposed Stormwater Management for Alternative 3;
15. Future Condition with Ultimate Urbanization except the Greenbelt; and,
16. Future Condition with Ultimate Urbanization except the Greenbelt – Regional Storm.

The 2005 existing condition model (scenario 3 above), provided by the TRCA, had some discrepancies with the hydrologic modelling parameters provided in Appendix B of the 2007 report. There were three (3) additional sub-catchments in the 2005 existing condition model that were not listed in Appendix B of the report. These additional sub-catchments were 135, 136, and 141.

However, the 2005 existing condition without the stormwater management ponds built since 2002 (scenario 5 above) was consistent with the report. This model was used as the base point for the 2008 condition model update. The additional stormwater management ponds built between the years 2002 and 2005 were added into this model before any other updates were made.

2.3. Sub-catchment Delineation

Development information from 2005 through 2008 was obtained from both the Town and Pickering. Development information obtained included: lists of developments, locations, and drainage plans for each relevant area. This information was then used to update both the 2005 land use and the 2005 sub-catchments mapping to the 2008 condition. In all, six (6) residential subdivisions and one (1) industrial development were added into the hydrology model. All of these developments occurred within the Town.

2.4. Time to Peak

The time to peak calculations completed in the 2007 hydrology update report were reviewed. The hydrology update had used the Bransby-Williams Method for all time to peak calculations. The Ministry of Transportation Ontario (MTO) Drainage Manual (which is a widely accepted practise document) as well as the VO2 Reference Manual state that for a drainage area where the runoff coefficient is less than 0.40 the Airport Method should be used for estimating the time to peak and the Bransby-Williams Method should be used of drainage areas with a runoff coefficient greater than 0.40.

As the majority of the undeveloped areas (represented by NASHYD VO2 commands) within the Carruthers Creek Watershed have a runoff coefficient less than 0.40, it is believed that the Bransby-Williams Method for calculating time to peak may underestimate the times to peak and overestimate flows generated from these catchments. This overestimation of flows in the undeveloped condition is expected to underestimate the impacts of development within portions of the watershed. Calculated runoff coefficients for the watershed are available in **Appendix B**. Runoff coefficients were aerially weighted using values based on land use and soil type from the MTO Design Chart 1.07 and the Town design standards.

The form of the Bransby-Williams equation used in the 2007 hydrology update report was shown as:

$$t_c = \frac{0.605L}{S^{0.2}A^{0.1}}$$

The more familiar form of the Bransby-Williams equation, which is the form in both the MTO Drainage Manual and the VO2 Reference Manual is:

$$t_c = \frac{0.057L}{S^{0.2}A^{0.1}}$$

In the above formula length is in metres, area is in hectares, and time of concentration is calculated in minutes. This formula was used by Cole Engineering when evaluating the time to peak calculations for the undeveloped portions of the watershed. The difference in the two (2) equations was attributed to the use of different units in the Philips model.

The equation used for the Airport Method was taken from the MTO Drainage Manual:

$$t_c = \frac{3.26(1.1 - C)}{S_w^{0.33}}$$

Time of concentration is calculated in minutes. The times to peak calculated with the Airport Method were significantly longer than those calculated with the Bransby-Williams Method, as shown below in **Table 2-1**. The time of concentration for the creek, which was added to the time of concentration calculated with the Airport Method, was calculated based on Regional storm velocities estimated by the existing HEC-RAS model and the length of the creek. The length of the creek was considered to be from the point where the tableland flow joins the creek to the outlet of the drainage area and was not taken as the entire length of the creek within the drainage area. The Regional storm was chosen because it provides the most conservative time to peak estimate. A time of concentration of the creek was added to the Airport Method time of concentrations and not the Bransby-Williams Method time of concentrations because the Bransby-Williams Method takes into account the area of the catchment, where the Airport Method does not. Therefore, the Bransby-Williams Method is calculating the time of concentration for the entire drainage area; whereas, the Airport Method is calculating the time of concentration for the table land areas and this must be summed with the time of concentration within the creek. For all time to peak calculations time to peak was calculated as

$$t_p = \frac{2}{3}t_c$$

Table 2-1 – 2008 Existing Model Time to Peak Summary

Sub-catchment	Recommended Method Based on MTO Drainage Manual and VO2 Reference Manual	Cole Engineering Tp (Airport Method)	Cole Engineering Tp (Bransby Williams Method)	Philips T_p (Bransby Williams Method)
		(hr)	(hr)	(hr)
105	BW	10.44	**3.21**	0.99
108	BW	3.93	**1.30**	0.46
112	Airport	**2.35**	0.22	1.01
117	BW	5.11	**2.44**	0.69
129	BW	10.68	**3.63**	0.95
134	BW	8.66	**2.99**	0.80
139	Airport	**3.37**	0.94	0.16
140	Airport	**1.78**	0.34	0.27
143	Airport	**2.95**	0.76	0.45
151	Airport	**1.89**	0.37	0.45
152	Airport	**5.26**	1.78	0.57
152F	BW	1.57	**0.40**	N/A
152I	Airport	**1.46**	0.28	N/A
153	Airport	**4.68**	1.35	0.26
154	Airport	**3.20**	0.97	0.44
157	Airport	**6.48**	1.84	0.26
158	Airport	**2.60**	0.63	0.16
160	Airport	**2.87**	0.58	0.33
161	Airport	**0.55**	0.07	0.48
162	Airport	**0.96**	0.07	0.46
164	Airport	**1.03**	0.09	0.27
170	BW	3.82	**1.24**	0.27
171	Airport	**3.62**	0.88	2.04
172	Airport	**5.36**	2.55	0.29
173	Airport	**4.06**	1.26	0.37
174	Airport	**8.17**	4.37	1.50
175	Airport	**8.02**	4.18	1.18
176	Airport	**4.41**	1.22	0.63
177	Airport	**5.59**	1.67	0.58
178	Airport	**2.52**	0.47	0.43
179	Airport	**4.68**	1.43	0.50
180	Airport	**3.80**	0.98	0.80
181	Airport	**4.55**	1.67	0.95
182	Airport	**9.88**	5.01	1.79
183	Airport	**5.98**	2.78	1.13

When the model calibration and validation was completed, as described later in **Section 3.0**, the time to peak values calculated with the Airport Method resulted in simulated stream flow that better matched the available measured stream flow data. Based on the calibration results as well as the recommendations from the MTO Drainage Manual and the VO2 Reference Manual it was determined that the Airport Method was the most appropriate for use within the Carruthers Creek Watershed for sub-catchments where the runoff coefficient is less than 0.40 and the Bransby-Williams Method should be used for sub-catchments where the runoff coefficient is greater than 0.40.

2.5. Sub-catchment Pervious Length and Slope

The sub-catchment pervious length and slope were uniformly set to the VO2 recommended defaults of 40 m and 2% respectively, this was found to be acceptable.

2.6. Sub-catchment Impervious Length and Slope

The sub-catchment impervious length was calculated with $A=1.5*L^2$. The impervious slope was calculated from topographic mapping. Both of these methods are acceptable.

2.7. Curve Numbers

Modified curve numbers (CN*) were used, which is appropriate.

CN* with the Antecedent Moisture Condition (AMC) II condition was used by Philips for the 2 through 100 year models. The AMC III condition was used the Regional Storm; this was correctly varied to represent a saturated ground condition.

The CN values assigned to each land use and soil type are reasonable, however, Cole Engineering had recalculated the CN* values for each of the 2008 sub-catchments based on the methodology described in the following section.

2.7.1. Soil and Land Use

According to the Soil Map of Ontario County, by Agriculture and Agri-Food Canada, the predominant soil types within the watershed are Bondhead loam with good internal drainage, Bondhead sandy loam with good drainage, and Smithfield clay loam with imperfect drainage. **Figure SM** illustrates the soil types located within the study area.

Table 2-2 below summarizes the soil types and their hydrologic soil group, which were included in the shape file, provided by the TRCA and were checked against the MTO Drainage Management Manual Design Chart 1.08. This shape file was used in the CN calculations.

Table 2-2 – Hydrologic Soil Groups

Soil Type (Abbreviation)	Parent Materials	Drainage	Hydrologic Soil Group
Bondhead loam (Bl)	Calcareous grey loam & sandy loam till	Good	B
Bondhead sandy loam (Bs)	Calcareous grey loam & sandy loam till	Good	AB
Milliken loam (Ml)	Calcareous brown loam till	Imperfect	BC
Brighton sandy loam (Brsl)	Calcareous sand	Good	AB
Woburn sandy loam (Wos)	Calcareous brown loam till	Good	A
Smithfield clay loam (Scl)	Calcareous clay	Imperfect	C
Tecumseth sandy loam (Tsl)	Calcareous sand	Imperfect	AB
Darlington loam (Dal)	Clay loam till derived from limestone and shale	Good	C
Guerin loam (Gul)	Calcareous grey loam & sandy loam till	Imperfect	B
Schomberg clay loam (Shc)	Calcareous clay	Good	C
Bottom Land (B.L.)	Recent alluvial deposits	Variable	-
Muck (M)	Well decomposed organic deposits	Very poor	B
Marsh (Ma)	Saturated mineral soil with marsh vegetation	Very poor	-
Brighton gravelly sandy loam (Brsl/g)	Calcareous sand	Good	AB
Brighton sandy loam stony phase (Brsl-st)	Calcareous sand	Good	AB

The predominant land uses over the study area are agriculture, low density residential, and natural areas. There are also some commercial, estate residential, golf courses, medium density residential, high density residential, highway, industrial, institutional, open water, recreation, railway, cemetery, and urban open space areas. Hydrologic soil modified Soil Conservation Service curve numbers for the watershed were generally taken from the 2007 hydrology update and are summarized below in **Table 2-3**. It should be noted that for marsh/bogs a CN of 50 was used. Bottom land was grouped with the most conservative hydrologic soil group within the catchment where the bottom land existed.

Table 2-3 – CN Values

Land Use	Soil Type				
	A	AB	B	BC	C
Estate Residential	39	50	61	67.5	74
Low Density Residential	39	50	61	67.5	74
Medium Density Residential	39	50	61	67.5	74
High Density Residential	39	50	61	67.5	74
Institutional	39	50	61	67.5	74
Industrial	39	50	61	67.5	74
Commercial	39	50	61	67.5	74
Agricultural	63	70	74	78	82
Natural Area	30	44	58	64.5	71
Recreational	39	50	61	67.5	74
Open Water	98	98	98	98	98
Railway	72	77	82	84.5	87
Highway	98	98	98	98	98
Urban Open Space	39	50	61	67.5	74
Golf Course	39	50	61	67.5	74
Cemetery	39	50	61	67.5	74

2.8. Initial Abstraction

The initial abstraction values were aerially weighted using 1.0 mm for impervious areas, 3.5 mm for agricultural areas, 5.0 mm for lawns, and 8.0 mm for meadows and woodlots. These values are on the higher end of the acceptable range. While it was found that sensitivity to these parameters was not significant, Cole Engineering adjusted the initial abstractions for the watershed based on the following:

- 1.0 mm for impervious areas;
- 3.0 mm for lawns;
- 4.0 mm for agricultural areas; and,
- 5.0 mm for meadow and woodlots.

These modified initial abstraction values are more conservative than the values assumed by Philips Engineering. It was determined through the calibration process that varying the initial abstraction values did not create a significant change to the hydrologic model results.

2.9. Channel Routing

The VO2 channel routing command was used for the sub-catchments draining to the various identified branches of Carruthers Creek. Information for the channel routing was determined by Philips Engineering from topographic information. This is acceptable practice.

Cole Engineering did an analysis to determine the sensitivity of the route channel command to changing the elevations of the cross section. Route channel 171 was chosen and a few cross sections (obtained from the 2009 HEC-RAS model by Burnside) were chosen along the route channel's length and the model was run with the varying cross sections. The three (3) cross sections chosen were: (1) 4.039, which is the most upstream cross section within this sub-catchment; (2) 4.001, which is the most downstream cross section of this sub-catchment; and (3) 4.021, which is roughly in the middle. The most upstream and downstream cross sections varied the flow output from the route channel command by 0.4% and 0.6%, respectively and the middle cross section varied by 1.7%. However, the impacts at Lake Ontario were observed as 0.3% at most. It was determined that changing the route channel cross section had little impact on the model and the cross section in the VO2 model were representative of an average cross section of those analyzed by Cole Engineering. Therefore it was determined to not change the route channel cross sections as input by Philips Engineering for the 2007 hydrology update.

A channel routing command was missing from the model for sub-catchment 172. Therefore, this was added in for the 2008 existing condition. The cross section for this channel was taken from topographical information provided by the TRCA.

2.10. Reservoir Routing

The stage storage discharge curves used within the watershed model were provided by the TRCA. The model was checked to confirm that the rating curves were consistent with the pond rating curves listed in Appendix A of the Philips Engineering Report. The rating curve for pond 194.0 (John Boddy-Warbler Swamp) in the model did not match the rating curve in the report. The TRCA confirmed that the rating curve in the report was correct.

Where necessary, Philips Engineering modified the rating curves with an overflow ordinate. This was done for ponds that were designed as erosion control facilities based on past stormwater management strategies. For these ponds, the rating curve in the report did not match the rating curve in the model. It was checked to determine if the 100 year storm event would exceed the rating last ordinate on the rating curves entered in the model. If it had the TRCA was contacted to confirm the rating curves. These ponds were 253.0 (Carruthers Creek Residential Phase II – South Pond), 253.1 (Carruthers Creek Residential Phase II – North Pond), and 254.0 (Guthrie Commercial - Hwy 2 Pond).

The locations of the ponds are shown in **Figure EX08**. TRCA Pond information is included in **Appendix C** for reference.

2.11. Calibration Storm Selection

The criteria used for selecting storms for model calibration were storms greater than 25 mm and a peak flow response greater than 1.0 m^3/s.

2.12. Aerial Reduction Factor

Philips Engineering calculated the aerial reduction factor for the Regional Storm for each node using the equivalent circular area method as per the MTO Drainage Management Manual, 2008 and the MNR Flood Plain Management Technical Guidelines, 1986. This resulted in a maximum aerial reduction factor of 92.7 being applied at Lake Ontario.

2.13. Summary

With the modifications, the Carruthers Creek watershed has been delineated into seventy (70) sub-catchments in the Existing 2008 scenario. Boundaries and land uses within several of the sub-catchments were also updated to reflect development from 2005 to 2008. **Figure EX08** illustrates the Carruthers Creek watershed with its 2008 land use, sub-catchments, and stormwater management ponds. The input parameters used are summarized in **Appendix D** for reference. With the exception of the time to peak used in the previous hydrology update, the previous update was generally acceptable with some minor revisions required.

3.0 Model Calibration / Flow Comparison

Once updated, the VO2 model was compared to the observed stream flow data. Stream flow data from Station 32 at Bayly Street was compared to flows at ADDHYD 1033 until July 1, 2007. The stream flow gauge was relocated to Station 112 at Achilles Road (ADDHYD 1038) after July 16, 2007.

Calibration of the VO2 model was considered in an attempt to replicate the observed stream flow data with the modelling results.

3.1. Storm Selection

Precipitation data from six (6) different gauges around the Carruthers Creek watershed were obtained from the TRCA and CLOCA. Three (3) of the precipitation gauges were within the Duffins Creek Watershed and three (3) were located within the Lynde Creek Watershed. Two (2) rain gauges were not used for the model calibration because the precipitation values were unreasonably inconsistent with the rest of the gauges. Therefore, two (2) gauges from the Duffins Creek Watershed and two (2) gauges from the Lynde Creek Watershed were used in the calibration analysis. For the model validation the precipitation gauge data from 2009 was markedly more consistent and so all six (6) gauges were able to be used.

Four (4) storms selected for calibration were November 30, 2006, July 20, 2008, August 11, 2008, and September 13, 2008. Cole Engineering selected these storms based upon available data and the same criteria established by Philips Engineering for selecting the storms, which was:

- Precipitation greater than 25 mm at some or all of the rain gauges; and,
- A peak flow response of greater than 1 m^3.

The magnitude of the observed flows is relatively small when compared to those under the Regional event.

The TRCA provided information regarding the magnitude of calibration events from other east end watersheds in the Greater Toronto Area (GTA), which is included in **Appendix E**. The TRCA concluded that the magnitude of the calibration events used in the other watersheds compared was significantly lower than events that cause flooding, which justifies the calibration storms used.

3.2. Base Flow Separation

The base flow separation was achieved by extending the base flow recession forward under the peak of the hydrograph, starting with the point of lowest discharge and then extending at constant discharge to a point on the recession limb, as described in "Hydrology and Floodplain Analysis Fourth Edition" by Bedient, Huber, and Vieux, 2008. **Appendix F** includes the base flow graphs illustrating the base flow for all of the calibration and validation storms. **Table 3-1** below summarizes the base flow for each storm.

Table 3-1 – Design Storms Base Flow

Storm	Base Flow (m^3/s)
November 30, 2006	0.326
July 20, 2008	0.0490
August 11, 2008	0.686
September 13, 2008	0.0728

3.3. Distributed Rainfall Modeling Technique

Distributed Rainfall Modeling Technique (DRMT) is a custom ArcGIS tool developed by Cole Engineering. The function was used in the calibration process to account for the spatial variation in the distribution of rainfall for areas between the rain gauges. Its algorithm involves three (3) main steps:

1. Populating geo-referenced rain gauge features with actual precipitation data;
2. Generating a surface of precipitation values using spline interpolation for each time step; and,
3. Calculating the average value of the section of the rain surface contained within each specified catchment.

As briefly discussed in **Section 3.1**, four (4) rain gauges were used to run DRMT for the calibration. These were TRCA gauge 84, TRCA gauge 97, CLOCA gauge 02HC018, and CLOCA gauge Prec5. The locations of these gauges are shown in **Figure 3-1**.

Data was provided to Cole Engineering for two (2) additional gauges, one (1) from the TRCA and one (1) from CLOCA however these gauges did not have adequate data for the calibration storms to be used in the DRMT process.

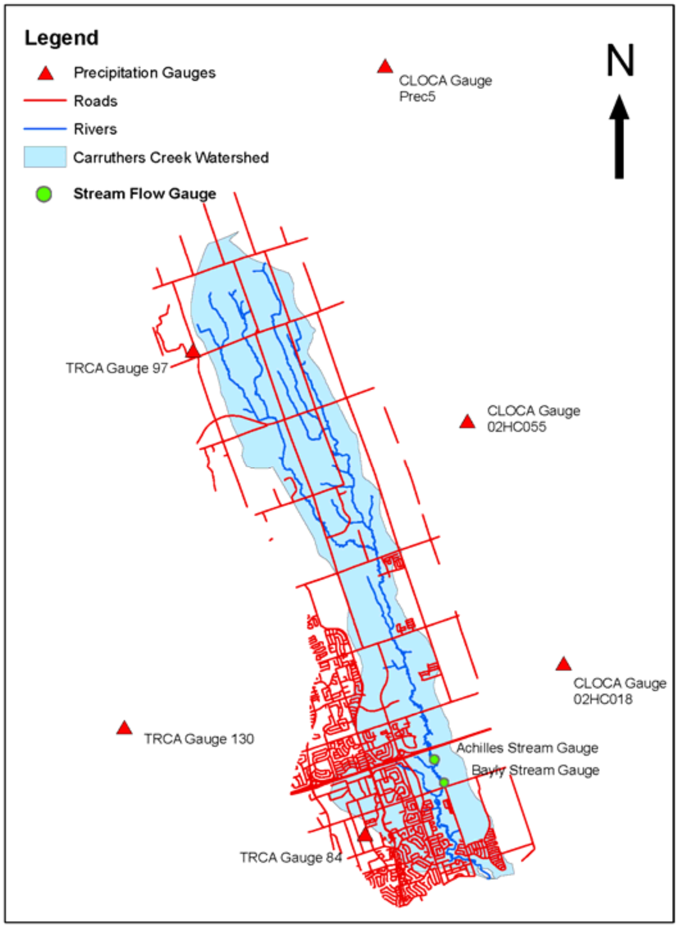

Figure 3-1 – Precipitation Gauges Locations

The result of the DRMT is a unique precipitation value for each of the sub-catchments. However as VO2 is limited to four (4) rain gauges in any scenario, the sub-catchments were grouped into four (4) larger catchments with similar precipitation values. The four (4) larger catchments were determined by first running DRMT for all of the sub-catchments in the watershed for four (4) storms. The range of precipitation values for each sub-catchment at a given point in time was analyzed and divided into four (4) equal ranges. For example, if the precipitation for a given storm ranged from 1 mm to 12 mm the ranges would be 1 mm to 4 mm, 4.1 mm to 6 mm, 6.1 mm to 9 mm, and 9.1 mm to 12 mm. The sub-catchments were then split into four (4) groups according to their precipitation value. The sub-catchments consistently were within the same rainfall range and so were able to be grouped into the four (4) larger catchments shown in **Figure 3-2**. DRMT was then run a second time to provide average precipitation data for these four (4) catchments. This created a surface with the rainfall as shown in **Figure 3-3**. For the sub-catchments that were further south than the rain gauges and so not a part of the surface created, precipitation values were assigned based on the catchments that they were nearest.

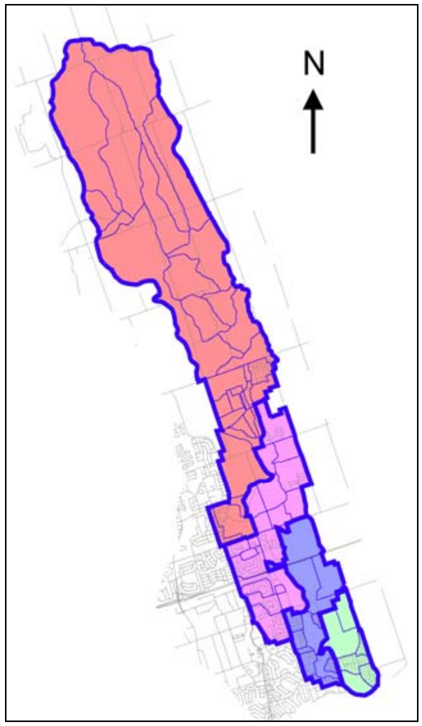

Figure 3-2 – DRMT Sub-catchments

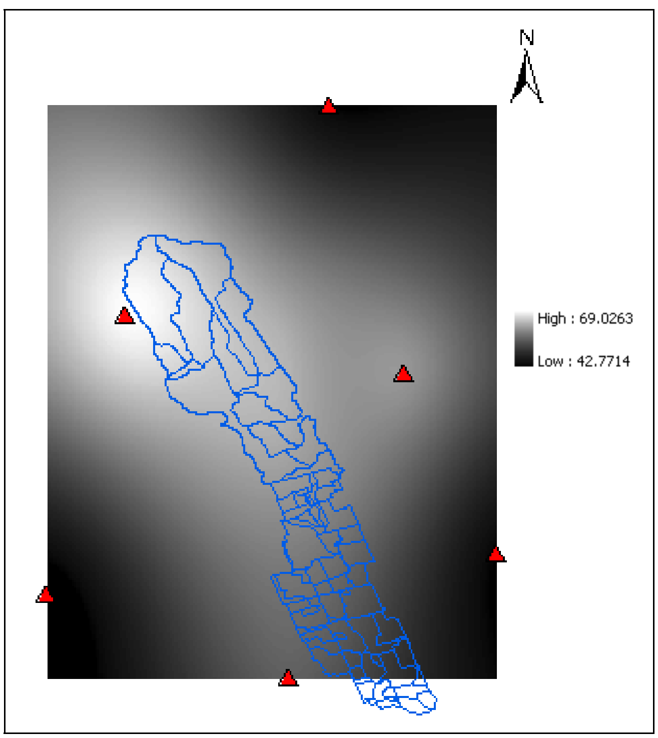

Figure 3-3 – DRMT Precipitation Surface – May 27, 2009 Storm

3.4. Antecedent Moisture Analysis

Based on the amount of precipitation for the five (5) days prior to the storm, the soil AMC was estimated using MTO Design Chart 1.10 as a guide. AMC II represents normal conditions, while AMC I and AMC III reflect dry and wet soil conditions, respectively. **Table 3-2** below lists the AMC of each of the storms used for calibration.

Table 3-2 – Calibration Storm Events

Storm Date	Average DRMT Precipitation (mm)	Total Average Precipitation Previous Five Days (mm)	Antecedent Moisture Condition	Description
November 30, 2006	49.1	0	AMC II	▪ Since this storm had a long duration and two (2) peaks in rainfall were observed the ground would have become saturated during the first rainfall peak. Therefore, even though there was no rainfall in the previous five (5) days an AMC II condition is justified. ▪ Historical temperature data available from Environment Canada was checked and the temperatures were below zero (0) prior to and when the time to peak occurred (though they were above zero (0) when the storm started). Therefore, the runoff from the storm would be increased and so this further justifies an AMC II condition. ▪ Since this storm was in November a larger peak flow response can also be attributed to decreased evaporation.
July 20, 2008	45.5	13.9	AMC II	▪ A medium sized storm (approximately 12 mm of precipitation) occurred on July 19, 2008, which would have wet the soils causing an AMC II condition.
August 11, 2008	49.7	52.3	Average of AMC II and AMC III	▪ There was a significant amount of rain in the five (5) days prior to the storm. According to the MTO Design Charts it is very close to AMC III conditions and since the amount of precipitation for this storm is also quite large this would cause an average of AMC II and AMC III conditions for this storm.
September 13, 2008	21.9	22.1	AMC II	▪ Due to the amount of rain in the five (5) days prior to this storm it should be AMC II condition. This storm was small and had a small flow response. More error is associated with routing for smaller events. Also, this storm is the least representative of larger storm events, compared to the other three (3) storms used for calibration.

3.5. Time to Peak

During the calibration process the model was first run with the time to peak calculated for the NASHYD areas using the Bransby-Williams Method. When the Airport Method was used for the sub-catchments, where the runoff coefficient was less than 0.40 and the Bransby-Williams Method was used for the sub-catchments, where the runoff coefficient was greater than 0.40, it was observed that the modelled peak flow aligned more closely with the peak flow from the stream flow data.

Figure 3-4 and **Figure 3-5** illustrate the modelled stream flow data for one (1) of the calibration storms and one (1) of the validation storms with the different time to peak methods.

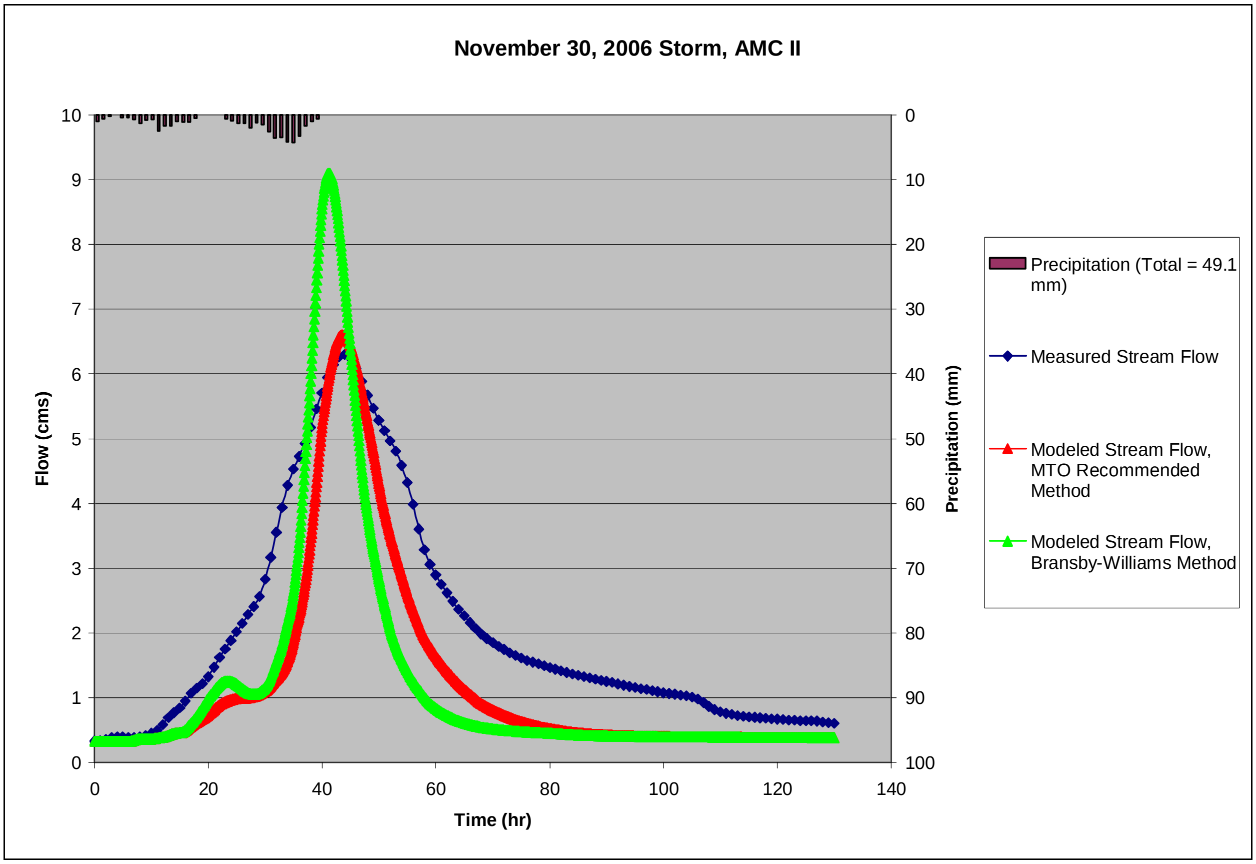

Figure 3-4 – Modeled and Observed Flow – November 30, 2006 Storm

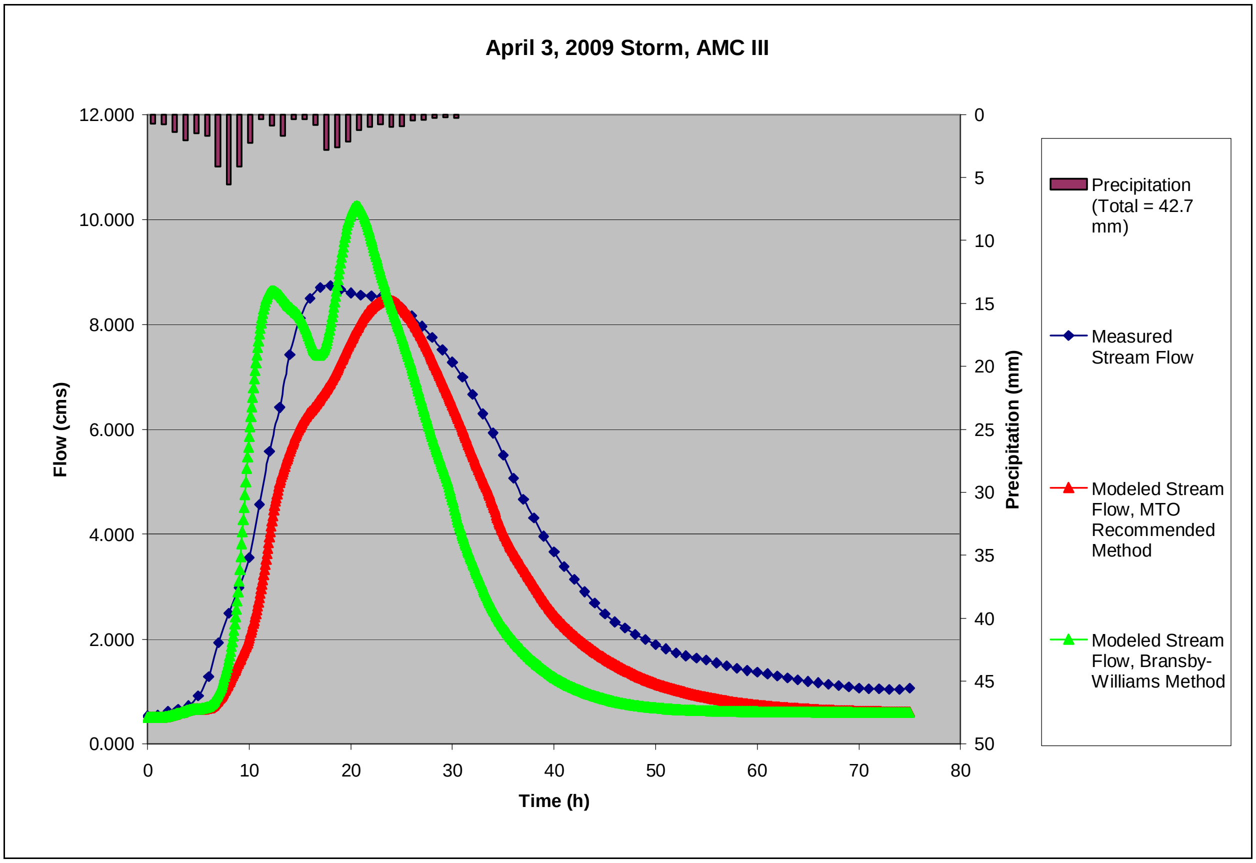

Figure 3-5 – Modeled and Observed Flow – April 3, 2009 Storm

3.6. Calibration to Stream Flow Data

A number of calibration steps were taken when comparing modelled flows to the observed stream flow data. These were as follows:

- The model was updated to the 2008 development condition;
- The use of DRMT used to calculate the precipitation;
- The recommended method by MTO (Airport Method or Bransby-Williams Method, depending on the imperviousness) was used for time to peak calculations;
- IA values calculated based on 1 mm for impervious areas, 3 mm for lawns, 4 mm for agriculture areas, and 5 mm for natural areas;
- The CN* value was adjusted to account for the AMC using MTO Design Chart 1.10 as a guide.

Other parameters were checked to determine their impact on the peak flows as well as the shape of the graph. These included:

- Varying the N value for the NASHYDs to increase the routing effects; and,
- Increasing the Manning's n values of the route channels.

Neither of these was determined to have a significant impact on the peak flows within the watershed and ultimately were not adjusted.

Table 3-3 below summarizes the calibration results. The results presented include base flow (summarized above in **Table 3-1**), which was added to the VO2 flow results. **Appendix G** includes the graphs of the calibrated storms. The calibration of the model generally appears quite accurate when analyzing the graphs shown in **Appendix G**. Also, the modeled peak flows are quite similar to the measured peak flows, well within the 25% desired by the TRCA.

Table 3-3 – Calibration Results

Storm Event	Peak Flow (m^3/s)			$C_V=V_{runoff}/V_{precipitation}$			Time to Peak (h)	
	Measured	Modeled	Difference	Measured	Modeled	Difference	Measured	Modeled
November 30, 2006	6.30	6.60	+4.8%	0.455	0.250	-45.1%	44	44
July 20, 2008	4.23	4.92	+ 16.3%	0.131	0.177	+ 35.1%	22	21
August 11, 2008	5.74	5.85	+ 1.9%	0.180	0.162	-10.0%	11	11
September 13, 2008	1.32	1.42	+ 7.6%	0.275	0.137	- 49.8%	36	16

The results illustrate that although the modeled peak flows are similar to the measured peak flows there are instances where the difference between the modeled and measured volumes is greater than a 25%. Specifically this occurs in the November 30, 2006, July 20, 2008, and September 13, 2008 storm events. Due to the variation in timing and movement of some systems through the watershed, representative results between the simulated and observed hydrographs can be difficult for certain types of storms. This is discussed further in **Section 3.8**.

As the results from this hydrologic model will ultimately be used to create the Regulation flood lines within the watershed, it is important that the peak flows closely align with the modeled peak flows. As a result volumes were considered as secondary.

3.7. Model Validation

Once the model was calibrated it was validated using three (3) additional storm events. The three (3) storms selected for validation were April 3, 2009, May 27, 2009, and July 25, 2009. These storms were selected using the same criteria as the calibration storms. The base flow for each of these storms was determined using the methodology described earlier and are presented in **Table 3-4** below**.** The base flow graphs are presented in **Appendix F** for reference.

Table 3-4 – Design Storms Base Flow

Storm	Base Flow (m^3/s)
April 3, 2009	0.511
May 27, 2009	0.0672
July 25, 2009	0.280

Six (6) rain gauges were used for the DRMT process for the validation storms. For the validation storms the precipitation data was consistent amongst all six (6) gauges. The data therefore appeared to be more accurate than it was for the calibration storms.

The gauges used were TRCA gauge 84, TRCA gauge 97, TRCA gauge 130, CLOCA gauge 02HC018, CLOCA gauge 02HC055, and CLOCA gauge Prec5. The locations of these gauges are shown above in **Figure 3-1**.

The AMC of the validation storms was calculated taking into account the rainfall from the previous five (5) days. **Table 3-5** below summarizes the AMC used for each validation storm event.

Table 3-5 – Validation Storm Events

Storm Date	Average DRMT Precipitation (mm)	Total Average Precipitation Previous Five Days (mm)	Antecedent Moisture Condition	Description
April 3, 2009	42.68	25.6	AMC III	▪ This storm took place during the dormant season and so according to the MTO Design Chart 1.10 it is almost categorized as an AMC III condition due to the amount of rainfall in the previous five (5) days. This storm should be increased from AMC II to an AMC III since there are two (2) visible peaks in the rainfall and so the ground would become saturated during the first rainfall peak and creating an AMC III condition. ▪ Antecedent moisture conditions are defined as AMC I, AMC II, or AMC III but in reality antecedent moisture in the soil is a sliding scale and is not always best represented by one (1) of these three (3) values. Therefore, this storm being modeled as an AMC III condition may not completely take into account the soil moisture before this storm occurred and this may explain the difference in peak flows between the measured stream flow and the modeled stream flow.
May 27, 2009	55.68	0.2	AMC I	▪ Since there was almost no rainfall during the previous five (5) days before the storm and the storm occurred in July it is classified as AMC I.
July 25, 2009	34.79	29.3	Average of AMC II and AMC III	▪ Due to the amount of rainfall in the five (5) days prior to the storm this should be classified as an AMC II. Similar to the April 3, 2009 storm an AMC II condition may not best represent the antecedent moisture conditions present when this storm occurred. When the results of modeling this storm as an AMC III condition were analyzed the modeled stream flow best matched the measured stream flow when the storm was modeled as an average of AMC II and AMC III.

The validation process did validate the calibration process as can be seen by the results in **Table 3-6** below and the graphs in **Appendix G**. The results in **Table 3-6** include the base flow (summarized in **Table 3-4** above), which was added to the flow results from VO2. For the validation events the modelled peak flow and volume are all within or very close to the 25% of the measured data.

Table 3-6 – Validation Results

Storm Event	Peak Flow (m^3/s)			$C_V=V_{runoff}/V_{precipitation}$			Time to Peak (h)	
	Measured	Modeled	Difference	Measured	Modeled	Difference	Measured	Modeled
April 3, 2009	8.74	8.46	-3.2%	0.574	0.428	-25.4%	18	24
May 27, 2009	1.67	2.00	+19.8%	0.193	0.180	-6.74%	53 (first peak at 37, second peak at 45)	24 (second peak at 42)
July 25, 2009	8.66	8.93	+3.1%	0.463	0.403	-13.0%	13	9

As additional validation, Cole Engineering compared the modelled Regional flows obtained from the 2008 existing condition model with the flows from other watersheds within the GTA as shown below in **Table 3-7**. Based on conversations with the TRCA it was determined that the Carruthers Creek Watershed most closely resembles the Duffins Creek Watershed due to similar topography, development form in the headwaters, geographically, and have similar soils. For this comparison, flows were converted to a flow per unit area for the Regional event.

The flows for the Duffins Creek Watershed were obtained from “Duffins Creek Hydrology Update”, dated May 2002 by Aquafor Beech and the remainder of the flows were provided by the TRCA. A comparison of the flow per area can be found below in **Table 3-7**. As the table suggests, flows generated from the updated model are consistent with flows within the Duffins Creek Watershed.

Table 3-7 – Flows per Area of Watersheds within the Greater Toronto Area

Location		Area (km^2)	Flow ($m^3/s/km^2$)
DR - German Mills Creek	Flow Node 32.84 (U/S of John St.)	32.84	8.60
Petticoat Creek	Flow Node 161 (@ Lake Ontario)	25.51	7.42
RR - Bruce Creek	Flow Node 867(D/S of 16th Ave)	35.51	5.68
DR - West Don River	Flow Node 5.2 (U/S of Langstaff Rd)	30.64	8.10
EC - Spring Creek	Flow Node J (D/S of HWY 407)	42.09	9.40
Duffins Creek	Flow Node 6.1 (West Duffins Ck s. of 9th Con Rd)	32.50	3.31
	Flow Node 4.1 (Reesor Ck at Townline Rd/N. of Green River)	39.50	3.41
	Flow Node 28.1 Duffins Ck at Lake ON	283.10	3.18
Carruthers Creek	Bayly Gauge (Node 1033)	29.56	3.56
	Carruthers at Lake Ontario (Node 1000)	36.50	4.01

The model validation summarized above in **Table 3-6** and illustrated in **Appendix G** along with the flow comparison to the Duffins Creek Watershed demonstrates an effective calibration based on the available data.

3.8. Sources of Error

While in general the peak flows calibrated well with the observed stream flow data, it is acknowledged that the volumes did not match as well. This section is intended to identify potential sources of error as it relates to the stream flow data that could ultimately impact the accuracy of the model calibration.

The rating curve, as shown below in **Figure 3-6,** is the stage storage relationship of the stream flow gauge within Carruthers Creek as provided by the TRCA. It was noted by the TRCA that the curve is mislabelled as Bayly Street and actually shows the relationship for the Achilles Gauge. As can be seen in the below relationship, the curve does not extend beyond 1.67 m^3/s. Flows beyond this limit have been extrapolated. Three (3) of the calibration storms and two (2) of the validation storms had measured stream flow above 1.67 m^3/s. If the flows in excess of 1.67 m^3/s spill into the floodplain or the channel cross-section is not accurately represented, peak flows may not be accurate.

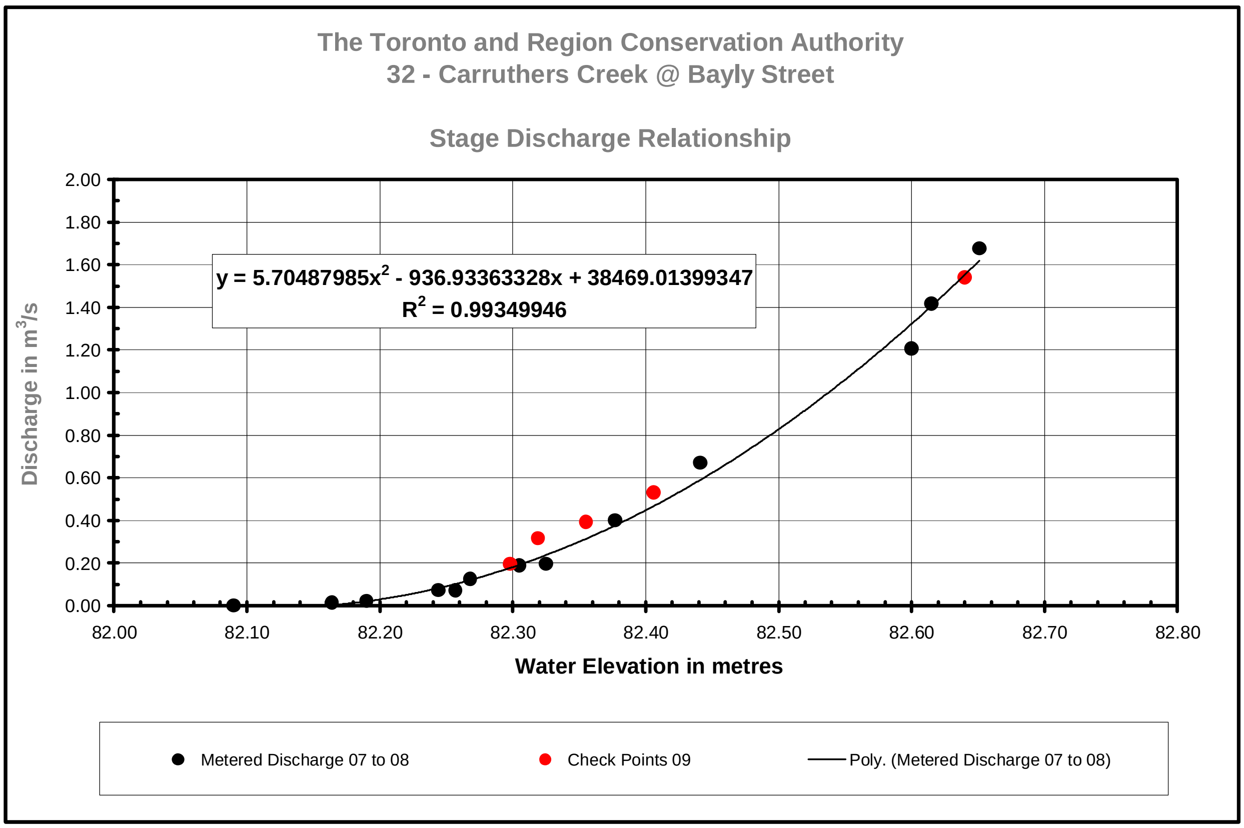

Figure 3-6 – Carruthers Creek Stream Flow Gauge Rating Curve

Using an event based model rather than a continuous model for the watershed does not account for interflow and changes in CN* that occur throughout the storm event. Therefore, the modelled stream flow will not exactly match the measured stream flow.

As a rule, it is desired that the modeled peak flow and volumes are within 25% of the measured data for all of the calibration and validation storms. As mentioned above the variation in timing and movement of a system through the watershed can generate inconsistent results between the simulated and observed hydrographs difficult in some cases. For example, based on rainfall data analyzed by the TRCA, as summarized in **Appendix G**, two (2) of the calibration and validation events had thunderstorms entering the area prior to the main front, which the model would not accurately represent. Additionally, since VO2 limits the number of gauges used in hydrologic modelling, the spatial variation in rainfall cannot be represented exactly as experienced.

The validation events resulted in the modeled peak flows and volumes more closely aligning with the measured data than the calibration events. This can be attributed to more accurate stream flow data related to the relocation of the stream gauge in 2007 as well as the availability of more accurate precipitation data. All six (6) precipitation gauges were used for the validation events while only four (4) were used for the calibration events. Two (2) of the gauges were not included in the DRMT for the calibration because they did not have adequate data.

3.9. Conclusions / Recommendations

There is a significant decrease in peak flows from the 2011 calibrated model, when compared to the 2007 model of the watershed. However, the peak flows obtained from the updated, calibrated model appear to accurately represent the observed stream flow. The differences between these two (2) models can be attributed to the fact that more data was available for the calibration of this updated model as well as more recent data. Rain gauges were available from the Duffins Creek Watershed as well as the Lynde Creek Watershed. As described above the more recent precipitation data also appeared to be more consistent, which is why six (6) gauges were able to be used for the validation events in 2009 while only four (4) could be used for the calibration events in 2006 and 2008. Also, more stream flow data has become available since the time of the last model update and the gauge was moved from its location at Bayly Street to Achilles Road.

The most significant change relates to the time to peak calculation using the MTO recommended method (Airport Method when the runoff coefficient was greater than 0.40 and Bransby-Williams Method when the runoff coefficient was less than 0.40) instead of solely the Bransby-Williams Method and the use of DRMT to help account for the special changes in precipitation values at each of the sub-catchments.

The modelling of Regional flows is paramount for protection of downstream flood areas. It is believed that the methods used to establish the calibrated model are appropriate. **Appendix D** includes a summary of all of the model input parameters for the calibrated 2008 existing conditions model for all of the NASHYDs and STANDHYDs.

It is recommended that the stream gauge and precipitation monitoring be continued so that the model can be further validated in the future. As the rating curve of the current stream flow gauge does not go beyond 1.67 m^3/s and the majority of the calibration and validation events had peak flows greater than this, it is recommended that stream flow monitoring be carried out for larger events. A possible method recommended for this is to carry out velocity panelling within the creek during events that would be larger than the current stream flow gauge can measure. As well, an additional flow gauge is recommended upstream of Highway 401. This will help to calibrate the model to take into account any routing effects. Also, an additional flow gauge is recommended at Taunton Road.

Taunton Road is currently the urban development boundary within the watershed. Therefore, having a gauge there will allow for calibration to occur for the undeveloped lands north of Taunton Road. This is especially important since changes in time to peak have been shown to have a significant impact on flows within this watershed. **Figure 3-7** illustrates the locations of these proposed gauges. These additional gauges would provide an opportunity for a more accurate calibration in the future.

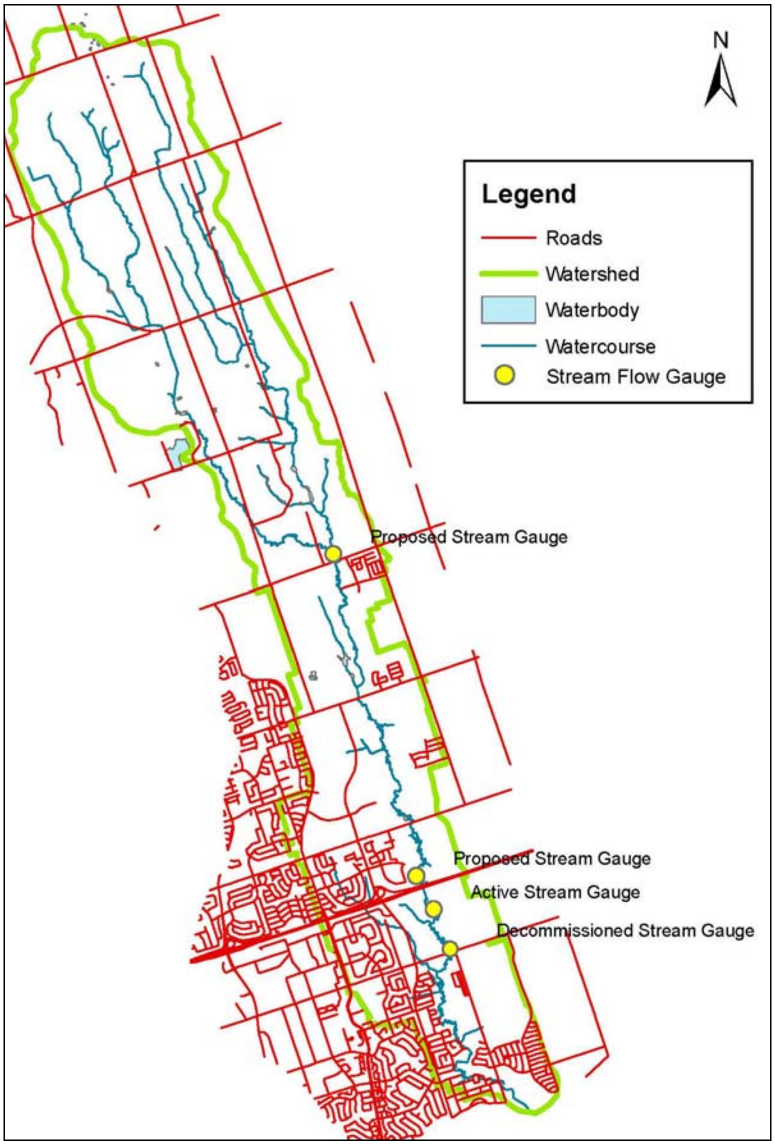

Figure 3-7 – Proposed Stream Gauge Locations

4.0 Design Storm Selection

The design storm selected in the 2007 hydrology update was the 12 hour AES storm distribution. To confirm if this is appropriate for the watershed the 100 year storm of the 6 hour, 12 hour, and 24 hour SCS Type II storm distributions, the 4 hour Chicago Distribution, and the 6 hour, 12 hour, and 24 hour AES storm distribution was compared.

The SCS and AES storm distributions were provided by the TRCA. The Chicago Storm Distribution was taken from the MTO Drainage Manual. **Table 4-1** below summarizes the results of this comparison. The 24 hour AES design storm produced the most conservative flows and therefore was selected to be the design storm for this study.

Table 4-1 –100 year Design Storm Peak Flow Comparison

Location	VO2 Sub-catchment	100 Year Design Storm Peak Flow (m^3/s)						
		6 Hour SCS Type II	12 Hour SCS Type II	24 Hour SCS Type II	6 Hour AES	12 Hour AES	24 Hour AES	4 hour Chicago Storm
Taunton Road	3092	12.899	13.853	14.275	14.123	15.673	15.792	12.180
D/S Bayly Street	1018	18.808	20.916	21.848	20.758	23.813	24.496	17.630
Lake Ontario	1000	19.527	21.698	23.398	22.372	24.830	26.153	18.869

5.0 2008 Calibrated Model Results

The peak flow rates from the 2008 existing condition are summarized below in **Table 5-1**. **Table 5-1** also compares of the peak flows from the 2007 report for the existing 2005 condition. Aerial reduction factors were applied to the Regional Storm peak flows using the methodology described in **Section 2.12**.

It can be observed that the peak flows from the 2008 condition model are generally smaller than the peak flows from the 2005 condition model created by Philips Engineering.

Table 5-1 – Simulated Peak Flows - 2008 Existing Condition

Location	Node	VO2 ID	Aerial Reduction Factor	Area (Cole Area if Different) (ha)	Peak Flow (m^3/s)													
					2-yr		5-yr		10-yr		25-yr		50-yr		100-yr		Regional Storm	
					2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX
U/S Hwy. 7 – W. Tributary		3096	100.0	408	2.57	0.97	4.19	1.50	5.41	1.88	7.07	2.40	8.39	2.80	9.76	3.22	35.04	13.07
		1175	100.0	245	1.78	0.59	2.92	0.91	3.80	1.14	4.99	1.46	5.93	1.70	6.92	1.95	23.33	7.65
		3095	100.0	653	4.34	1.56	7.10	2.40	9.21	3.01	12.06	3.84	14.31	4.48	16.66	5.14	58.26	20.62
D/S Hwy. 7 – E. Tributary		1181	100.0	120 (119)	0.90	0.40	1.51	0.62	1.98	0.79	2.62	1.01	3.12	1.19	3.66	1.37	12.13	13.92
		1182	100.0	281	1.67	0.59	2.72	0.90	3.51	1.13	4.59	1.44	5.44	1.67	6.33	1.92	22.66	7.32
		1183	100.0	162 (176)	1.15	0.52	1.91	0.81	2.49	1.02	3.29	1.30	3.91	1.51	4.57	1.74	15.60	6.99
		3103	100.0	564 (576)	3.53	1.39	5.81	2.15	7.56	2.70	9.93	3.45	11.81	4.02	13.78	4.62	49.19	18.71
D/S 5th Concession – E. Tributary		1179	100.0	192 (94)	0.58	0.20	1.01	0.32	1.35	0.42	1.83	0.55	2.21	0.65	2.62	0.76	8.63	4.03
		3102	99.2	577 (7.4)	3.72	1.63	6.14	2.54	8.03	3.21	10.65	4.11	12.74	4.81	14.97	5.54	57.88	23.79
		3101	99.2	769 (798)	3.95	1.82	6.55	2.85	8.58	3.60	11.41	4.63	13.68	5.43	16.09	6.27	64.43	115.17
U/S Taunton Rd. – Confluence		3094	98.2	1013	4.92	2.21	8.32	3.50	10.90	4.49	14.48	5.74	17.38	6.75	20.35	7.81	75.81	35.20
		3098	98.2	959 (990)	4.49	2.21	7.47	3.47	9.83	4.41	13.20	5.68	15.96	6.66	18.83	7.71	77.19	35.16
	G	3093	98.2	1972 (2004)	9.34	4.42	15.69	6.96	20.56	8.89	27.40	11.42	32.88	13.41	38.62	15.52	150.72	70.32
Taunton Rd.		3092	98.2	2025 (2056)	9.52	4.50	16.00	7.09	20.97	9.05	27.92	11.63	33.49	13.65	39.30	15.79	153.57	71.04
CPR	F	3087	97.1	2134 (2158)	9.52	4.55	16.11	7.23	21.18	9.28	28.22	11.99	33.91	14.09	40.27	16.31	160.56	70.12
U/S Rossland Rd.		3728	100.0	79 (85)	0.56	0.16	0.95	0.24	1.24	0.32	1.67	0.52	2.01	0.66	2.37	0.76	9.15	5.99
		3086	97.1	2144 (2168)	9.51	4.55	16.11	7.23	21.19	9.29	28.24	12.00	33.95	14.10	40.33	16.33	161.08	70.12
	E	3082	96.3	2223 (2252)	9.62	4.66	16.32	7.40	21.49	9.55	28.67	12.40	34.48	14.58	40.97	16.92	163.44	71.42
D/S Rossland Rd. -		1152	100.0	115 (103)	1.05	0.22	1.77	0.36	2.33	0.46	3.09	0.60	3.70	0.71	4.35	0.82	12.89	4.15
		3078	96.3	2329 (2360)	9.72	4.82	16.46	7.67	21.75	9.92	29.10	12.94	35.11	15.25	41.81	17.72	170.63	73.66

Location	Node	VO2 ID	Aerial Reduction Factor	Area (Cole Area if Different) (ha)	Peak Flow (m^3/s)													
					2-yr		5-yr		10-yr		25-yr		50-yr		100-yr		Regional Storm	
					2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX	2005 EX	2008 EX
Confluence		1071	96.3	2471 (2517)	10.10	5.10	17.13	8.11	22.70	10.49	30.40	13.71	36.71	16.20	43.74	18.87	183.76	79.42
Hwy. 2 E.	D	1044	95.4	2649 (2687)	10.21	5.38	17.46	8.59	23.37	11.17	31.25	14.63	37.82	17.28	45.24	20.13	191.42	82.18
Hwy. 2 W.		1030	100.0	96 (85)	0.32	0.68	0.37	1.07	0.42	1.37	0.47	1.74	0.51	1.99	0.54	2.26	11.19	11.84
Hwy. 401 E.		1038	94.8	2800 (2842)	10.30	5.71	17.81	9.06	23.87	11.79	32.06	15.51	38.38	18.59	45.60	21.64	194.68	85.45
Hwy. 401 W.		1001/ 1025 for Reg.	100.0	172 (164)	1.36	1.77	2.37	2.78	3.08	3.44	3.93	4.28	4.56	4.88	5.10	5.51	21.56	22.77
D/S Bayly St.		1019	100.0	301 (295)	2.44	2.40	4.22	3.91	5.56	4.90	7.28	6.17	8.55	7.17	9.83	8.19	34.80	32.72
	C	1033	94.2	2921 (2973)	10.17	6.05	17.60	9.56	23.60	12.38	31.95	16.28	38.40	19.41	45.56	22.64	199.46	88.13
		1018	94.2	3222 (3268)	10.99	6.70	18.84	10.36	25.27	13.39	34.08	17.69	40.86	21.10	48.49	24.50	218.36	108.12
Cluett Dr.		1014	93.5	3320 (3365)	10.85	6.80	18.48	10.49	24.77	13.48	33.46	17.76	40.37	21.20	47.94	24.61	214.27	110.04
		1011	100.0	112 (114)	1.64	0.93	2.98	1.51	3.92	2.04	5.00	2.66	5.88	3.08	6.77	3.52	14.65	10.98
		1008	93.5	3469 (3516)	11.14	7.00	18.92	10.86	25.38	13.93	34.30	18.42	41.42	21.99	49.24	25.52	222.30	121.99
Shoal Point Rd.	B	1005	92.7	3521 (3572)	11.01	7.06	18.73	10.98	25.19	14.08	34.00	18.59	41.11	22.20	48.79	25.77	219.33	117.77
Lake Ontario	A	1000	92.7	3614 (3665)	11.15	7.15	18.98	11.15	25.62	14.27	34.48	18.84	41.73	22.52	49.54	26.15	222.74	123.70

6.0 Predevelopment Model

A predevelopment model was chosen to be included to create a baseline model for evaluation of the effect of stormwater management design criteria on the watershed. This predevelopment model included developments either built or approved after the existing condition model used for calibration. Therefore, to best isolate the impacts of stormwater management criteria it was decided to create a base model that included all of the ponds that Cole Engineering was not assigning rating curves for (i.e. the rating curves were provided by the TRCA). This way the results of the stormwater management criteria could be isolated from changes being caused by these additional developments.

The predevelopment model also involved some sub-catchments from the existing 2008 model that were subdivided into several smaller sub-catchments, which better matched the discretization of the future conditions model.

6.1. Land Use

The 2008 land use was updated based on two (2) new subdivisions, Mulberry Meadows (Plans 40M-2404 and 40M-2407) and Pickering Beach Residential (40M-2396) that were developed within the watershed between 2008 and 2010. Mulberry Meadows had two (2) external drainage areas discharging to Carruthers Creek Watershed that were not included in the existing condition model. The VO2 models were provided by the Town for these developments.

6.2. Sub-catchment Delineation

Sub-catchments were delineated based on the subdivision plans provided by the Town and drainage area plans provided by the TRCA.

6.3. Reservoir Routing

The TRCA provided a list of the ponds to be included in the future conditions model (constructed after 2008). A list of these ponds is included in **Appendix C**. The drainage area plans for these ponds were used when delineating sub-catchments as well as for defining land use within these sub-catchments.

6.4. Summary

With the modifications described above, the Carruthers Creek Watershed has been divided into ninety-seven (97) sub-catchments. The input parameters for this model can be found in **Appendix D**. Boundaries and land uses were updated as described above.

Figure PRE-DEV illustrates the Carruthers Creek Watershed with its existing form, sub-catchments, and stormwater management ponds. This model will be used to determine the effect that the stormwater management criteria is having on the flows within the creek.

6.5. Peak Flow Results

The peak flow rates from the pre-development model are summarized below in **Table 6-1**. Aerial reduction factors were applied to the Regional Storm peak flows per MNR standards.

Table 6-1 - Simulated Peak Flows Pre-development Condition

Location	VO2 ID	Node	Aerial Reduction Factor	Area (ha)	Peak Flow (m³/s)						
					2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	Regional Storm
U/S Hwy. 7 – W. Tributary	3096		100.0	408	0.99	1.53	1.92	2.45	2.86	3.28	12.98
	1175		100.0	245	0.58	0.89	1.12	1.43	1.67	1.92	7.60
	3095		100.0	653	1.56	2.41	3.03	3.86	4.51	5.18	20.49
D/S Hwy. 7 – E. Tributary	1181		100.0	119	0.41	0.64	0.80	1.03	1.21	1.39	5.73
	1182		100.0	281	0.57	0.88	1.11	1.41	1.64	1.88	7.21
	1183		100.0	176	0.54	0.83	1.04	1.33	1.55	1.77	7.01
	3103		100.0	576	1.40	2.16	2.72	3.46	4.04	4.64	18.57
D/S 5th Concession – E. Tributary	1179		100.0	95	0.16	0.26	0.34	0.45	0.53	0.63	3.68
	3102		99.2	702	1.63	2.53	3.19	4.09	4.79	5.52	23.42
	3101		99.2	796	1.78	2.78	3.52	4.51	5.30	6.11	26.99
U/S Taunton Rd. – Confluence	3094		98.2	1013	2.27	3.59	4.60	5.89	6.91	8.00	35.13
	3098		98.2	989	2.15	3.37	4.29	5.52	6.47	7.48	33.76
	3093	G	98.2	2002	4.42	6.96	8.89	11.41	13.38	15.48	68.89
Taunton Rd.	3092		98.2	2054	4.62	7.27	9.28	11.92	13.97	16.15	71.61
CPR	3087	F	97.1	2156	4.65	7.37	9.47	12.24	14.37	16.64	70.66
U/S Rossland Rd.	3728		100.0	81	0.06	0.14	0.25	0.35	0.40	0.45	7.65
	3086		97.1	2166	4.66	7.37	9.48	12.25	14.38	16.66	70.65
	3082	E	96.3	2247	4.71	7.51	9.69	12.58	14.76	17.08	70.80
D/S Rossland Rd. - Confluence	1152		100.0	37	0.91	1.19	1.37	1.62	1.79	1.97	5.30
	3078		96.3	2410	4.91	7.89	10.23	13.31	15.59	18.05	71.47
	1071		96.3	2434	4.96	7.97	10.33	13.45	15.76	18.25	72.45
Hwy. 2 E.	1044	D	95.4	2694	5.50	8.84	11.46	14.93	17.49	20.21	86.60
Hwy. 2 W.	1030		100.0	87	0.92	1.34	1.62	1.95	2.21	2.46	11.52
Hwy. 401 E.	1038		94.8	2842	5.79	9.27	12.02	15.89	18.70	21.55	93.40
Hwy. 401 W.	1001/ 1025		100.0	167	2.16	3.19	3.83	4.69	5.30	5.92	23.48
D/S Bayly St.	1019		100.0	296	2.90	4.72	6.08	7.76	8.97	10.17	38.82
	1033	C	94.2	2972	6.02	9.56	12.39	16.26	19.18	22.11	97.89
	1018		94.2	3268	6.64	10.30	13.34	17.52	20.56	23.67	127.41
Cluett Dr.	1014		93.5	3365	6.74	10.43	13.41	17.56	20.66	23.80	129.12
	1011		100.0	119	0.50	1.08	1.70	2.28	2.63	2.98	10.11
	1008		93.5	3514	7.03	10.90	14.02	18.36	21.61	24.93	138.16
Shoal Point Rd.	1005	B	92.7	3569	7.08	11.00	14.14	18.51	21.80	25.18	132.84

Location	VO2 ID	Node	Aerial Reduction Factor	Area (ha)	Peak Flow (m³/s)						
					2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	Regional Storm
Lake Ontario	1000	A	92.7	3662	7.15	11.14	14.31	18.76	22.10	25.56	139.26

7.0 Future Scenarios

7.1. Overview

In order to predict the effects that future development will have on Carruthers Creek, two (2) future hydrologic scenarios were created.

The first model is based on the approved Official Plans (OPA) for Durham Region, Pickering, and the Town. The second is a future scenario based on Durham's Regional Official Plan Amendment No. 128 (ROPA 128). ROPA 128 has not yet been approved but would represent a possible ultimate build out scenario for the watershed.

7.2. Approved Official Plan Future Condition

Official plan amendments from the Town, Pickering, and Durham Region were reviewed and used in updating the existing hydrology model to reflect the approved OPA scenario. Changes made were:

- Modification to the land use of the watershed to match the OPA;
- Addition of proposed stormwater management facilities using the criteria outlined in the 2007 watershed report and summarized in **Table 8-1** below; and,
- Alteration of the sub-catchment boundaries and addition of new sub-catchments to reflect the changes that will occur within proposed development and the OPA.

Flows from this scenario will be used to determine the Regulatory floodplain within the watershed. Also, this model provides a benchmark that future proposed development can be compared to, to determine its impacts on flows within the watershed.

7.2.1. Land Use

The land uses assumed for the Ajax Official Plan Amendment are:

- The low density residential was defined as low density residential;
- The medium density residential was defined as medium density residential;
- The high density residential was defined as high density residential;
- The environmental protection areas were defined as natural areas;
- The open space was defined as urban open space;
- The midtown corridor was defined as commercial;
- The prestige employment was defined as commercial;
- The general employment was defined as industrial;
- The school were defined as institutional and areas were estimated;
- Downtown residential was defined as high density residential;

- Employment mixed use was defined as commercial; and,
- Commercial mixed use was defined as commercial.

The land uses assumed for the Pickering Official Plan Amendment are:

- E2 lands were defined as industrial;
- E3 was defined as cemetery;
- The active residential area was defined as golf course; and,
- The country residential areas were assumed to be estate residential.

Employment areas used the same land cover as commercial uses if no more details were available.

Two (2) new subdivisions, Mulberry Meadows (Plans 40M-2404 and 40M-2407) and Pickering Beach Residential (40M-2396) that were developed within the watershed between the years 2008 and 2010 were accounted for. Mulberry Meadows had two (2) external drainage areas discharging to Carruthers Creek Watershed that were not included in the existing condition model. The VO2 models were provided by the Town for these developments.

7.2.2. Sub-catchment Delineation

Given that the predevelopment model was further broken down to reflect this future condition, the sub-catchment delineation is consistent with the predevelopment model. **Figure FUT** illustrates the new sub-catchments for the Approved Official Plan Future Condition scenario along with the associated land uses.

7.2.3. Curve Numbers

CN values were adjusted based on the changed land use. Modified CN (CN*) values were calculated and input into the model. A summary of the input parameters for the Approved Official Plan Future Condition model can be found in **Appendix D**.

7.2.4. Reservoir Routing

For areas where the OPA had indicated significant development, a stormwater management pond will be required. Therefore, potential locations of ponds were identified and stage storage rating curves were determined using the stormwater management criteria outlined in the 2007 hydrology update report and summarized in **Table 8-1** below. The locations of these potential ponds are shown on **Figure FUT**. The rating curves for these ponds are summarized in **Appendix H**.

7.2.5. Summary

With the modifications described above, the Carruthers Creek Watershed has been delineated into ninety-seven sub-catchments in the Approved Official Plan Future Condition scenario. Boundaries and land uses within the sub-catchments were also updated as necessary. **Figure FUT** illustrates the Carruthers Creek Watershed with its approved OPA land use, sub-catchments, and stormwater management pond locations.

Peak Flow Results

The peak flow rates from the Approved Official Plan Future Condition using the 2007 stormwater management criteria are summarized below in **Table 7-1**. Aerial reduction factors were applied to the Regional Storm peak flows.

Table 7-1 – Simulated Peak Flows Approved Official Plan Future Condition

Location	VO2 ID	Node	Aerial Reduction Factor	Area (ha)	Peak Flow (m^3/s)						
					2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	Regional Storm
U/S Hwy. 7 – W. Tributary	3096		100.0	408	0.99	1.53	1.92	2.45	2.86	3.28	12.98
	1175		100.0	245	0.58	0.89	1.12	1.43	1.67	1.92	7.60
	3095		100.0	653	1.56	2.41	3.03	3.86	4.51	5.18	20.49
D/S Hwy. 7 – E. Tributary	1181		100.0	119	0.41	0.64	0.80	1.03	1.21	1.39	5.73
	1182		100.0	281	0.57	0.88	1.11	1.41	1.64	1.88	7.21
	1183		100.0	176	0.54	0.83	1.04	1.33	1.55	1.77	7.01
	3103		100.0	576	1.40	2.16	2.72	3.46	4.04	4.64	18.57
D/S 5th Concession – E. Tributary	1179		100.0	95	0.16	0.26	0.34	0.45	0.53	0.63	3.68
	3102		99.2	702	1.63	2.53	3.19	4.09	4.79	5.52	23.42
	3101		99.2	796	1.78	2.78	3.52	4.51	5.30	6.11	26.99
U/S Taunton Rd. – Confluence	3094		98.2	1013	2.27	3.59	4.60	5.89	6.91	8.00	35.13
	3098		98.2	989	2.15	3.37	4.29	5.52	6.47	7.48	33.76
	3093	G	98.2	2002	4.42	6.96	8.89	11.41	13.38	15.48	68.89
Taunton Rd.	3092		98.2	2054	4.62	7.27	9.28	11.92	13.97	16.15	71.61
CPR	3087	F	97.1	2156	4.65	7.37	9.47	12.24	14.37	16.64	70.66
U/S Rossland Rd.	3728		100.0	81	0.10	0.14	0.24	0.34	0.42	0.49	8.49
	3086		97.1	2166	4.66	4.37	9.48	12.25	14.38	16.66	70.65
	3082	E	96.3	2247	4.71	7.51	9.69	12.57	14.74	17.07	70.51
D/S Rossland Rd. - Confluence	1152		100.0	37	0.91	1.19	1.37	1.62	1.79	1.97	5.30
	3078		96.3	2410	4.91	7.88	10.21	13.28	15.56	18.01	70.72
	1071		96.3	2434	4.96	7.97	10.32	13.42	15.72	18.20	71.59
Hwy. 2 E.	1044	D	95.4	2694	5.61	8.91	11.49	14.92	17.44	20.11	94.07
Hwy. 2 W.	1030		100.0	87	0.92	1.34	1.62	1.95	2.21	2.46	11.52
Hwy. 401 E.	1038		94.8	2842	5.95	9.40	12.12	15.95	18.73	21.55	100.27
Hwy. 401 W.	1001/ 1025		100.0	167	2.16	3.19	3.83	4.69	5.30	5.92	23.48

Location	VO2 ID	Node	Aerial Reduction Factor	Area (ha)	Peak Flow (m³/s)						
					2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	Regional Storm
D/S Bayly St.	1019		100.0	296	2.88	4.65	5.96	7.61	8.79	9.98	38.86
	1033	C	94.2	2972	6.24	9.77	12.58	16.43	19.34	22.24	105.74
	1018		94.2	3268	6.89	10.57	13.58	17.75	20.77	23.85	135.69
Cluett Dr.	1014		93.5	3365	7.00	10.70	13.67	17.82	20.91	24.02	137.11
	1011		100.0	112	0.50	1.08	1.70	2.28	2.63	2.98	10.11
	1008		93.5	3514	7.31	11.19	14.29	18.65	21.90	25.17	146.35
Shoal Point Rd.	1005	B	92.7	3569	7.37	11.31	14.43	18.82	22.12	25.44	140.52
Lake Ontario	1000	A	92.7	3662	7.46	11.47	14.62	19.08	22.47	25.85	146.92

It can be observed that there is an increase in the peak flows for the 2 year through 100 year and the Regional storms downstream. The 2007 update had noted no significant change in Regional flows throughout the watershed with a slight decrease at the southern portion. The difference between the results of the 2007 update and the current results can be attributed to the change in method used for the time to peak calculations. The observation from this is that this watershed appears to be sensitive to timing. Since the Airport Method results in a much greater time to peak than the Bransby-Williams Method there is a more significant change to the timing when a sub-catchment is developed.

Table 7-2 below summarizes the change in flows from the existing condition to the Approved Official Plan Future Condition. The locations of the nodes described below in **Table 7-2** can be found on **Figure FUT**.

Table 7-2 – Flow Comparison –Approved Official Plan Future Condition to 2008 Existing Condition

Location	VO2 ID	Node	Storm	2008 Existing Condition (m³/s)	Approved OP Flow (m³/s)	Change in Flow Per Area	
						(m³/s/ha)	(%)
U/S Taunton Road - Confluence	3093	G	2-yr	4.42	4.42	0.00	0.10%
			5-yr	6.96	6.96	0.00	0.10%
			10-yr	8.89	8.89	0.00	0.10%
			25-yr	11.42	11.41	-0.01	0.01%
			50-yr	13.41	13.38	-0.03	-0.12%
			100-yr	15.52	15.48	-0.04	-0.16%
			Regional	70.32	68.89	-1.43	-1.94%
CPR	3087	F	2-yr	4.55	4.65	0.10	2.29%
			5-yr	7.23	7.37	0.14	2.03%
			10-yr	9.28	9.47	0.19	2.14%
			25-yr	11.99	12.24	0.25	2.18%
			50-yr	14.09	14.37	0.28	2.08%
			100-yr	16.31	16.64	0.33	2.12%
			Regional	70.12	70.66	0.54	0.86%
U/S Rossland Road	3082	E	2-yr	4.66	4.71	0.05	1.30%

						Change in Flow Per Area	
			5-yr	7.4	7.51	0.11	1.71%
			10-yr	9.55	9.69	0.14	1.69%
			25-yr	12.4	12.57	0.17	1.60%
			50-yr	14.58	14.74	0.16	1.32%
			100-yr	16.92	17.07	0.15	1.11%
			Regional	71.42	70.51	-0.91	-1.05%
Highway 2E	1044	D	2-yr	5.38	5.61	0.23	4.00%
			5-yr	8.59	8.91	0.32	3.46%
			10-yr	11.17	11.49	0.32	2.60%
			25-yr	14.63	14.92	0.29	1.72%
			50-yr	17.28	17.44	0.16	0.66%
			100-yr	20.13	20.11	-0.02	-0.36%
			Regional	82.18	94.07	11.89	14.17%
D/S Bayly Street	1033	C	2-yr	6.05	6.24	0.19	3.18%
			5-yr	9.56	9.77	0.21	2.23%
			10-yr	12.38	12.58	0.20	1.65%
			25-yr	16.28	16.43	0.15	0.96%
			50-yr	19.41	19.34	-0.07	-0.33%
			100-yr	22.64	22.24	-0.40	-1.73%
			Regional	88.13	105.74	17.61	20.02%
Shoal Point Road	1005	B	2-yr	7.06	7.37	0.31	4.48%
			5-yr	10.98	11.31	0.33	3.09%
			10-yr	14.08	14.43	0.35	2.57%
			25-yr	18.59	18.82	0.23	1.32%
			50-yr	22.2	22.12	-0.08	-0.28%
			100-yr	25.77	25.44	-0.33	-1.20%
			Regional	117.77	140.52	22.75	19.42%
Lake Ontario	1000	A	2-yr	7.15	7.46	0.31	4.42%
			5-yr	11.15	11.47	0.32	2.95%
			10-yr	14.27	14.62	0.35	2.54%
			25-yr	18.84	19.08	0.24	1.36%
			50-yr	22.52	22.47	-0.05	-0.14%
			100-yr	26.15	25.85	-0.30	-1.07%
			Regional	123.7	146.92	23.22	18.87%

7.3. Regional Official Plan Amendment 128

The second future condition model is based on the Regional Official Plan Amendment (ROPA) 128. The Approved Official Plan Future Condition scenario was modified to include this additional development in Pickering.

The ROPA 128 Future scenario land use was created using a shape file provided by the Region of Durham. Changes made were:

- Modification to the land use of the watershed to match ROPA 128; and,
- Inclusion of stormwater management ponds for areas where development is to occur under the OPAs and stormwater management ponds will be required. The stormwater management ponds designed were based on the stormwater management criteria developed for the watershed as described in **Table 8-1** below.

7.3.1. Land Use

The land uses within ROPA 128 were defined as follows:

- Residential areas in ROPA 128 were assumed to be medium density;
- The areas designated as “Regional Centre” were defined as commercial; and,
- The areas designated as employment areas were designated as commercial.

The natural areas surrounding the creek that are currently in the Pickering’s official plan were maintained for the ROPA condition even though they are not designated in the current ROPA 128 because it is assumed that the buffer surrounding the creek would be maintained.

7.3.2. Sub-catchment Delineation

Sub-catchment delineation was generally kept consistent with that of the future conditions model so that the discretization of the watershed did not affect the flow results when comparing it to the future condition, with minor exceptions. Areas where only a portion of the subcatchment is developed, under ROPA 128 conditions, were split based on the development boundary so that route reservoirs could be included for stormwater management within the development area. If the catchments were not subdivided based on the development boundary the stormwater management ponds would be sized to be controlling some undeveloped land. **Figure ROPA-128** illustrates the sub-catchments for the ROPA 128 future condition scenario model. There are a total of one hundred and three (103) sub-catchments for this model.

7.3.3. Curve Numbers

Curve Numbers (CN) were updated for sub-catchments where appropriate. For the sub-catchments where the land use or the sub-catchment boundary changed significantly the CN was re-calculated. Modified CN (CN*) values were calculated and input into the model. **Appendix D** includes a summary of the input parameters used for the ROPA 128 future model.

7.3.4. Reservoir Routing

Potential pond locations were identified and stage storage rating curves were determined based on the stormwater management criteria outlined in the 2007 watershed report. The locations of these potential ponds are shown on **Figure ROPA-128**.

7.3.5. Summary

With the modifications described above, the Carruthers Creek Watershed has been delineated into one hundred and three (103) sub-catchments in the ROPA 128 Future Condition scenario. Boundaries were adjusted slightly and land uses were changed within several of the sub-catchments.

Figure ROPA-128 illustrates the Carruthers Creek Watershed with its ROPA 128 Future Condition land use, sub-catchments, and stormwater management ponds.

7.3.6. Peak Flow Results

The peak flow rates from the ROPA 128 Future Condition using the 2007 stormwater management criteria as well as the 2011 stormwater management criteria described below in **Section 8.0** are summarized below in **Table 7-3**.

Table 7-4 below summarizes the differences in flows from the ROPA 128 future condition to the 2008 existing condition. An increase for the 2 to 100 year and Regional storm flows for the ROPA 128 future condition was observed throughout the watershed. This represented an approximate increase of 73% for the Regional storm at Lake Ontario. The largest flow increase was observed at Highway 2 East with an increase of 137% for the Regional storm. The large increases in flow when compared to the existing condition peak flows can be attributed to the increase in runoff generated from the significant increase in impervious area, as well as the substantial decrease in the time to peak associated with the developed condition.

Due to the elongated shape of the watershed and the fact that the tributaries are generally all in the upstream area where development is proposed under ROPA 128 a significant flow increase can be expected in the headwater areas of Carruthers Creek.

When modelling the ultimate land use condition, Philips Engineering observed an approximate 50% Regional flow increase in the headwaters of the watershed and a 16% Regional flow increase at Lake Ontario. This ultimate land use condition considered the same development area as ROPA 128. However, the total impervious and directly connected impervious assumptions for the ROPA 128 future condition model were more conservative than those made prior. Philips Engineering assumed a total imperviousness of 50% and a directly connected imperviousness of 30% for the ultimate land use condition. The ROPA 128 model assumed a 90% total and directly connected imperviousness for the commercial areas and a 55% total imperviousness and a 35% directly connected imperviousness for the residential areas. Therefore, the overall imperviousness assumptions for this model area more conservative than those previously made by Philips Engineering in the ultimate condition model. Also, Philips Engineering previously used the Bransby-Williams Method for calculating time to peak within the watershed. As described above the Bransby-Williams Method calculates significantly shorter time to peaks than the Airport Method, which was used in the headwaters of the watershed for this updated model. This significantly longer time to peak for the updated existing condition model would cause a significant change in peak flows between the existing condition and ROPA 128 model, which was observed.

It should be noted that when comparing the peak flows of the ROPA 128 model to the Ultimate Land Use Conditions model by Philips Engineering the Regional peak flows at the very upstream portion of the watershed are fairly consistent. The peak flows further downstream in the watershed are still approximately 20% less than the previous Ultimate Land Use Condition.

Table 7-3 -- Simulated Peak Flows ROPA 128 Future Condition (Regional Storm without Controls)

Location	VO2 Sub-catchment	Node	Aerial Reduction Factor	Area (ha)	2-year Peak Flow (2007 SWM Criteria) (m^3/s)	2-year Peak Flow (2011 SWM Criteria) (m^3/s)	5-year Peak Flow (Ex. SWM Criteria) (m^3/s)	5-year Peak Flow (2011 SWM Criteria) (m^3/s)	10-year Peak Flow (2007 SWM Criteria) (m^3/s)	10-year Peak Flow (2011 SWM Criteria) (m^3/s)	25-year Peak Flow (2007 SWM Criteria) (m^3/s)	25-year Peak Flow (2011 SWM Criteria) (m^3/s)	50-year Peak Flow (2007 SWM Criteria) (m^3/s)	50-year Peak Flow (2011 SWM Criteria) (m^3/s)	100-year Peak Flow (2007 SWM Criteria) (m^3/s)	100-year Peak Flow (2011 SWM Criteria) (m^3/s)	Regional Peak Flow (m^3/s)
U/S Hwy. 7 – W. Tributary	3096		100.0	408	1.58	1.58	2.18	2.18	2.61	2.61	3.85	3.85	4.73	4.73	6.00	6.00	48.80
	1175		100.0	245	4.71	4.71	6.34	6.34	7.48	7.48	8.92	8.92	10.07	10.07	11.19	11.19	32.71
	3095		100.0	653	2.54	2.54	3.45	3.45	4.12	4.12	6.09	6.09	7.48	7.48	9.51	9.51	80.99
D/S Hwy. 7 – E. Tributary	1181		100.0	52	0.22	0.22	0.35	0.35	0.45	0.45	0.58	0.58	0.68	0.68	0.78	0.78	3.44
	1182		100.0	236	3.33	3.33	4.69	4.69	5.70	5.70	7.05	7.05	8.05	8.05	9.09	9.09	30.69
	1183		100.0	150	2.79	2.79	3.89	3.89	4.68	4.68	5.66	5.66	6.40	6.40	7.20	7.20	20.62
	3103		100.0	576	2.09	2.09	2.96	2.96	3.61	3.61	5.05	5.05	6.27	6.27	7.81	7.81	61.05
D/S 5th Concession – E. Tributary	1179		100.0	95	0.16	0.16	0.26	0.26	0.34	0.34	0.45	0.45	0.53	0.53	0.63	0.63	3.68
	3102		99.2	702	2.37	2.37	3.42	3.42	4.19	4.19	5.75	5.75	7.07	7.07	8.63	8.63	60.88
	3101		99.2	796	2.52	2.52	3.66	3.66	4.51	4.51	6.16	6.16	7.55	7.55	9.16	9.16	62.74
U/S Taunton Rd. – Confluence	3094		98.2	1013	3.21	3.21	4.47	4.47	5.38	5.38	7.43	7.43	9.00	9.00	10.78	10.78	79.74
	3098		98.2	989	2.99	2.99	4.40	4.40	5.45	5.45	7.37	7.37	8.98	8.98	10.80	10.80	69.34
	3093	G	98.2	2002	6.17	6.17	8.80	8.80	10.74	10.74	14.78	14.78	17.97	17.97	21.57	21.57	148.97
Taunton Rd.	3092		98.2	2054	6.43	6.43	9.19	9.19	11.24	11.24	15.43	15.43	18.72	18.72	22.44	22.44	151.31
CPR	3087	F	97.1	2156	6.46	6.46	9.29	9.29	11.43	11.43	15.46	15.46	19.15	19.15	22.96	22.96	158.38
U/S Rossland Rd.	3728		100.0	81	0.10	0.07	0.14	0.16	0.24	0.26	0.34	0.35	0.42	0.39	0.49	0.44	8.49
	3086		97.1	2166	6.46	6.46	9.30	9.30	11.44	11.44	15.77	15.77	19.18	19.18	22.99	22.99	159.09
	3082	E	96.3	2247	6.52	6.53	9.43	9.45	11.68	11.70	16.10	16.13	19.55	19.57	23.41	23.43	163.38
D/S Rossland Rd. - Confluence	1152		100.0	37	0.91	0.91	1.19	1.19	1.37	1.37	1.62	1.62	1.79	1.79	1.97	1.97	5.30
	3078		96.3	2410	6.74	6.77	9.91	9.93	12.34	12.36	17.04	17.06	20.68	20.71	24.78	24.80	177.51
	1071		96.3	2434	6.81	6.84	10.02	10.04	12.48	12.50	17.23	17.26	20.92	20.94	25.07	25.10	179.03
Hwy. 2 E.	1044	D	95.4	2694	7.58	7.55	11.15	11.07	13.90	13.77	19.05	18.92	23.05	22.91	27.52	27.34	195.02
Hwy. 2 W.	1030		100.0	87	0.92	0.92	1.34	1.34	1.62	1.62	1.95	1.95	2.21	2.21	2.46	2.46	11.52
Hwy. 401 E.	1038		94.8	2842	7.98	7.93	11.77	11.66	14.84	14.60	20.29	20.14	24.49	24.34	29.11	28.91	190.07
Hwy. 401 W.	1001/1025		100.0	167	2.16	2.16	3.19	3.19	3.83	3.83	4.69	4.69	5.30	5.30	5.92	5.92	23.48
D/S Bayly St.	1019		100.0	296	2.88	2.88	4.65	4.65	5.96	5.96	7.61	7.61	8.79	8.79	9.98	9.98	38.86
	1033	C	94.2	2972	8.28	8.21	12.18	12.04	15.27	15.07	20.83	20.66	25.11	24.93	29.77	29.56	189.95
	1018		94.2	3268	9.04	8.92	13.27	13.07	16.63	16.36	22.44	22.22	27.05	26.81	32.20	31.91	210.96
Cluett Dr.	1014		93.5	3365	9.12	9.01	13.38	13.12	16.77	16.45	22.63	22.39	27.17	26.92	32.24	31.94	206.38
	1011		100.0	112	0.50	0.50	1.08	1.08	1.70	1.70	2.28	2.28	2.63	2.63	2.98	2.98	10.11
	1008		93.5	3514	9.50	9.36	13.97	13.68	17.51	17.17	23.57	23.31	28.29	28.01	33.59	33.26	212.75
Shoal Point Rd.	1005	B	92.7	3569	9.56	9.40	14.06	13.76	17.64	17.26	23.76	23.44	28.52	28.21	33.81	33.46	210.35
Lake Ontario	1000	A	92.7	3662	9.69	9.50	14.26	13.93	17.91	17.50	24.11	23.79	28.92	28.60	34.28	33.93	213.60

Table 7-4 – Flow Comparison –ROPA 128 Condition to 2008 Existing Condition

Location	VO2 ID	Node	Storm	2008 Existing Condition (m^3/s)	ROPA 128 Flow (Ex. SWM Criteria) (m^3/s)	ROPA 128 Flow (Prop. SWM Criteria) (m^3/s)	Change in Flow Per Area (Ex. SWM Criteria)		Change in Flow Per Area (Prop. SWM Criteria)	
							($m^3/s/ha$)	(%)	($m^3/s/ha$)	(%)
U/S Taunton Road - Confluence	3093	G	2-yr	4.42	6.17	6.17	1.75	39.66%	1.75	39.66%
			5-yr	6.96	8.80	8.80	1.84	26.55%	1.84	26.55%
			10-yr	8.89	10.74	10.74	1.85	20.94%	1.85	20.94%
			25-yr	11.42	14.78	14.78	3.36	29.58%	3.36	29.58%
			50-yr	13.41	17.97	17.97	4.56	34.11%	4.56	34.11%
			100-yr	15.52	21.57	21.57	6.05	39.11%	6.05	39.11%
			Regional	70.32	148.97	148.97	78.65	112.06%	78.65	112.06%
CPR	3087	F	2-yr	4.55	6.46	6.46	1.91	42.02%	1.91	42.02%
			5-yr	7.23	9.29	9.29	2.06	28.58%	2.06	28.58%
			10-yr	9.28	11.43	11.43	2.15	23.28%	2.15	23.28%
			25-yr	11.99	15.76	15.76	3.77	31.52%	3.77	31.52%
			50-yr	14.09	19.15	19.15	5.06	36.02%	5.06	36.02%
			100-yr	16.31	22.96	22.96	6.65	40.89%	6.65	40.89%
			Regional	70.12	158.38	158.38	88.26	126.08%	88.26	126.08%
U/S Rossland Road	3082	E	2-yr	4.66	6.52	6.53	1.86	40.12%	1.87	40.42%
			5-yr	7.4	9.43	9.45	2.03	27.72%	2.05	27.97%
			10-yr	9.55	11.68	11.70	2.13	22.53%	2.15	22.78%
			25-yr	12.4	16.10	16.13	3.70	30.16%	3.73	30.33%
			50-yr	14.58	19.55	19.57	4.97	34.38%	4.99	34.51%
			100-yr	16.92	23.41	23.43	6.49	38.66%	6.51	38.80%
			Regional	71.42	163.38	163.38	91.96	129.27%	91.96	129.27%
Highway 2E	1044	D	2-yr	5.38	7.58	7.55	2.20	40.49%	2.17	39.93%
			5-yr	8.59	11.15	11.07	2.56	29.45%	2.48	28.48%
			10-yr	11.17	13.90	13.77	2.73	24.10%	2.60	22.98%
			25-yr	14.63	19.05	18.92	4.42	29.86%	4.29	28.96%
			50-yr	17.28	23.05	22.91	5.77	33.06%	5.63	32.25%
			100-yr	20.13	27.52	27.34	7.39	36.38%	7.21	35.47%
			Regional	82.18	195.02	195.02	112.84	136.69%	112.84	136.69%
D/S Bayly Street	1033	C	2-yr	6.05	8.28	8.21	2.23	36.89%	2.16	35.75%
			5-yr	9.56	12.18	12.04	2.62	27.42%	2.48	25.96%
			10-yr	12.38	15.27	15.07	2.89	23.39%	2.69	21.78%
			25-yr	16.28	20.83	20.66	4.55	27.99%	4.38	26.93%
			50-yr	19.41	25.11	24.93	5.70	29.40%	5.52	28.50%
			100-yr	22.64	29.77	29.56	7.13	31.52%	6.92	30.61%
			Regional	88.13	189.95	189.95	101.82	115.61%	101.82	115.61%

							Change in Flow Per Area (Ex. SWM Criteria)		Change in Flow Per Area (Prop. SWM Criteria)	
Shoal Point Road	1005	B	2-yr	7.06	9.56	9.40	2.50	35.51%	2.34	33.24%
			5-yr	10.98	14.06	13.76	3.08	28.16%	2.78	25.41%
			10-yr	14.08	17.64	17.26	3.56	25.40%	3.18	22.71%
			25-yr	18.59	23.76	23.44	5.17	27.92%	4.85	26.20%
			50-yr	22.2	28.52	28.21	6.32	28.57%	6.01	27.19%
			100-yr	25.77	33.81	33.46	8.04	31.32%	7.69	29.96%
			Regional	117.77	210.35	210.35	92.58	78.76%	92.58	78.76%
Lake Ontario	1000	A	2-yr	7.15	9.69	9.50	2.54	35.58%	2.35	33.00%
			5-yr	11.15	14.26	13.93	3.11	27.96%	2.78	25.00%
			10-yr	14.27	17.91	17.50	3.64	25.58%	3.23	22.71%
			25-yr	18.84	24.11	23.79	5.27	28.07%	4.95	26.38%
			50-yr	22.52	28.92	28.60	6.40	28.52%	6.08	27.09%
			100-yr	26.15	34.28	33.93	8.13	31.20%	7.78	29.84%
			Regional	123.7	213.60	213.60	89.90	72.82%	89.90	72.82%

8.0 Stormwater Management Criteria Considerations

8.1. Approved Official Plan

For future development modelling Cole Engineering used the stormwater management criteria developed in the 2007 report as summarized below in **Table 8-1**. It should be noted that node 9a is associated with the tributary running through catchment 152 on **Figure-EX08**. The locations of these proposed ponds are shown on **Figure FUT**. The rating curves developed for these ponds are available in **Appendix H**.

Table 8-1 – Philips Engineering Stormwater Mangement Criteria

Facility Location/Receiving System	5-Year		25-Year		100-Year	
	Unitary Storage Volume (m^3/Impervious ha)	Unitary Discharge (m^3/s/ha)	Unitary Storage Volume (m^3/Impervious ha)	Unitary Discharge (m^3/s/ha)	Unitary Storage Volume (m^3/Impervious ha)	Unitary Discharge (m^3/s/ha)
Node 9a	190	0.023	300	0.047	350	0.094
Carruthers Main Branch	500	0.006	650	0.012	800	0.026

Table 8-2 below summarizes the flows within the creek at key nodes when the stormwater management criteria from the 2007 report is applied. It can be seen by the flow increases for the 2 through 100 year storms that using the stormwater management criteria outlined by Philips Engineering does not provide a high enough level of protection within the main branch of the creek.

Table 8-2 – Flow Comparison –Approved Official Plan Future Condition to Pre-development Condition

Location	VO2 ID	Node	Storm	Pre-development Condition	Approved OP Flow (m^3/s)	Change in Flow Per Area	
						(m^3/s/ha)	(%)
U/S Taunton Road - Confluence	3093	G	2-yr	4.42	4.42	0.00	0.00%
			5-yr	6.96	6.96	0.00	0.00%
			10-yr	8.89	8.89	0.00	0.00%
			25-yr	11.41	11.41	0.00	0.00%
			50-yr	13.38	13.38	0.00	0.00%
			100-yr	15.48	15.48	0.00	0.00%
			Reg.	68.89	68.89	0.00	0.00%
CPR	3087	F	2-yr	4.65	4.65	0.00	0.00%
			5-yr	7.37	7.37	0.00	0.00%
			10-yr	9.47	9.47	0.00	0.00%
			25-yr	12.24	12.24	0.00	0.00%
			50-yr	14.37	14.37	0.00	0.00%
			100-yr	16.64	16.64	0.00	0.00%
			Reg.	70.66	70.66	0.00	0.00%
U/S Rossland Road	3082	E	2-yr	4.71	4.71	0.00	0.00%
			5-yr	7.51	7.51	0.00	0.00%

Location	VO2 ID	Node	Storm	Pre-development Condition	Approved OP Flow (m^3/s)	Change in Flow Per Area	
						($m^3/s/ha$)	(%)
			10-yr	9.69	9.69	0.00	0.00%
			25-yr	12.58	12.57	-0.01	-0.08%
			50-yr	14.76	14.74	-0.02	-0.14%
			100-yr	17.08	17.07	-0.01	-0.06%
			Reg.	70.8	70.51	-0.29	-0.41%
Highway 2E	1044	D	2-yr	5.5	5.61	0.11	2.00%
			5-yr	8.84	8.91	0.07	0.79%
			10-yr	11.46	11.49	0.03	0.26%
			25-yr	14.93	14.92	-0.01	-0.07%
			50-yr	17.49	17.44	-0.05	-0.29%
			100-yr	20.21	20.11	-0.10	-0.49%
			Reg.	86.6	94.07	7.47	8.63%
D/S Bayly Street	1033	C	2-yr	6.02	6.24	0.22	3.65%
			5-yr	9.56	9.77	0.21	2.20%
			10-yr	12.39	12.58	0.19	1.53%
			25-yr	16.26	16.43	0.17	1.05%
			50-yr	19.18	19.34	0.16	0.83%
			100-yr	22.11	22.24	0.13	0.59%
			Reg.	97.89	105.74	7.85	8.02%
Shoal Point Road	1005	B	2-yr	7.08	7.37	0.29	4.10%
			5-yr	11	11.31	0.31	2.82%
			10-yr	14.14	14.43	0.29	2.05%
			25-yr	18.51	18.82	0.31	1.67%
			50-yr	21.8	22.12	0.32	1.47%
			100-yr	25.18	25.44	0.26	1.03%
			Reg.	132.84	140.52	7.68	5.78%
Lake Ontario	1000	A	2-yr	7.15	7.46	0.31	4.34%
			5-yr	11.14	11.47	0.33	2.96%
			10-yr	14.31	14.62	0.31	2.17%
			25-yr	18.76	19.08	0.32	1.71%
			50-yr	22.1	22.47	0.37	1.67%
			100-yr	25.56	25.85	0.29	1.13%
			Reg.	139.26	146.92	7.66	5.50%

As shown below in **Table 8-1**, Philips Engineering had outlined a separate set of stormwater management criteria for Node 9a than the main branch of Carruthers Creek. These criteria are not as strict as the criteria set out for the main branch of the creek. It was determined that based on the location of the observed flow increases the criteria for tributary 9a is likely contributing to this condition. As such, it was determined to use the criteria established for the main branch of Carruthers Creek for the areas associated with tributary 9a. The results of this analysis are shown below in **Table 8-3**.

Based on the observed results, it appears as though the main branch criteria would be more effective at maintaining the stream flows in the southern reaches of Carruthers Creek. The results are detailed **Appendix H** for reference.

Table 8-3 – Flow Comparison –Approved Official Plan Future Condition to Pre-development Condition with New Stormwater Management Criteria

Location	VO2 ID	Node	Storm	Pre-development Condition	Approved OP Flow with new Stormwater Management Criteria (m^3/s)	Change in Flow Per Area	
						($m^3/s/ha$)	(%)
U/S Taunton Road - Confluence	3093	G	2-yr	4.42	4.42	0.00	0.00%
			5-yr	6.96	6.96	0.00	0.00%
			10-yr	8.89	8.89	0.00	0.00%
			25-yr	11.41	11.41	0.00	0.00%
			50-yr	13.38	13.38	0.00	0.00%
			100-yr	15.48	15.48	0.00	0.00%
			Reg.	68.89	68.89	0.00	0.00%
CPR	3087	F	2-yr	4.65	4.65	0.00	0.00%
			5-yr	7.37	7.37	0.00	0.00%
			10-yr	9.47	9.47	0.00	0.00%
			25-yr	12.24	12.24	0.00	0.00%
			50-yr	14.37	14.37	0.00	0.00%
			100-yr	16.64	16.64	0.00	0.00%
			Reg.	70.66	70.66	0.00	0.00%
U/S Rossland Road	3082	E	2-yr	4.71	4.72	0.01	0.21%
			5-yr	7.51	7.53	0.02	0.27%
			10-yr	9.69	9.71	0.02	0.21%
			25-yr	12.58	12.59	7.01	0.08%
			50-yr	14.76	14.77	0.01	0.07%
			100-yr	17.08	17.09	0.01	0.06%
			Reg.	70.8	70.51	-0.29	-0.41%
Highway 2E	1044	D	2-yr	5.5	5.67	0.17	3.09%
			5-yr	8.84	8.97	0.13	1.47%
			10-yr	11.46	11.55	0.09	0.79%
			25-yr	14.93	14.96	0.03	0.20%
			50-yr	17.49	17.54	0.05	0.29%
			100-yr	20.21	20.23	0.02	0.10%
			Reg.	86.6	94.07	7.47	-1.53%
D/S Bayly Street	1033	C	2-yr	6.02	6.27	0.25	4.15%
			5-yr	9.56	9.79	0.23	2.41%
			10-yr	12.39	12.57	0.18	1.45%
			25-yr	16.26	16.4	0.14	0.86%
			50-yr	19.18	19.35	0.17	0.89%

Location	VO2 ID	Node	Storm	Pre-development Condition	Approved OP Flow with new Stormwater Management Criteria (m^3/s)	Change in Flow Per Area	
						($m^3/s/ha$)	(%)
			100-yr	22.11	22.32	0.21	0.95%
			Reg.	97.89	105.74	7.85	8.02%
Shoal Point Road	1005	B	2-yr	7.08	7.32	0.24	3.39%
			5-yr	11	11.2	0.20	1.82%
			10-yr	14.14	14.26	0.12	0.85%
			25-yr	18.51	18.63	0.12	0.65%
			50-yr	21.8	21.95	0.15	0.69%
			100-yr	25.18	25.33	0.15	0.60%
			Reg.	132.84	140.52	7.68	5.78%
Lake Ontario	1000	A	2-yr	7.15	7.38	0.23	3.22%
			5-yr	11.14	11.32	0.18	1.62%
			10-yr	14.31	14.42	0.11	0.77%
			25-yr	18.76	18.85	0.09	0.48%
			50-yr	22.1	22.24	0.14	0.63%
			100-yr	25.56	25.68	0.12	0.47%
			Reg.	139.26	146.92	7.66	5.50%

Therefore, given the sensitivity of the downstream reaches of Carruthers Creek, it would be advisable to consider applying the main branch peak flow criteria as summarized below in **Table 8-4** for all areas of the watershed. These criteria should be applied to all developments outlined in the currently approved official plans moving forward that have not yet been built or approved. This still results in a small increase in flows for the 2 year storm. The maximum increase in the 2 year storm, which is approximately 4%, is observed downstream of Bayly Street. This is considered minor and is within the error of the model and should be considered acceptable.

Table 8-4 – Revised Stormwater Management Criteria

Facility Location/Receiving System	5-Year		25-Year		100-Year	
	Unitary Storage Volume (m^3/Impervious ha)	Unitary Discharge ($m^3/s/ha$)	Unitary Storage Volume (m^3/Impervious ha)	Unitary Discharge ($m^3/s/ha$)	Unitary Storage Volume (m^3/Impervious ha)	Unitary Discharge ($m^3/s/ha$)
Carruthers Main Branch	500	0.006	650	0.012	800	0.026

In **Table 8-2** above it can be seen that there is an increase in flows for the Regional Storm in the downstream portion of the watershed. Therefore, it is recommended that the TRCA look into a mechanism to implement Regional controls. For regulatory purposes the hydraulic modeling will use the flows that incorporate this increase in flow.

8.2. Regional Official Plan Amendment 128

The stormwater management ponds for the ROPA 128 model were sized according to the stormwater management criteria summarized in **Table 8-1** above.

Table 8-5 below following demonstrates that there are significant flow increases within the main branch of the creek for the 2 to 100 year and the Regional storm Regional Storm for the ROPA 128 future conditions model were observed. These are likely a result of a marked reduction in time to peak within the northern portions of the watershed attributed to development. Therefore, Regional controls are likely required for this proposed development.

Table 8-5 – Flow Comparison – ROPA 128 Condition to Pre-development Condition

Location	VO2 ID	Node	Storm	Pre-development Condition	ROPA 128 Flow with 2007 SWM Criteria (m^3/s)	ROPA 128 Flow with 2011 SWM Criteria (m^3/s)	Change in Flow Per Area with 2007 SWM Criteria		Change in Flow Per Area with 2011 SWM Criteria	
							($m^3/s/ha$)	(%)	($m^3/s/ha$)	(%)
U/S Taunton Road - Confluence	3093	G	2-yr	4.42	6.167	6.17	1.75	39.52%	1.75	39.52%
			5-yr	6.96	8.799	8.80	1.84	26.42%	1.84	26.42%
			10-yr	8.89	10.741	10.74	1.85	20.82%	1.85	20.82%
			25-yr	11.41	14.783	14.78	3.37	29.56%	3.37	29.56%
			50-yr	13.38	17.966	17.97	4.59	34.28%	4.59	34.28%
			100-yr	15.48	21.568	21.57	6.09	39.33%	6.09	39.33%
			Reg.	68.89	148.97	148.97	80.08	116.24%	80.08	116.24%
CPR	3087	F	2-yr	4.65	6.456	6.46	1.81	38.84%	1.81	38.84%
			5-yr	7.37	9.288	9.29	1.92	26.02%	1.92	26.02%
			10-yr	9.47	11.43	11.43	1.96	20.70%	1.96	20.70%
			25-yr	12.24	15.755	15.76	3.52	28.72%	3.52	28.72%
			50-yr	14.37	19.147	19.15	4.78	33.24%	4.78	33.24%
			100-yr	16.64	22.958	22.96	6.32	37.97%	6.32	37.97%
			Reg.	70.66	158.38	158.38	87.72	124.14%	87.72	124.14%
U/S Rossland Road	3082	E	2-yr	4.71	6.515	6.53	1.81	38.32%	1.82	38.62%
			5-yr	7.51	9.43	9.45	1.92	25.57%	1.94	25.82%
			10-yr	9.69	11.676	11.70	1.99	20.50%	2.01	20.73%
			25-yr	12.58	16.104	16.13	3.53	28.11%	3.56	28.28%
			50-yr	14.76	19.549	19.57	4.81	32.63%	4.83	32.75%
			100-yr	17.08	23.41	23.43	6.34	37.14%	6.36	37.27%
			Reg.	70.8	163.38	163.38	92.87	131.71%	92.87	131.71%
Highway 2E	1044	D	2-yr	5.5	7.578	7.55	2.08	37.78%	2.05	37.24%
			5-yr	8.84	11.149	11.07	2.30	25.98%	2.22	25.03%
			10-yr	11.46	13.898	13.77	2.50	21.91%	2.37	20.82%
			25-yr	14.93	19.048	18.92	4.16	27.92%	4.03	27.04%

Location	VO2 ID	Node	Storm	Pre-development Condition	ROPA 128 Flow with 2007 SWM Criteria (m^3/s)	ROPA 128 Flow with 2011 SWM Criteria (m^3/s)	Change in Flow Per Area with 2007 SWM Criteria		Change in Flow Per Area with 2011 SWM Criteria	
							($m^3/s/ha$)	(%)	($m^3/s/ha$)	(%)
			50-yr	17.49	23.052	22.91	5.60	32.10%	5.46	31.30%
			100-yr	20.21	27.524	27.34	7.37	36.60%	7.19	35.69%
			Reg.	86.6	195.02	195.02	108.01	124.14%	108.01	124.14%
D/S Bayly Street	1033	C	2-yr	6.02	8.279	8.21	2.27	37.75%	2.20	36.61%
			5-yr	9.56	12.177	12.04	2.63	27.51%	2.49	26.05%
			10-yr	12.39	15.271	15.07	2.90	23.45%	2.70	21.84%
			25-yr	16.26	20.829	20.66	4.60	28.34%	4.43	27.28%
			50-yr	19.18	25.108	24.93	5.97	31.18%	5.79	30.27%
			100-yr	22.11	29.765	29.56	7.76	35.23%	7.55	34.31%
			Reg.	97.89	189.95	189.95	91.55	93.04%	91.55	93.04%
Shoal Point Road	1005	B	2-yr	7.08	9.559	9.40	2.49	35.21%	2.33	32.94%
			5-yr	11	14.06	13.76	3.07	27.93%	2.77	25.19%
			10-yr	14.14	17.642	17.26	3.52	24.94%	3.14	22.26%
			25-yr	18.51	23.76	23.44	5.28	28.57%	4.96	26.85%
			50-yr	21.8	28.518	28.21	6.75	31.00%	6.44	29.60%
			100-yr	25.18	33.813	33.46	8.67	34.50%	8.32	33.10%
			Reg.	132.84	210.35	210.35	77.11	57.87%	77.11	57.87%
Lake Ontario	1000	A	2-yr	7.15	9.686	9.50	2.55	35.66%	2.36	33.08%
			5-yr	11.14	14.256	13.93	3.13	28.09%	2.80	25.12%
			10-yr	14.31	17.905	17.50	3.62	25.30%	3.21	22.44%
			25-yr	18.76	24.108	23.79	5.39	28.78%	5.07	27.08%
			50-yr	22.1	28.918	28.60	6.85	31.03%	6.53	29.57%
			100-yr	25.56	34.282	33.93	8.74	34.23%	8.39	32.83%
			Reg.	139.26	213.6	213.60	73.95	52.95%	73.95	52.95%

9.0 Conclusion

Cole Engineering has undertaken the review and update of the hydrology model and prepared an accompanying report as part of the ongoing Municipal Class Environmental Assessment of the Carruthers Creek Watershed. In general the approach taken by Philips Engineering for the 2007 hydrology update was acceptable. However, it was determined that the time to peak calculations should be reconsidered using a more appropriate method as well as some other minor revisions.

Through flow comparison, sensitivity analysis, and calibration, it was determined that the MTO recommended method would be used to calculate the flows for this hydrology model update. Therefore, the Airport Method was used for sub-catchments where the runoff coefficient was less than 0.40 and the Bransby-Williams Method was used for sub-catchments where the runoff coefficient was greater than 0.40. This modelling produced results that closely matched the measured data available for the watershed. The peak flow results were lower than the peak flows previously reported for the watershed.

The stormwater management criteria established for the watershed seems acceptable with the exception of the specific criteria established for Node 9a. It is recommended to consider using the flow criteria established for the main branch of the creek throughout all areas of the watershed in order to minimize increases in flows in the southern portions of Carruthers Creek.

Additionally, the stormwater management criteria should be reconsidered for future development lands within the Carruthers Creek Watershed north of Taunton Road since increases in flows were observed for the Regional Official Plan Amendment 128 for the 2 year through 100 year storms.

Increases in Regional flows were observed for the Approved Official Plan Future Condition model and considerable increases in flows were observed for the ROPA 128 model, which is considered full build out of the watershed. Therefore, Regional controls should also be investigated as a mechanism to prevent increases in Regional flows within the downstream portions of the watershed. Further detailed study would be required to determine the affects of any approved land use north of Taunton Road.

Yours truly,

COLE ENGINEERING GROUP LTD.

LICENSED PROFESSIONAL ENGINEER
G. I. MASOTTI
100101541
Nov 9, 2011
PROVINCE OF ONTARIO

P. Osika

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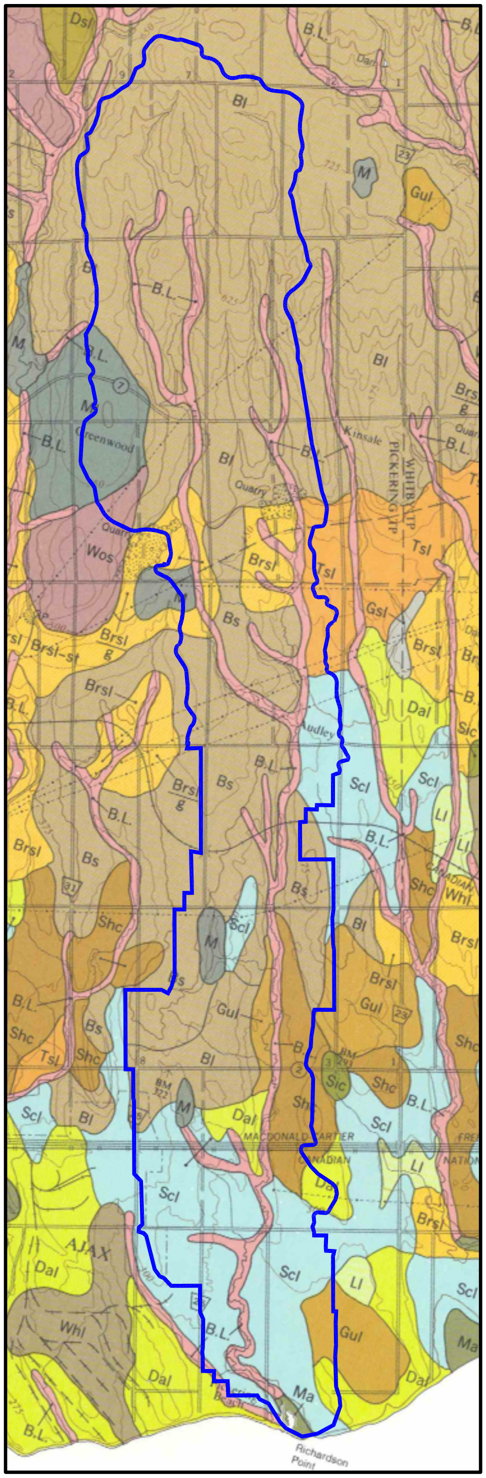
Water Resources Designer

Geoff Masotti, P.Eng.
Water Resources Engineer

CARRUTHERS CREEK SOILS MAP



LEGEND

MAP SYMBOL	SOIL TYPE	PARENT MATERIALS	DRAINAGE
Bl	BONDHEAD LOAM	CALCAREOUS GREY LOAM & SANDY LOAM TILL	GOOD
Bs	BONDHEAD SANDY LOAM	CALCAREOUS GREY LOAM & SANDY LOAM TILL	GOOD
Ml	MILLIKEN LOAM	CALCAREOUS BROWN LOAM TILL	IMPERFECT
Brsl	BRIGHTON SANDY LOAM	CALCAREOUS SAND	GOOD
Wos	WOBURN SANDY LOAM	CALCAREOUS BROWN LOAM TILL	GOOD
Scl	SMITHFIELD CLAY LOAM	CALCAREOUS CLAY	IMPERFECT
Tsl	TECUMSETH SANDY LOAM	CALCAREOUS SAND	IMPERFECT
Dal	DARLINGTON LOAM	CLAY LOAM TILL DERIVED FROM LIMESTONE AND SHALE	GOOD
Gul	GUERIN LOAM	CALCAREOUS GREY LOAM AND SANDY LOAM TILL	IMPERFECT
Shc	SCHOMBERG CLAY LOAM	CALCAREOUS CLAY	GOOD
B.L.	BOTTOM LAND	RECENT ALLUVIAL DEPOSITS	VARIABLE
M	MUCK	WELL DECOMPOSED ORGANIC DEPOSITS	VERY POOR
Ma	MARSH	SATURATED MINERAL SOIL WITH MARSH VEGETATION	VERY POOR
Brsl g	BRIGHTON GRAVELLY SANDY LOAM	CALCAREOUS SAND	GOOD
Brsl-st	BRIGHTON SANDY LOAM STONY PHASE	CALCAREOUS SAND	GOOD

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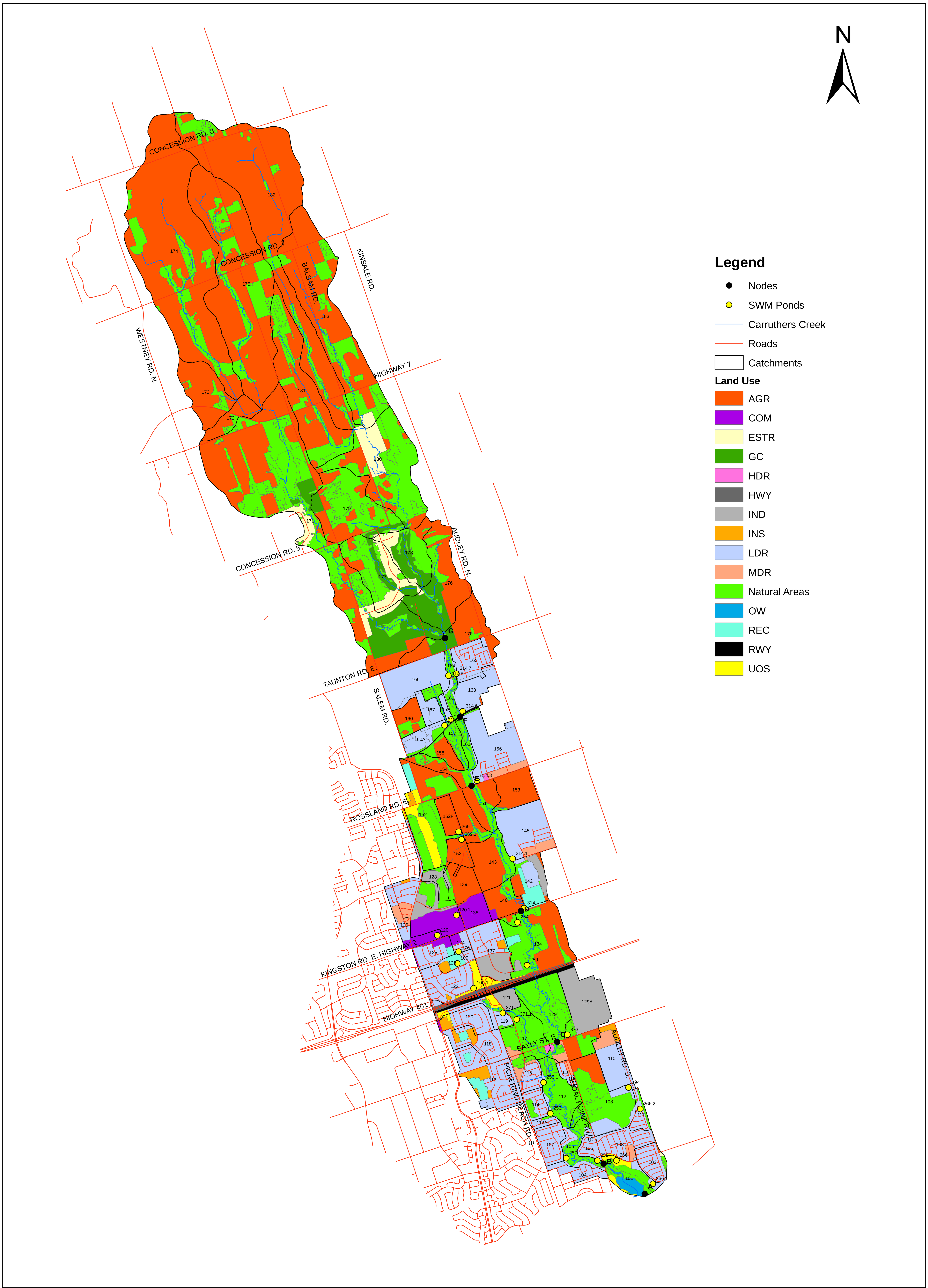
SOILS MAP
CARRUTHERS CREEK FLOOD MANAGEMENT AND ANALYSIS
MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT
TOWN OF AJAX

DATE:	OCTOBER 2011	PROJECT No.:	W10-288
SCALE:	N.T.S.	FIGURE No.:	SM



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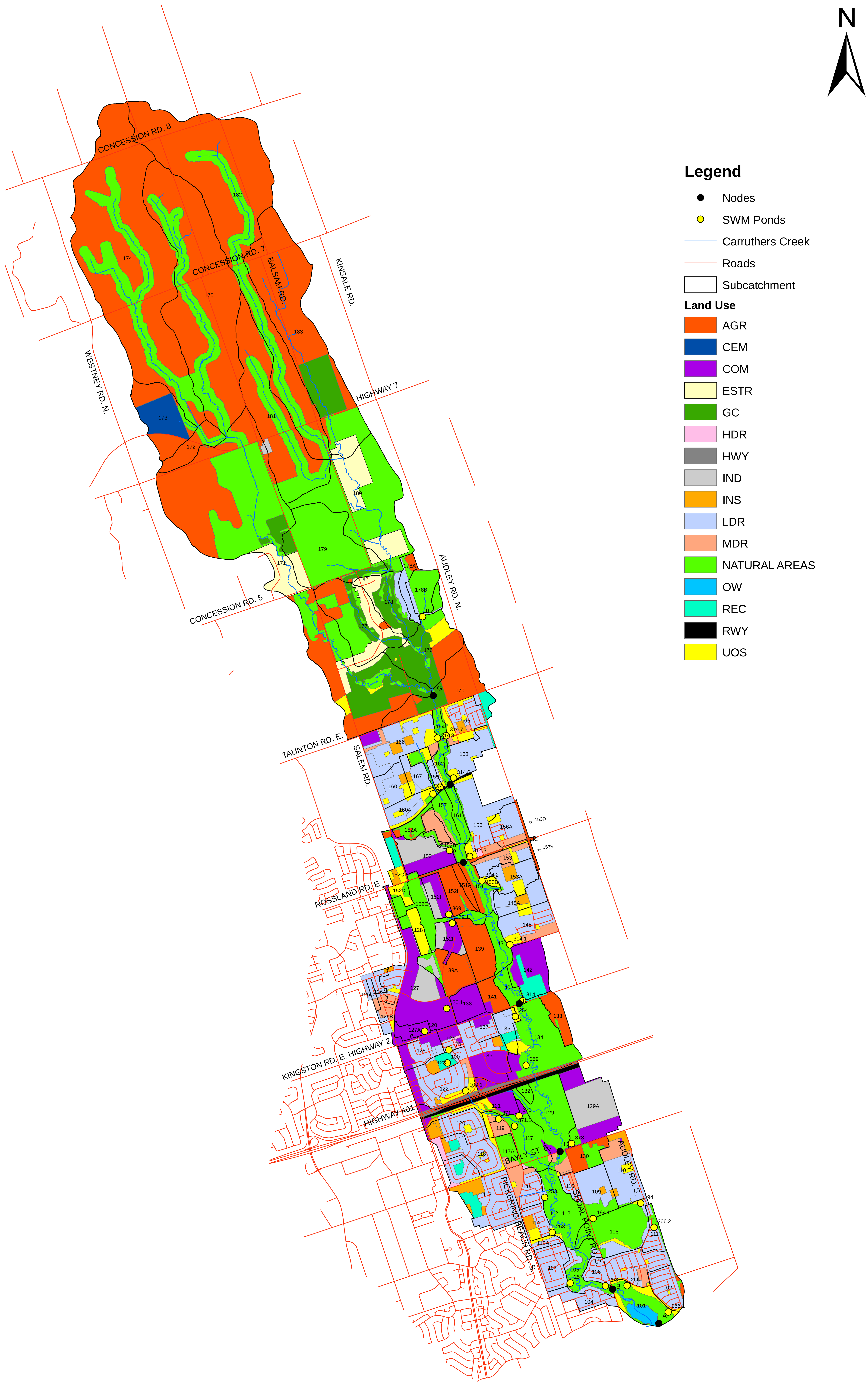
EXISTING 2008 CONDITIONS MAP
CARRUTHERS CREEK FLOOD MANAGEMENT AND ANALYSIS
MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT
TOWN OF AJAX

DATE: OCTOBER 2011	PROJECT No: W10-288
SCALE: 1:25 000	FIGURE No: EX08



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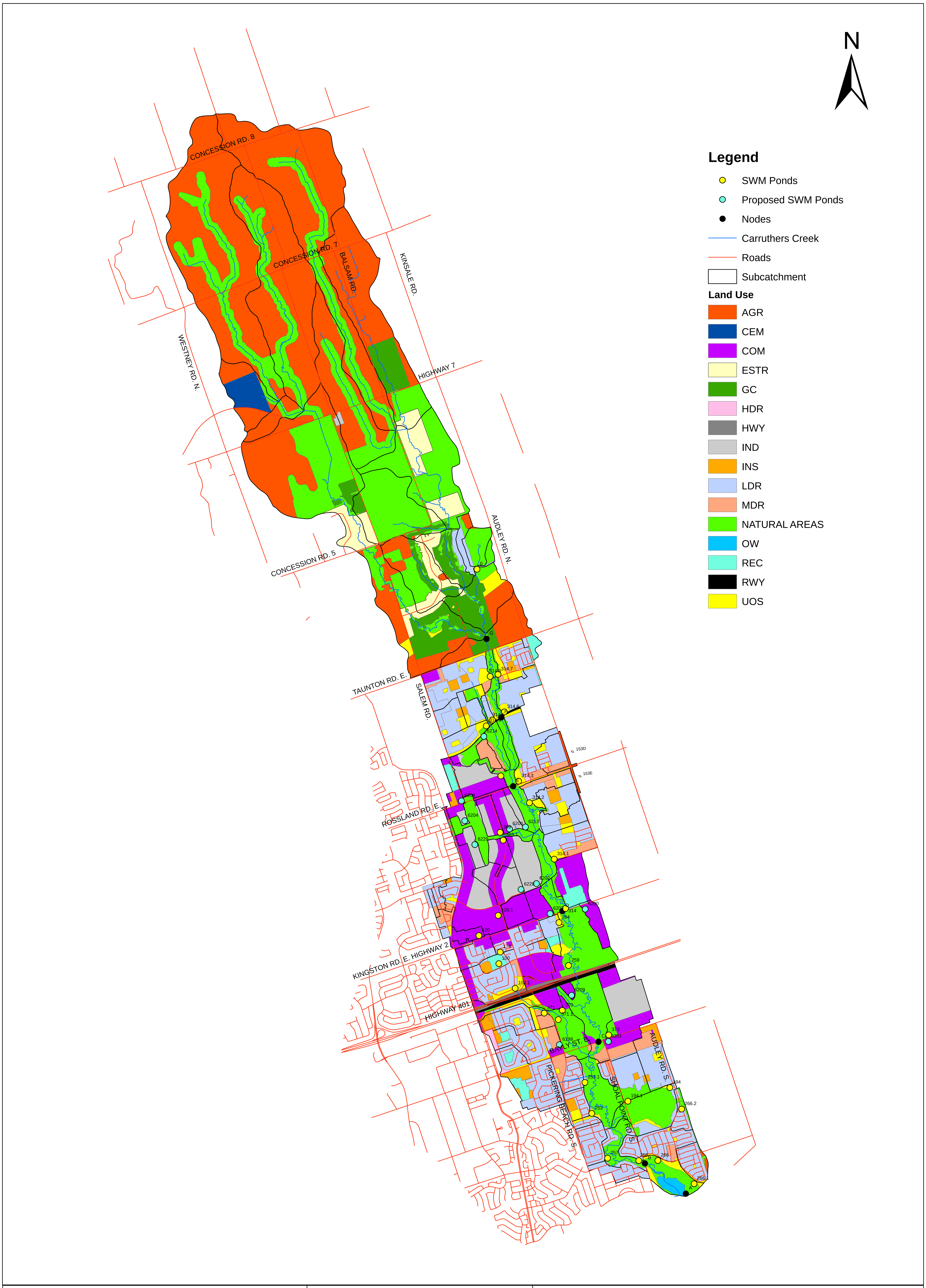
PREDEVELOPMENT CONDITION MAP
CARRUTHERS CREEK FLOOD MANAGEMENT AND ANALYSIS
MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT
TOWN OF AJAX

DATE: OCTOBER 2011	**PROJECT No: W10-288**
SCALE: 1:25 000	**FIGURE No: PRE-DEV**



APPROVED OFFICIAL PLAN FUTURE CONDITION MAP
CARRUTHER CREEK FLOOD MANAGEMENT AND ANALYSIS
MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT
TOWN OF AJAX

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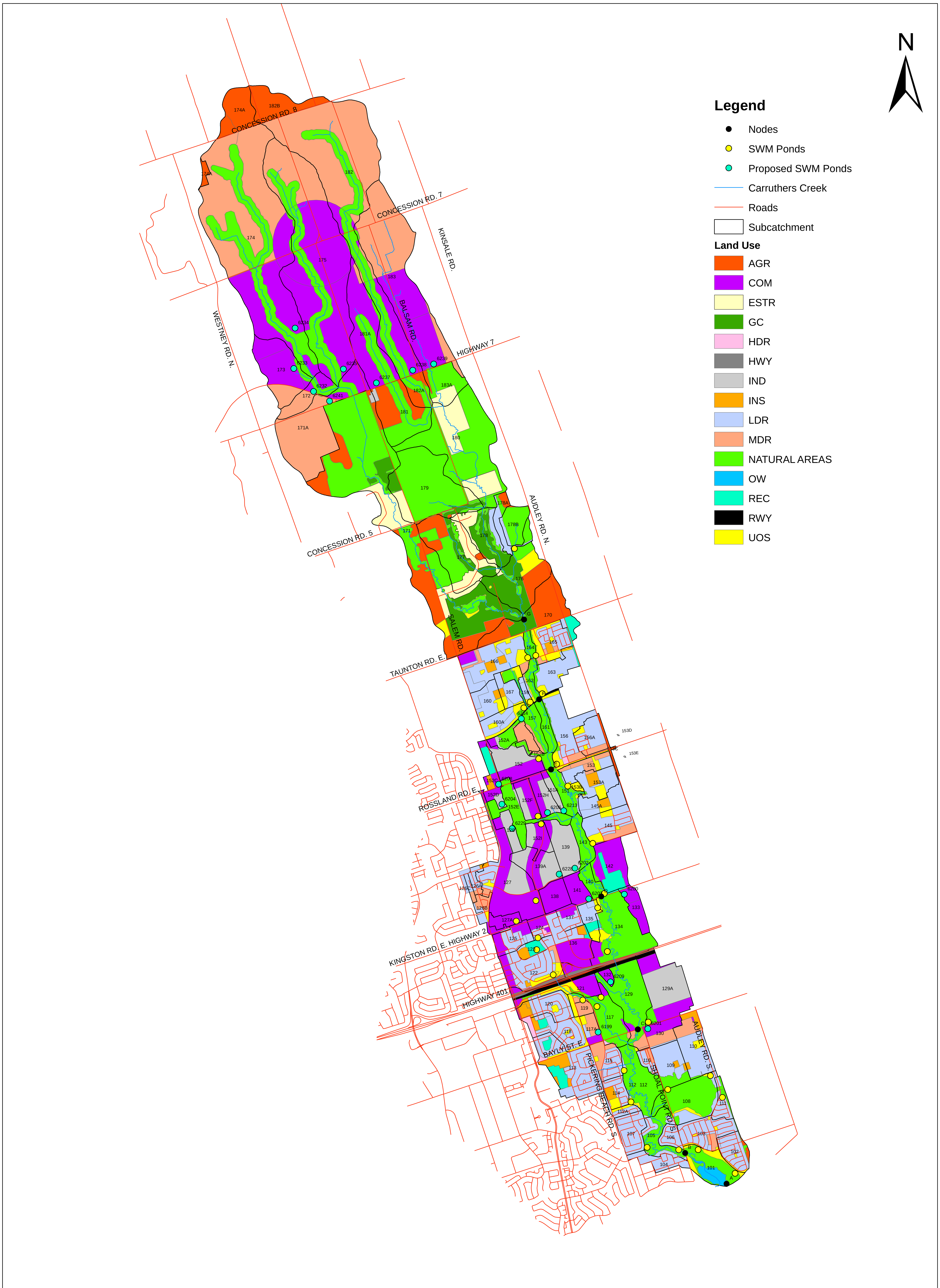
DATE: OCTOBER 2011	**PROJECT No: W10-288**
SCALE: 1:25 000	**FIGURE No: FUT**



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ROPA 128 FUTURE CONDITION MAP
CARRUTHERS CREEK FLOOD MANAGEMENT AND ANALYSIS
MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT
TOWN OF AJAX

DATE: OCTOBER 2011	**PROJECT No: W10-288**
SCALE: 1:25 000	**FIGURE No: ROPA-128**

APPENDIX A
Background Information

Background Information

The background information collected and used as reference for this update includes:

- Reports:
  - Philips Engineering, “Carruthers Creek Hydrology Update for Toronto and Region Conservation Authority”, March 2007;
  - R.J. Burnside & Associates Ltd., “Summary Report for Digital Floodplain Mapping: Carruthers Creek and Miller Creek Watersheds”, August 2007;
  - Sabourin Kimble & Associates Ltd., “Stormwater Management Design Brief Pickering Beach Residential Town of Ajax”, October 2007;
  - MMM Group, “Stormwater Management Plan Mulberry Meadows Town of Ajax, Audley Developments Limited 10-07043-050-W01”, April 2009; and,
  - R.J. Burnside & Associates Ltd., Summary Report for Digital Floodplain Mapping: Carruthers Creek Spill Analysis”, December 2009.
- Memoranda and Correspondence:
  - City of Pickering, “Summary of Major Residential Applications and Building Permits”, July 2010;
  - City of Pickering, “Summary of Non-Residential Applications and Building Permits”, July 2010;
  - Philips Engineering, Memorandum dated July 26, 2006, Re: Carruthers Creek Visual-OTTHYMO Model User’s Guide; and,
  - Town of Ajax, Carruthers Creek Development Info, received from Vanessa Lorrain
  - TRCA, Carruthers Creek SWM Pond Summary, received from Nick Lorrain.
- Drawings and Data:
  - TRCA, Carruthers Creek Watershed ESRI shape files for:
    - 1 metre contours;
    - Watercourses;
    - Roads;
    - Watershed and sub-catchment boundaries;
    - 2002 land use;
    - 2005 land use;
    - Soil types;
    - Crest of slope,
    - Engineered Floodline;
    - ESA – Carruthers;
    - Estimated Floodline;
    - Fauna;
    - Flora;
    - Meander belt;

- Natural cover 2008;
- Regulation limit;
- Regulation limit waterfront;
- Target system;
- Vegetation communities;
- Waterbodies;
- Wetlands areas of interference; and,
- Stormwater management ponds.

- TRCA, Streamflow data for 2007-2008:
  - Carruthers Creek @ Achilles Road, and,
  - Carruthers Creek @ Bayly Street.
- TRCA, Precipitation Data, 2007-2008:
  - Claremont CA gauge;
  - Brock West Landfill gauge, and,
  - Ajax Works Yard gauge.
- TRCA, Design Storms:
  - AES 1, 6, 12, and 24 hour design storms; and,
  - SCS 12 hour design storms.
- MTO, Regional Storm.
- CLOCA, Precipitation Data, 2007-2008:
  - Lynde Creek Near Whitby gauge;
  - Lynde Creek Near Kinsale gauge; and,
  - Green Wood Mushroom Farm gauge.
- Agriculture and Agri-Food Canada, Soils of Ontario County: Soil Survey Report No. 23, 1979:
  - Official Plans and Amendments.
- Town of Ajax, Subdivision Plans, 2010.
- Town of Ajax, Official Plan, December 2009.
- City of Pickering, Official Plan, December 2009.
- Durham Region, Official Plan, 1993.
- Durham Region, Regional Official Plan Amendment No. 128, 2010:
  - Models.
- TRCA, Carruthers Creek HEC-RAS Hydraulic Model, Last updated April 2010 by R.J. Burnside & Associates.
- TRCA, Carruthers Creek VO2 Hydrology Model, Last updated August 2007 by Phillips Engineering Ltd.
- Drainage Area Plans for the following developments:
  - Dillon Consulting, “Lakeside Subdivision Phase 3A Storm Drainage Plan”, May 1999;
  - Cole, Sherman, “Storm Drainage Plan:, August 1981;

- Sabourin Kimble & Associates Ltd., "Storm Drainage Plan Audley Road Lands SA-2003-08", May 2004;
- The Odan / Detech Group, "Loblaws Companies East Distribution Warehouse", May 2004;
- MMM Group "Proposed Drainage Area Plan Mulberry Meadows", March 2009;
- Sabourin Kimble & Associates Ltd., "Preliminary Storm Drainage Boundary – Blocks I, J and K Beechridge – Industrial", December 2010;
- Sabourin Kimble & Associates Ltd., "Storm Drainage Plan Central Guthrie Industrial Lands Phase 2 18T-99010", December 2009;
- Sabourin Kimble & Associates Ltd., "Storm Drainage Plan North Guthrie Industrial Lands Phase 1 18T-99010", December 2009;
- Sernas Associates, "OTTHYMO Drainage Area Plan Durham Centre Expansion RIO-CAN Real Estate Investment Trust", March 2006;
- C.C. Tatham & Associates Ltd., "Post-Development Drainage Plan Kinsale Properties Ltd. Golf Course City of Pickering", November 2008;
- Sernas Associates, "Deer Creek Estates Proposed Drainage";
- Sabourin Kimble & Associates Ltd., "Overall Storm Drainage Plan Runnymede Development Corporation", October 2007; and,
- MMM Group, "Functional Storm Drainage Plan Ajax Audley Developments Limited", August 2007.

APPENDIX B
Runoff Coefficients

Runoff Coefficient Calculations

		Soil Type										
		Bondhead (Bs)	Brighton (Brsl)	Wobunr (Wo)	Tecumseth (Tsl)	Bondhead (Bl)	Miliken (Ml)	Darlington (Dal)	Guerin (Gul)	Smithfield (Scl)	Schomberg (Shc)	Muck (M)
	Agricultural	0.22	0.22	0.22	0.22	0.35	0.35	0.35	0.35	0.55	0.55	0.30
	Golf Course	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	Natural Areas	0.08	0.08	0.08	0.08	0.25	0.25	0.25	0.25	0.35	0.35	0.30
	ESTR	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
	LDR	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	MDR	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Land Use	Commercial	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
	Paved Areas	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	HDR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Industrial	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
	Institutional	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Railway	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	Highway	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	Recreational	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

NASHYD Runoff Coefficients – 2008 Condition

Subcatchment	Runoff Coefficient
105	0.44
108	0.42
112	0.37
117	0.41
129	0.39
134	0.45
139	0.34
140	0.38
143	0.33
151	0.33
152	0.24
152F	0.44
152I	0.35
153	0.29
154	0.24
157	0.09
158	0.20
160	0.18
161	0.26
162	0.21
164	0.23
170	0.42
171	0.26
172	0.34
173	0.34
174	0.33
175	0.33
176	0.26
177	0.22
178	0.20
179	0.16
180	0.24
181	0.31
182	0.25
183	0.32

APPENDIX C
TRCA Pond Information

Carruthers Creek Stormwater Management Pond Information

		Storage-Discharge Curve	
		Discharge	Storage
Pond #	100.0	(m3/s)	(ha.m)
Name	Danovilla Park Pond	0.0000	0.0000
Status	Built	1.3500	0.1280
Type of Control	Quality - Online Storage	1.5800	0.2790
Drainage Area (ha)	26.93	1.9000	0.6950
Imperviousness	54%, 34%	3.1100	0.8150
Development Type	Medium Density Residential		
Drainage from Subcatchment	125, 123		
NHYD in Model	100		
In Scenario	All		
		Discharge	Storage
Pond #	100.1	(m3/s)	(ha.m)
Name	Danovilla South Pond	0.0000	0.0000
Status	Built	0.3000	0.1660
Type of Control	Quantity - Online Storage	0.3900	0.3010
Drainage Area (ha)	156.03 in ex, 166.68 in future, pre-dev, and ROPA	0.4500	0.6620
Imperviousness	47%	3.8300	0.9500
Development Type	Medium Density Residential	7.1400	1.2300
Drainage from Subcatchment	1122 and upstream		
NHYD in Model	1001		
In Scenario	All		
		Discharge	Storage
Pond #	120.0	(m3/s)	(ha.m)
Name	Chapters Pond	0.0000	0.0000
Status	Built	0.0100	0.2500
Type of Control	Quality, Quantity and Erosion	0.0200	0.1630
Drainage Area (ha)	19.57 in existing, 20.91 in future, pre-dev, ROPA	0.0300	0.3230
Imperviousness	various	0.0400	0.5000
Development Type	Commercial, Residential	0.1600	0.6910
Drainage from Subcatchment	126 in existing model, 127A and 126B minor and 126C minor in future, pre-dev, and ROPA	0.2300	0.8960
NHYD in Model	120	0.3000	1.1160
In Scenario	All		
		Discharge	Storage
Pond #	120.1 and 120.2	(m3/s)	(ha.m)
Name	Costco Pond	0.0000	0.0000
Status	Built	0.0050	0.0264
Type of Control	Quality, Quantity and Erosion	0.0160	0.1796
Drainage Area (ha)	60.4 in existing, 65.9 in future, pre-dev, and ROPA	0.0220	0.3678
Imperviousness	81%, 47%	0.0270	0.5894
Development Type	Commercial	0.2520	0.8424
Drainage from Subcatchment	127 and 126A minor	0.6600	1.1269
NHYD in Model	1201	1.1860	1.4427
In Scenario	Existing 2008, Future, Pre-Dev, ROPA		

Pond #	176.0	Discharge (m3/s)	Storage (ha.m)
Name	Heritage Market	0.0000	0.0000
Status	Built	0.1000	0.0263
Type of Control	Quality, Quantity and Erosion	0.3690	0.0537
Drainage Area (ha)	7.3	0.7873	0.0823
Imperviousness	73%	1.3423	0.1119
Development Type	Commercial and High Density Residential		
Drainage from Subcatchment	1124		
NHYD in Model	176		
In Scenario	All		

Pond #	194.0	Discharge (m3/s)	Storage (ha.m)
Name	John Boddy - Warbler Swamp	0.0000	0.0000
Status	Built	0.0390	0.2280
Type of Control	Quality, Quantity and Erosion	0.6100	0.5170
Drainage Area (ha)	32.7	3.4000	0.6649
Imperviousness	53%	5.2200	0.8468
Development Type	Medium Density Residential		
Drainage from Subcatchment	110		
NHYD in Model	194		
In Scenario	All		

Pond #	194.1	Discharge (m3/s)	Storage (ha.m)
Name	Lajter Lands - Warbler Swamp	0.0000	0.0000
Status	Not Built	0.0520	0.3000
Type of Control	Quality and Erosion	1.9200	0.3500
Drainage Area (ha)	22		
Imperviousness	34%		
Development Type	Medium Density Residential		
Drainage from Subcatchment	109		
NHYD in Model	1941		
In Scenario	Future, Pre-Dev, ROPA		

Pond #	253.0	Discharge (m3/s)	Storage (ha.m)
Name	Carruthers Creek Residential Phase I - South Pond	0.0000	0.0000
Status	Built	0.0500	0.1926
Type of Control	Quality and Erosion	0.9900	0.2000
Drainage Area (ha)	13.4		
Imperviousness	53%		
Development Type	Medium Density Residential		
Drainage from Subcatchment	114		
NHYD in Model	253		
In Scenario	All		
Notes	SSD based on volumes and release rates		

		Discharge (m3/s)	Storage (ha.m)
Pond #	253.1		
Name	Carruthers Creek Residential Phase II - North Pond	0.0000	0.0000
Status	Built	0.0200	0.3325
Type of Control	Quality and Erosion	0.0440	0.3800
Drainage Area (ha)	16.2 + 55 ha of external existing residential	0.0710	0.4045
Imperviousness	63%, 37%	0.1120	0.4825
Development Type	Medium Density Residential	5.5000	0.5000
Drainage from Subcatchment	113, 115		
NHYD in Model	2531		
In Scenario	All		

		Discharge (m3/s)	Storage (ha.m)
Pond #	254.0		
Name	Guthrie Commercial - Hwy 2 Pond	0.0000	0.0000
Status	Built	0.0580	0.1969
Type of Control	Quality, Quantity and Erosion	0.1800	0.2880
Drainage Area (ha)	16.69 in existing, 39.08 in future, pre-dev, and ROPA	0.3300	0.3054
Imperviousness	85%	0.5440	0.3218
Development Type	Commercial	0.7410	0.3370
Drainage from Subcatchment	Online	2.8900	0.3450
NHYD in Model	254		
In Scenario	All		

		(m3/s)	(ha.m)
Pond #	257.0		
Name	Pickering Plains Pond	0.0000	0.0000
Status	Built	0.7000	0.0900
Type of Control	Quality and Erosion	0.7100	0.1800
Drainage Area (ha)	22.7		
Imperviousness	39%		
Development Type	Medium Density Residential		
Drainage from Subcatchment	107		
NHYD in Model	257		
In Scenario	All		

		Discharge (m3/s)	Storage (ha.m)
Pond #	258.0		
Name	Blue Maple Holdings	0.0000	0.0000
Status	Built	0.0300	0.0080
Type of Control	Quantity	0.0900	0.0320
Drainage Area (ha)	9.4	0.1300	0.0710
Imperviousness	45%	0.1500	0.1190
Development Type	Medium Density Residential		
Drainage from Subcatchment	106		
NHYD in Model	258		
In Scenario	All		

		Discharge (m3/s)	Storage (ha.m)
Pond #	259.0		
Name	Pickering Beach Subdivision	0.0000	0.0000
Status	Built	0.5000	0.1100
Type of Control	Quantity	0.8000	0.6000
Drainage Area (ha)	44.64	0.8900	0.9100
Imperviousness	64% in existing, 71% and 61% in future, pre-dev, and ROPA	11.0000	1.6100
Development Type	Industrial		
Drainage from Subcatchment	1137 in existing, 136 and minor from 137 in future, pre-dev, and ROPA		
NHYD in Model	259		
In Scenario	All		

		Discharge (m3/s)	Storage (ha.m)
Pond #	266.0		
Name	Lake of the Woods Phase I	0.0000	0.0000
Status	Built	0.0080	0.0480
Type of Control	Quality and Erosion	0.0090	0.0950
Drainage Area (ha)	26.2	0.0090	0.1430
Imperviousness	45%	0.1490	0.1900
Development Type	Medium Density Residential	0.4030	0.2470
Drainage from Subcatchment	103	0.7320	0.3030
NHYD in Model	266	1.1200	0.3590
In Scenario	All	1.5620	0.4150
		2.0130	0.4710
		2.9140	0.6040
		3.8650	0.7360
		4.7400	0.8790
		5.0810	1.0320

		Discharge (m3/s)	Storage (ha.m)
Pond #	266.1		
Name	Lakeside Phase II	0.0000	0.0000
Status	Built	0.0090	0.0030
Type of Control	Quality and Erosion	0.0110	0.0310
Drainage Area (ha)	22.4	0.0130	0.0640
Imperviousness	50%	0.0140	0.1000
Development Type	Medium Density Residential	0.2370	0.1760
Drainage from Subcatchment	102	0.7700	0.2610
NHYD in Model	2661	0.8720	0.3540
In Scenario	All	0.9740	0.4550
		1.0760	0.5660
		1.2290	0.7490

		Discharge (m3/s)	Storage (ha.m)
Pond #	266.2	0.0000	0.0000
Name	Lakeside Phase III	0.0090	0.0900
Status	Built	0.0760	0.1080
Type of Control	Quality and Erosion	0.2990	0.1390
Drainage Area (ha)	8.5	0.6090	0.1700
Imperviousness	35%	0.9850	0.2020
Development Type	Medium Density Residential	1.4180	0.2350
Drainage from Subcatchment	111	1.5950	0.2690
NHYD in Model	2662	1.7280	0.3040
In Scenario	All	1.8610	0.3400
		2.1260	0.4140

		Interim		Ultimate	
		Discharge (m3/s)	Storage (ha.m)	Discharge (m3/s)	Storage (ha.m)
Pond #	314.0	0.0000	0.0000	0.0000	0.0000
Name	Picov Race Track	0.0030	0.0332	0.0260	0.4980
Status	Built	0.0070	0.1821	0.1410	0.6160
Type of Control	Quality, Quantity and Erosion	0.0090	0.2880	0.1570	0.7530
Drainage Area (ha)	26.2	0.0380	0.4030	0.1810	0.9300
Imperviousness	64%	0.0630	0.5258	0.1970	1.0680
Development Type	Industrial	0.0800	0.6556	0.2360	1.2180
Drainage from Subcatchment	142			50.0000	1.5000
NHYD in Model	314				
In Scenario	All				

		(m3/s)	(ha.m)
Pond #	314.1	0.0000	0.0000
Name	A8 - Lexington County	0.0050	0.1940
Status	Built	0.0210	0.5240
Type of Control	Quality, Quantity and Erosion	0.0380	0.8880
Drainage Area (ha)	49.12	0.0430	1.2070
Imperviousness	46% in existing, 59% and 39% in future, pre-dev, and ROPA	0.0890	1.4050
Development Type	Medium Density Residential	0.1720	1.6780
Drainage from Subcatchment	145 in existing, 145 and 145A in future	0.2420	2.1030
NHYD in Model	3141	0.3080	2.5500
In Scenario	All	0.5120	3.1840
		0.7900	3.8550

		Discharge (m3/s)	Storage (ha.m)
Pond #	314.2		
Name	A8 - Picov Lands	0.0000	0.0000
Status	Built	0.0100	0.2151
Type of Control	Quality, Quantity and Erosion	0.0150	0.4511
Drainage Area (ha)	50.52 + 18.88 of major flows from pond 314.3 area	0.0180	0.7090
Imperviousness	various	0.0210	0.9797
Development Type	Medium Density Residential	0.0230	1.1807
Drainage from Subcatchment	153, 153A, 153B, 153C, 153E, 152D, major from 156A	0.0530	1.2589
NHYD in Model	3142	0.3060	1.5468
In Scenario	Future, pre-dev, ROPA	0.6940	1.8433
		0.8580	1.9532
		1.4800	2.1486
		1.8480	2.2357
		5.0880	2.4671
		9.3220	2.6599

		Discharge (m3/s)	Storage (ha.m)
Pond #	314.3		
Name	A8 - Medallion	0.0000	0.0000
Status	Built	0.0080	0.5557
Type of Control	Quality, Quantity and Erosion	0.0120	1.1683
Drainage Area (ha)	58.03	0.0130	1.4286
Imperviousness	39%, 60%	0.0880	1.8368
Development Type	Medium Density Residential	0.1180	1.9779
Drainage from Subcatchment	156, 156A minor	0.2150	2.2675
NHYD in Model	3143	0.2740	2.4162
In Scenario	All	0.3390	2.5673
		0.4100	2.7207
		0.4850	2.8765

		Interim		Ultimate	
Pond #	314.4	Discharge (m3/s)	Storage (ha.m)	Discharge (m3/s)	Storage (ha.m)
Name	Hampstock Southwest Pond 1				
Status	Built	0.0000	0.0000	0.0000	0.0000
Type of Control	Quality, Quantity and Erosion	0.0083	0.2578	0.0180	0.9720
Drainage Area (ha)	30.19 existing, 48.38 future, pre-dev, ROPA	0.0087	0.2825	0.2190	1.2150
Imperviousness	57%	0.0302	0.3531	0.2480	1.4460
Development Type	Medium Density Residential	0.0516	0.4202	0.2920	1.7860
Drainage from Subcatchment	160A, 167 (existing), 160, 160A, 167 (future, pre-dev, ROPA)	0.0742	0.5191	0.3650	2.0290
NHYD in Model	3144	0.086	0.5897	0.4370	2.2480
In Scenario	All	0.0955	0.6533	3.0000	2.4500

		Discharge (m3/s)	Storage (ha.m)
Pond #	314.5		
Name	A8 - Hampstock Southwest Pond 2	0.0000	0.0000
Status	Built	0.0090	0.1010
Type of Control	Quality, Quantity and Erosion	0.0090	0.1107
Drainage Area (ha)	3.94	0.0210	0.1384
Imperviousness	57%	0.0300	0.1647
Development Type	Medium and High Density Residential	0.0390	0.2034
Drainage from Subcatchment	159	0.0440	0.2311
NHYD in Model	3145	0.0480	0.2560
In Scenario	All		

		Discharge (m3/s)	Storage (ha.m)
Pond #	314.6		
Name	A8 - Hampstock Phase II - Southeast Pond	0.0000	0.0000
Status	Built	0.0080	0.5040
Type of Control	Quality, Quantity and Erosion	0.0490	0.6300
Drainage Area (ha)	21	0.0870	0.7500
Imperviousness	60%	0.1240	0.9260
Development Type	Medium Density Residential	0.1430	1.0520
Drainage from Subcatchment	163	0.1550	1.1660
NHYD in Model	3146	5.3700	1.4820
In Scenario	All		

		Discharge (m3/s)	Storage (ha.m)
Pond #	314.7		
Name	A8 - Hampstock Phase I - Northeast Pond	0.0000	0.0000
Status	Built	0.0080	0.5090
Type of Control	Quality, Quantity and Erosion	0.0480	0.6360
Drainage Area (ha)	23.12	0.0840	0.7570
Imperviousness	30%	0.1320	0.9350
Development Type	Medium Density Residential	0.1680	1.0620
Drainage from Subcatchment	165	0.2070	1.1760
NHYD in Model	3147	7.0490	1.9360
In Scenario	All		

		Discharge (m3/s)	Storage (ha.m)
Pond #	314.8		
Name	A8 - Hampstock Phase III - Northwest Pond	0.0000	0.0000
Status	Built	0.0160	1.1160
Type of Control	Quality, Quantity and Erosion	0.1040	1.3940
Drainage Area (ha)	44.27	0.1800	1.6600
Imperviousness	45%	0.2660	2.0500
Development Type	Medium Density Residential	0.3120	2.3290
Drainage from Subcatchment	166	0.3460	2.5800
NHYD in Model	3148	9.3940	3.0010
In Scenario	All		

		Interim		Ultimate	
Pond #	369.0	Discharge	Storage	Discharge	Storage
Name	Guthrie Industrial - North Pond	(m3/s)	(ha.m)	(m3/s)	(ha.m)
Status	Interim Built	0.0000	0.0000	0.0000	0.0000
Type of Control	Quality, Quantity and Erosion	0.0050	0.4760	0.0050	0.4445
Drainage Area (ha)	13.21	0.0790	0.5800	0.0100	0.4623
Imperviousness	90%	0.1290	0.6500	0.0370	0.5713
Development Type	Industrial	0.1720	0.7200	0.0490	0.6510
Drainage from Subcatchment	152F	0.1990	0.7750	0.0600	0.7582
NHYD in Model	369	0.2200	0.8300	0.0680	0.8401
In Scenario	Interim in Existing; Ultimate in Future, Pre-Dev, ROPA			0.0740	0.9240

		Interim		Ultimate	
		Discharge	Storage	Discharge	Storage
Pond #	369.1	(m3/s)	(ha.m)	(m3/s)	(ha.m)
Name	Guthrie Industrial - South Pond	0.0000	0.0000	0.0000	0.0000
Status	Interim Built	0.0050	0.4620	0.0070	0.4407
Type of Control	Quality, Quantity and Erosion	0.0880	0.5650	0.0240	0.4647
Drainage Area (ha)	12.82	0.1250	0.6200	0.0730	0.5601
Imperviousness	90%	0.1660	0.6900	0.1140	0.6214
Development Type	Industrial	0.1920	0.7450	0.1520	0.7508
Drainage from Subcatchment	152I	0.2170	0.8100	0.1770	0.7725
NHYD in Model	3691			0.2000	0.8416
In Scenario	Interim in Existing; Ultimate in Future, Pre-Dev, ROPA				

		Discharge	Storage
Pond #	370.0	(m3/s)	(ha.m)
Name	Salem/Schilles - 401 Interchange	0.0000	0.0000
Status	Built	0.0260	0.1470
Type of Control	Quality, Quantity and Erosion	0.0370	0.3170
Drainage Area (ha)	26.77	0.0460	0.4960
Imperviousness	58%	0.1440	0.6840
Development Type	Roads and Commercial	0.7400	0.8820
Drainage from Subcatchment	121	1.2690	1.0880
NHYD in Model	370	1.3710	1.3050
In Scenario	Future, Pre-Dev, ROPA		

		Discharge	Storage
Pond #	371.0	(m3/s)	(ha.m)
Name	Salem Achilles - Retrofit Pond	0.0000	0.0000
Status	Built	0.0060	0.0281
Type of Control	Quality and Erosion	0.0090	0.0642
Drainage Area (ha)	23.88	1.2000	0.0670
Imperviousness	45%		
Development Type	Medium Density Residential		
Drainage from Subcatchment	120		
NHYD in Model	371		
In Scenario	All		

		Discharge (m3/s)	Storage (ha.m)
Pond #	371.1		
Name	Salem Achillies - Treatmeant Train Pond	0.0000	0.0000
Status	Built	0.0090	0.0299
Type of Control	Quality and Erosion	0.0150	0.0724
Drainage Area (ha)	4.38	0.0200	0.1179
Imperviousness	55%	0.0260	0.2046
Development Type	Medium Density Residential	0.1000	0.2060
Drainage from Subcatchment	119	2.6500	0.2410
NHYD in Model	3711		
In Scenario	All		

		Discharge (m3/s)	Storage (ha.m)
Pond #	373.0		
Name	Loblaws Distribution Centre Pond	0.0000	0.0000
Status	Built	0.0266	0.0371
Type of Control	Quality and Erosion	0.0461	0.1131
Drainage Area (ha)	53.7	0.0596	0.1915
Imperviousness	83%	0.0705	0.2724
Development Type	Industrial	0.0799	0.3557
Drainage from Subcatchment	129A	0.0883	0.4413
NHYD in Model	373	0.0960	0.5292
		0.1032	0.6193
In Scenario	All	0.1098	0.7118

		Discharge (m3/s)	Storage (ha.m)
Pond #			
Name	Deer Creek	0.0000	0.0000
Status	Not Built	0.0270	0.0547
Type of Control		0.0590	0.1558
Drainage Area (ha)	15.16	0.0780	0.2666
Imperviousness	32%	0.0860	0.3253
Development Type	Residential	0.1380	0.4278
Drainage from Subcatchment	178A		
NHYD in Model	0		
In Scenario	Future, pre-dev, ROPA		

		Discharge (m3/s)	Storage (ha.m)
Pond #			
Name	Beechridge	0.0000	0.0000
Status	Not Built	0.0140	1.0650
Type of Control		0.1280	1.3252
Drainage Area (ha)	36.88	0.3500	1.6299
Imperviousness	81%	0.9010	1.7163
Development Type	Residential and employment		
Drainage from Subcatchment	152		
NHYD in Model	6207		
In Scenario	Future, pre-dev, ROPA		

APPENDIX D
Model Input Parameters

Imperviousness Assumptions – Carruthers Creek Watershed

Land Use	TIMP	XIMP
Estate Residential	0.14	0.09
Low Density Residential	0.45	0.24
Medium Density Residential	0.55	0.35
High Density Residential	0.64	0.35
Institutional	0.55	0.3
Industrial	0.9	0.9
Commercial/Business	0.9	0.9
Agricultural	0	0
Natural Area	0	0
Open Space	0.01	0.01
Cemetery	0.01	0.01
Recreational	0.2	0.2
Open Water	1	1
Railway	0.5	0.5
Highway	1	1
Golf Course	0.01	0.01

TIMP and XIMP values were taken from "Carruthers Creek Hydrology Update for Toronto and Region Conservation Authority", March 2007 by Philips Engineering with the exception of the medium density residential and the industrial values, which were based on research and recommendations from the TRCA.

APPENDIX D-1
2008 Existing Condition Model Input Parameters

2008 Existing Condition NASHYD Model Input

	Unit	**Description**	**105**	**108**	**112**	**117**	**129**	**134**	**139**	**140**	**143**	**151**	**152**	**152F**	**152I**	**153**	**154**	**157**	**158**	**160**
DT	min	Time Step Increment									5									
Area	ha	Watershed Area	23.6	72.9	37.26	61.59	76.78	90.89	22.44	22.58	39.43	27.29	102.83	13.21	12.82	29.73	18.48	17.93	14.49	18.35
DWF	m3/s	Dry Weather Flow (Base Flow)									0									
CN* (AMC	-	SCS Modified Curve Number (CN*)	76.7	76.1	76.1	75.6	76.7	79.8	74.6	75.6	76.7	76.7	64.1	81.9	78.8	77.7	68.8	52.5	68.8	68.3
CN* (AMC	-	SCS Modified Curve Number (CN*)	88.7	88.5	88.5	88.1	88.7	91	87.5	88	88.7	88.7	81.1	91.4	89.8	89.5	84	71.5	83.81	83.5
IA	mm	Initial Abstraction	4.3	4.4	4.8	4.6	4.7	4.6	4.1	4.1	4.3	4.3	4.2	4	4	4	4.4	4.9	4.3	4.3
N	-	Number of Linear Reservoir									3									
TP	hr	Unit Hydrograph Time to Peaks	3.21	1.3	2.35	2.62	3.88	2.99	3.37	1.78	2.95	1.89	5.26	0.4	1.46	4.68	3.2	6.48	2.6	2.87
Rain	mm/h	Optional Rainfall Intensities									0 - Without Rain									

	Unit	**Description**	**161**	**162**	**164**	**170**	**171**	**172**	**173**	**174**	**175**	**176**	**177**	**178**	**179**	**180**	**181**	**182**	**183**
DT	min	Time Step Increment									5								
Area	ha	Watershed Area	10.08	8.46	5.14	51.64	360.73	21.41	50.29	336.31	244.69	78.4	67.03	46.85	94.63	127.29	118.67	281.36	176.21
DWF	m3/s	Dry Weather Flow (Base Flow)									0								
CN* (AMC	-	SCS Modified Curve Number (CN*)	51.5	53.0	52.5	80.9	66.2	79.8	79.8	73.5	76.1	69.3	56.7	57.2	61.4	63.0	74.0	76.7	75.6
CN* (AMC	-	SCS Modified Curve Number (CN*)	71	72	71.5	91.5	82.5	91	91	87.5	88.5	84	74.5	85	78.5	80	87.5	88.7	88
IA	mm	Initial Abstraction	4.8	4.5	4.4	3.9	4.2	4.1	4.1	3.8	4.2	3.8	4	3.8	4.5	4.5	4.4	4.1	4.3
N	-	Number of Linear Reservoir									3								
TP	hr	Unit Hydrograph Time to Peaks	0.55	0.96	1.03	1.37	3.62	5.36	4.06	8.17	8.02	4.41	5.59	2.52	4.68	3.8	4.55	9.88	5.98
Rain	mm/h	Optional Rainfall Intensities									0 - Without Rain								

2008 Existing Condition STANDHYD Model Input

Subcatchment	Unit	Description	101	102	103	104	106	107	110	111	112A	113	114	115	116	118	119	120	121	122
DT	min	Time Step Increment	5																	
Area	ha	Watershed Area	30.52	22.4	26.2	13.85	9.4	22.7	32.7	8.5	5.92	55	13.4	16.2	6.66	29.37	4.46	24.07	11.44	44.13
XIMP		Directly Connected Impervious Area	0.3	0.27	0.26	0.23	0.23	0.21	0.32	0.19	0.21	0.34	0.28	0.21	0.27	0.25	0.2	0.23	0.57	0.38
TIMP		Total Impervious Area Fraction	0.33	0.5	0.47	0.45	0.45	0.39	0.53	0.37	0.41	0.63	0.53	0.37	0.47	0.45	0.38	0.46	0.58	0.47
DWF	m3/s	Dry Weather Flow (Base Flow)	0																	
CN* (AMC II)		SCS Modified Curve Number (CN*)	75	77	77	77	77	77	74	64	76	77	76	76	75	76	75	77	79	73
CN* (AMC III)			88.6	89.2	89.2	89.2	89.2	89.2	87.5	81.2	88.4	89.2	88.3	88.3	88.4	88.9	88.3	89.2	90.81	87.3
IA		Initial Abstraction	4.2	3.1	3	3	3	3	3	3.3	89.2	3	3.4	3.4	3.1	3	3.3	3	3.2	3
SLPP	%	Average Slope of Pervious Area	2																	
LGP	m	Overland Flow Length for Pervious Areas	40																	
MNP		Manning's Roughness Coefficient for Pervious Areas	0.25																	
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area	0																	
DPSI	mm/hr	Impervious Area Depression Storage	1																	
SLPI	%	Average Slope of Impervious Area	0.1	0.5	0.4	0.4	0.5	0.8	2	0.5	1.3	0.8	0.8	0.8	0.5	1	1	1.5		0.5
LGI		A=1.5*L^2	461.2	349.6	437.6	304.4	245.2	368.8	483.4	259.5	207	622.3	298.8	364.2	209.9	436.7	170.9	399		528.7
MNI		Manning's Roughness Coefficient for Impervious Areas	0.013																	
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area	0																	
Rain	mm/hr	Optional Rainfall Intensities	0 - Without Rain																	

Subcatchment	Unit	Description	123	124	125	126	127	128	129A	137	138	142	145	156	159	160A	163	165	166	167
DT	min	Time Step Increment	5																	
Area	ha	Watershed Area	8.17	7.3	19.32	20.28	64.88	10.85	53.7	43.07	21.32	26.2	49.12	59.66	3.94	18.17	21	23.12	44.27	12.02
XIMP		Directly Connected Impervious Area	0.24	0.9	0.37	0.54	0.61	0.45	0.83	0.52	0.85	0.3	0.25	0.25	0.31	0.31	0.32	0.3	0.23	0.31
TIMP		Total Impervious Area Fraction	0.34	0.9	0.54	0.66	0.67	0.45	0.83	0.64	0.85	0.35	0.46	0.45	0.57	0.57	0.6	0.55	0.45	0.57
DWF	m3/s	Dry Weather Flow (Base Flow)	0																	
CN* (AMC II)		SCS Modified Curve Number (CN*)	65	64.5	64.5	61	58.5	53	76	67.5	64.5	76	66	61.5	55	64.5	66.5	77	55	55
CN* (AMC III)			82	81.1	81.1	78.1	76.1	70.9	88.8	85.6	80.9	88.7	82.1	78.3	73.3	73.1	82.5	88.9	73.5	76.5
IA		Initial Abstraction	3	3	3	3	3.3	4	3.1	3	3	5	3	3	3	3.4	3	3	3	3
SLPP	%	Average Slope of Pervious Area	2																	
LGP	m	Overland Flow Length for Pervious Areas	40																	
MNP		Manning's Roughness Coefficient for Pervious Areas	0.25																	
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area	0																	
DPSI	mm/hr	Impervious Area Depression Storage	1																	
SLPI	%	Average Slope of Impervious Area	0.5	0.9	0.9	1.3	1.4	1.9	1	1.1	0.3	1.6	3	1.2	1	1	0.8	0.8	2.2	2.5
LGI		A=1.5*L^2	227.4	219.1	357.5	361.2	660.4	271.4	598	531.7	345.2	458.4	553.5	630.6	157.9	348.1	413	420.6	574.4	283.1
MNI		Manning's Roughness Coefficient for Impervious Areas	0.013																	
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area	0																	
Rain	mm/hr	Optional Rainfall Intensities	0 - Without Rain																	

APPENDIX D-2
Pre-Development Model Input Parameters

Predevelopment Condition NASHYD Model Input

Subcatchment	Unit	Description	105	108	112	117	117A	128	129	130	132	133	134	139	139A	140	141	143	151	151A	152A	152B	152C	152D
DT	min	Time Step Increment	5																					
Area	ha	Watershed Area	23.60	46.27	37.26	51.06	9.76	11.26	54.07	15.9	4.31	13.26	63.52	27	27.61	9.86	12.56	13.93	17.24	5.88	9.18	7.00	10.79	5.81
DWF	m3/s	Dry Weather Flow (Base Flow)	0																					
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	75.6	74	76.7	75.6	77.7	58.8	76.7	81.6	81.9	85.5	77.7	78.8	72.5	64.1	77.7	72.5	68.8	76.1	53.6	62.5	60.9	58.8
CN* (AMC III)		SCS Modified Curve Number (CN*)	88.1	87.5	88.7	88.1	89.2	76.8	88.7	91.4	91.4	93.4	89.2	89.8	86.3	81.1	89.2	86.3	84	88.7	72.8	79.5	78.3	76.8
IA	mm	Initial Abstraction	4.4	4.6	4.8	4.6	4.6	3.5	4.7	4.4	4.4	4	4.6	4	4	5	3.9	5	4.7	4	4.7	4.5	3.2	3.6
N	-	Number of Linear Reservoir	3																					
TP	hr	Unit Hydrograph Time to Peaks	3.22	5.31	2.35	0.52	0.27	2.09	1.84	0.63	0.43	0.39	3.86	3.02	2.69	1.27	0.32	0.68	2.38	4.15	2.11	2.18	2.64	2.34
Rain	mm/h	Optional Rainfall Intensities	0 - Without Rain																					

Subcatchment	Unit	Description	152H	153D	153E	157	161	162	164	170	171	172	173	174	175	176	177	178	178B	179	180	181	182	183
DT	min	Time Step Increment	5																					
Area	ha	Watershed Area	16.47	4.60	2.57	19.55	10.09	8.46	5.14	51.64	360.73	21.41	50.29	336.31	244.69	56.53	67.03	35.31	18.37	94.63	125.58	118.67	281.36	176.21
DWF	m3/s	Dry Weather Flow (Base Flow)	0																					
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	79.8	76.13	76.13	51.5	50.9	52.5	50.9	80.9	67.2	77.7	75.6	74.6	75.6	68.3	59.9	57.2	54	52.5	59.9	73.5	74.6	75.6
CN* (AMC III)		SCS Modified Curve Number (CN*)	90.3	88.5	88.5	71.1	70.2	71.9	70.2	90.8	83.2	89.2	88.1	87.5	88.1	83.8	77.5	76	73.6	71.9	77.5	86.9	87.5	88.1
IA	mm	Initial Abstraction	4.1	5	5	4.5	5	4.5	5	3.7	4.1	4.2	3.6	4.3	4.2	3.5	3.8	3.3	4.8	4.6	4.4	4.4	4.3	3.9
N	-	Number of Linear Reservoir	3																					
TP	hr	Unit Hydrograph Time to Peaks	3.66	0.11	0.16	6.1	0.55	0.96	1.03	3.41	3.58	5.43	4.28	8.28	8.02	3.29	5.46	2.35	3.45	4.73	3.72	4.55	9.07	5.98
Rain	mm/h	Optional Rainfall Intensities	0 - Without Rain																					

Predevelopment Condition STANDHYD Model Input

	Unit	Description	101	102	103	104	106	107	109	110	111	112A	113	114	115	116	118	119	120	121	122	123	124	125	126A	126B	126C	127
DT	min	Time Step Increment	5																									
Area	ha	Watershed Area	30.52	22.4	26.2	13.85	9.4	22.7	22	32.7	8.5	5.92	55	13.4	16.2	6.66	29.37	4.38	23.88	26.77	44.4	7.76	7.3	19.17	5.5	10.3	2.6	69.73
XIMP	-	Directly Connected Impervious Area	0.27	0.27	0.24	0.23	0.23	0.21	0.18	0.27	0.18	0.19	0.34	0.21	0.27	0.27	0.23	0.54	0.25	0.57	0.38	0.24	0.63	0.54	0.26	0.44	0.28	0.77
TIMP	-	Total Impervious Area Fraction	0.27	0.5	0.45	0.45	0.45	0.39	0.34	0.48	0.35	0.35	0.63	0.39	0.48	0.47	0.41	0.55	0.45	0.58	0.47	0.34	0.73	0.65	0.47	0.56	0.49	0.81
DWF	m3/s	Dry Weather Flow (Base Flow)	0																									
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	76.0	77	77	77	77	77	74.0	74	64.0	76.0	77	76.0	76.0	75	75	75.0	77	80.0	73	65	64.5	64.5	54.0	59	54	58.5
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	90.3	89.2	89.2	89.2	89.2	89.2	87.5	87.5	81.2	90.3	89.2	90.3	90.3	88.4	88.9	88.3	89.2	90.9	87.3	82	83.2	83.2	73.8	77.8	73.8	79
IA	-	Initial Abstraction	4.5	3.1	3	3	3	3	3.5	3	3.5	3	3	3	3	3	3	3	3	3.2	3	3	3	3	3	3	3	3
SLPP	%	Average Slope of Pervious Area	2																									
LGP	m	Overland Flow Length for Pervious Areas	40																									
MNP	-	Manning's Roughness Coefficient for Pervious Areas	0.25																									
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area	0																									
DPSI	mm/hr	Impervious Area Depression Storage	1																									
SLPI	%	Average Slope of Impervious Area	0.1	0.5	0.4	0.4	0.5	0.8	2	2	0.5	1.3	0.8	2	0.8	0.5	1	1	2	2	0.5	0.5	2	2	2	2	2	2
LGI	-	A=1.5*L^2	451.1	360.6	440.2	303.9	245.6	368.9	421.3	483.4	264.6	198.7	622.3	300	364.1	210.7	442.5	172.4	400.6	296.9	543.6	233.4	240.1	352.6	191.5	262	131.7	681.8
MNI	-	Manning's Roughness Coefficient for Impervious Areas	0.013																									
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area	0																									
Rain	mm/hr	Optional Rainfall Intensities	0 - Without Rain																									

	Unit	Description	127A	129A	135	136	137	138	142	145	145A	152	152F	152I	153	153A	153B	153C	156	156A	159	160	160A	163	165	166	167	178A
DT	min	Time Step Increment	5																									
Area	ha	Watershed Area	8.01	53.7	12.31	37.39	11.87	14.9	26.2	30.42	18.7	36.88	13.21	12.82	16.7	20.34	1.78	4.53	38.42	18.88	3.94	18.35	18.17	21	23.12	44.27	12.02	15.16
XIMP	-	Directly Connected Impervious Area	0.9	0.84	0.26	0.62	0.53	0.85	0.64	0.21	0.56	0.77	0.9	0.9	0.68	0.53	0.99	0.77	0.21	0.32	0.18	0.22	0.15	0.21	0.17	0.27	0.21	0.12
TIMP	-	Total Impervious Area Fraction	0.9	0.84	0.44	0.71	0.61	0.85	0.64	0.39	0.59	0.81	0.9	0.9	0.71	0.56	0.99	0.79	0.39	0.6	0.33	0.58	0.41	0.37	0.3	0.44	0.39	0.32
DWF	m3/s	Dry Weather Flow (Base Flow)	0																									
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	64.0	76.0	77.0	74.0	68.7	64.1	76.0	66.0	72.5	59.5	71.0	65.0	71.9	72.5	72.5	72.5	59.5	43.3	55	55.0	55.0	70.0	77	55	53	55
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	83.2	88.8	89	88.1	84	80.5	90.3	84.5	86.5	79.7	86	83.8	86	86.5	86.5	86.5	79.7	63.5	76	76	76	86.9	90.8	76	73.2	76
IA	-	Initial Abstraction	3	3.1	5	3	3	4.8	3.1	3	5	3	3	3	5	5	5	5	3.1	5	3	3	3.1	3.1	3	3	3	3.8
SLPP	%	Average Slope of Pervious Area	2																									
LGP	m	Overland Flow Length for Pervious Areas	40																									
MNP	-	Manning's Roughness Coefficient for Pervious Areas	0.25																									
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area	0																									
DPSI	mm/hr	Impervious Area Depression Storage	1																									
SLPI	%	Average Slope of Impervious Area	2	2	0.3	2	1.1	0.3	2	2	2.3	2	2	2	1.6	2.5	1.1	1	2	1.2	2	2	2	0.8	0.8	2.2	2	2
LGI	-	A=1.5*L^2	231.1	605.6	286.5	499.3	281.3	315.2	468.2	450.2	941**	495.8	217.7	306.1	1114**	903**	108.9	173.8	506.1	354.8	156.2	349.8	348	411.4	422.1	574.5	281.5	317.9
MNI	-	Manning's Roughness Coefficient for Impervious Areas	0.013																									
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area	0																									
Rain	mm/hr	Optional Rainfall Intensities	0 - Without Rain																									

APPENDIX D-3
Approved Official Plan Future Condition Model Input Parameters

Future Condition NASHYD Model Input

Subcatchment	Unit	Description	105	108	112	117	129	134	140	143	151	152B	152E	153D	153E	157	161	162
DT	min	Time Step Increment	5															
Area	ha	Watershed Area	23.60	46.27	37.26	51.06	54.07	63.52	9.86	13.93	17.24	7.00	27.67	4.60	2.57	19.55	10.09	8.46
DWF	m3/s	Dry Weather Flow (Base Flow)	0															
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	75.6	74	76.7	75.6	76.7	77.7	64.1	72.5	68.8	62.5	67.2	76.13	76.13	51.5	50.9	52.5
CN* (AMC III)		SCS Modified Curve Number (CN*)	88.1	87.5	88.7	88.1	88.7	89.2	81.1	86.3	84	79.5	83.2	88.5	88.5	71.1	70.2	71.9
IA	mm	Initial Abstraction	4.4	4.6	4.8	4.6	4.7	4.6	5	5	4.7	4.5	4.9	5	5	4.5	5	4.5
N	-	Number of Linear Reservoir	3															
TP	hr	Unit Hydrograph Time to Peaks	3.22	5.31	2.35	0.52	1.84	3.86	1.27	0.68	2.38	2.18	4.86	0.11	0.16	6.1	0.55	0.96
Rain	mm/h	Optional Rainfall Intensities	0 - Without Rain															

Subcatchment	Unit	Description	164	170	171	172	173	174	175	176	177	178	178B	179	180	181	182	183
DT	min	Time Step Increment	5															
Area	ha	Watershed Area	5.14	51.64	360.73	21.41	50.29	336.31	244.69	56.53	67.03	35.31	18.37	94.63	125.58	118.67	281.36	176.21
DWF	m3/s	Dry Weather Flow (Base Flow)	0															
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	50.9	80.9	67.2	77.7	75.6	74.6	75.6	68.3	59.9	57.2	54	52.5	59.9	73.5	74.6	75.6
CN* (AMC III)		SCS Modified Curve Number (CN*)	70.2	90.8	83.2	89.2	88.1	87.5	88.1	83.8	77.5	76	73.6	71.9	77.5	86.9	87.5	88.1
IA	mm	Initial Abstraction	5	3.7	4.1	4.2	3.6	4.3	4.2	3.5	3.8	3.3	4.8	4.6	4.4	4.4	4.3	3.9
N	-	Number of Linear Reservoir	3															
TP	hr	Unit Hydrograph Time to Peaks	1.03	3.41	3.58	5.43	4.28	8.28	8.02	3.29	5.46	2.35	3.45	4.73	3.72	4.55	9.07	5.98
Rain	mm/h	Optional Rainfall Intensities	0 - Without Rain															

Future Condition STANDHYD Model Input

	Unit	Description	101	102	103	104	106	107	109	110	111	112A	113	114	115	116	117A	118	119	120	121	122	123	124	125	126A	126B	126C	127	127A	128	129A	130	132
DT	min	Time Step Increment	5																															
Area	ha	Watershed Area	30.52	22.4	26.2	13.85	9.4	22.7	22	32.7	8.5	5.92	55	13.4	16.2	6.66	9.76	29.37	4.38	23.88	26.77	44.4	7.76	7.3	19.17	5.5	10.3	2.6	69.73	8.01	11.26	53.7	15.9	4.31
XIMP	-	Directly Connected Impervious Area	0.27	0.27	0.24	0.23	0.23	0.21	0.18	0.27	0.18	0.19	0.34	0.21	0.27	0.27	0.43	0.23	0.54	0.25	0.57	0.38	0.24	0.63	0.54	0.26	0.44	0.28	0.77	0.9	0.9	0.84	0.63	0.82
TIMP	-	Total Impervious Area Fraction	0.27	0.5	0.45	0.45	0.45	0.39	0.34	0.48	0.35	0.35	0.63	0.39	0.48	0.47	0.56	0.41	0.55	0.45	0.58	0.47	0.34	0.73	0.65	0.47	0.56	0.49	0.81	0.9	0.9	0.84	0.73	0.82
DWF	m3/s	Dry Weather Flow (Base Flow)	0																															
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	76.0	77	77	77	77	77	74.0	74	64.0	76.0	77	76.0	76.0	75	76.0	75	75.0	77	80.0	73	65	64.5	64.5	54.0	59	54	58.5	64.0	73.5	76.0	76.0	78.0
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	90.3	89.2	89.2	89.2	89.2	89.2	87.5	87.5	81.2	90.3	89.2	90.3	90.3	88.4	88.5	88.9	88.3	89.2	90.9	87.3	82	83.2	83.2	73.8	77.8	73.8	79	83.2	79.7	88.8	88.5	90.1
IA	-	Initial Abstraction	4.5	3.1	3	3	3	3	3.5	3	3.5	3	3	3	3	3	3	3	3	3	3.2	3	3	3	3	3	3	3	3	3	3	3.1	3	3
SLPP	%	Average Slope of Pervious Area	2																															
LGP	m	Overland Flow Length for Pervious Areas	40																															
MNP	-	Manning's Roughness Coefficient for Pervious Areas	0.25																															
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area	0																															
DPSI	mm/hr	Impervious Area Depression Storage	1																															
SLPI	%	Average Slope of Impervious Area	0.1	0.5	0.4	0.4	0.5	0.8	2	2	0.5	1.3	0.8	2	0.8	0.5	2	1	1	2	2	0.5	0.5	2	2	2	2	2	2	2	2	2	2	2
LGI	-	A=1.5*L^2	451.1	360.6	440.2	303.9	245.6	368.9	421.3	483.4	264.6	198.7	622.3	300	364.1	210.7	255.1	442.5	172.4	400.6	296.9	543.6	233.4	240.1	352.6	191.5	262	131.7	681.8	231.1	274	605.6	325.6	169.5
MNI	-	Manning's Roughness Coefficient for Impervious Areas	0.013																															
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area	0																															
Rain	mm/hr	Optional Rainfall Intensities	0 - Without Rain																															

	Unit	Description	135	136	137	138	139	139A	141	142	145	145A	151A	152	152A	152C	152D	152F	152H	152I	153	153A	153B	153C	156	156A	159	160	160A	163	165	166	167	178A
DT	min	Time Step Increment																																5
Area	ha	Watershed Area	12.31	37.39	11.87	14.9	27	27.61	12.56	26.2	30.42	18.7	23.1	36.88	9.18	10.79	5.81	13.21	16.47	12.82	16.7	20.34	1.78	4.53	38.42	18.88	3.94	18.35	18.17	21	23.12	44.27	12.02	15.16
XIMP	-	Directly Connected Impervious Area	0.26	0.62	0.53	0.85	0.9	0.9	0.88	0.64	0.21	0.56	0.9	0.77	0.26	0.51	0.9	0.9	0.9	0.9	0.68	0.53	0.99	0.77	0.21	0.32	0.18	0.22	0.15	0.21	0.17	0.27	0.21	0.12
TIMP	-	Total Impervious Area Fraction	0.44	0.71	0.61	0.85	0.9	0.9	0.89	0.64	0.39	0.59	0.9	0.81	0.26	0.56	0.9	0.9	0.9	0.9	0.71	0.56	0.99	0.79	0.39	0.6	0.33	0.58	0.41	0.37	0.3	0.44	0.39	0.32
DWF	m3/s	Dry Weather Flow (Base Flow)	0																															
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	77.0	74.0	68.7	64.1	62.5	62.0	64.0	76.0	66.0	72.5	58.5	59.5	51.0	55.0	60.0	71.0	66.0	65.0	71.9	72.5	72.5	72.5	59.5	43.3	55	55.0	55.0	70.0	77	55	53	55
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	89	88.1	84	80.5	81.8	81.8	83.2	90.3	84.5	86.5	76.2	79.7	70.7	73.3	76.8	86	84.5	83.8	86	86.5	86.5	86.5	79.7	63.5	76	76	76	86.9	90.8	76	73.2	76
IA	-	Initial Abstraction	5	3	3	4.8	3	3	3	3.1	3	5	3	3	4.4	3	3	3	3	3	5	5	5	5	3.1	5	3	3	3.1	3.1	3	3	3	3.8
SLPP	%	Average Slope of Pervious Area	2																															
LGP	m	Overland Flow Length for Pervious Areas	40																															
MNP	-	Manning's Roughness Coefficient for Pervious Areas	0.25																															
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area	0																															
DPSI	mm/hr	Impervious Area Depression Storage	1																															
SLPI	%	Average Slope of Impervious Area	0.3	2	1.1	0.3	2	2	2	2	2	2.3	2	2	2	2	2	2	2	2	1.6	2.5	1.1	1	2	1.2	2	2	2	0.8	0.8	2.2	2	2
LGI	-	A=1.5*L^2	286.5	499.3	281.3	315.2	424.3	429	289.4	468.2	450.2	941**	198	495.8	247.4	268.2	196.8	217.7	331.4	306.1	1114**	903**	108.9	173.8	506.1	354.8	156.2	349.8	348	411.4	422.1	574.5	281.5	317.9
MNI	-	Manning's Roughness Coefficient for Impervious Areas	0.013																															
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area	0																															
Rain	mm/hr	Optional Rainfall Intensities	0 - Without Rain																															

APPENDIX D-4

Regional Official Plan Amendment 128 Future Condition Model Input Parameters

ROPA 128 Condition NASHYD Model Input

Subcatchment	Unit	Description	105	108	112	117	129	134	140	143	151	152B	152E	153D	153E
DT	min	Time Step Increment	5												
Area	ha	Watershed Area	23.60	46.27	37.26	51.06	54.07	63.52	9.86	13.93	17.24	7.00	27.67	4.60	2.57
DWF	m3/s	Dry Weather Flow (Base Flow)	0												
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	75.6	74	76.7	75.6	76.7	77.7	64.1	72.5	68.8	62.5	67.2	76.13	76.13
CN* (AMC III)		SCS Modified Curve Number (CN*)	88.1	87.5	88.7	88.1	88.7	89.2	81.1	86.3	84	79.5	83.2	88.5	88.5
IA	mm	Initial Abstraction	4.4	4.6	4.8	4.6	4.7	4.6	5	5	4.7	4.5	4.9	5	5
N	-	Number of Linear Reservoir	3												
TP	hr	Unit Hydrograph Time to Peaks	3.22	5.31	2.35	0.52	1.84	3.86	1.27	0.68	2.38	2.18	4.86	0.11	0.16
Rain	mm/h	Optional Rainfall Intensities	0 - Without Rain												

Subcatchment	Unit	Description	157	161	162	164	170	171	176	177	178	178B	179	180
DT	min	Time Step Increment	5											
Area	ha	Watershed Area	19.55	10.09	8.46	5.14	51.64	360.73	56.53	67.03	35.31	18.37	94.63	125.58
DWF	m3/s	Dry Weather Flow (Base Flow)	0											
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	51.5	50.9	52.5	50.9	80.9	65.1	68.3	59.9	57.2	54	52.5	59.9
CN* (AMC III)		SCS Modified Curve Number (CN*)	71.1	70.2	71.9	70.2	90.8	81.8	83.8	77.5	76	73.6	71.9	77.5
IA	mm	Initial Abstraction	4.5	5	4.5	5	3.7	3.9	3.5	3.8	3.3	4.8	4.6	4.4
N	-	Number of Linear Reservoir	3											
TP	hr	Unit Hydrograph Time to Peaks	6.1	0.55	0.96	1.03	3.41	3.31	3.29	5.46	2.35	3.45	4.73	3.72
Rain	mm/h	Optional Rainfall Intensities	0 - Without Rain											

ROPA 128 Condition STANDHYD Model Inpu

	Unit	Description	101	102	103	104	106	107	109	110	111	112A	113	114
DT	min	Time Step Increment	5											
Area	ha	Watershed Area	30.52	22.4	26.2	13.85	9.4	22.7	22	32.7	8.5	5.92	55	13.4
XIMP	-	Directly Connected Impervious Area	0.27	0.27	0.24	0.23	0.23	0.21	0.18	0.27	0.18	0.19	0.34	0.21
TIMP	-	Total Impervious Area Fraction	0.27	0.5	0.45	0.45	0.45	0.39	0.34	0.48	0.35	0.35	0.63	0.39
DWF	m3/s	Dry Weather Flow (Base Flow)	0											
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	76.0	77	77	77	77	77	74.0	74	64.0	76.0	77	76.0
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	90.3	89.2	89.2	89.2	89.2	89.2	87.5	87.5	81.2	90.3	89.2	90.3
IA	-	Initial Abstraction	4.5	3.1	3	3	3	3	3.5	3	3.5	3	3	3
SLPP	%	Average Slope of Pervious Area	2											
LGP	m	Overland Flow Length for Pervious Areas	40											
MNP	-	Manning's Roughness Coefficient for Pervious Areas	0.25											
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area	0											
DPSI	mm/hr	Impervious Area Depression Storage	1											
SLPI	%	Average Slope of Impervious Area	0.1	0.5	0.4	0.4	0.5	0.8	2	2	0.5	1.3	0.8	2
LGI	-	A=1.5*L^2	451.1	360.6	440.2	303.9	245.6	368.9	421.3	483.4	264.6	198.7	622.3	300
MNI	-	Manning's Roughness Coefficient for Impervious Areas	0.013											
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area	0											
Rain	mm/hr	Optional Rainfall Intensitie:	0 - Without Rain											

	Unit	Description	115	116	117A	118	119	120	121	122	123	124	125	126A
DT	min	Time Step Increment												
Area	ha	Watershed Area	16.2	6.66	9.76	29.37	4.38	23.88	26.77	44.4	7.76	7.3	19.17	5.5
XIMP	-	Directly Connected Impervious Area	0.27	0.27	0.43	0.23	0.54	0.25	0.57	0.38	0.24	0.63	0.54	0.26
TIMP	-	Total Impervious Area Fraction	0.48	0.47	0.56	0.41	0.55	0.45	0.58	0.47	0.34	0.73	0.65	0.47
DWF	m3/s	Dry Weather Flow (Base Flow)												
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	76.0	75	76.0	75	75.0	77	80.0	73	65	64.5	64.5	54.0
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	90.3	88.4	88.5	88.9	88.3	89.2	90.9	87.3	82	83.2	83.2	73.8
IA	-	Initial Abstraction	3	3	3	3	3	3	3.2	3	3	3	3	3
SLPP	%	Average Slope of Pervious Area												
LGP	m	Overland Flow Length for Pervious Areas												
MNP	-	Manning's Roughness Coefficient for Pervious Areas												
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area												
DPSI	mm/hr	Impervious Area Depression Storage												
SLPI	%	Average Slope of Impervious Area	0.8	0.5	2	1	1	2	2	0.5	0.5	2	2	2
LGI	-	A=1.5*L^2	364.1	210.7	255.1	442.5	172.4	400.6	296.9	543.6	233.4	240.1	352.6	191.5
MNI	-	Manning's Roughness Coefficient for Impervious Areas												
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area												
Rain	mm/hr	Optional Rainfall Intensitie:												

	Unit	Description	126B	126C	127	127A	128	129A	130	132	133	135	136	137
DT	min	Time Step Increment												
Area	ha	Watershed Area	10.3	2.6	69.73	8.01	11.26	53.7	15.9	4.31	13.26	12.31	37.39	11.87
XIMP	-	Directly Connected Impervious Area	0.44	0.28	0.77	0.9	0.9	0.84	0.63	0.82	0.88	0.26	0.62	0.53
TIMP	-	Total Impervious Area Fraction	0.56	0.49	0.81	0.9	0.9	0.84	0.73	0.82	0.88	0.44	0.71	0.61
DWF	m3/s	Dry Weather Flow (Base Flow)												
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	59	54	58.5	64.0	73.5	76.0	76.0	78.0	76.0	77.0	74.0	68.7
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	77.8	73.8	79	83.2	79.7	88.8	88.5	90.1	92.9	89	88.1	84
IA	-	Initial Abstraction	3	3	3	3	3	3.1	3	3	3	5	3	3
SLPP	%	Average Slope of Pervious Area												
LGP	m	Overland Flow Length for Pervious Areas												
MNP	-	Manning's Roughness Coefficient for Pervious Areas												
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area												
DPSI	mm/hr	Impervious Area Depression Storage												
SLPI	%	Average Slope of Impervious Area	2	2	2	2	2	2	2	2	2	0.3	2	1.1
LGI	-	A=1.5*L^2	262	131.7	681.8	231.1	274	605.6	325.6	169.5	297.3	286.5	499.3	281.3
MNI	-	Manning's Roughness Coefficient for Impervious Areas												
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area												
Rain	mm/hr	Optional Rainfall Intensitie:												

	Unit	Description	138	139	139A	141	142	145	145A	151A	152	152A	152C	152D
DT	min	Time Step Increment												
Area	ha	Watershed Area	14.9	27	27.61	12.56	26.2	30.42	18.7	23.1	36.88	9.18	10.79	5.81
XIMP	-	Directly Connected Impervious Area	0.85	0.9	0.9	0.88	0.64	0.21	0.56	0.9	0.77	0.26	0.51	0.9
TIMP	-	Total Impervious Area Fraction	0.85	0.9	0.9	0.89	0.64	0.39	0.59	0.9	0.81	0.26	0.56	0.9
DWF	m3/s	Dry Weather Flow (Base Flow)	0											
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	64.1	62.5	62.0	64.0	76.0	66.0	72.5	58.5	59.5	51.0	55.0	60.0
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	80.5	81.8	81.8	83.2	90.3	84.5	86.5	76.2	79.7	70.7	73.3	76.8
IA	-	Initial Abstraction	4.8	3	3	3	3.1	3	5	3	3	4.4	3	3
SLPP	%	Average Slope of Pervious Area	2											
LGP	m	Overland Flow Length for Pervious Areas	40											
MNP	-	Manning's Roughness Coefficient for Pervious Areas	0.25											
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area	0											
DPSI	mm/hr	Impervious Area Depression Storage	1											
SLPI	%	Average Slope of Impervious Area	0.3	2	2	2	2	2	2.3	2	2	2	2	2
LGI	-	A=1.5*L^2	315.2	424.3	429	289.4	468.2	450.2	941**	198	495.8	247.4	268.2	196.8
MNI	-	Manning's Roughness Coefficient for Impervious Areas	0.013											
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area	0											
Rain	mm/hr	Optional Rainfall Intensitie:	0 - Without Rain											

	Unit	Description	152F	152H	152I	153	153A	153B	153C	156	156A	159	160	160A
DT	min	Time Step Increment												
Area	ha	Watershed Area	13.21	16.47	12.82	16.7	20.34	1.78	4.53	38.42	18.88	3.94	18.35	18.17
XIMP	-	Directly Connected Impervious Area	0.9	0.9	0.9	0.68	0.53	0.99	0.77	0.21	0.32	0.18	0.22	0.15
TIMP	-	Total Impervious Area Fraction	0.9	0.9	0.9	0.71	0.56	0.99	0.79	0.39	0.6	0.33	0.58	0.41
DWF	m3/s	Dry Weather Flow (Base Flow)												
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	71.0	66.0	65.0	71.9	72.5	72.5	72.5	59.5	43.3	55	55.0	55.0
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	86	84.5	83.8	86	86.5	86.5	86.5	79.7	63.5	76	76	76
IA	-	Initial Abstraction	3	3	3	5	5	5	5	3.1	5	3	3	3.1
SLPP	%	Average Slope of Pervious Area												
LGP	m	Overland Flow Length for Pervious Areas												
MNP	-	Manning's Roughness Coefficient for Pervious Areas												
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area												
DPSI	mm/hr	Impervious Area Depression Storage												
SLPI	%	Average Slope of Impervious Area	2	2	2	1.6	2.5	1.1	1	2	1.2	2	2	2
LGI	-	A=1.5*L^2	217.7	331.4	306.1	1114**	903**	108.9	173.8	506.1	354.8	156.2	349.8	348
MNI	-	Manning's Roughness Coefficient for Impervious Areas												
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area												
Rain	mm/hr	Optional Rainfall Intensitie:												

	Unit	Description	163	165	166	167	172	173	174	175	178A	181	182	183
DT	min	Time Step Increment												5
Area	ha	Watershed Area	21	23.12	44.27	12.02	21.41	50.29	336.31	244.69	15.16	118.67	281.36	176.21
XIMP	-	Directly Connected Impervious Area	0.21	0.17	0.27	0.21	0.42	0.74	0.36	0.57	0.12	0.36	0.27	0.5
TIMP	-	Total Impervious Area Fraction	0.37	0.3	0.44	0.39	0.52	0.78	0.44	0.61	0.32	0.36	0.37	0.6
DWF	m3/s	Dry Weather Flow (Base Flow)												
CN* (AMC II)	-	SCS Modified Curve Number (CN*)	70.0	77	55	53	69	69	63	63	55	64	63	63
CN* (AMC III)	-	SCS Modified Curve Number (CN*)	86.9	90.8	76	73.2	84.6	84.7	81.1	80.6	76	81.3	81	81.8
IA	-	Initial Abstraction	3.1	3	3	3	3.4	3.1	3.6	3.5	3.8	4	3.6	3.2
SLPP	%	Average Slope of Pervious Area												
LGP	m	Overland Flow Length for Pervious Areas												
MNP	-	Manning's Roughness Coefficient for Pervious Areas												
SCP	hr	Storage Coefficient for Linear Reservoir for the Pervious Area												
DPSI	mm/hr	Impervious Area Depression Storage												
SLPI	%	Average Slope of Impervious Area	0.8	0.8	2.2	2	2	2	2	2	2	2	2	2
LGI	-	A=1.5*L^2	411.4	422.1	574.5	281.5	377.8	579	1497.4	1277.2	317.9	889.5	1369.6	1083.9
MNI	-	Manning's Roughness Coefficient for Impervious Areas												
SCI	hr	Storage Coefficient for Linear Reservoir for the Impervious Area												
Rain	mm/hr	Optional Rainfall Intensitie:												

APPENDIX E
Calibration Event Validation

Duffins Creek			Calibration/Validation Events - Observed Flows					
Sub Watershed	Drainage Ares (km^2)	Regional Flow (m^3/s)	17-Jul-99 33.0mm	29-Sep-99 60.2mm	13-Oct-99 45.0mm	11-May-00 61.8mm	13-Jun-00 45.4mm	24-Jun-00 41.0mm
Reesor Creek	32.6	146.9 m^3/s	1.4 m^3/s	3.8 m^3/s	3.2 m^3/s	9.0 m^3/s	7.8 m^3/s	6.5 m^3/s
Duffins Creek	255	862.5 m^3/s	10.2 m^3/s	7.6 m^3/s	10.9 m^3/s	68.2 m^3/s	68.9 m^3/s	54.7 m^3/s

Petticoat Creek		Calibration/Validation Events - Observed Flows (m^3/s)*							
Drainage Areas (km^2)	Regional Flow (m^3/s)	15-May-03 53.3mm	23-May-03 37.9mm	13-Jun-03 18.4mm	15-Jul-03 15.1mm	24-May-04 22.2mm	4-Aug-04 13.3mm	29-Aug-04 23.7mm	9-Sep-04 33.1mm
157.2	260.02	23.3	7.5	2.8	4.6	2.9	5.0	14.2	3.6

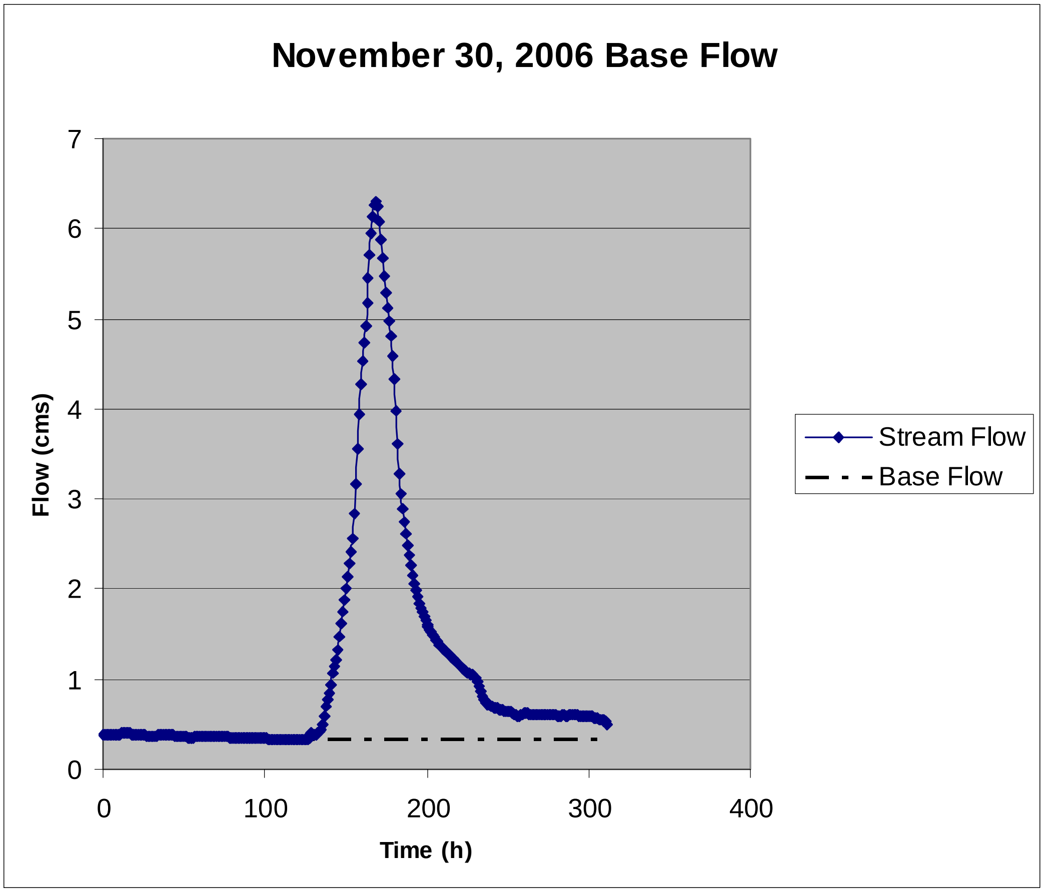
*note - Observed Flows read off of hydrograph (assume (+/- 5%)

Highland Creek			Calibration/Validation Events - Observed Flows (m3/s)*						
Subwatershed	Drainage Areas (km^2)	Regional Flow (m^3/s)*	13-Jul-95 14.3mm	28-Jul-95 15.1mm	5-Oct-95 54.4mm	10-Nov-95 54.4mm	7-Sep-96 73mm	29-Sep-99 40.9mm	24-Jun-00 34.8mm
Bendale Branch (2)	25.34	257.4						18.1	17.2
West Branch (9012)	39.12	400.2							21.48
WSC Station (02HC013)	93.79	863.3	29.8	46.89	122.7	86.71	113.31		

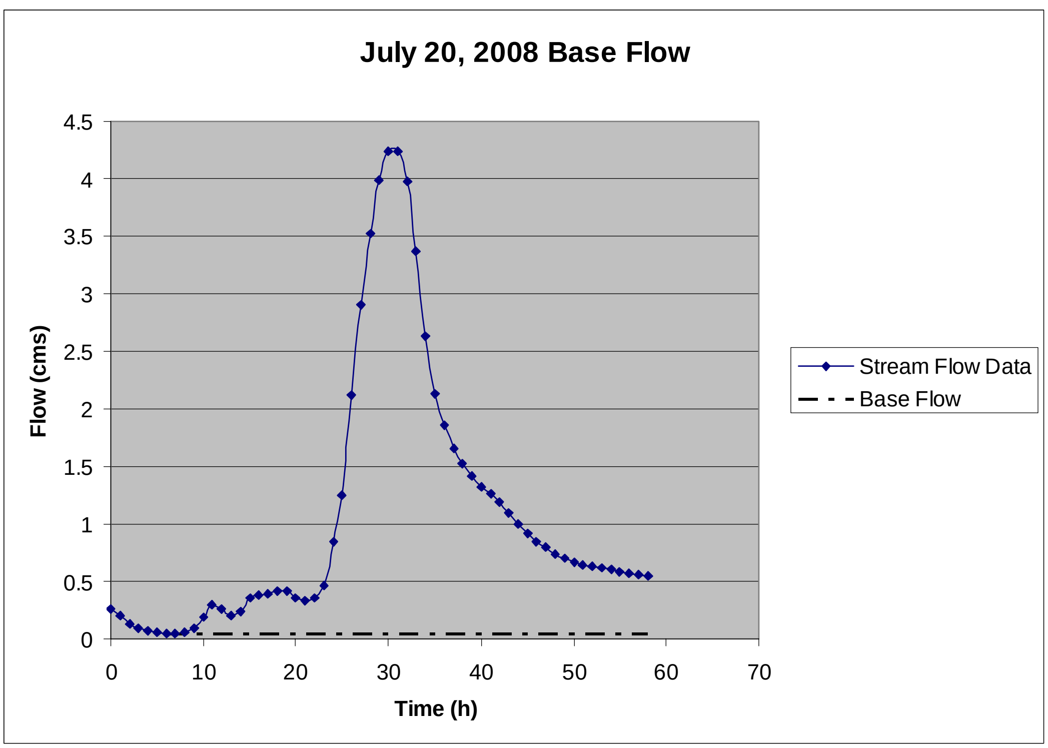
*Drainage area for Regional Flow calc is 88.26 at WSC Station

Don River			Calibration/Validation Events - Observed Flows (m3/s)*	
Subwatershed	Drainage Areas (km^2)	Regional Flow (m^3/s)*	12-May-00 66mm	26-Aug-86 68mm
Todmorden Gauge (48.3)	334	1728.34	208.99	207
Yonge-York Mills (11.2)	87.13	561.1	52.99	55.2
Lower Don (East Don) (41.3)	131.59	878.59	-	153

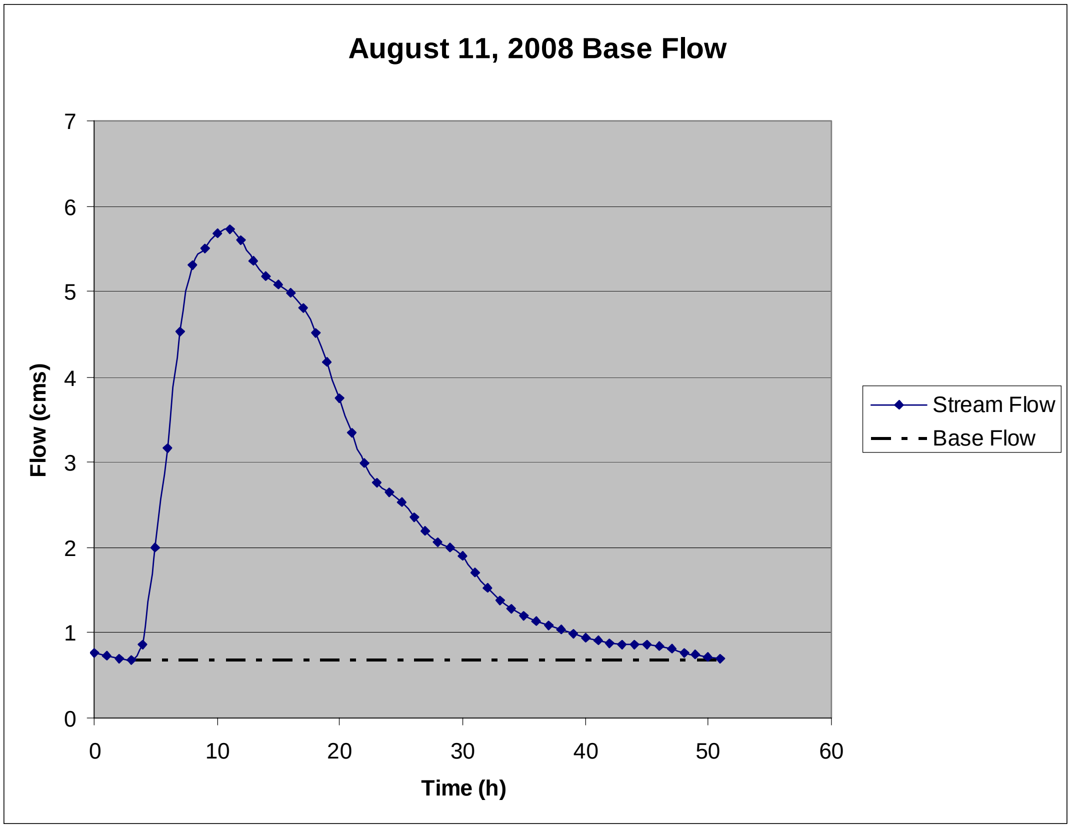
APPENDIX F
Base Flow Graphs for Calibration and Validation Storms



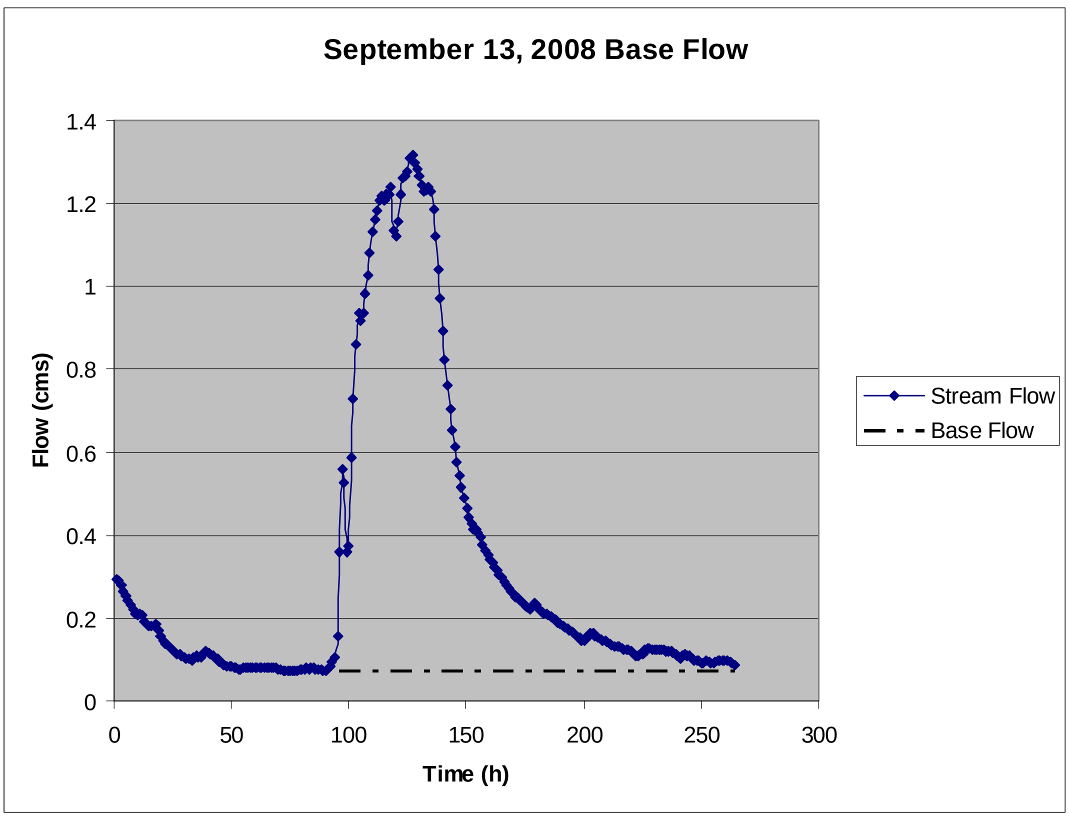
November 30, 2006 Base Flow
Flow (cms)
Time (h)
Stream Flow
Base Flow



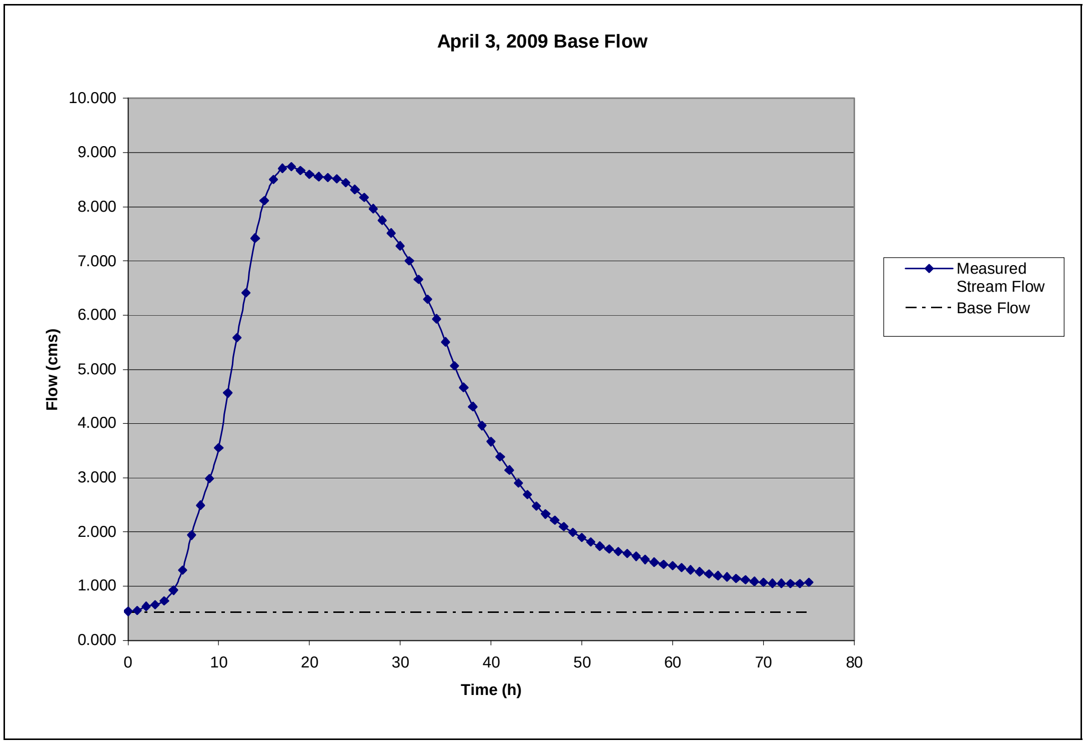
July 20, 2008 Base Flow
Flow (cms)
Time (h)
Stream Flow Data
Base Flow

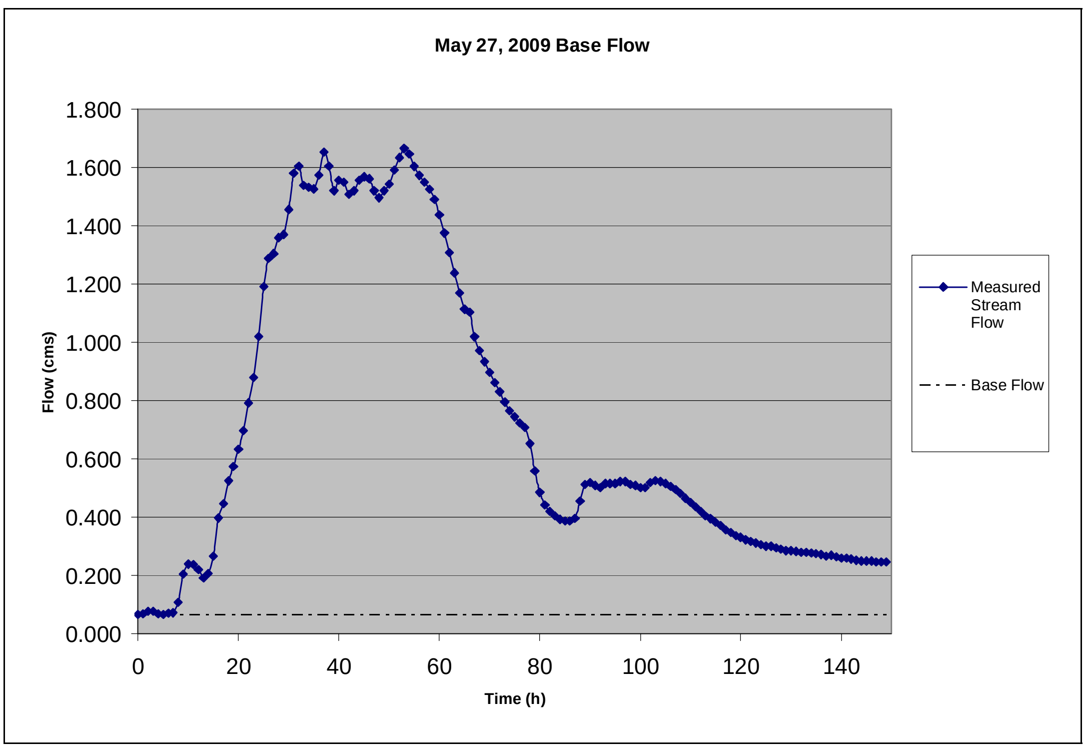


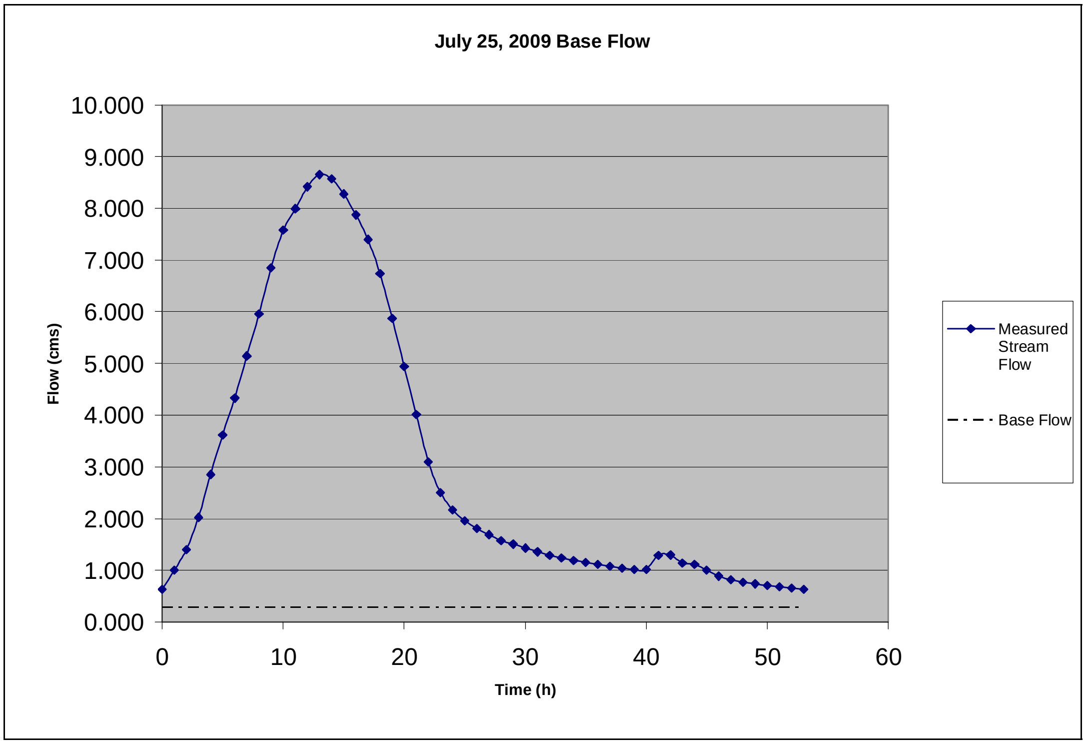
August 11, 2008 Base Flow
Flow (cms)
Time (h)
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
Stream Flow
Base Flow



September 13, 2008 Base Flow
Flow (cms)
Time (h)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
50
100
150
200
250
300
Stream Flow
Base Flow


April 3, 2009 Base Flow
Flow (cms)
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
0
10
20
30
40
50
60
70
80
Time (h)
Measured Stream Flow
Base Flow


May 27, 2009 Base Flow
Flow (cms)
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0
20
40
60
80
100
120
140
Time (h)
Measured Stream Flow
Base Flow

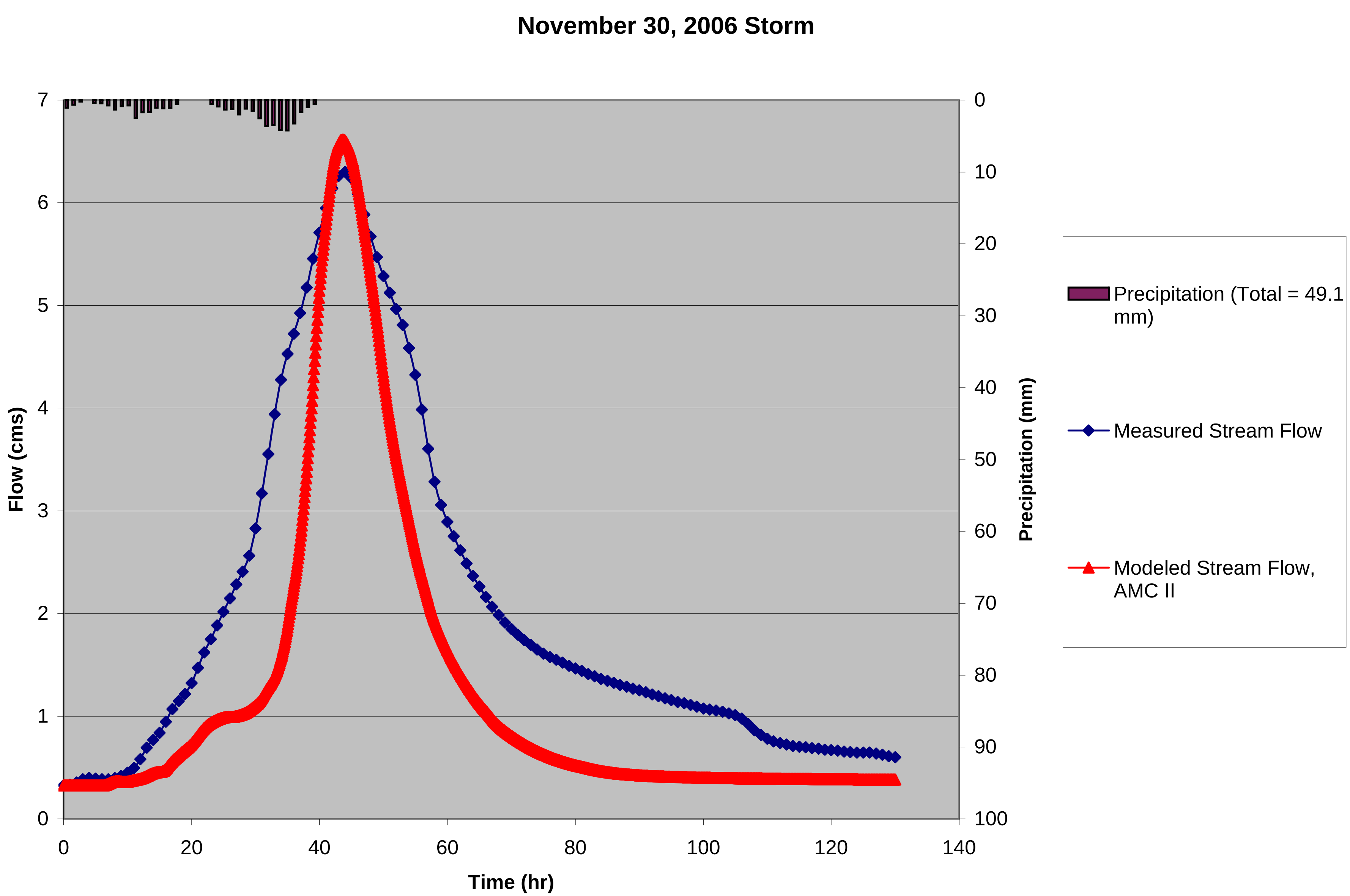


July 25, 2009 Base Flow
Flow (cms)
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
0
10
20
30
40
50
60
Time (h)
Measured Stream Flow
Base Flow

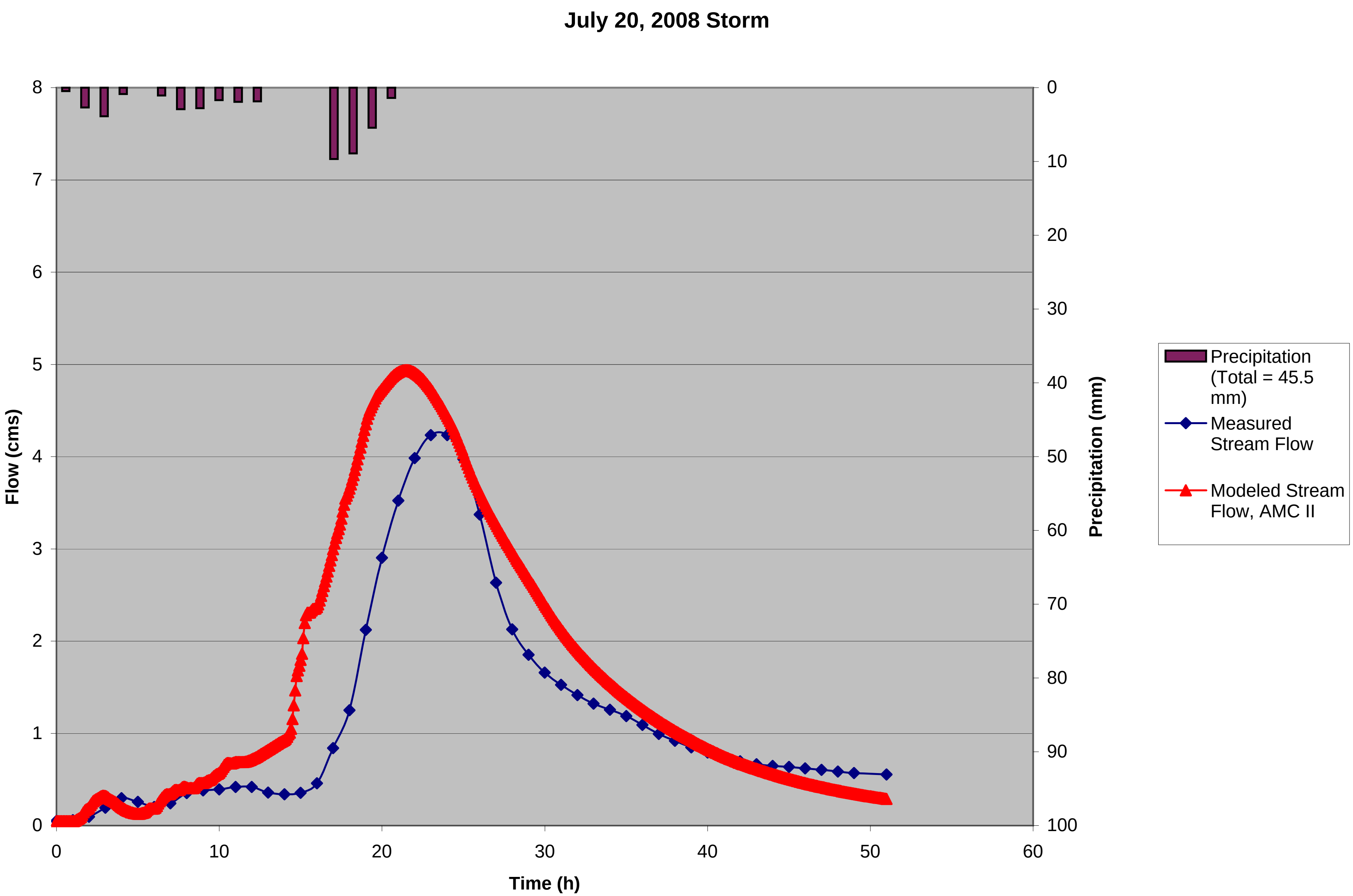
APPENDIX G
Calibration and Validation Results

APPENDIX G-1

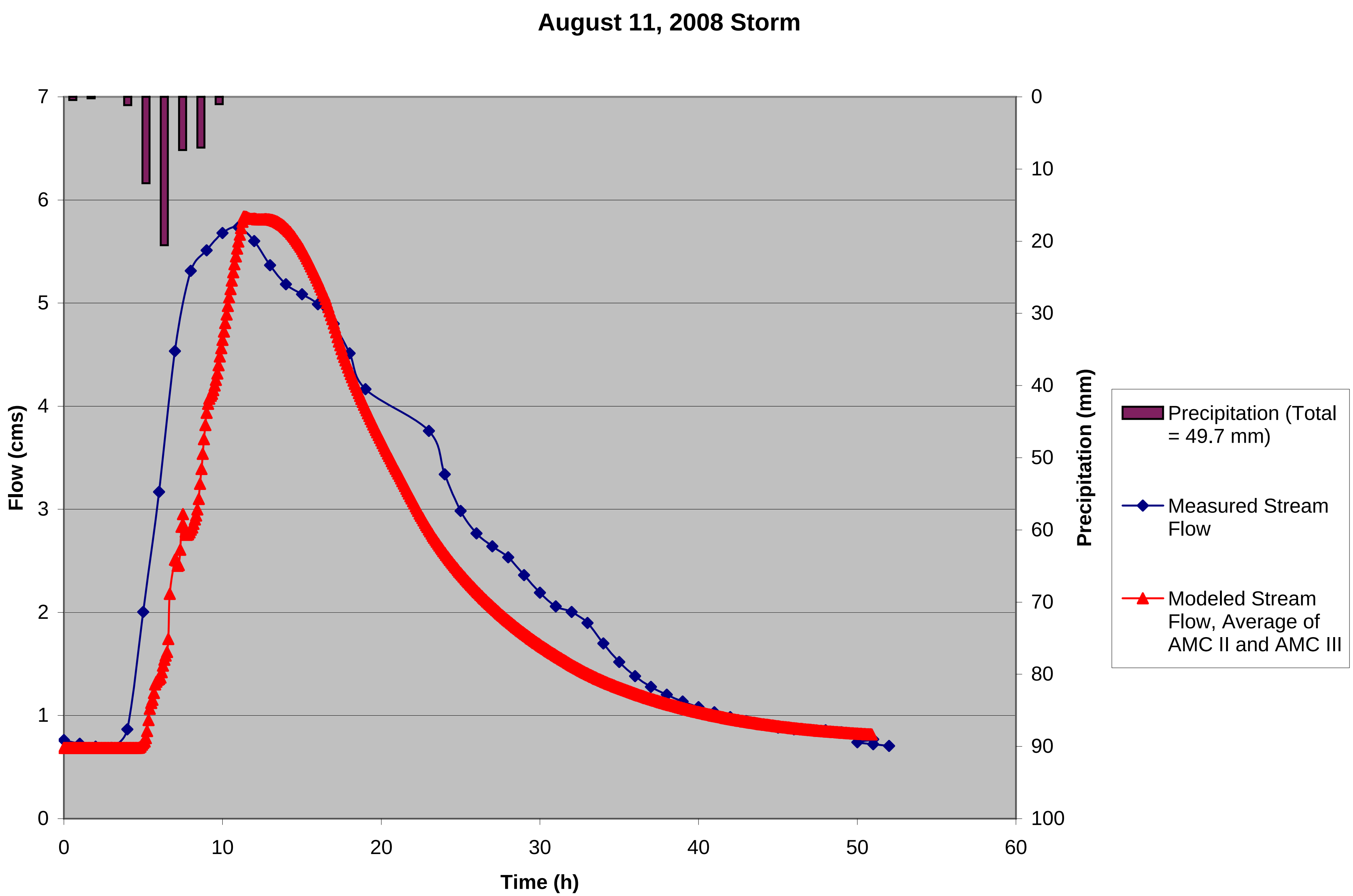
Graphs of Results of Calibration Storms



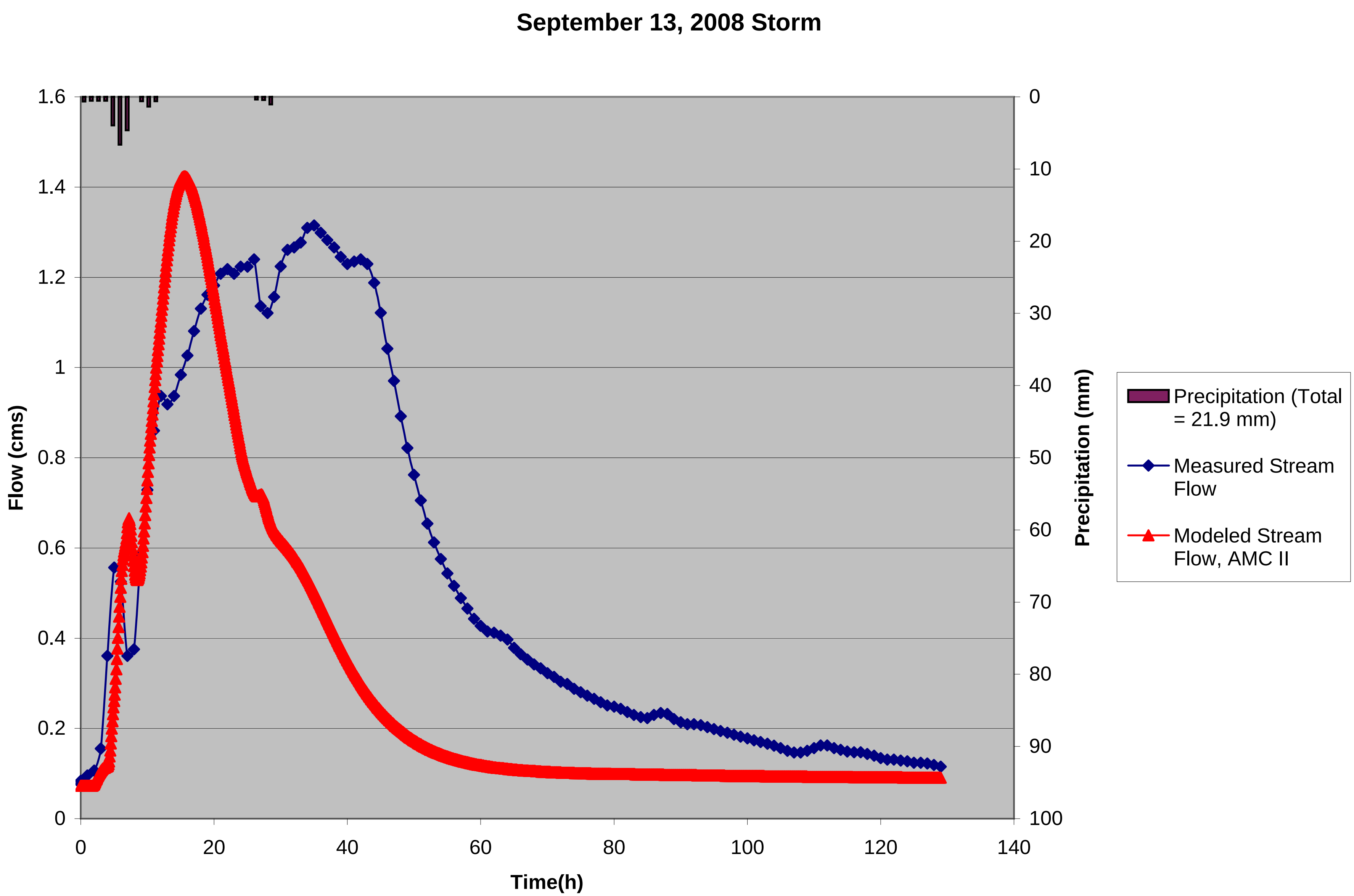
November 30, 2006 Storm
Flow (cms)
Precipitation (mm)
Time (hr)
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120
140
Precipitation (Total = 49.1 mm)
Measured Stream Flow
Modeled Stream Flow, AMC II



July 20, 2008 Storm
Flow (cms)
Precipitation (mm)
Time (h)
0
1
2
3
4
5
6
7
8
0
10
20
30
40
50
60
70
80
90
100
0
10
20
30
40
50
60
Precipitation (Total = 45.5 mm)
Measured Stream Flow
Modeled Stream Flow, AMC II

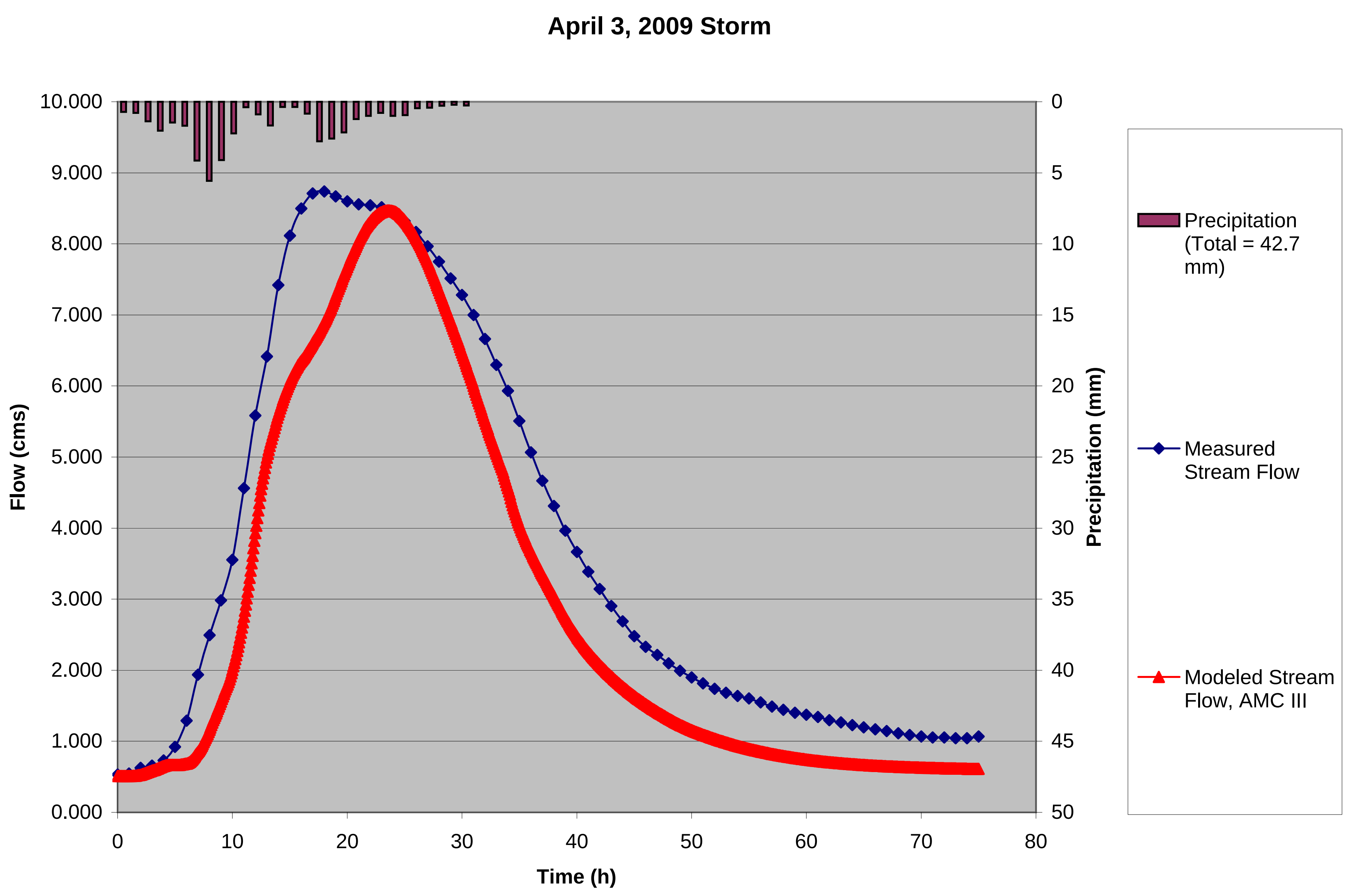


August 11, 2008 Storm
Flow (cms)
Precipitation (mm)
Time (h)
0
1
2
3
4
5
6
7
10
20
30
40
50
60
70
80
90
100
Precipitation (Total = 49.7 mm)
Measured Stream Flow
Modeled Stream Flow, Average of AMC II and AMC III

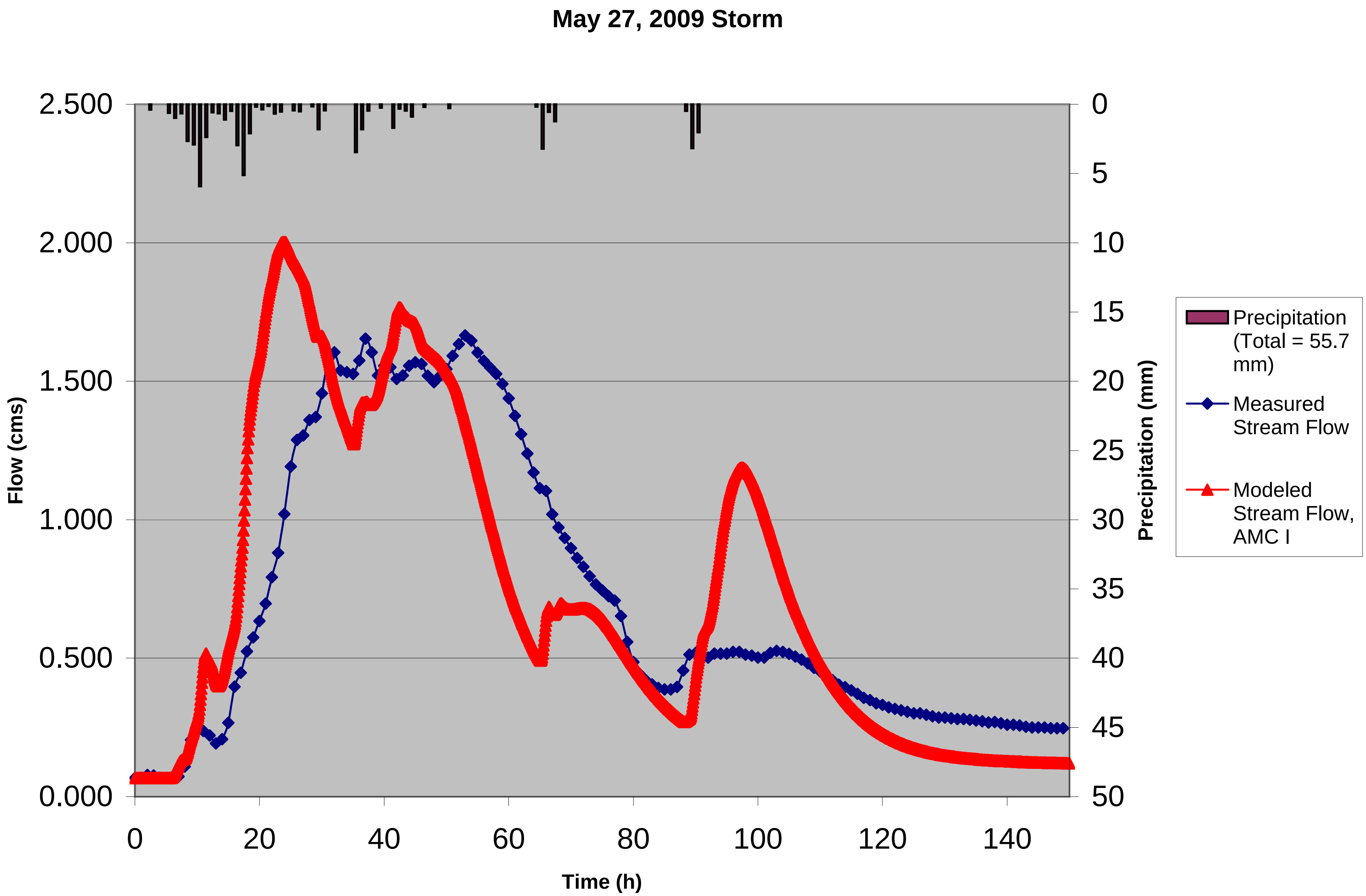


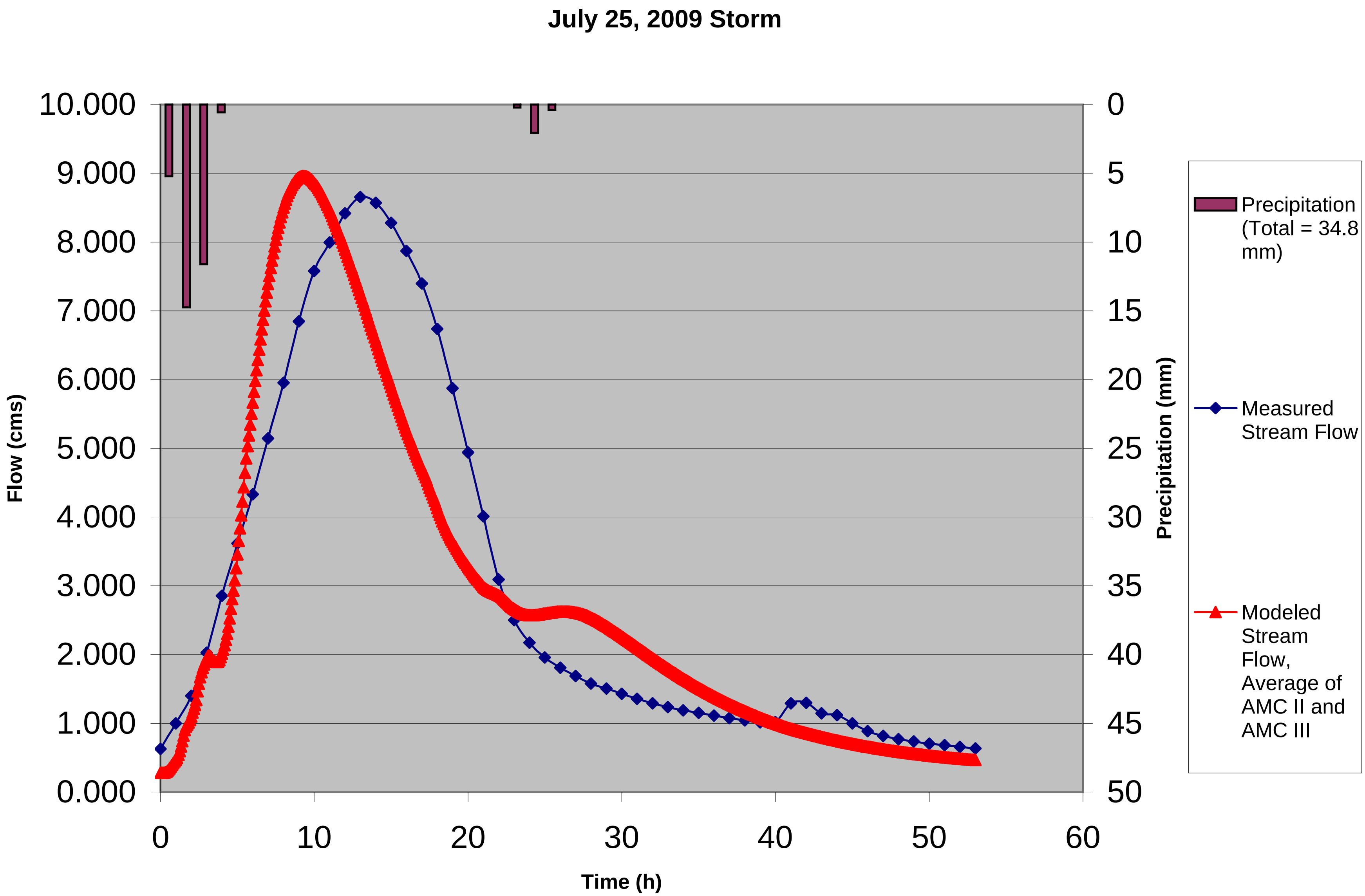
September 13, 2008 Storm
Flow (cms)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Precipitation (mm)
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120
140
Time(h)
Precipitation (Total = 21.9 mm)
Measured Stream Flow
Modeled Stream Flow, AMC II

APPENDIX G-2
Graphs of Results of Validation Storms



April 3, 2009 Storm
Flow (cms)
Precipitation (mm)
Time (h)
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70
80
Precipitation (Total = 42.7 mm)
Measured Stream Flow
Modeled Stream Flow, AMC III


May 27, 2009 Storm
2.500
2.000
1.500
1.000
0.500
0.000
Flow (cms)
0
5
10
15
20
25
30
35
40
45
50
Precipitation (mm)
0
20
40
60
80
100
120
140
Time (h)
Precipitation (Total = 55.7 mm)
Measured Stream Flow
Modeled Stream Flow, AMC I


July 25, 2009 Storm
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
Flow (cms)
0
10
20
30
40
50
60
Time (h)
0
5
10
15
20
25
30
35
40
45
50
Precipitation (mm)
Precipitation (Total = 34.8 mm)
Measured Stream Flow
Modeled Stream Flow, Average of AMC II and AMC III

APPENDIX G-3
TRCA Memo – Hydrology Discussion

MEMORANDUM

TO:	Geoff Masotti	DATE:	July 14, 2011
FROM:	Nick Lorrain	CFN:	
RE:	Carruthers Creek Flood Management and Analysis – Hydrology Discussion		
CC:			

Hi Geoff,

As discussed in April, here is a synopsis of the September 13, 2008, May 27, 2009, and July 25, 2009 calibration events used for the Carruthers Creek hydrology update where the calibration process was not ideal.

Using Radar data I was able to determine the following:

September 13, 2008

- Bottom portion of the watershed was affected by the event; majority of the watershed upstream of 401 received little precipitation.
- Event was frontal in nature with a south west to north east direction.
- 1st pulse of precipitation occurs in the morning with a break in rain for approximately an hour, before steady precipitation entered the area and persisted for a majority of the day.

May 27, 2009

- Event associated with thunderstorms entering the area prior to the main front, where northern portions of the watershed being hit with precipitation at various times through out the morning until the full front moved through the area, after which and hour or so of persistent low intensity precipitation had occurred.
- Lag time of approximately 1 to 2 hours had occurred from the end of the thunderstorms until the front moved through the area.

July 25, 2009

- A similar system to the May 27, 2009 event where thunderstorms had occurred in the area prior to the main front moving through the area.
- Direction of the event was from a south to north direction with the system moving from the downstream to upstream direction.

As can be seen above due to the variation in timing and movement of the systems thorough the watershed getting representative results between simulated and observed hydrographs would be difficult. Compounding the issue is also the fact that VO2 limits the amount of gauges used in hydrologic modeling (something I'm sure you'll address in VO3).

It should be noted that although 3 events were excluded from the assessment, the amount of events used in the calibration/validation process are appropriate, and are consistent with the number of events used in other watershed hydrology studies within TRCA jurisdictions (typically 4 to 6).

Based on the above and as previously discussed (April 2011) Authority staff has no concerns with the calibration process used for the Carruthers Creek.

Please feel free to contact me should you have any questions or concerns.

Regards,

Nick Lorrain
Ex. 5336

APPENDIX H
Proposed Pond Results and Rating Curves

APPENDIX H-1

Approved Official Plan Proposed Pond Results and Rating Curves

Approved Official Plan - Existing (2007) SWM Criteria

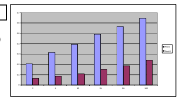
PHILIPS SWM CRITERIA

	MAIN BRANCH		NODE 9a	
	Q (UNIT)	S	Q (UNIT)	S
	(m3/s/ha)	(m3/ha imp)	(m3/s/ha)	(m3/ha imp)
5 YEAR	0.006	500	0.023	190
25 YEAR	0.012	650	0.047	300
100 YEAR	0.026	800	0.094	350

NOTE:
ID 1128, 1239, 1952, 1752, 1152, 1452, 1552
ARE WITHIN NODE 9a

PRE-DEVELOPMENT
24 HOUR AES STORMS

POST-DEVELOPMENT
24 HOUR AES STORMS



ID 1130	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1130	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.209	10.333	18.218	39%	0.013		2	47.08	0.066	13.25	36.146	77%	0.3851	VO2 DST		-0.14	32%
A	5	60.08	0.316	10.333	27.438	46%	0.020	A	5	60.08	0.088	13.167	47.778	80%	0.5097	DISCH	STORAGE	-0.23	28%
(ha)	10	68.76	0.393	10.333	34.043	50%	0.025	(ha)	10	68.76	0.107	12.833	55.703	81%	0.5935	0	0	-0.29	27%
15.9	25	79.70	0.492	10.333	42.755	54%	0.031	15.9	25	79.70	0.153	12.5	65.828	83%	0.682	0.10	0.5804	-0.34	31%
	50	87.80	0.568	10.333	49.429	56%	0.036	0.69	50	87.80	0.185	12.417	73.404	84%	0.7451	0.19	0.7545	-0.38	33%
	100	95.92	0.646	10.333	56.274	59%	0.041		100	95.92	0.241	12.333	81.055	85%	0.7948	0.41	0.9286	-0.41	37%

ID 1217	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1217	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.127	10.167	15.506	33%	0.013		2	47.08	0.041	12.917	30.401	65%	0.1861	VO2 DST		-0.09	32%
A	5	60.08	0.193	10.167	23.77	40%	0.020	A	5	60.08	0.055	12.833	41.176	69%	0.2528	DISCH	STORAGE	-0.14	28%
(ha)	10	68.76	0.24	10.167	29.776	43%	0.025	(ha)	10	68.76	0.076	12.583	48.622	71%	0.2948	0	0	-0.16	32%
9.76	25	79.70	0.302	10.167	37.781	47%	0.031	9.76	25	79.70	0.107	12.333	58.225	73%	0.3375	0.06	0.2733	-0.20	35%
	50	87.80	0.349	10.167	43.964	50%	0.036	0.51	50	87.80	0.136	12.083	65.463	75%	0.3654	0.12	0.3553	-0.21	39%
	100	95.92	0.398	10.167	50.345	52%	0.041		100	95.92	0.179	11	72.809	76%	0.3923	0.25	0.4372	-0.22	45%

ID 1132	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1132	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.062	10.333	18.408	39%	0.014		2	47.08	0.02	12.583	40.457	86%	0.1195	VO2 DST		-0.04	32%
A	5	60.08	0.093	10.167	27.687	46%	0.022	A	5	60.08	0.026	12.583	52.651	88%	0.1555	DISCH	STORAGE	-0.07	28%
(ha)	10	68.76	0.115	10.167	34.327	50%	0.027	(ha)	10	68.76	0.031	12.583	60.878	89%	0.1796	0	0	-0.08	27%
4.31	25	79.70	0.143	10.167	43.078	54%	0.033	4.31	25	79.70	0.041	12.417	71.323	89%	0.2068	0.03	0.1767	-0.10	29%
	50	87.80	0.165	10.167	49.777	57%	0.038	0.82	50	87.80	0.048	12.333	79.1	90%	0.2263	0.05	0.2297	-0.12	29%
	100	95.92	0.187	10.167	56.645	59%	0.043		100	95.92	0.063	12.25	86.93	91%	0.242	0.11	0.2827	-0.12	34%

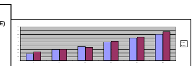
ID 1133	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1133	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.227	10.167	21.496	46%	0.017		2	47.08	0.055	14.333	42.285	90%	0.3991	VO2 DST		-0.17	24%
A	5	60.08	0.332	10.167	31.651	53%	0.025	A	5	60.08	0.071	14.333	54.697	91%	0.5161	DISCH	STORAGE	-0.26	21%
(ha)	10	68.76	0.404	10.167	38.809	56%	0.030	(ha)	10	68.76	0.084	14.25	63.043	92%	0.5927	0	0	-0.32	21%
13.26	25	79.70	0.497	10.167	48.145	60%	0.037	13.26	25	79.70	0.121	12.5	73.615	92%	0.6739	0.08	0.5834	-0.38	24%
	50	87.80	0.566	10.167	55.233	63%	0.043	0.88	50	87.80	0.148	12.417	81.473	93%	0.7318	0.16	0.7585	-0.42	26%
	100	95.92	0.637	10.167	62.458	65%	0.048		100	95.92	0.187	12.333	89.374	93%	0.7849	0.34	0.9335	-0.45	29%

ID 1141	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1141	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.164	10.167	15.99	34%	0.013		2	47.08	0.053	14.25	41.753	89%	0.3696	VO2 DST		-0.11	32%
A	5	60.08	0.248	10.167	24.342	41%	0.020	A	5	60.08	0.068	14.25	53.942	90%	0.4772	DISCH	STORAGE	-0.18	27%
(ha)	10	68.76	0.308	10.167	30.4	44%	0.025	(ha)	10	68.76	0.079	14.25	62.141	90%	0.5495	0	0	-0.23	26%
12.56	25	79.70	0.387	10.167	38.465	48%	0.031	12.56	25	79.70	0.109	12.5	72.532	91%	0.6296	0.08	0.5589	-0.28	28%
	50	87.80	0.447	10.167	44.691	51%	0.036	0.89	50	87.80	0.133	12.417	80.26	91%	0.6852	0.15	0.7266	-0.31	30%
	100	95.92	0.509	10.167	51.113	53%	0.041		100	95.92	0.163	12.333	88.035	92%	0.739	0.33	0.8943	-0.35	32%

ID 1139	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1139	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.144	13.333	16.657	35%	0.005		2	47.08	0.108	14.333	42.389	90%	0.8212	VO2 DST		-0.04	75%
A	5	60.08	0.221	13.333	25.278	42%	0.008	A	5	60.08	0.139	14.333	54.655	91%	1.0587	DISCH	STORAGE	-0.08	63%
(ha)	10	68.76	0.277	13.167	31.51	46%	0.010	(ha)	10	68.76	0.161	14.333	62.894	91%	1.2176	0	0	-0.12	58%
27	25	79.70	0.352	13.167	39.785	50%	0.013	27	25	79.70	0.233	12.583	73.326	92%	1.3817	0.16	1.2150	-0.12	66%
	50	87.80	0.409	13.167	46.159	53%	0.015	0.81	50	87.80	0.285	12.5	81.08	92%	1.4998	0.32	1.5795	-0.12	70%
	100	95.92	0.469	13.167	52.724	55%	0.017		100	95.92	0.355	12.417	88.876	93%	1.6132	0.70	1.9440	-0.11	76%

ID 1251 (151A)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1251 (151A)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.02	15	12.902	27%	0.002		2	47.08	0.026	12.75	42.049	89%	0.173	VO2 DST		0.01	130%
A	5	60.08	0.031	14.833	20.052	33%	0.002	A	5	60.08	0.034	12.667	54.256	90%	0.223	DISCH	STORAGE	0.00	110%
(ha)	10	68.76	0.039	14.833	25.338	37%	0.003	(ha)	10	68.76	0.039	12.667	62.454	91%	0.2564	0	0	0.00	100%
5.88	25	79.70	0.05	14.833	32.475	41%	0.004	5.88	25	79.70	0.052	12.417	72.833	91%	0.2953	0.04	0.2646	0.00	104%
	50	87.80	0.059	14.667	38.05	43%	0.005	0.9	50	87.80	0.062	12.333	80.545	92%	0.322	0.07	0.3440	0.00	105%
	100	95.92	0.068	14.667	43.852	46%	0.005		100	95.92	0.074	12.333	88.302	92%	0.3482	0.15	0.4234	0.01	109%

NODE 9a



ID 1128	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1128	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.037	12.333	8.572	18%	0.003		2	47.08	0.219	10.417	42.886	91%	0.4996	VO2 DST		0.18	592%
A	5	60.08	0.06	12.167	13.648	23%	0.005	A	5	60.08	0.296	10.417	55.346	92%	0.6444	DISCH	STORAGE	0.24	493%
(ha)	10	68.76	0.077	12.167	17.509	25%	0.007	(ha)	10	68.76	0.36	10.333	63.715	93%	0.7414	0	0	0.28	468%
11.26	25	79.70	0.101	12.167	22.844	29%	0.009	11.26	25	79.70	0.435	10.333	74.308	93%	0.8423	0.07	0.5065	0.33	431%
	50	87.80	0.121	12.167	27.095	31%	0.011	0.9	50	87.80	0.488	10.333	82.18	94%	0.9141	0.14	0.6585	0.37	403%
	100	95.92	0.141	12.167	31.589	33%	0.013		100	95.92	0.568	10.25	90.091	94%	0.9834	0.29	0.8104	0.43	403%

ID 139A	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 139A	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.125	13	13.311	28%	0.011		2	47.08	0.528	10.417	42.437	90%	0.4996	VO2 DST		0.40	422%
A	5	60.08	0.196	13	20.633	34%	0.017	A	5	60.08	0.708	10.417	54.696	91%	0.6444	DISCH	STORAGE	0.51	361%
(ha)	10	68.76	0.249	12.833	26.032	38%	0.022	(ha)	10	68.76	0.86	10.417	62.93	92%	0.7414	0	0	0.61	345%
27.61	25	79.70	0.32	12.833	33.308	42%	0.028	27.61	25	79.70	1.04	10.333	73.355	92%	0.8423	0.17	1.2425	0.72	325%
	50	87.80	0.376	12.833	38.982	44%	0.033	0.9	50	87.80	1.169	10.333	81.103	92%	0.9141	0.33	1.6152	0.79	311%
	100	95.92	0.434	12.833	44.879	47%	0.039		100	95.92	1.296	10.333	88.894	93%	0.9834	0.72	1.9879	0.86	299%

ID 1952 (152H)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1952 (152H)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.081	14.333	17.219	37%	0.005		2	47.08	0.317	10.417	42.571	90%	0.2348	VO2 DST		0.24	391%
A	5	60.08	0.123	14.167	26.054	43%	0.007	A	5	60.08	0.426	10.417	54.894	91%	0.3017	DISCH	STORAGE	0.30	346%
(ha)	10	68.76	0.154	14	32.421	47%	0.009	(ha)	10	68.76	0.517	10.333	63.171	92%	0.3402	0	0	0.36	336%
16.47	25	79.70	0.194	14	40.854	51%	0.012	16.47	25	79.70	0.624	10.333	73.653	92%	0.3848	0.38	0.2816	0.43	322%
	50	87.80	0.226	14	47.337	54%	0.014	0.85	50	87.80	0.701	10.333	81.443	93%	0.4169	0.77	0.4447	0.48	310%
	100	95.92	0.258	13.833	54.004	56%	0.016		100	95.92	0.804	10.333	89.275	93%	0.4483	1.55	0.5188	0.55	312%

ID 1252 (152A)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1252 (152A)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.026	12.333	6.848	15%	0.002		2	47.08	0.088	10.333	16.674	35%	0.0271	VO2 DST		0.06	338%
A	5	60.08	0.042	12.333	11.141	19%	0.003	A	5	60.08	0.123	10.333	23.008	38%	0.0395	DISCH	STORAGE	0.08	293%
(ha)	10	68.76	0.055	12.333	14.452	21%	0.003	(ha)	10	68.76	0.148	10.333	27.55	40%	0.0474	0	0	0.09	269%
9.18	25	79.70	0.073	12.167	19.075	24%	0.004	36.88	25	79.70	0.184	10.333	33.594	42%	0.0555	0.21	0.0453	0.11	252%
	50	87.80	0.087	12.167	22.792	26%	0.005	0.82	50	87.80	0.211	10.333	38.281	44%	0.0608	0.43	0.0716	0.12	243%
	100	95.92	0.103	12.167	26.747	28%	0.006		100	95.92	0.25	10.25	43.143	45%	0.0662	0.86	0.0835	0.15	243%

ID 1452 (152C)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1452 (152C)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.028	13	7.548	16%	0.003		2	47.08	0.154	10.333	27.668	59%	0.0711	VO2 DST		0.13	550%
A	5	60.08	0.044	13	12.068	20%	0.004	A	5	60.08	0.205	10.417	36.732	61%	0.0947	DISCH	STORAGE	0.16	466%
(ha)	10	68.76	0.057	13	15.529	23%	0.005	(ha)	10	68.76	0.242	10.417	43.01	63%	0.1114	0	0	0.19	425%
10.79	25	79.70	0.075	12.833	20.341	26%	0.007	10.79	25	79.70	0.306	10.333	51.148	64%	0.1298	0.25	0.1148	0.23	408%
	50	87.80	0.09	12.833	24.195	28%	0.008	0.6	50	87.80	0.353	10.333	57.318	65%	0.1418	0.51	0.1813	0.26	392%
	100	95.92	0.105	12.833	28.286	29%	0.010		100	95.92	0.4	10.333	63.616	66%	0.1541	1.01	0.2115	0.30	381%

ID 1552 (152D)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1552 (152D)	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)			Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.015	12.667	7.177	15%	0.003		2	47.08	0.11	10.417	42.347	90%	0.0847	VO2 DST		0.10	733%
A	5	60.08	0.025	12.667	11.542	19%	0.004	A	5	60.08	0.151	10.333	54.576	91%	0.1084	DISCH	STORAGE	0.13	604%
(ha)	10	68.76	0.032	12.5	14.895	22%	0.006	(ha)	10	68.76	0.183	10.333	62.788	91%	0.1219	0	0	0.15	572%
5.81	25	79.70	0.042	12.5	19.565	25%	0.007	5.81	25	79.70	0.221	10.333	73.186	92%	0.1375	0.13	0.0994	0.18	526%
	50	87.80	0.05	12.5	23.314	27%	0.009	0.86	50	87.80	0.248	10.25	80.915	92%	0.1488	0.27	0.1569	0.20	496%
	100	95.92	0.059	12.5	27.299	28%	0.010		100	95.92	0.29	10.25	88.686	92%	0.1594	0.55	0.1830	0.23	492%

U/S Taunton Road - Confluence

ID 3093	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 3093	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	4.417	17.25	12.996	28%	0.002		2	47.08	4.417	17.25	12.996	28%	0.000	100%
A	5	60.08	6.959	17	20.143	34%	0.003	A	5	60.08	6.959	17	20.143	34%	0.000	100%
(ha)	10	68.76	8.887	16.833	25.413	37%	0.004	(ha)	10	68.76	8.887	16.833	25.413	37%	0.000	100%
2002	25	79.70	11.41	16.667	32.516	41%	0.006	2002	25	79.70	11.41	16.667	32.516	41%	0.000	100%
	50	87.80	13.383	16.667	38.058	43%	0.007		50	87.80	13.383	16.667	38.058	43%	0.000	100%
	100	95.92	15.48	16.583	43.821	46%	0.008		100	95.92	15.48	16.583	43.821	46%	0.000	100%

CPR

ID 3087	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 3087	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	4.652	17.25	13.036	28%	0.002		2	47.08	4.652	17.25	13.036	28%	0.00	100%
A	5	60.08	7.369	17.167	20.162	34%	0.003	A	5	60.08	7.369	17.167	20.162	34%	0.00	100%
(ha)	10	68.76	9.471	17	25.463	37%	0.004	(ha)	10	68.76	9.471	17	25.463	37%	0.00	100%
2169	25	79.70	12.235	16.667	32.609	41%	0.006	2169	25	79.70	12.235	16.667	32.609	41%	0.00	100%
	50	87.80	14.372	16.667	38.18	43%	0.007		50	87.80	14.372	16.667	38.18	43%	0.00	100%
	100	95.92	16.639	16.5	43.968	46%	0.008		100	95.92	16.639	16.5	43.968	46%	0.00	100%

U/S Rossland Rd

ID 3082	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 3082	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	4.708	17.417	12.891	27%	0.002		2	47.08	4.706	17.417	12.933	27%	0.00	100%
A	5	60.08	7.511	17.25	19.937	33%	0.003	A	5	60.08	7.506	17.25	19.987	33%	0.00	100%
(ha)	10	68.76	9.692	17	25.2	37%	0.004	(ha)	10	68.76	9.685	17	25.256	37%	-0.01	100%
2260	25	79.70	12.578	16.667	32.295	41%	0.006	2260	25	79.70	12.566	16.667	32.358	41%	-0.01	100%
	50	87.80	14.757	16.75	37.827	43%	0.007		50	87.80	14.742	16.75	37.894	43%	-0.01	100%
	100	95.92	17.084	16.583	43.576	45%	0.008		100	95.92	17.066	16.583	43.647	46%	-0.02	100%

Hwy 2 E

ID 1044	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1044	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	5.504	17.583	13.692	29%	0.002		2	47.08	5.614	17.417	14.912	32%	0.11	102%
A	5	60.08	8.835	17.25	20.881	35%	0.003	A	5	60.08	8.912	17.167	22.307	37%	0.08	101%
(ha)	10	68.76	11.457	16.917	26.269	38%	0.004	(ha)	10	68.76	11.494	16.917	27.813	40%	0.04	100%
2701	25	79.70	14.927	16.583	33.513	42%	0.006	2701	25	79.70	14.917	16.667	35.191	44%	-0.01	100%
	50	87.80	17.491	16.5	39.148	45%	0.006		50	87.80	17.439	16.5	40.913	47%	-0.05	100%
	100	95.92	20.206	16.333	44.992	47%	0.007		100	95.92	20.109	16.333	46.838	49%	-0.10	100%

D/S Bayly St

ID 1033	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1033	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	6.017	18.417	14.808	31%	0.002		2	47.08	6.235	18.333	16.135	34%	0.22	104%
A	5	60.08	9.561	18.167	22.252	37%	0.003	A	5	60.08	9.772	18.083	23.792	40%	0.21	102%
(ha)	10	68.76	12.386	17.75	27.786	40%	0.004	(ha)	10	68.76	12.577	17.667	29.448	43%	0.19	102%
2983	25	79.70	16.262	17.083	35.199	44%	0.005	2983	25	79.70	16.43	17	36.998	46%	0.17	101%
	50	87.80	19.176	17	40.95	47%	0.006		50	87.80	19.335	17	42.838	49%	0.16	101%
	100	95.92	22.113	17	46.903	49%	0.007		100	95.92	22.242	17.083	48.873	51%	0.13	101%

Shoal Point Rd

ID 1005	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1005	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	7.075	18.917	16.534	35%	0.002		2	47.08	7.369	18.583	17.68	38%	0.29	104%
A	5	60.08	11.003	18.083	24.363	41%	0.003	A	5	60.08	11.308	17.583	25.693	43%	0.31	103%
(ha)	10	68.76	14.139	17.75	30.116	44%	0.004	(ha)	10	68.76	14.431	17.5	31.552	46%	0.29	102%
3602	25	79.70	18.509	17.333	37.781	47%	0.005	3602	25	79.70	18.819	17.083	39.335	49%	0.31	102%
	50	87.80	21.795	16.917	43.704	50%	0.006		50	87.80	22.115	16.833	45.335	52%	0.32	101%
	100	95.92	25.183	16.833	49.819	52%	0.007		100	95.92	25.436	16.75	51.52	54%	0.25	101%

Lake Ontario

ID 1000	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha	ID 1000	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	7.148	18.917	16.76	36%	0.002		2	47.08	7.462	18.5	17.877	38%	0.31	104%
A	5	60.08	11.142	18.167	24.646	41%	0.003	A	5	60.08	11.473	17.4	25.942	43%	0.33	103%
(ha)	10	68.76	14.312	17.833	30.432	44%	0.004	(ha)	10	68.76	14.621	17.5	31.831	46%	0.31	102%
3695	25	79.70	18.756	17.25	38.135	48%	0.005	3695	25	79.70	19.082	17.0	39.65	50%	0.33	102%
	50	87.80	22.106	17.25	44.084	50%	0.006		50	87.80	22.47	16.8	45.674	52%	0.36	102%
	100	95.92	25.556	16.75	50.224	52%	0.007		100	95.92	25.854	16.5	51.883	54%	0.30	101%

Approved Official Plan - Updated SWM Criteria

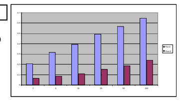
Approved Official Plan - Updated (2011) SWM Criteria

SWM CRITERIA

	MAIN BRANCH	
	Q (UNIT)	S
	(m3/s/ha)	(m3/ha imp)
5 YEAR	0.006	500
25 YEAR	0.012	650
100 YEAR	0.026	800

PRE-DEVELOPMENT 24 HOUR AES STORMS | **POST-DEVELOPMENT 24 HOUR AES STORMS**

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1130		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1130		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.209	10.333	18.218	39%	0.013		2	47.08	0.066	13.25	36.146	77%	0.3851	VO2 DST		-0.14	32%
A	5	60.08	0.316	10.333	27.438	46%	0.020	A	5	60.08	0.088	13.167	47.778	80%	0.5097	DISCH	STORAGE	-0.23	28%
(ha)	10	68.76	0.393	10.333	34.043	50%	0.025	(ha)	10	68.76	0.107	12.833	55.703	81%	0.5935	0	0	-0.29	27%
15.9	25	79.70	0.492	10.333	42.755	54%	0.031	15.9	25	79.70	0.153	12.5	65.828	83%	0.682	0.10	0.5804	-0.34	31%
	50	87.80	0.568	10.333	49.429	56%	0.036	0.69	50	87.80	0.185	12.417	73.404	84%	0.7451	0.19	0.7545	-0.38	33%
	100	95.92	0.646	10.333	56.274	59%	0.041		100	95.92	0.241	12.333	81.055	85%	0.7948	0.41	0.9286	-0.41	37%



ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1217		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1217		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.127	10.167	15.506	33%	0.013		2	47.08	0.041	12.917	30.401	65%	0.1861	VO2 DST		-0.09	32%
A	5	60.08	0.193	10.167	23.77	40%	0.020	A	5	60.08	0.055	12.833	41.176	69%	0.2528	DISCH	STORAGE	-0.14	28%
(ha)	10	68.76	0.24	10.167	29.776	43%	0.025	(ha)	10	68.76	0.076	12.583	48.622	71%	0.2948	0	0	-0.16	32%
9.76	25	79.70	0.302	10.167	37.781	47%	0.031	9.76	25	79.70	0.107	12.333	58.225	73%	0.3375	0.06	0.2733	-0.20	35%
	50	87.80	0.349	10.167	43.964	50%	0.036	0.51	50	87.80	0.136	12.083	65.463	75%	0.3654	0.12	0.3553	-0.21	39%
	100	95.92	0.398	10.167	50.345	52%	0.041		100	95.92	0.179	11	72.809	76%	0.3923	0.25	0.4372	-0.22	45%

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1132		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1132		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.062	10.333	18.408	39%	0.014		2	47.08	0.02	12.583	40.457	86%	0.1195	VO2 DST		-0.04	32%
A	5	60.08	0.093	10.167	27.687	46%	0.022	A	5	60.08	0.026	12.583	52.651	88%	0.1555	DISCH	STORAGE	-0.07	28%
(ha)	10	68.76	0.115	10.167	34.327	50%	0.027	(ha)	10	68.76	0.031	12.583	60.878	89%	0.1796	0	0	-0.08	27%
4.31	25	79.70	0.143	10.167	43.078	54%	0.033	4.31	25	79.70	0.041	12.417	71.323	89%	0.2068	0.03	0.1767	-0.10	29%
	50	87.80	0.165	10.167	49.777	57%	0.038	0.82	50	87.80	0.048	12.333	79.1	90%	0.2263	0.05	0.2297	-0.12	29%
	100	95.92	0.187	10.167	56.645	59%	0.043		100	95.92	0.063	12.25	86.93	91%	0.242	0.11	0.2827	-0.12	34%

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1133		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1133		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.227	10.167	21.496	46%	0.017		2	47.08	0.055	14.333	42.285	90%	0.3991	VO2 DST		-0.17	24%
A	5	60.08	0.332	10.167	31.651	53%	0.025	A	5	60.08	0.071	14.333	54.697	91%	0.5161	DISCH	STORAGE	-0.26	21%
(ha)	10	68.76	0.404	10.167	38.809	56%	0.030	(ha)	10	68.76	0.084	14.25	63.043	92%	0.5927	0	0	-0.32	21%
13.26	25	79.70	0.497	10.167	48.145	60%	0.037	13.26	25	79.70	0.121	12.5	73.615	92%	0.6739	0.08	0.5834	-0.38	24%
	50	87.80	0.566	10.167	55.233	63%	0.043	0.88	50	87.80	0.148	12.417	81.473	93%	0.7318	0.16	0.7585	-0.42	26%
	100	95.92	0.637	10.167	62.458	65%	0.048		100	95.92	0.187	12.333	89.374	93%	0.7849	0.34	0.9335	-0.45	29%

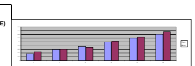
ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1141		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1141		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.164	10.167	15.99	34%	0.013		2	47.08	0.053	14.25	41.753	89%	0.3696	VO2 DST		-0.11	32%
A	5	60.08	0.248	10.167	24.342	41%	0.020	A	5	60.08	0.068	14.25	53.942	90%	0.4772	DISCH	STORAGE	-0.18	27%
(ha)	10	68.76	0.308	10.167	30.4	44%	0.025	(ha)	10	68.76	0.079	14.25	62.141	90%	0.5495	0	0	-0.23	26%
12.56	25	79.70	0.387	10.167	38.465	48%	0.031	12.56	25	79.70	0.109	12.5	72.532	91%	0.6296	0.08	0.5589	-0.28	28%
	50	87.80	0.447	10.167	44.691	51%	0.036	0.89	50	87.80	0.133	12.417	80.26	91%	0.6852	0.15	0.7266	-0.31	30%
	100	95.92	0.509	10.167	51.113	53%	0.041		100	95.92	0.163	12.333	88.035	92%	0.739	0.33	0.8943	-0.35	32%

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1139		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1139		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.144	13.333	16.657	35%	0.005		2	47.08	0.108	14.333	42.389	90%	0.8212	VO2 DST		-0.04	75%
A	5	60.08	0.221	13.333	25.278	42%	0.008	A	5	60.08	0.139	14.333	54.655	91%	1.0587	DISCH	STORAGE	-0.08	63%
(ha)	10	68.76	0.277	13.167	31.51	46%	0.010	(ha)	10	68.76	0.161	14.333	62.894	91%	1.2176	0	0	-0.12	58%
27	25	79.70	0.352	13.167	39.785	50%	0.013	27	25	79.70	0.233	12.583	73.326	92%	1.3817	0.16	1.2150	-0.12	66%
	50	87.80	0.409	13.167	46.159	53%	0.015	0.81	50	87.80	0.285	12.5	81.08	92%	1.4998	0.32	1.5795	-0.12	70%
	100	95.92	0.469	13.167	52.724	55%	0.017		100	95.92	0.355	12.417	88.876	93%	1.6132	0.70	1.9440	-0.11	76%

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1251 (151A)		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1251 (151A)		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.02	15	12.902	27%	0.003		2	47.08	0.026	12.75	42.049	89%	0.173	VO2 DST		0.01	130%
A	5	60.08	0.031	14.833	20.052	33%	0.005	A	5	60.08	0.034	12.667	54.256	90%	0.223	DISCH	STORAGE	0.00	110%
(ha)	10	68.76	0.039	14.833	25.338	37%	0.007	(ha)	10	68.76	0.039	12.667	62.454	91%	0.2564	0	0	0.00	100%
5.88	25	79.70	0.05	14.833	32.475	41%	0.009	5.88	25	79.70	0.052	12.417	72.833	91%	0.2953	0.04	0.2646	0.00	104%
	50	87.80	0.059	14.667	38.05	43%	0.010	0.9	50	87.80	0.062	12.333	80.545	92%	0.322	0.07	0.3440	0.00	105%
	100	95.92	0.068	14.667	43.852	46%	0.012		100	95.92	0.074	12.333	88.302	92%	0.3482	0.15	0.4234	0.01	109%

NODE 9a

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1128		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1128		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.037	12.333	8.572	18%	0.003		2	47.08	0.047	14.333	42.739	91%	0.3423	VO2 DST		0.01	127%
A	5	60.08	0.06	12.167	13.648	23%	0.005	A	5	60.08	0.061	14.25	55.199	92%	0.4418	DISCH	STORAGE	0.00	102%
(ha)	10	68.76	0.077	12.167	17.509	25%	0.007	(ha)	10	68.76	0.071	14.25	63.568	92%	0.5082	0	0	-0.01	92%
11.26	25	79.70	0.101	12.167	22.844	29%	0.009	11.26	25	79.70	0.103	12.417	74.162	93%	0.5779	0.07	0.5065	0.00	102%
	50	87.80	0.121	12.167	27.095	31%	0.011	0.9	50	87.80	0.125	12.417	82.033	93%	0.6271	0.14	0.6585	0.00	103%
	100	95.92	0.141	12.167	31.589	33%	0.013		100	95.92	0.155	12.333	89.944	94%	0.6742	0.29	0.8104	0.01	110%



ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
139A		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	139A		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.125	13	13.311	28%	0.011		2	47.08	0.114	14.333	42.377	90%	0.8322	VO2 DST		-0.01	91%
A	5	60.08	0.196	13	20.633	34%	0.017	A	5	60.08	0.147	14.333	54.636	91%	1.0728	DISCH	STORAGE	-0.05	75%
(ha)	10	68.76	0.249	12.833	26.032	38%	0.022	(ha)	10	68.76	0.169	14.333	62.869	91%	1.2339	0	0	-0.08	68%
27.61	25	79.70	0.32	12.833	33.308	42%	0.028	27.61	25	79.70	0.24	12.583	73.294	92%	1.4059	0.17	1.2425	-0.08	75%
	50	87.80	0.376	12.833	38.982	44%	0.033	0.9	50	87.80	0.292	12.5	81.043	92%	1.5274	0.33	1.6152	-0.08	78%
	100	95.92	0.434	12.833	44.879	47%	0.039		100	95.92	0.361	12.417	88.834	93%	1.6449	0.72	1.9879	-0.07	83%

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1952 (152H)		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1952 (152H)		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.081	14.333	17.219	37%	0.007		2	47.08	0.067	14.333	42.467	90%	0.4996	VO2 DST		-0.01	83%
A	5	60.08	0.123	14.167	26.054	43%	0.011	A	5	60.08	0.087	14.333	54.79	91%	0.6444	DISCH	STORAGE	-0.04	71%
(ha)	10	68.76	0.154	14	32.421	47%	0.014	(ha)	10	68.76	0.1	14.333	63.068	92%	0.7414	0	0	-0.05	65%
16.47	25	79.70	0.194	14	40.854	51%	0.017	16.47	25	79.70	0.145	12.583	73.55	92%	0.8423	0.10	0.7412	-0.05	75%
	50	87.80	0.226	14	47.337	54%	0.020	0.85	50	87.80	0.178	12.417	81.34	93%	0.9141	0.20	0.9635	-0.05	79%
	100	95.92	0.258	13.833	54.004	56%	0.023		100	95.92	0.22	12.417	89.171	93%	0.9834	0.43	1.1858	-0.04	85%

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1252 (152A)		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1252 (152A)		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.026	12.333	6.848	15%	0.002		2	47.08	0.036	12	16.625	35%	0.0706	VO2 DST		0.01	138%
A	5	60.08	0.042	12.333	11.141	19%	0.004	A	5	60.08	0.049	12	22.959	38%	0.098	DISCH	STORAGE	0.01	117%
(ha)	10	68.76	0.055	12.333	14.452	21%	0.005	(ha)	10	68.76	0.059	11.917	27.5	40%	0.1175	0	0	0.00	107%
9.18	25	79.70	0.073	12.167	19.075	24%	0.006	36.88	25	79.70	0.087	11.083	33.545	42%	0.1383	0.06	0.1193	0.01	119%
	50	87.80	0.087	12.167	22.792	26%	0.008	0.82	50	87.80	0.108	10.917	38.231	44%	0.1536	0.11	0.1551	0.02	124%
	100	95.92	0.103	12.167	26.747	28%	0.009		100	95.92	0.149	10.667	43.094	45%	0.1659	0.24	0.1909	0.05	145%

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1452 (152C)		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1452 (152C)		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.028	13	7.548	16%	0.003		2	47.08	0.038	12.833	27.559	59%	0.1921	VO2 DST		0.01	136%
A	5	60.08	0.044	13	12.068	20%	0.004	A	5	60.08	0.051	12.833	36.624	61%	0.2553	DISCH	STORAGE	0.01	116%
(ha)	10	68.76	0.057	13	15.529	23%	0.005	(ha)	10	68.76	0.059	12.75	42.902	62%	0.2989	0	0	0.00	104%
10.79	25	79.70	0.075	12.833	20.341	26%	0.007	10.79	25	79.70	0.091	12.333	51.04	64%	0.3427	0.06	0.3021	0.02	121%
	50	87.80	0.09	12.833	24.195	28%	0.008	0.6	50	87.80	0.114	12.333	57.211	65%	0.3718	0.13	0.3928	0.02	127%
	100	95.92	0.105	12.833	28.286	29%	0.010		100	95.92	0.14	12.25	63.508	66%	0.3988	0.28	0.4834	0.04	133%

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1552 (152D)		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1552 (152D)		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.015	12.667	7.177	15%	0.003		2	47.08	0.021	14.417	41.998	89%	0.1817	VO2 DST		0.01	140%
A	5	60.08	0.025	12.667	11.542	19%	0.004	A	5	60.08	0.027	14.333	54.227	90%	0.2342	DISCH	STORAGE	0.00	108%
(ha)	10	68.76	0.032	12.5	14.895	22%	0.006	(ha)	10	68.76	0.033	14.25	62.439	91%	0.268	0	0	0.00	103%
5.81	25	79.70	0.042	12.5	19.565	25%	0.007	5.81	25	79.70	0.05	12.417	72.838	91%	0.3006	0.03	0.2615	0.01	119%
	50	87.80	0.05	12.5	23.314	27%	0.009	0.86	50	87.80	0.062	12.333	80.566	92%	0.3249	0.07	0.3399	0.01	124%
	100	95.92	0.059	12.5	27.299	28%	0.010		100	95.92	0.078	12.333	88.336	92%	0.348	0.15	0.4183	0.02	132%

U/S Taunton Road - Confluence | U/S Taunton Road - Confluence

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		Q CHANGE	
3093		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	3093		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	4.417	17.25	12.996	28%	0.002		2	47.08	4.417	17.25	12.996	28%	0.000	100%
A	5	60.08	6.959	17	20.143	34%	0.003	A	5	60.08	6.959	17	20.143	34%	0.000	100%
(ha)	10	68.76	8.887	16.833	25.413	37%	0.004	(ha)	10	68.76	8.887	16.833	25.413	37%	0.000	100%
2002	25	79.70	11.41	16.667	32.516	41%	0.006	2002	25	79.70	11.41	16.667	32.516	41%	0.000	100%
	50	87.80	13.383	16.667	38.058	43%	0.007		50	87.80	13.383	16.667	38.058	43%	0.000	100%
	100	95.92	15.48	16.583	43.821	46%	0.008		100	95.92	15.48	16.583	43.821	46%	0.000	100%

CPR | CPR

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		Q CHANGE	
3087		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	3087		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	4.652	17.25	13.036	28%	0.002		2	47.08	4.652	17.25	13.036	28%	0.00	100%
A	5	60.08	7.369	17.167	20.162	34%	0.003	A	5	60.08	7.369	17.167	20.162	34%	0.00	100%
(ha)	10	68.76	9.471	17	25.463	37%	0.004	(ha)	10	68.76	9.471	17	25.463	37%	0.00	100%
2169	25	79.70	12.235	16.667	32.609	41%	0.006	2169	25	79.70	12.235	16.667	32.609	41%	0.00	100%
	50	87.80	14.372	16.667	38.18	43%	0.007		50	87.80	14.372	16.667	38.18	43%	0.00	100%
	100	95.92	16.639	16.5	43.968	46%	0.008		100	95.92	16.639	16.5	43.968	46%	0.00	100%

U/S Rossland Rd | U/S Rossland Rd

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		Q CHANGE	
3082		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	3082		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	4.708	17.417	12.891	27%	0.002		2	47.08	4.721	17.417	12.933	27%	0.01	100%
A	5	60.08	7.511	17.25	19.937	33%	0.003	A	5	60.08	7.526	17.25	19.987	33%	0.01	100%
(ha)	10	68.76	9.692	17	25.2	37%	0.004	(ha)	10	68.76	9.708	17	25.256	37%	0.02	100%
2260	25	79.70	12.578	16.667	32.295	41%	0.006	2260	25	79.70	12.592	16.75	32.358	41%	0.01	100%
	50	87.80	14.757	16.75	37.827	43%	0.007		50	87.80	14.768	16.75	37.894	43%	0.01	100%
	100	95.92	17.084	16.583	43.576	45%	0.008		100	95.92	17.091	16.583	43.647	46%	0.01	100%

Hwy 2 E | Hwy 2 E

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		Q CHANGE	
1044		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1044		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	5.504	17.583	13.692	29%	0.002		2	47.08	5.674	17.833	14.909	32%	0.17	103%
A	5	60.08	8.835	17.25	20.881	35%	0.003	A	5	60.08	8.973	17.417	22.304	37%	0.14	102%
(ha)	10	68.76	11.457	16.917	26.269	38%	0.004	(ha)	10	68.76	11.547	17.167	27.81	40%	0.09	101%
2701	25	79.70	14.927	16.583	33.513	42%	0.006	2701	25	79.70	14.961	16.667	35.188	44%	0.03	100%
	50	87.80	17.491	16.5	39.148	45%	0.006		50	87.80	17.541	16.583	40.91	47%	0.05	100%
	100	95.92	20.206	16.333	44.992	47%	0.007		100	95.92	20.23	16.5	46.835	49%	0.02	100%

D/S Bayly St | D/S Bayly St

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		Q CHANGE	
1033		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1033		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	6.017	18.417	14.808	31%	0.002		2	47.08	6.266	18.75	16.132	34%	0.25	104%
A	5	60.08	9.561	18.167	22.252	37%	0.003	A	5	60.08	9.794	18.417	23.789	40%	0.23	102%
(ha)	10	68.76	12.386	17.75	27.786	40%	0.004	(ha)	10	68.76	12.574	18	29.445	43%	0.19	102%
2983	25	79.70	16.262	17.083	35.199	44%	0.005	2983	25	79.70	16.398	17.25	36.995	46%	0.14	101%
	50	87.80	19.176	17	40.95	47%	0.006		50	87.80	19.352	17.083	42.835	49%	0.18	101%
	100	95.92	22.113	17	46.903	49%	0.007		100	95.92	22.318	17.167	48.871	51%	0.21	101%

Shoal Point Rd | Shoal Point Rd

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		Q CHANGE	
1005		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1005		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	7.075	18.917	16.534	35%	0.002		2	47.08	7.315	19.083	17.677	38%	0.24	103%
A	5	60.08	11.003	18.083	24.363	41%	0.003	A	5	60.08	11.197	18.5	25.691	43%	0.19	102%
(ha)	10	68.76	14.139	17.75	30.116	44%	0.004	(ha)	10	68.76	14.258	18.167	31.55	46%	0.12	101%
3602	25	79.70	18.509	17.333	37.781	47%	0.005	3602	25	79.70	18.627	17.417	39.333	49%	0.12	101%
	50	87.80	21.795	16.917	43.704	50%	0.006		50	87.80	21.953	17.167	45.332	52%	0.16	101%
	100	95.92	25.183	16.833	49.819	52%	0.007		100	95.92	25.326	17	51.518	54%	0.14	101%

Lake Ontario | Lake Ontario

ID	EVENT	P	Q	TP	R		Q (UNIT)	ID	EVENT	P	Q	TP	R		Q CHANGE	
1000		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha	1000		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	7.148	18.917	16.76	36%	0.002		2	47.08	7.381	19.2	17.875	38%	0.23	103%
A	5	60.08	11.142	18.167	24.646	41%	0.003	A	5	60.08	11.323	18.5	25.94	43%	0.18	102%
(ha)	10	68.76	14.312	17.833	30.432	44%	0.004	(ha)	10	68.76	14.416	18.3	31.829	46%	0.10	101%
3695	25	79.70	18.756	17.25	38.135	48%	0.005	3695	25	79.70	18.848	17.5	39.648	50%	0.09	100%
	50	87.80	22.106	17.25	44.084	50%	0.006		50	87.80	22.239	17.2	45.671	52%	0.13	101%
	100	95.92	25.556	16.75	50.224	52%	0.007		100	95.92	25.683	16.8	51.88	54%	0.13	100%

APPENDIX H-2

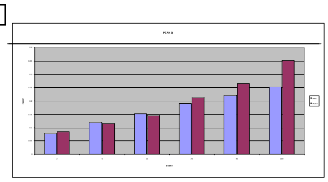
Regional Official Plan Amendment 128 Proposed Pond Results and Rating Curves

ROPA 128 - Existing (2007) SWM Criteria

2007 SWM CRITERIA

	MAIN BRANCH Q (UNIT) (m3/s/ha)	MAIN BRANCH S (m3/ha imp)	NODE 9a Q (UNIT) (m3/s/ha)	NODE 9a S (m3/ha imp)
5 YEAR	0.006	500	0.023	190
25 YEAR	0.012	650	0.047	300
100 YEAR	0.026	800	0.094	350

NOTE:
ID 1128, 1239, 1952, 1752, 1152, 1452, 1552 ARE WITHIN NODE 9a



PRE-DEVELOPMENT 24 HOUR AES

POST-DEVELOPMENT 24 HOUR AES

PRE-DEVELOPMENT

ID 1172	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	0.079	16.417	16.841	36%	0.004
A	5	60.08	0.121	16.333	25.557	43%	0.006
(ha)	10	68.76	0.151	16.25	31.85	46%	0.007
21.4	25	79.70	0.19	16.167	40.199	50%	0.009
	50	87.80	0.221	16.083	46.624	53%	0.010
	100	95.92	0.253	16.083	53.236	56%	0.012

POST-DEVELOPMENT

ID 1172	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	(ha-m)	Q (UNIT)
	2	47.08	0.08	13	27.496	58%	0.3606	
A	5	60.08	0.12	12.917	37.3	62%	0.4911	
(ha)	10	68.76	0.15	12.667	44.134	64%	0.5786	
21.41	25	79.70	0.21	12.417	53.015	67%	0.6647	
0.52	50	87.80	0.27	12.333	59.752	68%	0.7265	
	100	95.92	0.35	11.167	66.624	69%	0.7752	

VO2 DST DISCH	STORAGE
0	0
0.13	0.5567
0.26	0.7237
0.56	0.8907

ID 1173	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	0.2	14.833	15.069	32%	0.004
A	5	60.08	0.308	14.75	23.039	38%	0.006
(ha)	10	68.76	0.388	14.667	28.856	42%	0.008
50.3	25	79.70	0.494	14.583	36.635	46%	0.010
	50	87.80	0.576	14.583	42.663	49%	0.011
	100	95.92	0.662	14.5	48.899	51%	0.013

ID 1173	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)
	2	47.08	0.20	14.333	37.71	80%	1.3077
A	5	60.08	0.26	14.25	49.259	82%	1.7087
(ha)	10	68.76	0.31	13.75	57.099	83%	1.978
50.29	25	79.70	0.45	12.75	67.1	84%	2.529
0.78	50	87.80	0.55	12.583	74.578	85%	2.4586
	100	95.92	0.71	12.417	82.128	86%	2.6381

VO2 DST DISCH	STORAGE
0	0
0.30	1.9613
0.60	2.5497
1.31	3.1381

ID 1174	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	0.782	19.667	14.669	31%	0.002
A	5	60.08	1.209	19.5	22.586	38%	0.004
(ha)	10	68.76	1.522	19.417	28.374	41%	0.005
336.3	25	79.70	1.939	19.333	36.124	45%	0.006
	50	87.80	2.264	19.333	42.134	48%	0.007
	100	95.92	2.601	19.25	48.354	50%	0.008

ID 1174	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	1.25	13.417	23.666	50%	4.5852	0.47	160%
A	5	60.08	1.72	13.333	32.331	54%	6.2981	0.51	142%
(ha)	10	68.76	2.11	13.167	38.437	56%	7.492	0.58	138%
336.31	25	79.70	3.17	12.667	46.44	58%	8.6613	1.23	163%
0.44	50	87.80	3.92	12.5	52.558	60%	9.4815	1.65	173%
	100	95.92	5.17	11.75	58.835	61%	10.1513	2.57	199%

VO2 DST DISCH	STORAGE
0	0
2.02	7.3988
4.04	9.6185
8.74	11.8381

ID 1175	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	0.575	19.5	14.612	31%	0.002
A	5	60.08	0.89	19.333	22.521	37%	0.004
(ha)	10	68.76	1.121	19.333	28.306	41%	0.005
244.7	25	79.70	1.429	19.25	36.051	45%	0.006
	50	87.80	1.669	19.167	42.058	48%	0.007
	100	95.92	1.918	19.083	48.276	50%	0.008

ID 1175	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.96	13.667	30.886	66%	4.8537	0.38	166%
A	5	60.08	1.27	13.5	40.915	68%	6.4426	0.38	143%
(ha)	10	68.76	1.51	13.333	47.826	70%	7.5301	0.39	135%
244.69	25	79.70	2.24	12.833	56.742	71%	8.6339	0.81	157%
0.61	50	87.80	2.75	12.583	63.473	72%	9.4117	1.08	165%
	100	95.92	3.51	12.333	70.319	73%	10.0787	1.60	183%

VO2 DST DISCH	STORAGE
0	0
1.47	7.4630
2.94	9.7020
6.36	11.9409

ID 1181	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	0.409	15.5	14.103	30%	0.003
A	5	60.08	0.637	15.417	21.808	36%	0.005
(ha)	10	68.76	0.804	15.333	27.461	40%	0.007
118.64	25	79.70	1.03	15.25	35.048	44%	0.009
	50	87.80	1.205	15.25	40.944	47%	0.010
	100	95.92	1.388	15.167	47.055	49%	0.012

ID 1181	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.492	12.833	22.97	49%	1.4806	0.08	120%
A	5	60.08	0.676	12.75	31.379	52%	2.034	0.04	106%
(ha)	10	68.76	0.946	12.5	37.314	54%	2.3491	0.14	118%
118.67	25	79.70	1.324	11.75	45.105	57%	2.6902	0.29	129%
0.36	50	87.80	1.8	11.25	51.069	58%	2.9228	0.60	149%
	100	95.92	2.351	11	57.196	60%	3.1354	0.96	169%

VO2 DST DISCH	STORAGE
0	0
0.71	2.1361
1.42	2.7769
3.09	3.4177

ID 1182	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	0.57	21.5	14.932	32%	0.002
A	5	60.08	0.879	21.333	22.952	38%	0.003
(ha)	10	68.76	1.105	21.25	28.807	42%	0.004
281.36	25	79.70	1.406	21.167	36.635	46%	0.005
	50	87.80	1.64	21.167	42.701	49%	0.006
	100	95.92	1.883	21.083	48.974	51%	0.007

ID 1182	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	1.017	13.333	20.612	44%	3.1333	0.45	178%
A	5	60.08	1.429	13.167	28.708	48%	4.4008	0.55	163%
(ha)	10	68.76	1.782	13	34.479	50%	5.2902	0.68	161%
281.36	25	79.70	2.696	12.583	42.103	53%	6.1348	1.29	192%
0.37	50	87.80	3.349	12.25	47.967	55%	6.7384	1.71	204%
	100	95.92	4.529	11.5	54.009	56%	7.2225	2.65	241%

VO2 DST DISCH	STORAGE
0	0
1.69	5.2052
3.38	6.7667
7.32	8.3283

ID 1183	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	0.539	17.167	15.165	32%	0.003
A	5	60.08	0.829	17.083	23.216	39%	0.005
(ha)	10	68.76	1.041	17	29.087	42%	0.006
176.21	25	79.70	1.325	16.917	36.933	46%	0.008
	50	87.80	1.545	16.917	43.008	49%	0.009
	100	95.92	1.773	16.833	49.291	51%	0.010

ID 1183	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	S (ha-m)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	0.66	13.667	29.081	62%	3.268	0.12	122%
A	5	60.08	0.88	13.5	38.886	65%	4.3804	0.05	106%
(ha)	10	68.76	1.03	13.417	45.683	66%	5.1457	-0.01	99%
176.21	25	79.70	1.52	12.833	54.486	68%	5.9748	0.19	114%
0.6	50	87.80	1.88	12.667	61.151	70%	6.5296	0.34	122%
	100	95.92	2.38	12.5	67.942	71%	7.0473	0.61	134%

VO2 DST DISCH	STORAGE
0	0
1.06	5.2863
2.11	6.8722
4.58	8.4581

U/S Taunton Road - Confluence

ID 3093	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	4.417	17.25	12.996	28%	0.002
A	5	60.08	6.959	17	20.143	34%	0.003
(ha)	10	68.76	8.887	16.833	25.413	37%	0.004
2002	25	79.70	11.41	16.667	32.516	41%	0.006
	50	87.80	13.383	16.667	38.058	43%	0.007
	100	95.92	15.48	16.583	43.821	46%	0.008

U/S Taunton Road - Confluence

ID 3093	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	6.63	14.75	19.726	42%	2.212	150%
A	5	60.08	9.52	14.583	27.566	46%	2.565	137%
(ha)	10	68.76	11.74	14.25	33.17	48%	2.857	132%
2002	25	79.70	16.41	13.833	40.588	51%	4.997	144%
	50	87.80	19.91	13.583	46.304	53%	6.526	149%
	100	95.92	24.21	13	52.202	54%	8.734	156%

CPR

ID 3087	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	4.652	17.25	13.036	28%	0.002
A	5	60.08	7.369	17.167	20.162	34%	0.003
(ha)	10	68.76	9.471	17	25.463	37%	0.004
2169	25	79.70	12.235	16.667	32.609	41%	0.006
	50	87.80	14.372	16.667	38.18	43%	0.007
	100	95.92	16.639	16.5	43.968	46%	0.008

CPR

ID 3087	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	6.93	15.083	19.286	41%	2.28	149%
A	5	60.08	10.03	14.833	27.056	45%	2.66	136%
(ha)	10	68.76	12.46	14.5	32.668	48%	2.98	132%
2169	25	79.70	17.39	14.083	40.106	50%	5.15	142%
	50	87.80	21.10	13.833	45.838	52%	6.73	147%
	100	95.92	25.60	13.25	51.752	54%	8.96	154%

U/S Rossland Rd

ID 3082	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	4.708	17.417	12.891	27%	0.002
A	5	60.08	7.511	17.25	19.937	33%	0.003
(ha)	10	68.76	9.692	17	25.2	37%	0.004
2260	25	79.70	12.578	16.667	32.295	41%	0.006
	50	87.80	14.757	16.75	37.827	43%	0.007
	100	95.92	17.084	16.583	43.576	45%	0.008

U/S Rossland Rd

ID 3082	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	6.99	15.167	18.93	40%	2.29	149%
A	5	60.08	10.17	15	26.602	44%	2.66	135%
(ha)	10	68.76	12.72	14.5	32.168	47%	3.03	131%
2260	25	79.70	17.74	14.167	39.55	50%	5.17	141%
	50	87.80	21.50	13.917	45.241	52%	6.74	146%
	100	95.92	26.06	13.25	51.115	53%	8.97	153%

Hwy 2 E

ID 1044	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	5.504	17.583	13.692	29%	0.002
A	5	60.08	8.835	17.25	20.881	35%	0.003
(ha)	10	68.76	11.457	16.917	26.269	38%	0.004
2701	25	79.70	14.927	16.583	33.513	42%	0.006
	50	87.80	17.491	16.5	39.148	45%	0.006
	100	95.92	20.206	16.333	44.992	47%	0.007

Hwy 2 E

ID 1044	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	8.12	15.583	19.915	42%	2.61	147%
A	5	60.08	11.99	15.167	27.825	46%	3.15	136%
(ha)	10	68.76	15.12	14.833	33.579	49%	3.66	132%
2701	25	79.70	20.94	14.333	41.191	52%	6.01	140%
	50	87.80	25.20	14.25	47.042	54%	7.71	144%
	100	95.92	30.39	13.667	53.068	55%	10.18	150%

D/S Bayly St

ID 1033	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	6.017	18.417	14.808	31%	0.002
A	5	60.08	9.561	18.167	22.252	37%	0.003
(ha)	10	68.76	12.386	17.75	27.786	40%	0.004
2983	25	79.70	16.262	17.083	35.199	44%	0.005
	50	87.80	19.176	17	40.95	47%	0.006
	100	95.92	22.113	17	46.903	49%	0.007

D/S Bayly St

ID 1033	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	8.85	16.667	20.669	44%	2.83	147%
A	5	60.08	13.07	16.167	28.794	48%	3.51	137%
(ha)	10	68.76	16.55	15.75	34.675	50%	4.16	134%
2983	25	79.70	22.67	15.417	42.437	53%	6.41	139%
	50	87.80	27.31	15.167	48.394	55%	8.13	142%
	100	95.92	32.48	14.667	54.521	57%	10.37	147%

Shoal Point Rd

ID 1005	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	7.075	18.917	16.534	35%	0.002
A	5	60.08	11.003	18.083	24.363	41%	0.003
(ha)	10	68.76	14.139	17.75	30.116	44%	0.004
3602	25	79.70	18.509	17.333	37.781	47%	0.005
	50	87.80	21.795	16.917	43.704	50%	0.006
	100	95.92	25.183	16.833	49.819	52%	0.007

Shoal Point Rd

ID 1005	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	10.24	16.833	21.455	46%	3.17	145%
A	5	60.08	15.11	16.5	29.857	50%	4.11	137%
(ha)	10	68.76	19.02	16.25	35.903	52%	4.89	135%
3602	25	79.70	25.75	15.917	43.863	55%	7.24	139%
	50	87.80	30.96	15.583	49.96	57%	9.17	142%
	100	95.92	36.89	15.167	56.222	59%	11.71	146%

Lake Ontario

ID 1000	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q (UNIT) m3/s/ha
	2	47.08	7.148	18.917	16.76	36%	0.002
A	5	60.08	11.142	18.167	24.646	41%	0.003
(ha)	10	68.76	14.312	17.833	30.432	44%	0.004
3695	25	79.70	18.756	17.25	38.135	48%	0.005
	50	87.80	22.106	17.25	44.084	50%	0.006
	100	95.92	25.556	16.75	50.224	52%	0.007

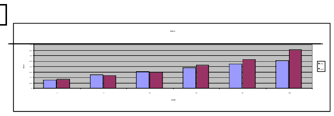
Lake Ontario

ID 1000	EVENT	P (mm)	Q (m3/s)	TP (hr)	R (mm)	R (%)	Q CHANGE (m3/s)	Q CHANGE (% OF PRE)
	2	47.08	10.40	16.8	21.556	46%	3.25	145%
A	5	60.08	15.33	16.6	30.001	50%	4.19	138%
(ha)	10	68.76	19.33	16.3	36.072	52%	5.01	135%
3695	25	79.70	26.14	15.9	44.063	55%	7.39	139%
	50	87.80	31.38	15.8	50.182	57%	9.27	142%
	100	95.92	37.42	15.2	56.465	59%	11.87	146%

ROPA 128 - Updated (2011) SWM Criteria

2011 SWM CRITERIA

	MAIN BRANCH		NODE 9a	
	Q (UNIT)	S	Q (UNIT)	S
	(m3/s/ha)	(m3/ha imp)	(m3/s/ha)	(m3/ha imp)
5 YEAR	0.006	500	0.023	190
25 YEAR	0.012	650	0.047	300
100 YEAR	0.026	800	0.094	350



PRE-DEVELOPMENT
24 HOUR AES

POST-DEVELOPMENT
24 HOUR AES

ID	EVENT	P	Q	TP	R		Q (UNIT)
1172		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	0.079	16.417	16.841	36%	0.004
A	5	60.08	0.121	16.333	25.557	43%	0.006
(ha)	10	68.76	0.151	16.25	31.85	46%	0.007
21.4	25	79.70	0.19	16.167	40.199	50%	0.009
	50	87.80	0.221	16.083	46.624	53%	0.010
	100	95.92	0.253	16.083	53.236	56%	0.012

ID	EVENT	P	Q	TP	R			Q (UNIT)	
1172		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)		
	2	47.08	0.08	13	27.496	58%	0.3606	VO2 DST	
A	5	60.08	0.12	12.917	37.3	62%	0.4911	DISCH	STORAGE
(ha)	10	68.76	0.15	12.667	44.134	64%	0.5786	0	0
21.41	25	79.70	0.21	12.417	53.015	67%	0.6647	0.13	0.5567
0.52	50	87.80	0.27	12.333	59.752	68%	0.7265	0.26	0.7237
	100	95.92	0.35	11.167	66.624	69%	0.7752	0.56	0.8907

ID	EVENT	P	Q	TP	R		Q (UNIT)
1173		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	0.2	14.833	15.069	32%	0.004
A	5	60.08	0.308	14.75	23.039	38%	0.006
(ha)	10	68.76	0.388	14.667	28.856	42%	0.008
50.3	25	79.70	0.494	14.583	36.635	46%	0.010
	50	87.80	0.576	14.583	42.663	49%	0.011
	100	95.92	0.662	14.5	48.899	51%	0.013

ID	EVENT	P	Q	TP	R		S		
1173		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)		
	2	47.08	0.20	14.333	37.71	80%	1.3077	VO2 DST	
A	5	60.08	0.26	14.25	49.259	82%	1.7087	DISCH	STORAGE
(ha)	10	68.76	0.31	13.75	57.099	83%	1.978	0	0
50.29	25	79.70	0.45	12.75	67.1	84%	2.529	0.30	1.9613
0.78	50	87.80	0.55	12.583	74.578	85%	2.4586	0.60	2.5497
	100	95.92	0.71	12.417	82.128	86%	2.6381	1.31	3.1381

ID	EVENT	P	Q	TP	R		Q (UNIT)
1174		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	0.782	19.667	14.669	31%	0.002
A	5	60.08	1.209	19.5	22.586	38%	0.004
(ha)	10	68.76	1.522	19.417	28.374	41%	0.005
336.3	25	79.70	1.939	19.333	36.124	45%	0.006
	50	87.80	2.264	19.333	42.134	48%	0.007
	100	95.92	2.601	19.25	48.354	50%	0.008

ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1174		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	1.25	13.417	23.666	50%	4.5852	VO2 DST		0.47	160%
A	5	60.08	1.72	13.333	32.331	54%	6.2981	DISCH	STORAGE	0.51	142%
(ha)	10	68.76	2.11	13.167	38.437	56%	7.492	0	0	0.58	138%
336.31	25	79.70	3.17	12.667	46.44	58%	8.6613	2.02	7.3988	1.23	163%
0.44	50	87.80	3.92	12.5	52.558	60%	9.4815	4.04	9.6185	1.65	173%
	100	95.92	5.17	11.75	58.835	61%	10.1513	8.74	11.8381	2.57	199%

ID	EVENT	P	Q	TP	R		Q (UNIT)
1175		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	0.575	19.5	14.612	31%	0.002
A	5	60.08	0.89	19.333	22.521	37%	0.004
(ha)	10	68.76	1.121	19.333	28.306	41%	0.005
244.7	25	79.70	1.429	19.25	36.051	45%	0.006
	50	87.80	1.669	19.167	42.058	48%	0.007
	100	95.92	1.918	19.083	48.276	50%	0.008

ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1175		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.96	13.667	30.886	66%	4.8537	VO2 DST		0.38	166%
A	5	60.08	1.27	13.5	40.915	68%	6.4426	DISCH	STORAGE	0.38	143%
(ha)	10	68.76	1.51	13.333	47.826	70%	7.5301	0	0	0.39	135%
244.69	25	79.70	2.24	12.833	56.742	71%	8.6339	1.47	7.4630	0.81	157%
0.61	50	87.80	2.75	12.583	63.473	72%	9.4117	2.94	9.7020	1.08	165%
	100	95.92	3.51	12.333	70.319	73%	10.0787	6.36	11.9409	1.60	183%

ID	EVENT	P	Q	TP	R		Q (UNIT)
1181		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	0.409	15.5	14.103	30%	0.003
A	5	60.08	0.637	15.417	21.808	36%	0.005
(ha)	10	68.76	0.804	15.333	27.461	40%	0.007
118.64	25	79.70	1.03	15.25	35.048	44%	0.009
	50	87.80	1.205	15.25	40.944	47%	0.010
	100	95.92	1.388	15.167	47.055	49%	0.012

ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1181		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.492	12.833	22.97	49%	1.4806	VO2 DST		0.08	120%
A	5	60.08	0.676	12.75	31.379	52%	2.034	DISCH	STORAGE	0.04	106%
(ha)	10	68.76	0.946	12.5	37.314	54%	2.3491	0	0	0.14	118%
118.67	25	79.70	1.324	11.75	45.105	57%	2.6902	0.71	2.1361	0.29	129%
0.36	50	87.80	1.8	11.25	51.069	58%	2.9228	1.42	2.7769	0.60	149%
	100	95.92	2.351	11	57.196	60%	3.1354	3.09	3.4177	0.96	169%

ID	EVENT	P	Q	TP	R		Q (UNIT)
1182		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	0.57	21.5	14.932	32%	0.002
A	5	60.08	0.879	21.333	22.952	38%	0.003
(ha)	10	68.76	1.105	21.25	28.807	42%	0.004
281.36	25	79.70	1.406	21.167	36.635	46%	0.005
	50	87.80	1.64	21.167	42.701	49%	0.006
	100	95.92	1.883	21.083	48.974	51%	0.007

ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1182		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	1.017	13.333	20.612	44%	3.1333	VO2 DST		0.45	178%
A	5	60.08	1.429	13.167	28.708	48%	4.4008	DISCH	STORAGE	0.55	163%
(ha)	10	68.76	1.782	13	34.479	50%	5.2902	0	0	0.68	161%
281.36	25	79.70	2.696	12.583	42.103	53%	6.1348	1.69	5.2052	1.29	192%
0.37	50	87.80	3.349	12.25	47.967	55%	6.7384	3.38	6.7667	1.71	204%
	100	95.92	4.529	11.5	54.009	56%	7.2225	7.32	8.3283	2.65	241%

ID	EVENT	P	Q	TP	R		Q (UNIT)
1183		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	0.539	17.167	15.165	32%	0.003
A	5	60.08	0.829	17.083	23.216	39%	0.005
(ha)	10	68.76	1.041	17	29.087	42%	0.006
176.21	25	79.70	1.325	16.917	36.933	46%	0.008
	50	87.80	1.545	16.917	43.008	49%	0.009
	100	95.92	1.773	16.833	49.291	51%	0.010

ID	EVENT	P	Q	TP	R		S			Q CHANGE	
1183		(mm)	(m3/s)	(hr)	(mm)	(%)	(ha-m)			(m3/s)	(% OF PRE)
	2	47.08	0.66	13.667	29.081	62%	3.268	VO2 DST		0.12	122%
A	5	60.08	0.88	13.5	38.886	65%	4.3804	DISCH	STORAGE	0.05	106%
(ha)	10	68.76	1.03	13.417	45.683	66%	5.1457	0	0	-0.01	99%
176.21	25	79.70	1.52	12.833	54.486	68%	5.9748	1.06	5.2863	0.19	114%
0.6	50	87.80	1.88	12.667	61.151	70%	6.5296	2.11	6.8722	0.34	122%
	100	95.92	2.38	12.5	67.942	71%	7.0473	4.58	8.4581	0.61	134%

U/S Taunton Road - Confluence

ID	EVENT	P	Q	TP	R		Q (UNIT)
3093		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	4.417	17.25	12.996	28%	0.002
A	5	60.08	6.959	17	20.143	34%	0.003
(ha)	10	68.76	8.887	16.833	25.413	37%	0.004
2002	25	79.70	11.41	16.667	32.516	41%	0.006
	50	87.80	13.383	16.667	38.058	43%	0.007
	100	95.92	15.48	16.583	43.821	46%	0.008

U/S Taunton Road - Confluence

ID	EVENT	P	Q	TP	R		Q CHANGE	
3093		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	6.63	14.75	19.726	42%	2.212	150%
A	5	60.08	9.52	14.583	27.566	46%	2.565	137%
(ha)	10	68.76	11.74	14.25	33.17	48%	2.857	132%
2002	25	79.70	16.41	13.833	40.588	51%	4.997	144%
	50	87.80	19.91	13.583	46.304	53%	6.526	149%
	100	95.92	24.21	13	52.202	54%	8.734	156%

CPR

ID	EVENT	P	Q	TP	R		Q (UNIT)
3087		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	4.652	17.25	13.036	28%	0.002
A	5	60.08	7.369	17.167	20.162	34%	0.003
(ha)	10	68.76	9.471	17	25.463	37%	0.004
2169	25	79.70	12.235	16.667	32.609	41%	0.006
	50	87.80	14.372	16.667	38.18	43%	0.007
	100	95.92	16.639	16.5	43.968	46%	0.008

CPR

ID	EVENT	P	Q	TP	R		Q CHANGE	
3087		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	6.93	15.083	19.286	41%	2.28	149%
A	5	60.08	10.03	14.833	27.056	45%	2.66	136%
(ha)	10	68.76	12.46	14.5	32.668	48%	2.98	132%
2169	25	79.70	17.39	14.083	40.106	50%	5.15	142%
	50	87.80	21.10	13.833	45.838	52%	6.73	147%
	100	95.92	25.60	13.25	51.752	54%	8.96	154%

U/S Rossland Rd

ID	EVENT	P	Q	TP	R		Q (UNIT)
3082		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	4.708	17.417	12.891	27%	0.002
A	5	60.08	7.511	17.25	19.937	33%	0.003
(ha)	10	68.76	9.692	17	25.2	37%	0.004
2260	25	79.70	12.578	16.667	32.295	41%	0.006
	50	87.80	14.757	16.75	37.827	43%	0.007
	100	95.92	17.084	16.583	43.576	45%	0.008

U/S Rossland Rd

ID	EVENT	P	Q	TP	R		Q CHANGE	
3082		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	7.01	15.167	18.929	40%	2.30	149%
A	5	60.08	10.19	15	26.602	44%	2.68	136%
(ha)	10	68.76	12.74	14.5	32.168	47%	3.05	131%
2260	25	79.70	17.76	14.25	39.55	50%	5.18	141%
	50	87.80	21.52	13.917	45.241	52%	6.76	146%
	100	95.92	26.08	13.25	51.115	53%	8.99	153%

Hwy 2 E

ID	EVENT	P	Q	TP	R		Q (UNIT)
1044		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	5.504	17.583	13.692	29%	0.002
A	5	60.08	8.835	17.25	20.881	35%	0.003
(ha)	10	68.76	11.457	16.917	26.269	38%	0.004
2701	25	79.70	14.927	16.583	33.513	42%	0.006
	50	87.80	17.491	16.5	39.148	45%	0.006
	100	95.92	20.206	16.333	44.992	47%	0.007

Hwy 2 E

ID	EVENT	P	Q	TP	R		Q CHANGE	
1044		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	8.04	15.917	19.912	42%	2.53	146%
A	5	60.08	11.84	15.5	27.822	46%	3.01	134%
(ha)	10	68.76	14.89	15	33.576	49%	3.43	130%
2701	25	79.70	20.69	14.5	41.188	52%	5.76	139%
	50	87.80	24.97	14.25	47.039	54%	7.48	143%
	100	95.92	30.09	13.75	53.065	55%	9.89	149%

D/S Bayly St

ID	EVENT	P	Q	TP	R		Q (UNIT)
1033		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	6.017	18.417	14.808	31%	0.002
A	5	60.08	9.561	18.167	22.252	37%	0.003
(ha)	10	68.76	12.386	17.75	27.786	40%	0.004
2983	25	79.70	16.262	17.083	35.199	44%	0.005
	50	87.80	19.176	17	40.95	47%	0.006
	100	95.92	22.113	17	46.903	49%	0.007

D/S Bayly St

ID	EVENT	P	Q	TP	R		Q CHANGE	
1033		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	8.74	17	20.666	44%	2.72	145%
A	5	60.08	12.88	16.5	28.791	48%	3.32	135%
(ha)	10	68.76	16.25	15.917	34.672	50%	3.87	131%
2983	25	79.70	22.40	15.583	42.434	53%	6.14	138%
	50	87.80	27.04	15.25	48.391	55%	7.86	141%
	100	95.92	32.13	14.75	54.518	57%	10.02	145%

Shoal Point Rd

ID	EVENT	P	Q	TP	R		Q (UNIT)
1005		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	7.075	18.917	16.534	35%	0.002
A	5	60.08	11.003	18.083	24.363	41%	0.003
(ha)	10	68.76	14.139	17.75	30.116	44%	0.004
3602	25	79.70	18.509	17.333	37.781	47%	0.005
	50	87.80	21.795	16.917	43.704	50%	0.006
	100	95.92	25.183	16.833	49.819	52%	0.007

Shoal Point Rd

ID	EVENT	P	Q	TP	R		Q CHANGE	
1005		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	10.01	17.333	21.453	46%	2.94	141%
A	5	60.08	14.75	16.833	29.855	50%	3.75	134%
(ha)	10	68.76	18.60	16.5	35.901	52%	4.46	132%
3602	25	79.70	25.36	16.167	43.861	55%	6.85	137%
	50	87.80	30.55	15.75	49.958	57%	8.76	140%
	100	95.92	36.37	15.25	56.219	59%	11.19	144%

Lake Ontario

ID	EVENT	P	Q	TP	R		Q (UNIT)
1000		(mm)	(m3/s)	(hr)	(mm)	(%)	m3/s/ha
	2	47.08	7.148	18.917	16.76	36%	0.002
A	5	60.08	11.142	18.167	24.646	41%	0.003
(ha)	10	68.76	14.312	17.833	30.432	44%	0.004
3695	25	79.70	18.756	17.25	38.135	48%	0.005
	50	87.80	22.106	17.25	44.084	50%	0.006
	100	95.92	25.556	16.75	50.224	52%	0.007

Lake Ontario

ID	EVENT	P	Q	TP	R		Q CHANGE	
1000		(mm)	(m3/s)	(hr)	(mm)	(%)	(m3/s)	(% OF PRE)
	2	47.08	10.14	17.4	21.554	46%	2.99	142%
A	5	60.08	14.94	16.9	29.998	50%	3.80	134%
(ha)	10	68.76	18.87	16.6	36.07	52%	4.55	132%
3695	25	79.70	25.73	16.3	44.061	55%	6.97	137%
	50	87.80	30.96	15.9	50.179	57%	8.86	140%
	100	95.92	36.87	15.3	56.462	59%	11.32	144%

APPENDIX I
Statement of Limiting Conditions and Assumptions

Statement of Limiting Conditions and Assumptions

1. This Report/Study (the “Work”) has been prepared at the request of, and for the exclusive use of, the Owner, and its affiliates (the “Intended Users”). No one other than the Intended Users has the right to use and rely on the Work without first obtaining the written authorization of Cole Engineering Group Ltd. (Cole Engineering) and its Owner.

2. Cole Engineering expressly excludes liability to any party except the Intended Users for any use of, and/or reliance upon, the Work.

3. Cole Engineering notes that the following assumptions were made in completing the Work:

   a) the land use description(s) supplied to us are correct;
   b) the surveys and data supplied to Cole Engineering by the Owner are accurate;
   c) market timing, approval delivery and secondary source information is within the control of Parties other than Cole Engineering; and
   d) there are no encroachments, leases, covenants, binding agreements, restrictions, pledges, charges, liens or special assessments outstanding, or encumbrances which would significantly affect the use or servicing.

   Investigations have not been carried out to verify these assumptions. Cole Engineering deems the sources of data and statistical information contained herein to be reliable, but we extend no guarantee of accuracy in these respects.

4. Cole Engineering accepts no responsibility for legal interpretations, questions of survey, opinion of title, hidden or inconspicuous conditions of the property, toxic wastes or contaminated materials, soil or sub-soil conditions, environmental, engineering or other factual and technical matters disclosed by the Owner, the Client, or any public agency, which by their nature, may change the outcome of the Work. Such factors, beyond the scope of this Work, could affect the findings, conclusions and opinions rendered in the Work. We have made disclosure of related potential problems that have come to our attention. Responsibility for diligence with respect to all matters of fact reported herein rests with the Intended Users.

5. Cole Engineering practices engineering in the general areas of infrastructure and transportation. It is not qualified to and is not providing legal or planning advice in this Work.

6. The legal description of the property and the area of the site were based upon surveys and data supplied to us by the Owner. The plans, photographs, and sketches contained in this report are included solely to aide in visualizing the location of the property, the configuration and boundaries of the site, and the relative position of the improvements on the said lands.

7. We have made investigations from secondary sources as documented in the Work, but we have not checked for compliance with by-laws, codes, agency and governmental regulations, etc., unless specifically noted in the Work.

8. Because conditions, including capacity, allocation, economic, social, and political factors change rapidly and, on occasion, without notice or warning, the findings of the Work expressed herein, are as of the date of the Work and cannot necessarily be relied upon as of any other date without subsequent advice from Cole Engineering.

9. The value of proposed improvements should be applied only with regard to the purpose and function of the Work, as outlined in the body of this Work. Any cost estimates set out in the Work are based on construction averages and subject to change.

10. Neither possession of the Work, nor a copy of it, carries the right of publication. All copyright in the Work is reserved to Cole Engineering. The Work shall not be disclosed, produced or reproduced, quoted from, or referred to, in whole or in part, or published in any manner, without the express written consent of Cole Engineering and the Owner.

11. The Work is only valid if it bears the professional engineer’s seal and original signature of the author, and if considered in its entirety. Responsibility for unauthorized alteration to the Work is denied.