C.C. Tatham & Associates Ltd.
Consulting Engineers

BRECHIN AND LAGOON CITY COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Township of Ramara

Municipal Class Environmental Assessment

Final Report

prepared by:

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1 Introduction

C.C. Tatham and Associates Ltd. (CCTA) was retained by the Township of Ramara (Township) to prepare a Comprehensive Stormwater Management (SWM) Master Plan for the settlement areas of Brechin and Lagoon City in accordance with the Lake Simcoe Protection Act.

The Township is located along the north east shoreline of Lake Simcoe and is bounded by Lake Simcoe, the City of Orillia and Lake Couchiching to the west, the Township of Brock to the south, the City of Kawartha Lakes to the east and the Town of Gravenhurst to the north. The settlement areas of Brechin and Lagoon City which are the focus of this study are located in the Ramara Creeks subwatershed. Their locations are shown on Figure 1, attached at the back of this report.

1.1 General Background

In December 2008, the Lake Simcoe Protection Act was passed by the Ontario Legislature and the Lake Simcoe Protection Plan (LSPP) followed in July 2009. The intent of the LSPP is to protect and restore the ecological health of Lake Simcoe and its watershed and it includes SWM policies to improve the management of stormwater runoff from both existing and future development. LSPP Policy 4.5 SA states within 5 years of the date the plan came into effect (i.e. by July 2014) municipalities in collaboration with the LSRCA, must prepare and implement Comprehensive SWM Master Plans for their settlement areas located in the Lake Simcoe watershed. The Comprehensive SWM Master Plans will serve as a tool for municipalities to use for improving existing drainage infrastructure (including SWM ponds). It will also define a strategy to establish guidelines to manage stormwater and reduce phosphorus loadings prior to and following development including an evaluation of stormwater retrofit opportunities.

1.2 Background Reports and Data Gap Analysis

This report was prepared using a number of past reports and guidelines on water resources and the environment, including the following publications:

<u>Township of Ramara Engineering Design Criteria and Standard Drawings</u>, CCTA, 2014;

<u>Provincial Policy Statement</u>, Ministry of Municipal Affairs and Housing, 2014;

<u>Technical Guidelines for Stormwater Management Submissions</u>, LSRCA, April 26, 2013;

<u>Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed</u>, Hutchinson Environmental Sciences Ltd, Greenland International Consulting Ltd. and Stoneleigh Associates Inc., March 2012;

<u>Lake Simcoe Region Conservation Authority Watershed Development Policies</u>, LSRCA, March 2012;

Proposed Residential and Commercial Development, Township of Ramara (Brechin) Stormwater Management Report, AECOM, August 2011;

The Approved Assessment Report Lake Simcoe and Couchiching – Black River Source Protection Area, Part 1: Lake Simcoe Watershed, LSRCA, Nottawasaga Valley Conservation Authority and Severn Sound Environmental Associations, November 2011;

Comprehensive Stormwater Management Master Plan Guidelines, LSRCA, April 2011;

Estimation of the Phosphorus Loadings to Lake Simcoe, The Louis Berger Group Inc., September 2010;

Lake Simcoe Phosphorus Reduction Strategy, Ministry of the Environment, June 2010;

Lake Simcoe Protection Plan, Ministry of the Environment and Climate Change (MOECC), July 2009;

Lake Simcoe Region Conservation Authority Integrated Watershed Management Plan, LSRCA, June 2008;

County of Simcoe Official Plan, County of Simcoe, August 2007;

Natural Heritage System for the Lake Simcoe Watershed Phase 1: Components and Policy Templates, LSRCA, July 2007;

Township of Ramara Industrial Park Lands SWM Facility Design Drawings, K. Smart Associates Ltd., 2005;

Township of Ramara Official Plan, Township of Ramara, July 2003;

Stormwater Management Practices Planning and Design Manual, MOECC 2003;

Stormwater Management and Construction Mitigation Report, Proposed Expansion to Brechin Public School, Dearden and Stanton Limited, January 2002; and

Natural Hazard Technical Guide, Ministry of Natural Resources, 2001.

1.2.1 Data Gap Analysis

CCTA has reviewed the background reports and has utilized the available information from the Lake Simcoe Region Conservation Authority (LSRCA), County of Simcoe (County) and the Township to identify data gaps to be addressed in order to fulfil the completion of a Master Plan.

Specifically, an existing and future condition hydrologic analysis of the Study Area is required as well as identification of development constraint areas. Phosphorus loading and water balance calculations are also required. Other data gaps with respect to erosion analyses along the receiving watercourses downstream of future development areas were identified by the LSRCA for inclusion as part of the Master Plan and are required to meet the policies of the LSPP.

1.3 Master Planning Class Environmental Assessment Process

The Comprehensive SWM Master Plan (CSWM MP) was developed following the Municipal Engineers Association Municipal Class EA process for Master Plans to meet the requirements of the Ontario Environmental Assessment Act (OEAA) for municipal infrastructure without having to undertake individual EAs or requesting a specific exemption from the project. The Municipal Class EA is a planning and design process to identify, compare and evaluate alternative solutions to a problem. It considers all aspects of the environment: natural, social, cultural and economic, and involves consultation with the public, affected parties and review agencies throughout the process.

Master Plans are long-range plans integrating infrastructure improvements for existing and future land uses with environmental assessment planning principles.

This CSWM MP is proceeding through the first two phases of the Class EA process:

Phase 1: Identify the problem;

Phase 2: Identify and assess, at a strategic level, alternative solutions, then recommend the preferred Master Plan to be implemented as separate subsequent projects.

A Public Information Centre (PIC) was held on March 20, 2014 at the Township Administration Office in Brechin. The comments received from all parties following the PIC have been incorporated into this CSWM MP. The Notice of Study Commencement & Public Open House, PIC sign-in sheet, comment sheets, and comment responses are included in Appendix A.

This CSWM MP has been prepared upon the conclusion of Phases 1 and 2 of the Class EA process and made available for public comment prior to being approved and adopted by the Township.

Projects undertaken to implement the specific elements of the recommended Master Plan will be the subject of more detailed investigations to fulfil the documentation requirements of the Class EA process.

2 Problem and Opportunity Statement

Over the past several decades, the Lake Simcoe watershed has experienced pressures from human-related activities including urban and rural uses, which have impaired the heath of Lakes Simcoe and its watershed. Excessive phosphorus loading has been identified as a key cause of the water quality degradation in Lake Simcoe. An estimated 1/3 of the phosphorus loadings to Lake Simcoe are from stormwater runoff.

The SWM policies of the LSPP require municipalities to prepare a CSWM MP for all settlement areas located in the Lake Simcoe watershed to improve the management of stormwater from existing and future development.

2.1 Study Goals, Objectives and Scope of Work

This CSWM MP will establish opportunities and constraints as they relate to stormwater quality and quantity and serve to establish a comprehensive framework to identify existing SWM improvement opportunities and to guide all future development in each settlement area. The implementation of drainage improvements will result in opportunities to minimizing erosion, phosphorus loadings, and changes in water balance throughout the Lake Simcoe watershed which are in alignment with the overall objectives of the LSPP.

This CSWM MP has been developed according to the LSRCA Comprehensive Stormwater Management Master Plan Guidelines, dated April 26, 2011 to meet the intent of the LSPP.

CCTA met with LSRCA staff in July 2012 and confirmed the project terms of reference. Minutes from the meeting with the LSRCA are attached in Appendix B.

This CSWM MP has been organized according to the ten steps of the LSRCA's Comprehensive Stormwater Management Master Plan Guidelines as follows:

- Step One - Scoping
- Step Two - Determine the Study Area for the Settlement Area
- Step Three – Develop a Characterization of the Study Area
- Step Four – Divide the Area into Management Units
- Step Five – Evaluate the Cumulative Environmental Impact of Stormwater from Existing and Planned Development
- Step Six – Determine the Effectiveness of Existing Stormwater Management Systems
- Step Seven – Identify and Evaluate Stormwater Improvement and Retrofit Opportunities
- Step Eight – Establish a Recommended Approach for Stormwater Management for the Study Area
- Step Nine – Develop an Implementation Plan for the Recommended Approaches
- Step Ten – Develop Programs for Inspection and Maintenance of Stormwater Management Facilities

3 Scoping

The Township of Ramara Official Plan, Land Use Plan (Schedule A) identifies Brechin and Lagoon City as settlement areas. The requirements of Policy 4.5 of the LSPP are applicable to these areas. The locations of the settlement areas are shown on Figure 1.

Other settlement areas in the Township of Ramara identified in the Official Plan include: Atherley, Uptergrove, Udney, Longford Mills, Cooper's Falls, Sebright, and Gamebridge however, the purpose of this study was to focus on Brechin and Lagoon City where the majority of development activity is occurring. This Plan will need to be updated in the future if major development is proposed in these other areas.

The majority of land within the Township which is not included within the boundaries of these settlement areas is agricultural/rural, with a limited amount of proposed future development.

4 Study Area

The primary Study Area is comprised of the Brechin and Lagoon City settlement areas including permanent and intermittent streams and upstream drainage areas which drain to each. The Study Area also includes lands downstream of the settlement areas to Lake Simcoe which have the potential to be affected by future development in the upstream settlement areas.

For the purposes of hydrologic modelling, areas upstream of the settlement areas, which are included in the overall Study Area and which drain through the settlement area have been modelled in order to predict peak flows through and downstream of the settlement areas. However, the areas upstream are not considered in the water balance and phosphorus budget calculations provided herein. The Study Area is illustrated on Figure 1.

5 Study Area Characterization

The Study Area has been characterized according to the applicable direction and policies and physical watershed characteristics separately as follows:

5.1 Direction and Policies

Township of Ramara Engineering Design Criteria and Standard Drawings (May 2014)

The Township of Ramara Engineering Design Criteria and Standard Drawings document was adopted by Council resolution on May 26, 2014 and includes requirements related to SWM for all development applications. Specifically, Section 4.2.2 describes the SWM design requirements which are summarized as follows:

- A SWM report is required for all development applications and shall be consistent with any applicable Watershed Planning Studies and/or Master Drainage Plans and shall be in accordance with LSRCA, LSPP and DFO policies and requirements.
- SWM reports shall address stormwater quality, stormwater quantity, sediment and erosion control, and baseflow maintenance. Specific requirements of each are included in the Township engineering design criteria document. Note, the hydrology of rural catchments and urban catchments shall be modelled with OTTHYMO using the SCS 24 hour design storm and 4 hour Chicago design storms respectively.

The document also includes specific SWM facility design criteria for dry ponds, wet ponds and wetlands.

Provincial Policy Statement (April 2014)

The Provincial Policy Statement is issued under Section 3 of the Planning Act and is used by municipalities to develop their official plans and to make decisions on planning matters. All planning matters within the Study Area must be consistent with the Provincial Policy Statement.

LSRCA Technical Guidelines for SWM Submissions (April 2013)

The LSRCA Technical Guidelines for SWM Submissions applies to all future development located in an area regulated by LSRCA. This document provides detailed guidance regarding SWM requirements to satisfy the LSRCA Watershed Development Policies and the LSPP. A number of key policies from this document are summarized below:

- A ‘treatment train’ approach to SWM is encouraged, using lot level (including rooftop storage, rear yard storage, disconnected roof leaders), conveyance controls (including grassed swales pervious pipe systems) and end-of –pipe controls (including infiltration basins/trenches, oil grit separators, sand filters, dry ponds, wet ponds, hybrid ponds etc.).
- Quantity control is not required if a site is directly adjacent to Lake Simcoe with a safe outlet or connected to a municipal system designed to discharge uncontrolled flows from the site to the Lake.
- Unless specified otherwise by a subwatershed study, or fluvial geomorphic analysis, the post-development peak flow rates must not exceed pre-development peak flow rates for the 2, 5, 10, 25, 50 and 100 year design storm events.
- It is a developer’s responsibility to demonstrate safe conveyance of the Regulatory Storm (the greater of the 100 year design storm or Hurricane Hazel/Timmins) through the development to a sufficient outlet, such that there are no adverse impacts to downstream landowners.

- The minimum level of water quality treatment required for any development within the LSRCA watershed is the Enhanced Protection Level as per MOECC's SWM Planning and Design Manual (March 2003). This corresponds to the long-term removal of 80% of suspended solids.
- For all new major developments within the LSRCA, a phosphorous loading study is to be completed. Best efforts shall be employed to minimize any increase in loading.
- For all new major developments within the LSRCA, an evaluation of the site water balance must be completed
- An erosion and sediment control plan must be provided for all development works.
- The following design storms are to be used for modelling sites with drainage areas greater than 5 ha: Regional Storm event, 4 hour Chicago Distribution, 12 hour SCS Type II distributions, and any sub-watershed, watershed or master drainage plan storm distributions.

LSRCA Watershed Development Policies (March 2012)

Section 6 of the LSRCA Watershed Development Policies identifies SWM criteria for development located within the Lake Simcoe watershed. The SWM criteria are defined in greater detail in the LSRCA technical guidelines for SWM submissions described above.

Growth Plan (2006, Office Consolidation January 2012)

The Study Area is located within the Greater Golden Horseshoe as defined in the Growth Plan. The Growth Plan for the Greater Golden Horseshoe was prepared under the Places to Grow Act (2005) and provides the principles for guiding decisions on how land is to be developed and how resources are to be managed. The Growth Plan provides population and employment forecasts and policies for municipalities to plan for forecasted growth. Brechin and Lagoon City represent rural settlement areas as defined by the Growth Plan.

Phosphorus Reduction Strategy of LSPP (June 2010)

The Phosphorus Reduction Strategy is intended to serve as a long term framework to reduce annual phosphorus loading into Lake Simcoe to approximately 44 T/yr. Urban runoff and stormwater account for an estimated 31% of total phosphorus loads to Lake Simcoe. Specifically related to SWM, 160 retrofit opportunities have been identified in the Lake Simcoe watershed to reduce phosphorus loadings by approximately 4.2 T/yr via retrofitting quantity facilities (i.e. dry ponds) into water quantity and quality facilities (i.e. wet ponds. Wet/dry ponds, and wetlands). Low Impact Development (LID) practices are encouraged for all new development to promote water retention onsite and to enhance the percolation of water through the soil. The goal of Phosphorus Reduction Strategy Direction #3 is no net increase in phosphorus loading from new development. Phosphorus reduction tools identified in the phosphorus reduction strategy document include:

- Enhanced level protection for all new SWM systems;

- Retrofit existing SWM facilities;
- Municipal options, e.g. Cash-In-Lieu offsetting program;
- Explore potential for treating stormwater before it is released into the watershed from new and existing developments;
- Improved clean-out frequency and maintenance of SWM systems;
- Implement innovative technologies and approaches (i.e. LID, water re-use);
- Oil-grit separators in SWM systems;
- Public education and outreach programs;
- Reduce or eliminate phosphorus rich lawn fertilizers;
- Promote natural meadow field lawns requiring little or no fertilizer and reduced lawn cutting; and
- Use of rain barrels to harvest rainwater for watering lawns.

Lake Simcoe Protection Plan (July 2009)

The LSPP was developed following the passing of the Lake Simcoe Protection Act, in December 2008. Chapter four of the LSPP describes the policies related to SWM for both existing and planned development. The specific policies from the LSPP related to SWM are summarized as follows:

4.5-SA Within five years, municipalities will prepare and implement comprehensive SWM Master Plans in accordance with the Municipal Class Environmental Assessment.

4.6 – SA Municipalities are encouraged to implement stormwater retrofits prior to completing a SWM master plan if a stormwater retrofit opportunity has been identified as a priority for a settlement area and is economically feasible.

4.7 – DP Municipalities incorporate into their official plans policies related to reducing stormwater runoff volume and pollutant loadings from major and existing development.

4.8 –DP An application for major development shall be accompanied by a SWM plan that demonstrates:

a. consistency with SWM master plans prepared under policy 4.5, when completed.

b. consistency with subwatershed evaluations prepared under policy 8.3 and water budgets prepared under policy 5.2 of the LSPP, when completed.

c. an integrated treatment train approach to minimize SWM flows and reliance on end-of-pipe controls through measures including source controls, lot-level controls and conveyance techniques.

d. through an evaluation of anticipated changes in the water balance between pre-development and post-development, how such changes shall be minimized; and

e. through an evaluation of anticipated changes in phosphorous loading between pre-development and post-development, how the loadings shall be minimized.

4.9-DP SWM works established to serve new major development must be designed to satisfy the Enhanced Protection level specified in Chapter 3 of the MOECC's Stormwater Management Planning and Design Manual 2003.

4.10-DP Every owner and operator of a new SWM system shall be required to inspect and maintain the works on a periodic basis.

4.11-DP Every owner and operator of a new priority SWM system shall be required to monitor the operation of works, including monitoring the quality of the effluent from the work, on a periodic basis.

4.12-SA The MOECC will review the approvals issued under section 53 of the Ontario Water Resources Act in respect of existing priority SWM works. If a review of an approval for an existing priority SWM system determines the conditions in the approval are inadequate, having regard to the objectives of the Plan, including the conditions related to inspection, maintenance and monitoring, the approval will be referred to the Director for the purposes of determining whether an amendment to the approval is necessary to assist in meeting the objectives of the plan.

County of Simcoe Transportation Master Plan (July 2008)

There are no transportation improvements proposed in the County of Simcoe Transportation Master Plan applicable to the Study Area.

LSRCA Integrated Watershed Management Plan (June 2008)

The LSRCA Integrated Watershed Management Plan was prepared under Section 21 of the Conservation Authorities Act and provides expanded and updated information on the Lake Simcoe Environmental Management Strategy Document, State of the Lake Simcoe Watershed (2003). The Plan is intended to be a holistic road-map to provide future direction for the protection and rehabilitation of the Lake Simcoe watershed ecosystem.

County of Simcoe Official Plan (August 2007)

Section 3.3.16 of the County of Simcoe Official Plan requires a SWM report to accompany all plans of subdivision and condominium, the creation of more than five lots or units and all industrial, commercial and institutional development where impervious areas of over 1,000 square metres and/or chemical storage and use is proposed. The SWM report is to be prepared according to municipal, provincial and conservation authority requirements.

Township of Ramara Official Plan (July 2013) and Zoning By-Law (October 2005)

The Township of Ramara Schedule 'A' Land Use Plan illustrates the Township divided into the landuse designations including: Natural Area Protection, Agriculture, Rural, Village, Hamlet, Shoreline Residential Area, Industrial, Destination Commercial, Highway Commercial and Mineral Aggregate Extraction Area.

Schedules I-2 Interim Secondary Plan Brechin Village and I-3 Interim Secondary Plan Lagoon City Village provide specific land use designations in each of the settlement areas. The land uses include: Village Industrial, Village Residential, Village Commercial, Institutional, Agriculture and Rural.

Section 6.3 of the Township's Official Plan identifies the requirements for SWM systems which apply to all development and/or site alteration that exceeds five residential lots or units in settlement areas including Brechin and Lagoon City. All SWM systems must be designed and operated according to provincial and LSRCA standards and regulations.

SWM facilities are permitted in all zones as defined by the Township of Ramara Zoning By-Law.

MOECC Stormwater Management Planning and Design Manual (March 2003)

The Ministry of the Environment SWM Planning and Design Manual provides technical and procedural guidance for the planning, design, and review of SWM practices across Ontario. It is considered a baseline reference document for design and review of SWM applications for approval under section 53 of the Ontario Water Resources Act as administered by the Ministry of the Environment. The following provides a summary of where to find key aspects in the document regarding SWM quality controls.

- Section 3.3.1.1 outlines the three water quality protection levels: Enhanced, Normal, and Basic.
- Section 3.3.2 (Table 3.2) outlines SWM facility volumetric sizing requirements based on the water quality protection level required, and the level of imperviousness of the contributing drainage area. The Enhanced level is applicable to all developments within the LSRCA boundary.

Ramara Creeks Subwatershed Plan (September 2015)

The LSRCA prepared a subwatershed plan for Ramara Creeks which includes the Study Area. This document contains approximately 85 recommendations in total which have been summarized as follows:

- Continuing to implement on-the-ground stewardship projects to improve aquatic habitat and water quality, promote infiltration of precipitation, and broaden the extent of natural features;
- Naturalizing swales and watercourses to preserve water quantity and maintain flow, particularly in the Lagoon City area;
- Adopting policies that protect the recharge of groundwater;
- Educating members of the public and targeted industries on topics including the dangers of using invasive species in horticulture, the importance of maintaining groundwater recharge areas, and good practices for the use of road salt to minimize environmental impacts;
- Studying the potential impacts of climate change and developing plans to limit its impacts;
- Researching and using new and innovative solutions, such as Low Impact Development practices, to address uncontrolled stormwater in urban areas;
- Evaluating monitoring activities, and adjusting programs as necessary to achieve program goals; and
- Working to make information about the health of the subwatershed readily available to all stakeholders.

5.2 Physical Watershed Characteristics

Background information has been consolidated for the Study Area and characterized according to physical watershed characteristics as follows:

5.2.1 Study Area Watershed

The Study Area is located in the Ramara Creeks Subwatershed and includes five main tributaries draining south and south east from their upper headwaters to Lake Simcoe. The Study Area consists of approximately 1,900 hectares of land including: 58% agricultural, 20% wetland, 14% developed, and 8% forest and open field. The location of the Study Area is illustrated on Figure 1.

Brechin is located in the headwater areas of the Prophet Drain and the Donnelly Drain. There are four SWM features located in the Brechin settlement area including a dry SWM pond, a wet SWM pond, an oil-grit separator and two surface bioswales. These will be discussed in greater detail in the sections to follow.

Lagoon City is located on the north east shoreline of Lake Simcoe. Lagoon City consists of a network of canals (lagoons) which are directly connected to each other and Lake Simcoe. No SWM features exist in Lagoon City as runoff from the majority of the settlement area discharges via grassed swales, ditches and storm sewers into the existing canals or Lake Simcoe directly.

Figures 2 and 3, Existing and Future Conditions Drainage Plans illustrate the Study Area broken up according to drainage catchment areas under the existing and future conditions. Figure 2 and Figure 3 are attached at the back of this report.

5.2.2 Natural Heritage Systems

The LSRCA Natural Heritage System for the Lake Simcoe Watershed (July 2007) identifies components of the Natural Heritage System (NHS) across the Study Area including significant habitats for endangered and threatened species, wetland, woodlands, valley lands, wildlife and fish habitats, areas of natural and scientific interest and linkages.

The NHS area for the Study Area was mapped using land use mapping for the entire Lake Simcoe watershed which is included in the LSRCA Natural Heritage system for the Lake Simcoe Watershed Phase 1: Components and Policy Templates (LSRCA, June 2007) document. The NHS throughout the Study area are illustrated on Figure 4, attached at the back of this report. A four-tiered policy approach was utilized to direct the protection of the natural features of the NHS where tier 1 and 2 are assigned a "provincially significant" designation and considered to be those features that would be identified if following the guidelines and intent of the Provincial Policy Statement (2005). Tier 3 applies to features with significance at the watershed level. Tier 4 applies to features supporting elements of the natural heritage system within the watershed. The recommended policy levels (i.e. Level 1 – 4) and the implications on development or land use change are explained in detail in the natural heritage system for the Lake Simcoe watershed document. All future development located in any of these areas is to be accompanied by an updated natural heritage investigation analysis.

The natural heritage land is further divided into detailed land uses listed including:

- Coniferous Forest;
- Coniferous Swamp;
- Cultural Meadow;
- Cultural Thicket;
- Cultural Woodland;
- Deciduous Forest;
- Deciduous Swamp;

- Meadow Marsh;
- Mixed Forest;
- Mixed Shallow Aquatic;
- Mixed Swamp;
- Open Water;
- Shallow Marsh;
- Thicket Swamp;
- Submerged Shallow Aquatic; and
- Cultural Plantation.

The Brechin settlement is primarily characterized as having Level 4 supporting feature with a few small Level 2 feature areas.

The Lagoon City settlement area consists of areas identified as Level 1 and Level 3 features.

The Township Official Plan identifies natural heritage system areas as “Natural Area Protection”. The purpose of the Natural Area Protection designation in the Official Plan is to protect, conserve and enhance natural areas features and functions.

5.2.3 Soil Conditions

Soil characterization for the Study Area has been provided by the Soil Survey of Ontario County (Report 23 of the Ontario Soil Survey, Research Branch Canada Department of Agriculture and Ontario Agricultural College, 1950) and is illustrated on Figure 5, attached at the back of this report.

5.2.4 Natural Hazards

The LSRCA regulates natural hazard lands which present a potential natural threat to human safety and/or the environment. These include floodplain, erosion prone (including meanderbelt) and wetland areas. The natural hazard areas located within the Study Area, which are taken from the LSRCA Regulation Mapping are illustrated on Figure 6, attached at the back of this report.

In most circumstances, the natural hazard areas are conservatively estimated by the LSRCA however detailed floodplain, erosion and wetland evaluations are available for certain areas. All future development located in an LSRCA regulated area requires permitting from the LSRCA including detailed analysis and confirmation of the natural hazard areas in accordance with the Conservation Authorities Act (O.Reg. 179/06) and the Planning Act.

5.2.5 Significant Groundwater Features and Functions If Known

Following the Walkerton tragedy in 2000, the province enacted the Clean Water Act (2006) introducing source water protection for the Province's drinking water resources. The Approved Assessment Report Lake Simcoe and Couchiching – Black River Source Protection Area, Part 1: Lake Simcoe Watershed (November 2011) was prepared and is applicable to areas located within the Lake Simcoe watershed including the Study Area. Chapter 12 of the above document discusses source water protection areas in the Township of Ramara.

Included in this report is a figure (Figure 4.3-2) illustrating Significant Groundwater Recharge Areas (SGRA) and Vulnerability Scores. SGRA's are defined as areas where the recharge is 15% greater than the average recharge in the Lake Simcoe watershed, which allow surface water to infiltrate into the ground and flow to an aquifer. The information from Figure 4.3-2 has been used to illustrate the SGRA's in the Study Area which are shown on Figure 7, attached at the back of this report. These areas are characterized as significant in maintaining the water level in an aquifer supplying a community with drinking water or contributing groundwater to an ecosystem that depends on recharge to maintain its ecological function (i.e. a surface watercourse). The Vulnerability score of an SGRA is determined by its proximity to a well and how easily water can travel through it including factors such as soil type, water table elevation, contaminant concentration, and the confined/unconfined nature of the aquifer. It is noted the information illustrated on Figure 7 is based on a broad level assessment and the best available information at the time of this report. These will be confirmed with more detailed analysis being conducted as part of a Tier 2 water budget being conducted by the LSRCA.

The entire Study Area is located in an area characterized as a having highly vulnerable aquifer (score=6). On this basis, SWM practices to infiltrate stormwater will require detailed studies to confirm there are no anticipated impacts to an existing aquifer.

The water supply for Brechin and the majority of Lagoon City is from the Lagoon City surface water intake. A portion of Lakeshore Drive from Simcoe Road to Concession 3 is serviced by private wells.

5.2.6 Surface Water Features and Functions

Surface drainage across the Study Area is generally towards the south and south west via four watercourses. Characteristics of each watercourse are described in the following subsections and reflect background information and field observations recorded in the fall of 2013. The watercourses are shown on Figure 1.

Prophet Drain – North of Village of Brechin Urban Area

The Prophet Drain, located on the north side of the Village of Brechin urban area is a 1st order watercourse with an upstream drainage area of 1.62 km^2 to the CN Rail Line. The drain combines with a manmade channel in Lagoon City approximately 1.8 km further downstream which subsequently discharges to Lake Simcoe at an assumed similar backwater elevation. The feature falls within the Simcoe Lowlands physiographic region. Topography is generalized as wide, shallow, low gradient riparian flood plain and large separation from drumlin elevations to the north and east. Upstream and downstream of the rail crossing the feature has been historically straightened for agricultural drainage through adjacent row cropping. Naturalized encroachment within the channel and in narrow buffers on each side of dense groundcover and wet to dry meadow transition is observed. Cattail stands are evident discontinuously through the channel feature.

The existing feature geometry is a legacy of past alteration and the cross-section is highly influenced by biotechnical reinforcement. Bedforms are indistinct and the feature is generally defined as a continuous run flowing through heterogeneous deposits of clay-silt, sand, and some gravel. Erosion scars are not explicitly evident and low flow definition is muted by the dense vegetative cover. Channel sinuosity is essentially non-existent and the reach average slope is just less than 0.5%. Minor low flow discharge was observed at the time of fall field work however it is assumed the feature is ephemeral to intermittent.

Unnamed Lake Simcoe Tributary – Immediately South of Lagoon City

The Lake Simcoe Tributary south of Lagoon City is a 1st order watercourse with an upstream drainage area of 1.32 km^2 just above Lakeshore Drive. The tributary discharges to Lake Simcoe approximately 250 m downstream on the south side of Brechin Point. The feature falls within the Simcoe Lowlands physiographic region. The reach upstream and downstream of future stormwater connection is a low gradient swamp forest wetland channel. High levels of organic detritus in various stages of decomposition fill and define the channel as it flows over and through medium density groundcover, shrub, and tree thicket conditions. The channel is very low gradient and low energy with the noted organic debris conditions resulting in relatively wide and shallow cross-section definition. The levels of deposition and decomposition indicate the channel lacks the ability to transport high volumes of bedload. Flows appear permanent but sluggish, bedforms are indistinct, and excessive erosion scares are not evident. The channel likely experiences minor adjustments due to freeze-thaw processes and pore pressure changes in the mesic soil conditions.

Donnelly Drain

The Donnelly Drain (Award Drain under the Drainage Act) located south of the Village of Brechin urban area is a 1st order watercourse with an upstream drainage area of 0.66 km^2 to the CN Rail Line where future conditions stormwater will be confluent. Below the rail line the feature is tile drained for agricultural use over a length of approximately 700 m until a defined channel reappears. From this point the tributary is confluent with Lake Simcoe approximately 2.1 km further downstream in Brechin Beach. The feature falls within the Simcoe Lowlands physiographic region. Topography, historic alteration, and channel characterization are very similar to the tributary on the north side of the village, except for smaller relative cross-sectional area and width and a lower presence of cattail vegetation. Groundcover vegetation encroachment and biotechnical reinforcement is continuous on the upstream side of the rail line, and low flow discharge is assumed to be primarily ephemeral to only occasionally intermittent as demonstrated by the conditions downstream of the rail line.

McNabb Municipal Drain

The McNabb Municipal Drain south of the Village of Ramara Industrial Park is a 1st order feature originating as a roadside ditch with an upstream drainage area of 0.80 km^2 that includes input from an existing SWM pond. The drain discharges to Lake Simcoe approximately 4.9 km downstream in Mara Beach. The feature falls within the Simcoe Lowlands physiographic region. Cross-section geometry in the reach immediately below the existing stormwater pond is typical of a manmade trapezoidal to triangular ditch that has rounded slightly through natural processes over time. Groundcover vegetation encroachment levels are very high and combined with low gradient of approximately 0.25 % the channel is dynamically stable parallel to the adjacent road. The channel bed is a continuous run and soil conditions are a heterogeneous mix of materials up to gravel with a higher fraction of sand and gravel assumed to be from winter maintenance and gravel shoulder inputs. Low flows appear to be intermittent but could have longer post event durations due to the effect of the existing stormwater pond.

A 12.2 ha area located at the north limit of the Lagoon City settlement area drains north through a wooded wetland area eventually discharging into the Harrington Municipal Drain. The area located in the Lagoon City settlement area is on the site of the municipal wastewater treatment plant and is not anticipated for redevelopment. On this basis, a detailed field inspection and survey was not completed for this watercourse since there are no anticipate land use changes in this area.

Murray Municipal Drain

The Murray Municipal Drain north of the Village of Brechin urban area is a 1st order watercourse with an upstream drainage area of approximately 3.0 km^2 to the CN Rail Line. A branch of the Murray Municipal Drain located south of the main branch and having an upstream drainage area of approximately 2.1 km^2 to the CN Rail Line discharges into the main branch downstream of the CN Rail Line. Portions of the Murray Municipal Drain and branch are tile drained for large scale agricultural use. Downstream of the CN Rail Line a defined channel reappears through a low lying wetland area. From this point, the watercourse discharges to Lake Simcoe at the east limit of the Lagoon City settlement area. In total, the Murray Municipal Drain drains an area of approximately 6.7 km^2 consisting primarily of active agricultural areas. Runoff to the municipal drain is believed to contain high levels of nutrients including nitrogen and phosphorous, originating from agricultural fertilizers. The discharge of nutrient rich runoff at Lagoon City was noted by the Township to be a contributing factor to the blue-green algae observed over the past several years in the Lagoon City lagoons.

5.2.7 Wellhead and Intake Protection Areas

The Lagoon City water treatment plant is located beyond the east shore of Lake Simcoe in the community of Lagoon City. It provides potable water to approximately 3,000 people in the communities of Lagoon City, Brechin, and Concord Point. The Intake Protection Zones (IPZ) for the Lagoon City water treatment plan are shown on Figure 8, attached at the back of this report. IPZ-1 consists of a 1 km radius centred on the intake and a 120 m setback from the shoreline. IPZ-2 includes transport pathways such as drains and ditches that may contribute water to the intake where the time of travel to the intake is equal to or less than the time that is sufficient to allow the operator of the system to respond. A two hour minimum response time was used to delineate the IPZ-2 zones. Where the IPZ-2 zones abut land, the greater of 120 m inland measured from the high water mark or the area of land regulated by the LSRCA governs. IPZ-3 is defined as the entire Lake Simcoe and Lake Couchiching sub-watershed. The vulnerability scores of IPZ-1, IPZ-2, and IPZ-3 for the Lagoon City intake are 9 and 8.1 and are generally within the middle of the ranges for each.

The South Georgian Bay Lake Simcoe Source Protection Plan, dated January 26, 2015 describes 21 Policy threats and defines the circumstances and vulnerability score needed for a significant threat to exist for each. Also contained in this document are land use planning policies, restricted land use policies, education and outreach policies and incentive policies, and monitoring policies. Policy 2 (a) of the draft document deals with SWM facilities. The severity of a threat from stormwater runoff is determined by the drainage area serviced by the SWM facility. The circumstances and vulnerability score needed for a significant threat are facilities having an upstream drainage area of 10-100 ha that are located in an IPZ 9 – 10 and greater than 100 ha for a facility located in an IPZ 8 - 10.

5.2.8 Existing SWM Facilities

Four SWM facilities exist in the Brechin settlement area including a dry SWM pond, a wet SWM pond, an oil-grit separator unit, and two surface bioswales.

A dry SWM pond provides water quantity control for the Brechin Public School site which is located on the north side of Ramara Road 47 at the west limit of the settlement boundary. The pond was designed as a dry SWM pond but retains water during dry periods signifying a potential blockage at the outlet. This facility was designed and constructed in 2002 to mitigate impacts related to increased runoff from a school addition only, not for the total site area. SWM was not provided for the original school building which was constructed in the early 1970s.

A wet SWM pond provides water quality and quantity control for the existing and future development located in the Ramara Industrial Park lands, servicing an area of approximately 25.8 hectares.

These facilities have been modelled for their stage-storage-discharge functions in order to incorporate them into the hydrologic modelling of this report. The existing ponds are illustrated on Figure 2.

A Stormceptor STC 1000 water quality treatment unit is located on the Township of Ramara administration building site and was constructed in 2010 as part of a treatment train approach combined with two surface bioswales to provide water quality treatment for runoff generated by the Township building and parking areas.

No SWM facilities exist in Lagoon City.

5.2.9 Areas of Known Environmental Degradation

In 1994, the Township undertook a Lagoon City Sewer Needs Study. Surveys of privately serviced lots, located in close proximity to the Lake between Lagoon City and Concession 3 concluded there are concerns with malfunctioning septic systems including high levels of E.Coli and Total Coliforms in roadside drainage systems. The survey concluded the majority of septic systems were undersized and only a small percentage of the lots had sufficient area for replacement septic systems sized in accordance with current standards. A conceptual Lakeshore water and sewer servicing project was completed including installation of a low pressure sewer system on Ridge Avenue, Lone Birch Trail, Maple Trail and Lakeshore Drive (which are located in the Lagoon City settlement area) from Lagoon City to Concession 3, discharging into an existing pump station in Lagoon City. In August 2011 a Public Open House was held at the Township Administration Office to provide information to the public and receive their feedback. The cost to residents was identified as the primary concern of the respondents opposed to the project. Engineering design and construction of the project is pending future funding opportunities in order to lessen the cost to the public.

The Lakeshore water and sewer servicing project conforms to the objectives of the LSPP.

The remaining portions of the settlement areas are connected to municipal water and sanitary services. There are no other areas located in the Study Area with known environmental degradation including: polluted groundwater, elevated pollutant concentrations arising from malfunctioning sewage systems, areas of accelerated erosion, etc.

5.2.10 Existing Land Uses

For the purposes of this study, the LSRCA provided a GIS Existing Land Condition file for the Study Area. We have confirmed this information using current aerial photography to classify the existing land uses throughout the Study Area. The existing land uses include: forest, cultivated, wetland, lawn/pasture and developed area. The existing land uses for the Study Area are illustrated on Figure 9, attached at the back of this report.

5.2.11 Land Use Designations in the Official Plan and Zoning By-Law

The Township of Ramara Official Plan (2003), Schedule ‘A’ Land Use Plan designations for the Study Area are illustrated on Figure 10, attached at the back of this report.

Schedules I-2 Interim Secondary Plan Brechin Village and I-3 Interim Secondary Plan Lagoon City Village provide land use designations specific to each of the settlement areas and are illustrated on Figure 11 and Figure 12 respectively. The land uses include: Village Industrial, Village Residential, Village Commercial, Institutional, Agriculture and Rural.

The Brechin and Lagoon City settlement boundaries identified on the above plans have been used in the future condition hydrologic modelling to evaluate areas of growth, within the settlement boundaries, and to determine opportunities to mitigate impacts related to SWM from future development.

5.2.12 Existing Municipal Services

Gravity sanitary sewers exist throughout Brechin and Lagoon City and drain with the assistance of several sewage pumping stations to the Lagoon City Sewage Treatment Plant.

The Township of Ramara has undertaken a septic system reinspection program which consists of detailed inspections of existing septic system located in close proximity to the Lake. The program is ongoing and has been successful in identifying deficient septic systems and enforcing reconstruction if required, that will have the effect of reducing nutrient loading on Lake Simcoe.

5.2.13 Previously Identified SWM Facility and System Retrofit Opportunities

During recent years the LSRCA has conducted research and investigation into the treatment level of existing SWM ponds and the retrofit opportunities for existing SWM ponds located throughout the Lake Simcoe watershed.

These studies were focused on larger urban areas and areas of significant growth such as Aurora, Barrie, Newmarket etc. There have been no analyses with regards to the existing SWM ponds or SWM retrofit opportunities in either settlement area. However as noted in Section 5.2.9, there is an existing dry SWM facility located at the Brechin Public School site and therefore a retrofit opportunity to provide water quality treatment exists at this location.

5.2.14 Potential Land Use Changes

The land designations provided in the Township Official Plan have been used to represent the future land use scenario, which show increases in development in comparison with the existing land use categories. The Official Plan will be updated in the future which may alter the land uses shown and the limits of the settlement boundary. It will be expected that all future development not currently addressed in this CSWM MP will follow Township guidelines, as well as any applicable recommendations made in this report.

Site Plan approval exists for a future Tim Horton's commercial building located on Highway 12 in Brechin (Catchment 118). The SWM plan for this infill type development consists of post to pre-development peak flow control via underground storage. A Stormceptor is proposed for water quality treatment. Final design of the Tim Horton's site was completed prior to the completion of this CSWM MP and is in general compliance with this study and the LSPP.

A Draft Plan exists for a future residential subdivision and commercial block located on a 32.2 ha parcel of land located east side of Highway 12, north and west of Simcoe County Road No. 47 and south of Concession Road No. 4. The proposal for the property provides for approximately 400-450 residential units, a 1.8 ha medium density block, 1.4 ha of park, 1.0 ha SWM block, 8.4 ha of roads and a 3.0 ha commercial block. The preliminary SWM plan for the development consists of a wet SWM pond to provide quantity and quality control for the proposed development. This development is herein referred to as the Veltri Development.

6 Management Units

The Study Areas, as previously outlined, will serve as individual units for modelling and discussion purposes. These will be discussed in detail in the sections to follow.

7 Cumulative Environmental Impact of Stormwater From Existing and Planned Development

An evaluation of the cumulative environmental impact of stormwater from existing and future development is required based on the anticipated changes in land use contained in the Township's Official Plan. The future development lands in Brechin include: Village Industrial, Village Residential, Village Commercial and Institutional. As indicated in Section 5.2.14, a Tim Horton's development and the Veltri Development are two developments expected to proceed in the near future.

The future development lands in Lagoon City are represented by Village Residential and Rural land uses. Portions of the future development lands are occupied by natural heritage and natural hazard lands (Figures 6 & 7 respectively) which are not identified on the Township Official Plan Land Use Schedules. The potential for development in these areas requires detailed site level analyses to fully understand the existing natural heritage and natural hazard features. The analyses included herein assumes the future developed condition according to the land uses identified by the Township Official Plan Land Use Schedule. This is conservative as it relates to SWM improvement alternatives.

The existing lands uses are illustrated on Figure 9. The expansion of the existing settlement areas to the limits identified in the Township Official Plan will result in the reduction of forest and cultivated lands in Brechin and Lagoon City.

An analysis of the impacts of stormwater in terms of peak flow, erosion, phosphorous and water budget will be assessed in the sections to follow.

7.1 Water Quantity

Surface drainage across the Study Area is generally towards the south and southwest. The existing condition surface drainage patterns are shown on Figure 2.

7.1.1 Existing Condition Hydrology

A hydrologic model of the Study Area was completed using the single event Visual Otthymo Hydrologic Model Version 2.2.4. Peak flow rates for the 2 -100-year storm events and Regional (Hurricane Hazel) were calculated. Rainfall data from the City of Orillia (Orillia Brain Gauge, AES States ID 6115820) 12-hour and 24-hour SCS Type II and Hurricane Hazel rainfall events were utilized as per LSRCA criteria.

The Study Area was divided up into individual catchment areas. The catchment delineations were completed using a combination of 2.0 m contours provided by the County of Simcoe and 5.0 m 1:10,000 OBM base mapping. Hydrologic reference points (HRPs) were created to evaluate existing and future condition hydrographs at specific locations throughout the Study Area. Catchment areas were cross-referenced with existing catchment delineation mapping prepared for the previously completed studies.

Land uses for the Study Area were established using a combination of digital existing land condition information provided by the LSRCA and current aerial photography. The land uses in combination with the area soil types, taken from the Ontario County Soils Survey, were used to establish the runoff CN numbers and catchment parameters used in the hydrologic model. The projected total impervious (TIMP) and directly connected impervious (XIMP) for existing developed areas and future expansion areas were based on the Township Official Plan land use plans and Appendix C of the LSRCA Technical Guidelines for Stormwater Management Submission (April, 2013) for appropriate TIMP and XIMP values. Time to peak values for the catchment areas were calculated using the Bransby Williams Formula and Airport Method for runoff coefficients greater than and less than 0.4 respectively.

The existing condition hydrologic model assumes no peak flow attenuation effects at the existing SWM facility at the Brechin Public School on the basis the SWM facility was designed to mitigate the impacts of the increased runoff for the school addition only and therefore the peak flow attenuation effects of this facility, considering the total contributing drainage area is only 0.9 hectares, is negligible.

A Regional Storm (Hurricane Hazel) analysis was completed in accordance with LSRCA SWM guidelines. This involved modelling the last 12-hours of the Hurricane Hazel storm, eliminating all existing and future SWM ponds from the model, and using AMC III conditions for all curve numbers to reflect saturated ground conditions.

The wet SWM facility located at the Ramara Industrial Park was designed and constructed in 2006 to provide water quality and quantity controls for runoff to current MOECC criteria. The facility is intended to service a drainage area of approximately 25.8 ha. The facility has been assumed to match the pre-existing condition peak flow rates from an identically sized drainage area under a full build out condition. This is an approximation of current pond conditions recognizing detailed field reconnaissance and site measurements were not completed as part of this study to confirm existing conditions. Approximately 50% of the total contributing drainage area is developed. On this basis, the SWM facility is expected to over control pre-existing condition peak flows until full-build out conditions exist.

The total rainfall depths used in the hydrologic model reflect the Orillia Brain Gauge utilizing rainfall data between 1965 and 2004 and are summarized in Table 1.

Table 1: Orillia Brain Gauge (AES Station ID 6115820) – Total Rainfall Depths

Event	Total Rainfall Depth (mm)		
	12-hr SCS Type II	24-hr SCS Type II	4-hr CHI
2-Year	41.4	46.7	33.7
5-Year	56.2	60.6	45.7
10-Year	66.0	69.8	53.7
25-Year	78.4	81.4	63.8
50-Year	87.5	90.1	71.2
100-Year	96.7	98.7	78.8
Regional (Hazel)	212		

The Study Area catchment areas and locations of the existing SWM ponds are illustrated on Figure 2. The existing condition hydrologic catchment parameters are summarized in Table 2.

Table 2: Existing Condition Hydrologic Catchment Parameters

Catchment ID	Subwatershed	Drainage Area (ha)	AMC II Curve Number / % Imperviousness	AMC III Curve Number	TP (hrs)
101	Unnamed Tributary to Lake Simcoe	84.4	52.3	71.6	1.72
102	Unnamed Tributary to Lake Simcoe	53.3	80.0	90.2	0.53
103	Murray Municipal Drain	296.2	71.2	85.0	2.53
104	Branch of Murray Municipal Drain	207.0	76.2	88.1	0.80
105	Prophet Drain	53.8	73.9	86.7	0.86

106	Donnelly Drain	263.2	79.6	90.0	1.24
107	Unnamed Tributary to Lake Simcoe	39.4	55.9	74.5	1.66
108	Prophet Drain	52.0	78.0	89.1	0.98
109	Unnamed Tributary to Lake Simcoe	35.0	74.1	86.8	0.77
110	Murray Municipal Drain	169.3	59.3	76.8	1.67
111	Unnamed Tributary to Lake Simcoe	12.4	58.9	76.7	1.07
112	Prophet Drain	108.3	71.9	85.5	0.96
113	Donnelly Drain	45.2	70.7	84.7	1.43
114	Lake Simcoe	211.6	39%	-	-
115	McNabb Municipal Drain	54.5	76.0	88.0	1.65
116*	McNabb Municipal Drain	25.8	80.0	90.2	0.66
117	Unnamed Tributary to Lake Simcoe	92.8	53.3	72.4	2.06
118	Prophet Drain	36.3	63%	-	-
119	Donnelly Drain	5.4	75%	-	-
120	Donnelly Drain	8.4	75%	-	-
121	Harrington Municipal Drain	12.2	67.4	82.6	0.85
122	Donnelly Drain	7.0	80	90.2	0.36

Note: Catchment 116 is approximately 50% developed in the existing condition and runoff is controlled by an existing SWM pond which was designed for full build-out (i.e. 100% developed) conditions. Both conditions are included in the hydrologic model however the pre-existing catchment parameters are shown in the above table.

The existing condition peak flows have been determined at the HRPs and summarized in Table 3. Detailed model results for the complete Study Area are included in Appendix C.

Table 3: Existing Condition Peak Flow Summary

Watercourse Name	Contributing Catchments	Model Node ID	HRP Number & Description	24-hr SCS Type II Peak Flow (m^3/s)						Hazel (m^3/s)
				2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
Prophet Drain	105, 112	2502	1 - CN Rail Tracks	1.44	2.49	3.28	4.35	5.20	6.09	16.97
Prophet Drain	105, 112,108, 118	17	2 - At Lagoon City	2.67	4.21	5.12	6.63	7.86	9.12	26.09
Donnelly Drain	113,119, 120, 122	2505	3 - CN Rail Tracks	1.23	1.76	2.14	2.63	3.07	3.62	5.93

Donnelly Drain	113, 119, 120,122, 106	319	4 - At Lake Simcoe	2.94	4.89	6.31	8.22	9.71	11.23	31.03
McNabb Drain	115, 116*	2504	5 - At Concession Road 3	0.66	1.09	1.42	1.85	2.19	2.54	7.24
Unnamed Tributary	107, 117	2503	6- At Lakeshore Drive	0.27	0.52	0.73	1.02	1.26	1.52	8.93

Note: Catchment 116 is approximately 50% developed in the existing condition and runoff is controlled by an existing SWM facility which was designed for full build-out (i.e. 100% developed) conditions. The pre-existing (i.e. 100% undeveloped) and existing conditions are included in the hydrologic model however the pre-existing condition has been reported in the above table.

7.1.2 Future Condition Hydrology

A future condition hydrologic model was prepared following the same procedures as the existing conditions analysis described in Section 7.1.1.

Runoff from catchment areas where future development is anticipated and which will not discharge directly to Lake Simcoe were attenuated in the modelled using a route reservoir command.

The future land use hydrologic model uses the same catchment delineation as for the existing model. The catchment parameters have been altered to reflect any proposed change in land use within the Study Area based on the land use categories specified in the Township Official Plan. All catchments located outside of either settlement boundary remain the same as in the existing model in order to achieve the best comparison between existing and future land uses.

Route Reservoir commands were used in the future conditions hydrologic model to simulated future development peak flows attenuated to pre development peak flow rates for the 2 to 100-year design storms. It should be noted the Route Reservoir commands used are not based on a physical pond design but are instead conceptual in origin to predict estimated pond size and flow restriction requirements for future development. Detailed sizing of these facilities should occur as part of the development application process for the lands in question. The remaining catchments which do not include any future development are modelled as per the existing condition.

The majority of catchments in the Study Area are located outside of the settlement areas and will remain unchanged (i.e. no major development is anticipated in these catchments) from existing to the future condition. The future condition peak flows in watercourses receiving future condition runoff have been determined at the HRPs and summarized in Table 4 Detailed model results for the complete Study Area are included in Appendix C.

Table 4: Future Condition Peak Flow Summary (Post to Pre Peak Flow Control)

Watercourse Name	Contributing Catchments	Model Node ID	HRP Number & Description	24-hr SCS Type II Existing Peak Flow (m^3/s) / Future Peak Flow (m3/s) / (% Increase/Decrease)						
				2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Hazel
Prophet Drain	205, 112	2502	1 - CN Rail Tracks	1.44 / 1.42 (-1.4%)	2.49 / 2.47 (-0.8%)	3.28 / 3.25 (-0.9%)	4.35 / 4.29 (-1.4%)	5.20 / 5.13 (-1.3%)	6.09 / 5.96 (-2.1%)	16.97 / 16.85 (-0.7%)
Prophet Drain	205, 112,108, 118	17	2 - At Lagoon City	2.67 / 2.55 (-4.5%)	4.21 / 4.22 (0.2%)	5.12 / 5.11 (-0.2%)	6.63 / 6.73 (1.5%)	7.86 / 7.91 (0.6%)	9.12 / 9.31 (2.1%)	26.09 / 26.00 (-0.3%)
Donnelly Drain	213, 222, 119, 120	2505	3 - CN Rail Tracks	1.23 / 1.16 (-5.7%)	1.76 / 1.74 (-1.1%)	2.14 / 2.19 (2.3%)	2.63 / 2.78 (5.7%)	3.07 / 3.38 (10.1%)	3.62 / 4.00 (10.5%)	5.93 / 9.23 (55.6%)
Donnelly Drain	213, 222, 119, 120, 106	319	4 - At Lake Simcoe	2.94 / 2.97 (1.0%)	4.89 / 4.99 (2.0%)	6.31 / 6.44 (2.1%)	8.22 / 8.37 (1.8%)	9.71 / 9.87 (1.6%)	11.23 / 11.40 (1.5%)	31.03 / 31.83 (2.6%)
McNabb Drain	115, 216	2504	5 - At Concession Road 3	0.66 / 0.69 (4.5%)	1.09 / 1.15 (5.5%)	1.42 / 1.46 (2.8%)	1.85 / 1.88 (1.6%)	2.19 / 2.20 (0.5%)	2.54 / 2.53 (-0.4%)	7.24 / 6.95 (-4.0%)
Unnamed Tributary	117, 207	2503	6 - At Lake Simcoe	0.27 / 0.27 (0.0%)	0.52 / 0.52 (0.0%)	0.73 / 0.72 (-1.4%)	1.02 / 1.00 (-2.0%)	1.26 / 1.24 (-1.6%)	1.52 / 1.49 (-2.0%)	8.93 / 8.91 (-0.2%)

The future condition catchment areas, HRPs, and locations of future SWM ponds are illustrated on Figure 3.

As shown in Table 4, changes in peak flows from existing to future conditions (with post to pre development SWM controls in-place) at each flow node are expected to range between -5.7% (i.e. decrease) and 10.5% for design storms ranging from the 2-100-year. At a number of HRPs, the future conditions peak flows with synthetic ponds have decreased/increased in comparison to existing. This can be explained because the simulated ponds are increasing the time to peak for a number of catchments, which is resulting in either coinciding or non-coinciding hydrograph peaks at the HRPs.

For this study, it was determined that at HRPs where the future condition peak flows are within +/-5.0% of existing, applying the typical post to pre development peak flow control approach during all design storm events, for all upstream development is appropriate. However a detailed SWM design is required as part of all future development and is to be prepared in accordance with the applicable Municipal, Provincial and LSRCA SWM guidelines including the LSPP. At a minimum all future development is required to control post development peak flows to pre development peak flows rates for all design storms ranging from the 2-100 year storms, regardless of any possible scenarios that support the use of no or partial water quantity controls based on peak flow reductions calculated in the model. It is recommended that the hydrologic model contained herein be updated by the Township as development proceeds to ensure future SWM controls that are designed at the site level also consider potential impacts downstream in the watershed with the goal of 0% increases in peak flows to the outlet.

There is a need for more specific peak flow control criteria via unit flow rates for future development areas draining to the Donnelly Drain, upstream of the CN Rail line (Catchments 213, including the Veltri Development and Catchment 222) where there are reported increases in peak flows of up to 10.5% compared to existing. Utilizing unit flow rates is keeping with Section 4.2.2 of the Township's Engineering Design Criteria document which requires consideration of potential adverse downstream effects due to uncoordinated timing of in the design of future SWM facilities. The unit flow rates for Catchment 213 and 222 were calculated based on the same level of overcontrol of the existing peak flows from the total future development area upstream, until the existing peak flow rates at HRP 3 were achieved. It was determined that overcontrol during the 10-year and 25-year storms is required whereas typical post to pre development peak flow control is sufficient for all other design storms. The unit flow rates for future development areas directed to the Donnelly Drain upstream of the CN Rail line are summarized in Table 5 and Table 6 and will slightly overcontrol the peak flows from the future contributing development areas in order to match the existing peak flow rates at HRP 3. The future condition after applying the overcontrol measures shown in Table 5 and Table 6 at Catchment 213 and 222 is shown in Table 7.

Table 5: Unit Flow Requirements for Catchments 213

Total Area (ha)	Unit Flow Rate ($m^3/s/ha$)					
	2-year	5-year	10-year	25-year	50-year	100-year
52.2	-	-	0.008 (approx. 45% overcontrol)	0.009 (approx. 50% overcontrol)	-	-

Notes: Typical post to pre development peak flow control is sufficient for storms up to and including the 5 year storm and the 50 and 100 year storms.

Table 6: Unit Flow Requirements for Catchments 222

Total Area (ha)	Unit Flow Rate ($m^3/s/ha$)					
	2-year	5-year	10-year	25-year	50-year	100-year
52.2	-	-	0.031 (approx. 45% overcontrol)	0.009 (approx. 50% overcontrol)	-	-

Notes: Typical post to pre development peak flow control is sufficient for storms up to and including the 5 year storm and the 50 and 100 year storms.

Table 7: Future Condition Peak Flow Summary (Where Unit Flow Rates Are Applied)

Watercourse Name	Contributing Catchments	Model Node ID	HRP Number & Description	24-hr SCS Type II Existing Peak Flow (m³/s) / Future Peak Flow (m3/s) / (% Increase/Decrease)						
				2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Hazel
Donnelly Drain	213, 222, 119, 120	2505	3 - CN Rail Tracks	1.23 / 1.16 (-5.7%)	1.76 / 1.74 (-1.1%)	2.14 / 2.13 (-0.5%)	2.63 / 2.60 (-1.1%)	3.07 / 3.01 (-2.0%)	3.62 / 3.52 (-2.2%)	5.93 / 9.23 (55.6%)
Donnelly Drain	213, 222, 119, 120, 106	319	4 - At Lake Simcoe	2.94 / 2.93 (-0.3%)	4.89 / 4.84 (-1.0%)	6.31 / 6.17 (-2.2%)	8.22 / 7.94 (-3.4%)	9.71 / 9.71 (0%)	11.23 / 11.29 (0.5%)	31.03 / 31.83 (2.6%)

Overall, existing and future Regional Storm peak flows shown in Table 4 are within +/- 5.0% with the exception of Donnelly Drain at the CN Rail line which reports an increase of 55.6% from existing. This is due to the conversion of the majority of lands upstream of the HRP from pervious to impervious and coincident peak flows of these areas with the already developed industrial areas in catchments 119 and 120. At the next HRP downstream (i.e. Lake Simcoe), the existing and future Regional Storm flows are within 2.6%. A detailed hydraulic analysis of the receiving watercourses was not undertaken as part of this study. However, based on the results of this analysis, a detailed floodplain analysis should be completed as part of all future development (including the Veltri Development) draining to the Donnelly Drain, upstream of the CN Rail line to confirm the potential flood impacts of the increased Regional Storm peak flows directed to areas downstream. This will ensure consideration is given for the need to attenuate Regional Storm peak flows at the site level, to mitigate the potential for flood impacts on the downstream lands. Section 4.2.6 of the Township's Engineering Design Criteria document states if an overland flow route travels across downstream property not municipally owned, the developer must obtain the necessary agreement(s) from downstream owner(s) accepting the increased quantity of runoff.

Future condition peak flows from Catchment 214 (Lagoon City) are assumed to discharge directed to Lake Simcoe and therefore do not require water quantity control. However, water quality control for this area is especially important due to the close proximity to Lake Simcoe and the limited opportunity for filtering of sediment and nutrients uptake. This will be discussed further in the sections to follow.

7.2 Water Budget

7.2.1 General

A water budget assessment has been completed for each settlement area in the Study Area. Existing and future land uses, in combination with soil types and land topography, were analysed to calculate evapotranspiration, infiltration and runoff produced from precipitation during existing and future conditions. The overall intent of the water budget assessments is identify the need to incorporate infiltration mechanisms into all future development with the goal of mitigating any changes in infiltration following development. In particular, infiltration measures are strongly encouraged in existing areas classified as SGRA's with consideration for areas with highly vulnerable aquifers. Extra precautions should be taken for infiltration in these areas.

7.2.2 Background

The development of land typically involves converting pervious surfaces such as pasture, open field, and wooded areas into impervious surfaces including roads, driveways, buildings etc. This results in changes to the existing hydrologic regime including increases in runoff volume and decreases in infiltration and evapotranspiration.

In accordance with Section 4.8-DP of the Lake Simcoe Protection Plan, all major development requires a water budget assessment including an evaluation of existing and future development conditions and any impacts to the existing hydrologic regime are to be minimized as much as possible.

7.2.3 Water Balance Assessment

In accordance with the Hydrogeological Assessment Submissions Guidelines, Conservation Authority Guidelines to Support Development Applications (June 2013), a water budget was developed for each settlement area. The Thornthwaite method was determined to be an appropriate method for calculating evapotranspiration based on average temperature and precipitation from the Orillia Brain climate normal data (1992-2006) from Environment Canada. A weighted runoff coefficient was developed for each settlement area using the individual runoff coefficients of each individual catchment. Average annual precipitation data from the Orillia Brain station was also used over the same period. The evapotranspiration, infiltration and runoff components were calculated for each settlement area. The water budget assessment calculations are attached in Appendix D and are summarized for each settlement area below.

Table 8: Brechin – Existing & Future Annual Water Budget Summary

		Existing	Future
Area (ha)		181.9	
Precipitation	mm	1055.7	
	m^3	1,920,295	
Evapotranspiration	mm	436.8	330.0
	m^3	794,601	600,322

Infiltration	mm	208.0	109.6
	m^3	378,313	199,285
Runoff	mm	410.9	616.1
	m^3	747,381	1,120,689

Table 9: Lagoon City – Existing & Future Annual Water Budget Summary

		Existing	Future
Area (ha)		263.2	
Precipitation	mm	1055.7	
	m^3	2,779,625	
Evapotranspiration	mm	410.2	365.6
	m^3	1,079,978	962,653
Infiltration	mm	183.4	142.3
	m^3	482,913	374,798
Runoff	mm	462.1	547.7
	m^3	1,216,734	1,442,174

Based on the results of the water budget indicated in Table 8 and, Table 9 development in Brechin and Lagoon City are shown to increase runoff volume while decreasing infiltration volume. SWM design measures are required to mitigate changes in infiltration for all new development. Target infiltration rates have been calculated based on the expansion areas of each settlement area. The following table illustrates the annual infiltration targets that are expected to mitigate changes in the existing water budget.

Table 10: Annual Infiltration Targets Summary

Settlement Area	Future Infiltration Deficit Compared to Existing		Annual Infiltration Target in Future Expansion Area
	(mm)	(m^3)	(m^3/ha)
Brechin Total Area = 181.9 ha Expansion Area = 97.8 ha	98.4	179,028	1,831
Lagoon City Total Area = 263.2 ha Expansion Area = 65.8 ha	41.1	108,115	1,643

Table 10 reports annual infiltration targets of 1,831 and 1,643 m^3/ha in expansion areas of Brechin and Lagoon City respectively. These values provide a reasonable estimate based on a broad level assessment and the information available at the time of this study.

The feasibility of infiltration practices is dependent on many factors including the infiltration capacity of the native soil, depth to bedrock, depth to the groundwater table etc. The settlement area of Brechin generally consists of shallow bedrock and high groundwater conditions. Lagoon City also has high groundwater conditions. These conditions can limit the effectiveness of infiltration practices. Maintaining a water balance via infiltration is an objective of the LSPP and opportunities should be investigated wherever soil, bedrock, and groundwater conditions permit to maximize infiltration as part of all future development. Proposed infiltration measures must also recognize the constraints specific to water quality and well head protection areas.

Individual water budget assessments completed at a suitable level of detail are required as part of all future individual development applications.

A Tier 2 water budget is being completed by the LSRCA for the Ramara Creeks, Talbot River and Black Creek. The information included in this report should be read in conjunction with the information contained in the LSRCA report when ready, related to all future development.

7.2.4 Water Balance and Climate Change

In order to assess how a changing climate will affect water balance and infiltration rates, a number of scenarios have been modelled. The future water balance scenario has been used as a baseline infiltration value, and has been compared to 11 other scenarios. The scenarios account for a +/- 10 monthly precipitation variation, coupled with an average monthly temperature increase of up to 4°C.

The sources for the climate change values used are projections for the Province of Ontario referenced from the following sources:

- *Climate Change – Climate Science – Trends and Forecasts,* Toronto and Region Conservation Authority (TRCA)
- *Climate Change Projections for Ontario: Practical Information for Policymakers and Planners*, Ontario Ministry of Natural Resources (2007)

Since the precipitation and temperature values apply to each settlement area, the percent increase/decrease in infiltration compared to the baseline value is the same for each. On this basis, only the Brechin settlement area has been analyzed for this climate change scenario and is included in Appendix D of this report. Table 11 summarizes the assumptions made in each scenario, as well as the increase/decrease in infiltration.

Table 11: Water Balance Climate Change Summary

Scenario #	Precipitation Change (%)	Temperature Change (°C)	Annual Infiltration Change (%)
1 (Baseline)	0	0	0
2	0	1	-2
3	0	2	-4
4	0	4	-7
5	-10	0	-12
6	-10	1	-14
7	-10	2	-15
8	-10	4	-18
9	10	0	15
10	10	1	12
11	10	2	9
12	10	4	4

The worst case scenario is represented by a 10% decrease in monthly precipitation in combination with a significant average monthly temperature increase of 4 °C. This scenario resulted in an 18% reduction in annual infiltration. It is considered the proposed infiltration targets specified above will offset the potential differences in water balance that could occur under different climate change scenarios.

The possibility of decreased infiltration rates further stresses the importance of implementing the use of LID infiltration methods.

7.3 Water Quality

7.3.1 Phosphorus Loading

Excessive phosphorus has been the most significant cause for the water quality impairment in Lake Simcoe and its tributaries. It leads to the excessive growth of plants and algae in the lake which contributes to the depletion of dissolved oxygen in the deep waters of the lake and degradation of the critical habitat of coldwater species.

In June 2010, the MOECC released the *Lake Simcoe Phosphorus Reduction Strategy*. The strategy sets an aggressive phosphorus reduction target in order to improve water quality. The goal is to reduce overall annual loading to the Lake to 44 tonnes or approximately 38.9% (ultimate target) reduction over existing annual loading levels (72 tonnes per year). However, the strategy also recognizes opportunities and technology presently exists to reduce loading to 58 tonnes annually or approximately 19.4% (feasible target reduction).

The Study Area is approximately 1,900 hectares in size. The combined settlement areas of Brechin and Lagoon City including the expansion areas identified in the Official Plan is 445 hectares.

Since the combined area of Brechin and Lagoon City, where the majority of efforts to reduce phosphorus loadings from stormwater runoff to Lake Simcoe are focussed, is less than 750 ha, a desktop based unit area load approach (i.e. spreadsheet) was deemed appropriate and used for estimating the existing and future condition phosphorus loading on Lake Simcoe. This was determined in consultation with LSRCA staff.

Unit area loading rates were used from the MOECC's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012), prepared by Hutchinson Environmental Sciences Ltd. as these were determined to be the most appropriate rates to be applied to the Study Area. These loading rates were developed using the Estimation of Phosphorus Loading to Lake Simcoe (2010), prepared by the Louis Berger Group Inc. as a base but were modified to address unexplained variance in loading rates between land uses and subwatersheds in the Lake Simcoe watershed. The phosphorus loading coefficients are summarized in Table 12.

Table 12: Phosphorus Loading Coefficients

MOECC Phosphorus Tool Land Use	Existing / Future Condition Land Use	Existing P Loading Coefficient (kg/ha/yr)	Future P Loading Coefficient (kg/ha/yr)
Hay - Pasture	Pasture	0.07	0.07
Cropland	Cultivated	0.19	0.19
High Intensity Development - R	Single family residential	1.32	1.32
High Intensity Development – C/I	Commercial, Institutional, Industrial	1.82	1.82
Forest	Forest	0.05	0.05
Wetland	Wetland	0.05	0.05

The Hutchinson report has also provided phosphorus reduction rates for a number of different kinds of SWM Best Management Practices (BMPs). Specific phosphorus reduction rates which are to be applied to existing and future SWM facilities on a site by site basis are summarized in Table 13. For the purposes of comparison in this Master Plan, the rates applicable to Wet Ponds and LID Controls have been applied to existing controlled areas, and have also been used to model the retrofit scenario. They have also been applied to future developed areas to help assess the potential phosphorus reduction for each option.

Table 13: Phosphorus Removal Rates

SWM Control	Removal Efficiency (%)
Constructed Wetlands	77
Dry Detention Ponds	10
Perforated Pipe Infiltration/Exfiltration Systems	87
Sand or Media Filters	45
Soakaways – Infiltration Trenches	60
Sorbtive Media Interceptors	79
Underground Storage	25
Vegetated Filter Strips/Stream Buffers	65
Wet Detention Ponds	63
LID Controls	85

The LID Controls removal rate is based on a removal rate of 87% for a perforated pipe infiltration system and assumes new developments will be provided with a ‘treatment train’ approach incorporating multiple LID controls, most likely including a perforated pipe/infiltration system. Therefore, the value of 85% was chosen to be representative for LID SWM solutions.

The combined Brechin and Lagoon City settlement expansion areas total approximately 183 ha of existing undeveloped land. Future development of these areas results in the reduction of forest and cultivated areas replaced with high and low intensity development. The phosphorus loading coefficients were applied to each catchment in each of the settlement areas for comparing phosphorus loadings from existing to future conditions. The estimated existing phosphorus load to Lake Simcoe based on existing land uses in the Study Area is summarized in Table 14.

Water quality control, as part of this CSWM MP requires water quality treatment to MOECC enhanced level as part of all new development. Note, the design of all major development located in the Lake Simcoe watershed must also consider phosphorus loading with the goal of no net increase phosphorus loading to Lake Simcoe following development. In order to assess the benefit of controlling future developments with standard end-of-pipe controls (wet ponds) in comparison to LID controls, these two scenarios have been modeled. The scenarios assume all increases in land use in the Future scenarios will be provided with either LID or Wet Pond controls. The two scenarios have also included the removal efficiency rates of any proposed SWM facility retrofits (if applicable). The estimated future condition phosphorus loads to Lake Simcoe based on future conditions with SWM facilities in-place (wet ponds or LIDs) according to the removal efficiencies included in Table 13 is summarized in Table 14. The complete phosphorus loading calculations are attached in Appendix E.

Table 14: Existing and Future Condition Phosphorus Loading to Lake Simcoe

Settlement Area	MOECC Phosphorus Tool Land Use	Existing Conditions with Existing SWM Controls		Future Conditions with Future SWM Controls		
		Area (ha)	Phosphorus Loading (kg/year)	Area (ha)	Phosphorus Loading with 63% Removal Applied to Future SWM controls (kg/year)	Phosphorus Loading with 85% Removal Applied to Future SWM controls (kg/year)
Brechin	Hay - Pasture	-	-	-	-	-
	Cropland	92.7	17.6	8.2	1.6	1.6
	Low Intensity Development	23.3	30.8	99.2	67.8	45.8
	High Intensity Development – C/I	39.7	57.4	74.5	80.8	71.2
	Forest	13.4	0.7	-	-	-
	Wetland	12.8	0.6	-	-	-
	TOTAL	181.9	107.0	181.9	150.2 (40.4%)	118.5 (10.7%)
Lagoon City	Hay - Pasture	1.3	0.1	-	-	-
	Cropland	5.65	1.1	12.6	2.4	2.4
	Low Intensity Development	167.0	220.4	250.6	261.2	236.9
	High Intensity Development – C/I	5.0	9.2	-	-	-
	Forest	12.6	0.6	-	-	-
	Wetland	71.7	3.6	-	-	-
	TOTAL	263.2	234.9	263.2	263.6 (12.2%)	239.3 (1.9%)
	STUDY AREA TOTAL	445.1	114.8	445.1	118.6 (3.3%)	104.9 (-8.6%)

Table 14 confirms phosphorus removal from typical wet SWM pond type facilities (i.e. 63% phosphorus removal) in Brechin is expected to result in an annual increase in phosphorus loading of approximately 43.2 kg or 40.4 % following future build-out conditions. Utilizing LID measures having a phosphorous removal efficiency of 85%, will result in an annual increase in phosphorus loading of approximately 11.5 kg or 10.7 % compared to existing which reinforces the need for a treatment train approach to

SWM consisting of LID measures for all new development with the goal of no net increase in annual phosphorus loadings to Lake Simcoe.

Phosphorus loading from Lagoon City utilizing typical wet SWM pond type facilities or LIDs results in increases in phosphorus loading of 28.7 kg (12.2%) and 4.4 kg (1.9%) respectively. These results indicate the need for a treatment train approach to SWM consisting of LID measures for all new development with the goal of no net increase in annual phosphorus loadings to Lake Simcoe.

Based on these results, LID measures are highly recommended in future development areas in Brechin and Lagoon City wherever they are feasible.

A detailed phosphorus budget is required as part of each development application and must conform to the LSPP (4-8-DP) with the goal of no net increase in phosphorus from existing conditions.

7.4 Stream Channel Characteristics & Erosion Threshold Analysis

An erosion threshold analysis has been undertaken for four watercourses that will receive stormwater discharge from future development areas in Brechin and Lagoon City. The 12.2 ha portion of Lagoon City zoned residential and draining to the Harrington Municipal Drain located to the north has been excluded from the erosion threshold analysis since this area is the site of the existing municipal wastewater treatment plan and is not anticipated for development well into the future. On this basis, there are no anticipated changes in runoff in this area and therefore an erosion threshold analysis was not deemed necessary for this area.

Analysis on the remaining four watercourses has been completed based on field review of channel sensitivity below future SWM pond outlets and detailed cross-section surveys of the downstream locations that will receive combined flows from the development blocks. Erosion threshold modelling results were then used in vegetation-hydroperiod analysis for all reaches under study.

Allowable flow durations within the depth range of channel capacity were checked and determined to meet allowable criteria for extended level of saturation and to not be detrimental to vegetative integrity from a vegetation-hydroperiod basis.

Based on the above, the modelling confirmed runoff produced across the future development lands from the greater of $40m^3$/ha of contributing area or the runoff volume produced from a 25 mm design storm released over a minimum period of 24 hours is sufficient erosion control in each of the receiving watercourses.

A detailed account of the erosion threshold analysis is included in Appendix F.

8 Determine the Effectiveness of Existing SWM Systems

The Study Area consists of four SWM facilities including the Brechin Public School dry SWM pond, the Ramara Industrial Park wet SWM pond, and the oil grit separator (STC 1000) and two surface bioswales located at the Township administration office. The majority of runoff from the Study Area discharges uncontrolled to the existing drainage routes outletting to Lake Simcoe. The following section describes the overall effectiveness of the existing SWM systems including the potential long and short-term impacts of climate change that could affect the function of the existing SWM systems over time.

8.1 Brechin

Highway 12 bisects Brechin east and west and is a fully urbanized road section from one end of the village to the other. A rural road section extends beyond the urban section in either direction. Ramara Road 47 is also fully urbanized from the Highway 12 / Ramara Road 47 intersection to the west. Residential roads in Brechin have a rural section with shallow ditches and individual driveway culverts.

Runoff from a large portion of the urban areas of Brechin is piped via storm sewer to an outfall located on the south side of Ramara Road 47 immediately west of the CN rail tracks where it is conveyed westerly in the south roadside ditch before crossing Ramara Road 47 to the north. The open channel ditch sections from the west end of the settlement area provide opportunities for groundwater recharge and filtering of runoff prior to discharging into Lake Simcoe at the north limit of Lagoon City. During field reconnaissance, there was no evidence of channel erosion observed and therefore the existing conveyance system appears to be operating under normal conditions. The open channel sections provide water quality treatment, for runoff from an urban area with no SWM controls in place. A storm sewer also exists at Highway 12 draining to the north and discharging into Prophet Drain at the north limit of the settlement area.

8.1.1 Township of Ramara Administration Building Site SWM System

The Township of Ramara Administration building and associated parking areas were constructed in 2010. The SWM design for the site included a treatment train approach including a Stormceptor STC 1000 and surface bio swales for water quality control and two (2) orifice plates, oversized storm sewer and parking lot storage for water quantity control. The treatment train approach to SWM eliminates the reliance on any single system to provide the overall SWM for the site. Specifically, the bio swales provide pre-treatment and an opportunity for infiltration thereby reducing post development runoff volume at the source, and upstream of the Stormceptor. The Stormceptor provides enhanced level water quality treatment for storms up to and including the quality storm event (25 mm storm event). It is equipped with a bypass that allows less frequent storms to bypass the unit.

8.1.2 Brechin Public School Dry SWM Pond

The Brechin Public School dry SWM pond provides stormwater quantity control for runoff generated on the school site. The pond was designed and constructed in 2002 to mitigate potential flood impacts from the school addition and parking lot expansion (also constructed in 2002) and is also expected to provide a small level of quality treatment via filtering of runoff. The pond consists of an overland flow inlet from the adjacent parking lot and a piped outlet which directs runoff to the northwest where it discharges beneath the CN rail tracks via a 750 mm diameter CSP culvert. The SWM pond was observed as having excessive vegetation and therefore it is recommended it be regularly maintained to reduce the potential for a blockage at the outlet. The pond was designed to mitigate the increase in runoff from the site following the building expansion. It does not provide quality control and therefore opportunities to enhance the treatment capacity of the pond exist including considerations for the effects of climate change.

8.1.3 Ramara Industrial Park Wet SWM Pond

The Ramara Industrial Park, located east of highway 12 and south of Ramara Road 47, includes a wet SWM pond providing stormwater quantity and quality control for the existing and future industrial park area. The wetland was constructed in 2006 and services an area of approximately 25.8 hectares. Approximately 50% of the future industrial park lands is developed in the existing condition. It currently provides an Enhanced Level of water quality treatment through the permanent pool and extended detention it provides. The facility outlets to the Concession Road 3 north ditch via a concrete weir structure and runoff is conveyed to the south to the McNabb Municipal Drain.

8.2 Lagoon City

Lagoon City consists primarily of residential areas connected by roads having a rural road cross section including shallow ditches and individual driveway culverts. As discussed above, there are no SWM facilities located in Lagoon City. During field reconnaissance, there was no evidence of significant erosion observed in the ditches which suggests the flows generated during frequent storm events (i.e. up to the 2 year storm), do not cause erosion to the conveyance routes.

The extensive network of canals (lagoons) throughout Lagoon City provides multiple outlets for stormwater runoff thereby eliminating the need for stormwater quantity controls. The open vegetated ditches provide opportunities for filtering of runoff and infiltration. However due to the short drainage paths the potential for sediment and nutrient loading on Lake Simcoe exists. Residential lawn fertilizers, car wash detergents, and other outdoor residential activities involving the use of chemicals in close proximity to Lake Simcoe increase the potential for sediment and nutrient loading. Opportunities to treat stormwater runoff upstream of the discharge point or at the source will be discussed in detail in the sections to follow.

The Murray Municipal Drain drains an area of approximately 6.7 km^2 of primarily active agricultural land and discharges into the Lagoon City canals. Runoff from this area is known to contain high levels of nutrients (including phosphorus and nitrogen) which are believed to be contributing factors to the blue-green algae observed throughout Lagoon City. The Township is continuing to investigate BMPs to reduce the nutrient concentration in runoff in order to prevent the excessive growth of algae.

Brechin and the majority of Lagoon City are serviced with sanitary sewers which eliminates the potential for point source loadings from individual private sewage systems. A small portion of Lagoon City including Ridge Avenue, Lone Birch Trail, Maple Trail and Lakeshore Drive from Simcoe Road to Concession 3 are serviced by private well and septic systems. A conceptual design to provide municipal services for these areas is pending future funding opportunities.

8.3 Effectiveness of Existing SWM Systems in a Changing Climate

Only a small portion of the lands located in the Brechin settlement area are controlled by an existing SWM facility. There are no existing SWM facilities in Lagoon City. On this basis, the majority of the Study Area does not rely on upstream SWM systems for either water quality or quantity controls and thus the receiving watercourses or water bodies are especially vulnerable to the effects of stormwater caused by climate chance. The following is a list of effects of climate change having the potential to affect the existing and future SWM systems and are to be considered for retrofit opportunities and for the design of all future SWM systems:

- More frequent and intense storm events;
- More frequent and extended droughts;
- More frequent winter thaws;
- Earlier spring thaws and associated freshets; and
- Plant community die-offs due to the above environmental conditions.

8.3.1 Township of Ramara Administration Building Site SWM System

Increased intensity, duration, and frequency of runoff caused by climate change has the potential to cause the Stormceptor to bypass more frequently, however the majority of storms will remain less than the quality storm event. On this basis, the Stormceptor unit is expected to maintain its intended water quality function. The bio swales located upstream further contribute to water quality enhancement of runoff as these features were originally designed as supplementary to the water quality requirements on the site.

Regarding quantity control, the site was designed to store the 5-year storm underground with shallow ponding areas in the parking lot providing additional storage for storms up to and including the 100-year storm. The potential increase in rainfall intensity and depth caused by climate change has the potential to cause temporary surface ponding on a slightly more frequent basis however this is not expected to impact the regular use of the parking area. Any increases in outflow from the site during frequent storms would be immeasurable and therefore the existing quantity control provided at the Township Administration Office site is expected to function as intended even under a variety of climate change scenarios.

The existing SWM system at the Township Administration Office is therefore expected to maintain its effectiveness even while considering the potential effects of climate change.

8.3.2 Brechin Public School SWM System

The Brechin Public School dry SWM pond was designed to mitigate the potential increase in peak flows for the school expansion area only. The pond was not designed to function with enhanced water quality control function although it provides some filtering of sediment and nutrient uptake by vegetation as a result of the retention of runoff. A retrofit opportunity for this SWM facility should be evaluated in detail including the potential to provide water quality and quantity control for the site and external areas. Any retrofit opportunity is to consider the potential effects of climate change described above.

8.3.3 Ramara Industrial Park SWM System

The Ramara Industrial Park SWM facility was constructed in 2006 and consists of a u-shaped wet SWM facility, complete with a permanent pool, extended detention storage (for the 25 mm storm event), and additional active storage volume to control runoff up to the 100-year storm. The facility is equipped with a concrete rectangular outlet weir structure having three notches with a weir length of 0.5 m set at the permanent pool level and 3.0 m at the high water level. Since the contributing area is only partially developed and the SWM facility constructed for the full build-out conditions, it is expected it will overcontrol outflows compared to existing until the upstream lands are fully developed. Until then, additional storage is available and is expected to reduce the potential effects of increased intensity, duration and frequency of rainfall caused by climate change. Once the contributing area is fully developed, it is recommended the function of the facility be reviewed in detail considering the effects of climate change.

The above analyses focus on wet weather conditions resulting in increased runoff caused by increased rainfall intensity and depth. Similar effects can occur during more frequent winter thaws, and earlier spring freshet which are also attributed to climate change. However, climate change can also cause extended droughts and plant community die-offs which have the potential to increase soil erodibility and surface runoff due to the change in surface cover. Without an intensive vegetation assessment survey it is difficult to determine how resistant the existing SWM systems are to drought conditions. However, in case of a large planting die-off, a timely replanting strategy utilizing using native, drought tolerant plant species is recommended.

Managing for climate change is an ongoing process and not a one-time task. Consideration of the above factors will assist in managing the effects of climate change in the Study Area into the future. These considerations will be discussed further in Section 9.

9 Identify and Evaluate Stormwater Improvement and Retrofit Opportunities

Integral to the planning process is the consideration of improvement and retrofit opportunities/alternatives to address the problem statement and where possible, correct the noted deficiencies.

Since there are a limited number of existing SWM systems in place, the Township is well positioned to implement measures and guidelines targeting future development that consider the effects of climate change and will result in more flexible and robust SWM systems for a wide range of environmental conditions and storm events. On this basis the majority of the SWM improvement alternatives are focussed on SWM policy and guidelines for all future development as opposed to physical retrofits to existing systems. The alternatives were developed recognizing a number of alternatives would be selected and that selection of one does not preclude the selection of another.

The SWM improvement alternatives are intended to meet the objectives of the LSPP including consideration for climate change thereby improving the overall health of the Lake Simcoe watershed. The alternatives have been organized into a number of categories including: Do Nothing, Existing Developments, Future Developments (Quantity Controls), Future Developments (Quality Controls), and General SWM Improvement Alternatives.

9.1 "Do Nothing"

The "Do Nothing" alternative represents a scenario where no SWM controls are provided for any future developments, and no retrofits or maintenance are provided for any of the existing SWM Facilities and development areas. This scenario results in increased peak flows, increased flooding and increased erosion. Water quality is not addressed in this alternative. As such the phosphorus loadings to Lake Simcoe will increase. Infiltration rates in developed areas are also expected to decrease without efforts to maintain existing infiltration rates through a water budget exercise. This alternative is does nothing to improve stormwater management in the Township, and is therefore not a viable option.

Alternative 1 is not compliant with the Lake Simcoe Protection Act.

9.2 SWM Alternatives With Focus on Existing Developments

9.2.1 Alternative 1 – Existing SWM Facility Retrofit Opportunities

Based on the existing SWM facility analyses provided in Section 8, a number of retrofit opportunities have been identified to increase the performance of existing SWM facilities. These opportunities include partial re-design and modifications to a facility and improvements to inlet/outlet structures. Implementing these changes provides various improvements to the existing stormwater runoff by improving water quantity and quality control and reducing erosion. Each existing SWM facility presents different opportunities for retrofits which result in different impacts. In Brechin, the proposed SWM facility retrofits are expected to reduce annual phosphorous loadings to Lake Simcoe by approximately 1 kg.

9.2.2 Alternative 2 – Improve Existing Conditions Stormwater Runoff Using LIDs

LID measures can be implemented in areas where runoff is controlled or uncontrolled to provide additional stormwater runoff quality and quantity controls. There are many existing developed areas in the Study Area which release stormwater completely uncontrolled into neighbouring watercourses or directly into Lake Simcoe. These uncontrolled areas present opportunities for SWM BMPs to be implemented to increase quality and quantity control, as well as promote infiltration.

For existing developments which are controlled by a traditional end-of-pipe SWM facilities, it is also possible to incorporate LID measures to increase runoff quality (depending on available space and development type). A detailed description of the various LID controls is provided in Sections 9.4.2 and 9.4.3.

9.2.3 Alternative 3 – Improve Existing Condition Uncontrolled Stormwater Using End-of-Pipe Controls

It may be possible to construct new end-of-pipe SWM facilities (dry pond, wet pond, constructed wetland) downstream of existing developed areas to provide water quality and/or quantity control of stormwater runoff This option is dependent on the availability of land downstream of existing development. The traditional end-of-pipe facilities are described below.

Wet SWM Pond

Wet ponds are the most common end-of-pipe SWM facility employed in Ontario. They are less land-intensive than wetland systems and are normally reliable in operation, especially during adverse conditions (winter/spring). A few benefits of wet SWM ponds are:

- Performance does not depend on soil characteristics;
- The permanent pool minimizes re-suspension;

- The permanent pool minimizes blockage of the outlet;
- The permanent pool provides for extended settling;
- MOECC Enhanced Stormwater Quality control can be achieved with proper design; and
- Can attenuate stormwater runoff with proper orifice/outlet design.

Dry SWM Pond

Dry SWM ponds have no permanent pool of water. While they can be effectively used for erosion and flood (quantity) control, the removal of sediments is a function of the detention time in the pond. For a 24 hour retention period, this normally means a lower contaminant removal, as inter event settling time does not exist. Dry SWM ponds cannot achieve MOECC Enhanced stormwater quality control; they are only capable of providing Basic Level control. They should be used where other SWM options are not feasible, or as part of a treatment train approach.

Constructed Wetlands

The constructed wetland is one of the preferred end-of-pipe SWM facilities for water quality enhancement. Wetlands are normally more land-intensive than wet ponds because of their shallower depth (both in permanent pool and active storage). They are suitable for providing the storage needed for erosion control purposes, but will generally be limited in their quantity control capabilities due to restricted active storage depth.

The benefits of constructed wetlands are similar to wet ponds and include:

- Performance does not depend on soil characteristics;
- The permanent pool minimizes re-suspension;
- The permanent pool minimizes blockage of the outlet;
- The biological removal of pollutants (enhanced nutrient removal) occurs; and

The permanent pool provides extended settling.

9.3 SWM Alternatives With Focus on Future Developments (Quantity Control)

The following options have been assessed in regards to providing stormwater quantity controls for future development.

9.3.1 Alternative 4 - Standard Post to Pre Development Peak Flow Control

This option would require all future developments to control the post development runoff to the pre development peak flow rate using a standard end-of-pipe SWM facility (wet/dry pond or wetland) for each proposed new development. This option will reduce the peak flow rates for the 2-100 year storm events, however the Regional Storm event will not be controlled. This option has been modeled in the Future Conditions Hydrologic Model. This option does not address existing flooding problems or erosion control. This option may also lead to increased peak flow in some watercourses due to coincident peak flows from multiple pond outlets.

9.3.2 Alternative 5 - Peak Design Flow Targets

As an alternative to the standard post-to pre development peak flow control, post development peak flow control criteria for new development can also be determined by establishing peak design flow targets (m^3/s/ha) for each design storm on a larger scaled drainage area basis. This is done by calculating the total existing condition design peak flow rates (i.e. 2-year to 100-year) to a given HRP and dividing the peak flows for each design storm by the total area upstream. All future development in the larger scaled upstream drainage area will design future condition peak flow controls according to the peak design flows targets established for each design storm. The benefit of peak design flow targets is that the potential for coincident peak flows has been considered in the overall peak design flow targets and therefore will not exceed the pre development peak flow rate for the overall area.

9.3.3 Alternative 6 - Centralized New SWM Pond Locations

Centralized SWM facilities intended to provide quantity controls for multiple upstream properties are an effective and efficient means of providing SWM. These facilities are typically located at the downstream limit of a settlement area immediately upstream of a receiving watercourse. Specifically centralized SWM facilities have the following overall benefits:

- Reduced potential for coincident peak flows from multiple upstream SWM facilities;
- Less overall total land required compared to the combined land required for individual SWM ponds; and
- Reduced long-term operation and maintenance required by the Township.

9.3.4 Alternative 7 - Extended Detention Over-control

This option involves increasing the extended detention draw-down time beyond 24 – 48 hours. This will provide increased time for particle settling, reducing the total sediment transported to the receiving watercourse. However, by increasing the extended detention draw-down time a greater potential exists for insufficient extended detention storage volume during a consecutive storm when a SWM facility has not fully drawn down.

9.3.5 Alternative 8 - Water Balance and Infiltration Measures (LID Measures)

This option involves implementing LID measures to increase infiltration rates for new developments. In this option, new developments are required to match pre development infiltration rates. Recommended approaches are listed below:

- In areas where soil/groundwater conditions permit, at-source infiltration measures such as soakaway pits or equivalent measures installed at the lot level are recommended. In these areas, roof leaders and other impervious surfaces are to be directed towards pervious surfaces including lawns, side and rear yard swales, boulevards, parks and other open space areas throughout the development to promote infiltration;

- Road infiltration trenches should be installed where soil/groundwater conditions permit;

- End-of-pipe infiltration and exfiltration systems should be installed where soil and groundwater conditions permit.

9.3.6 Alternative 9 - Over-Control Infiltration Rates

This option requires the post development infiltration rates for future developments be increased beyond the pre development infiltration rate. This increase in infiltration at a site level is intended to help offset the existing development which did not consider any infiltration measures. This increase in infiltration rate may also help to offset the potential decrease in infiltration due to climate change.

9.4 SWM Alternatives With Focus on Future Development (Quality Controls)

9.4.1 Alternative 10 - MOECC Enhanced Level Water Quality Control

This option involves all future development providing MOECC Enhanced Level stormwater quality control by whatever means necessary including: wet pond, wetland, OGS, LID or a combination thereof.

9.4.2 Alternative 11 - LID At-Source Controls

The following sections describe various LID at-source control measures which are recommended for consideration in the Study Area. These alternatives involve measures located at the source where runoff is generated. At-Source controls will improve stormwater runoff quality by promoting filtration and infiltration, as well as reducing stormwater runoff volumes and peak flows generated from impervious surfaces which for the most part originate in developed areas. At-Source controls can be used in a variety of different land uses including residential, industrial and commercial. At-Source controls can be retrofitted in existing developments, and should be implemented in all new proposed developments.

Roof Downspout Disconnection

Downspout disconnection involves directing flow from roof downspouts to a pervious area that drains away from a building. This prevents stormwater from directly entering the storm sewer system or flowing across a directly connected impervious surface, such as a driveway, and into a storm sewer. Downspout disconnection recommends a minimum flow path length of 5 m across a pervious area.

When the infiltration rate of the soil in the pervious area is less than 15 mm/hr (i.e. hydraulic conductivity of less than $1x10^{-6}$ cm/s), the area should be tilled to a depth of 300 mm and amended with compost to achieve an organic content in the range of 8 to 15% by weight or 30 to 40% by volume.

Bioretention

As a stormwater filter and infiltration practice, bioretention temporarily stores, treats and infiltrates stormwater runoff. Depending on the native soil infiltration rate, the system may be designed without an underdrain for full infiltration, with an underdrain for partial infiltration, or with an impermeable liner and underdrain for filtration only, which can also be referred to as a biofilter. The primary component of a bioretention practice is the filter bed with a mixture of sand, fines and organic material. Other important elements of bioretention include a mulch ground cover and plants adapted to the conditions of the stormwater practice. Pre-treatment, such as a settling forebay, vegetated filter strip, or stone diaphragm, often precedes the bioretention to remove particles that would otherwise clog the filter bed. Bioretention is designed to capture small storm events or the water quality storage requirements. An overflow bypass is necessary to pass large storm events.

Bioretention can be adapted to fit into many different development contexts and provides a convenient area for snow storage and treatment. In a low density development, it might have a soft edge and gentle slopes, while a high density application might have a hard edge with vertical slopes.

Green Roofs (Roof Gardens)

Green roofs consist of a thin layer of vegetation and growing medium installed on top of a conventional flat or sloped roof. Green roofs are publicized for their benefits to cities, as they improve energy efficiency, reduce urban heat island effects, and create green space for passive recreation or aesthetic enjoyment. With regards to water resources, they are attractive for their water quality, water balance, and peak flow control benefits. From a hydrologic perspective, the green roof acts like a lawn or meadow by storing rainwater in the growing medium and ponding areas. Excess rainfall enters underdrains and overflow is conveyed in the building drainage system. After the storm, a large portion of the stored water is evapotranspirated by the plants, evaporates or slowly drains away.

Soakaway Pits, Infiltration Trenches and Chambers

On sites suitable for underground stormwater infiltration practices, there are a variety of facility design options to consider, such as soakaway pits, infiltration trenches and infiltration chambers. Soakaway pits are rectangular or circular excavations lined with geotextile fabric and filled with clean granular stone or other void forming material, which receives runoff from a perforated pipe inlet and allows it to infiltrate into the native soil. They typically service individual lots and receive only roof and walkway runoff, but can also be designed to receive flows from other sources. Soakaway pits can also be referred to as infiltration galleries or dry wells.

Infiltration trenches are rectangular trenches lined with geotextile fabric and filled with clean granular stone or other void forming material. Like soakaway pits, they typically service an individual lot and receive only roof and walkway runoff. This design variation is well suited to sites where available space for infiltration is limited to narrow strips of land between buildings or properties, or along road right of ways. They can also be referred to as infiltration galleries or linear soakaways.

Infiltration chambers are another design variation of soakaway pits. They include a range of proprietary manufactured modular structures installed underground, typically under parking or landscaped areas that create large void spaces for temporary storage of stormwater runoff and allow it to infiltrate into the underlying native soil. Structures typically have open bottoms, perforated side walls, and optional underlying granular stone reservoirs. They can be installed individually or in series in trench or bed configurations. They can infiltrate roof, walkway, parking lot and road runoff with adequate pre-treatment. Due to the large volume of underground void space they create in comparison to a soakaway of the same dimensions, and the modular nature of their design, they are well suited to sites where available space for other types of LID practices are limited, or where it is desirable for the facility to have little or no surface footprint (high density developments).

Permeable Pavement

Permeable pavements, an alternative to traditional impervious pavement, allow stormwater to drain through them into a stone reservoir where it is infiltrated into the underlying native soil or temporarily detained. They can be used for low traffic roads, parking lots, driveways, pedestrian plazas and walkways. Permeable pavement is ideal for sites with limited space for other surface stormwater BMPs. Depending on the native soils and physical constraints, the system may be designed with no underdrain for full infiltration, with an underdrain for partial infiltration, or with an impermeable liner and underdrain to provide filtration only. Permeable paving allows for filtration, storage, or infiltration of runoff, and can reduce or eliminate surface stormwater flows compared to traditional impervious paving surfaces.

Rainwater Harvesting

Rainwater harvesting is the process of intercepting, conveying and storing rainfall for future use. Harvesting rainwater for domestic uses has proved to be practical in rural Ontario for over a century. Interest in adapting this practice to urban areas is increasing as it provides combined benefits of conserving potable water and reducing stormwater runoff. When harvested rainwater is used to irrigate landscaped areas, the water is either evapotranspirated by vegetation or infiltrated into the soil, thereby helping to maintain predevelopment water balance.

A full list of LID at-source controls including design guidelines are described in detail in the *Low impact Development Stormwater Management Planning and Design Guide (TRCA/CVC, 2010)*.

9.4.3 Alternative 12 - LID Conveyance Controls

Conveyance controls involve controlling the stormwater runoff as it travels along a designed drainage path. There are a variety of existing drainage features within the Study Area which could be retrofitted to provide specific LID treatment targets for stormwater runoff. These LID measures increase water quality by promoting filtration and infiltration, as well as reducing the stormwater runoff volume and peak flows. The proposed LID conveyance controls are listed in the following section.

Vegetated Filter Strips

Vegetated filter strips (also known as buffer strips and grassed filter strips) are gently sloping, densely vegetated areas that treat runoff as sheet flow from adjacent impervious areas. They function by slowing runoff velocity and filtering out suspended sediment and associated pollutants, and by providing some infiltration into underlying soils. Originally used as an agricultural treatment practice, filter strips have evolved into an urban SWM practice. Vegetation may be comprised of a variety of trees, shrubs and native plants to add aesthetic value as well as water quality benefits. With proper design and maintenance, filter strips can provide relatively high pollutant removal. Maintaining sheet flow into the filter strip through the use of a level spreading device is essential. Using vegetated filter strips as pre-treatment practices to other BMPs is highly recommended. They also provide a convenient area for snow storage and treatment, and are particularly valuable due to their capacity for snowmelt infiltration. If used for snow storage, the area should be planted with salt-tolerant, non-woody plant species. Because of the simplicity of filter strip designs, physical changes to the practice are not needed for winter operation.

Enhanced Grass Swale

Enhanced grass swales are vegetated open channels designed to convey, treat and attenuate stormwater runoff (also known as enhanced vegetated swales). Check dams and vegetation in the swale slows the water to allow sedimentation, filtration through the root zone and soil matrix, evapotranspiration, and infiltration into the underlying native soil. Simple grass channels or ditches have long been used for stormwater conveyance, particularly for roadway drainage. Enhanced grass swales incorporate design features such as modified geometry and check dams that improve the contaminant removal and runoff reduction functions of simple grass channel and roadside ditch designs.

A dry swale is a design variation incorporating an engineered soil media bed and optional perforated pipe underdrain system. Enhanced grass swales are not capable of providing the same water balance and water quality benefits as dry swales, as they lack the engineered soil media and storage capacity of that best management practice.

Where development density, topography and depth to water table permit, enhanced grass swales are a preferred alternative to both curb and gutter and storm drains as a stormwater conveyance system. When incorporated into a site design, they can reduce impervious cover, accent natural landscape, and provide aesthetic benefits.

Dry Swales

A dry swale can be thought of as an enhanced grass swale incorporating an engineered soil bed and optional perforated pipe underdrain or a bioretention cell configured as a linear open channel. They can also be referred to as infiltration swales or bio-swales. Dry swales are similar to enhanced grassed swales in terms of the design of their surface geometry, slope, check dams and pre-treatment devices. They are similar to bioretention cells in terms of the design of the filter media bed, gravel storage layer and optional underdrain components. In general, they are open channels designed to convey, treat and attenuate stormwater runoff. Vegetation or aggregate material on the surface of the swales slows the runoff water to allow sedimentation, filtration through the root zone and engineered soil bed, evapotranspiration, and infiltration into the underlying native soil. Dry swales may be planted with grasses or have more elaborate landscaping.

Perforated Pipe Systems

Perforated pipe systems can be thought of as long infiltration trenches or linear soakaway pits designed for both conveyance and infiltration of stormwater runoff. They are underground stormwater conveyance systems designed to attenuate runoff volume and reduce contaminant loads to receiving waters. They are composed of perforated pipes installed in gently sloping granular stone beds lined with geotextile fabric to allow infiltration of runoff into the gravel bed and underlying native soil while it is being conveyed from source areas or other BMPs to an end-of pipe facility or receiving waterbody. Perforated pipe systems can be used in place of conventional storm sewer pipes, where topography, water table depth, and runoff quality conditions are suitable. They are suitable for treating runoff from roofs, walkways, parking lots and low to medium traffic roads, with adequate pre-treatment. A design variation can include perforated catchbasins, where the catchbasin sump is perforated to allow for runoff to infiltrate into the underlying native soil. Perforated pipe systems can also be referred to as pervious pipe systems, exfiltration systems, clean water collector systems and percolation drainage systems.

A full list of LID conveyance controls including design guidelines are described in detail in the *Low impact Development Stormwater Management Planning and Design Guide (TRCA/CVC, 2010)*.

9.5 General Stormwater Improvement Alternatives

The following alternatives represent a number of options, all of which can be implemented concurrently.

9.5.1 Alternative 13 – SWM System Design Rainfall to Account for Climate Change

Fluctuating weather patterns have been shown to change rainfall patterns. Climate change has the potential to increase the intensity, duration and frequency of storms. If it is not considered as part of the design of future SWM systems, climate change has the potential to jeopardize the water quantity and quality functions of existing and future SWM systems. In extreme circumstances, public safety could be at risk due to downstream flooding or erosion, pond berm failure etc. To account for climate change, the design of all future SWM systems in the Township should consider a 15% increase in rainfall depth and intensity for all design storms including the 2 – 100-year storm events. The expected result is more robust SWM facilities capable of functioning as designed for a wider range of runoff scenarios. The function of SWM facilities designed for increased rainfall depth and frequency is expected to result in more sustainable SWM systems.

A 15% increase in rainfall depth and intensity applied to all design storms has been used in other municipalities and has been shown to produce similar rainfall results to those produced using larger scale climate models.

9.5.2 Alternative 14 – Landscape Program Including Drought and Flood Tolerant Species

SWM facilities including wet ponds, dry ponds, wetlands, bio swales, bioretention cells, etc. play a vital role in water quality treatment throughout a number of biological and physical mechanisms. Nutrient uptake by plants and sediment filtering by vegetation are incorporated into SWM facilities to improve water quality and treatment of runoff. Landscape plans incorporating native plant species able to tolerate extended wet and dry conditions are to be prepared with all proposed SWM systems. Selection of appropriate vegetation will ensure long term water quality treatment of runoff in all future SWM facilities. Efforts by the Township to replace unhealthy or dead vegetation in existing SWM facilities or along existing drainage paths etc. should be incorporated in the Township's operation and maintenance plans and should also consider proper selection of plants to encourage water quality treatment and to avoid the need for repeated re-planting.

9.5.3 Alternative 15 – Convert Roadside Ditches to Enhanced Grass Swales

A vast majority of the developed land in the Study Area is uncontrolled and this presents an opportunity to implement LID controls in appropriate areas to treat runoff from existing developments. A large portion of the roads in the Study Area are a rural section and consist of open ditches. These ditches convey runoff from a variety of developments including residential, commercial and industrial. Converting these ditches to Enhanced Grass Swales provides an opportunity increase the quality of stormwater runoff, as well as promote infiltration. Enhanced Grass Swales are discussed in detail in the Toronto and Region and Credit Valley Conservation Authority's *Low Impact Development Stormwater Management Planning and Design Guide* (2010), and are summarized below.

Enhanced Grass Swales are vegetated open channels designed to convey, treat and attenuate stormwater runoff. Check dams and vegetation in the swale slows the water to allow sedimentation, filtrating, evapotranspiration and infiltration. It is estimated a volumetric runoff reduction of between 10-20% can be achieved by Enhanced Grass Swales, depending on soil type (20% for Type A or B, 10% for type C or D). It is also estimated these swales can remove 76% of Total Suspended Solids, and have a 55% phosphorus reduction. Some design considerations to consider are listed below:

- Longitudinal swale slope should be between 0.5 and 4%. For slopes steeper than 3%, check dams should be used. Slopes less than 1% enhance the removal rate of pollutants;
- Bottom width of swales should be between 0.75 and 3.0 m;
- A maximum flow depth of 100 mm is recommended during a 4-hour, 25 mm Chicago storm event;
- Bottom of swale should be separated from the seasonally high water table or top of bedrock by at least 1 m;
- Grass swales can be applied on any type of soils, however increased soil infiltration rates (greater than 15 mm/hr) will enhance the removal of pollutants;
- Pre-treatment with vegetated filter strips or sediment forebays enhance the pollutant removal rate; and
- A planting strategy for Enhanced Grass Swales is provided in the TRCA/ CVCA Guide. Salt tolerant species are preferred as road salt often enters ditch.

Cost considerations for the construction of these swales are provided in the TRCA/ CVCA Guide, however these costs are for full construction as opposed to retrofitting existing ditches. The costs for retrofitting existing ditches would include installing additional vegetation and providing check dams where appropriate. Therefore, this is a very cost effective option of increasing stormwater runoff quality.

9.5.4 Alternative 16 – As-Constructed Drawings for All New SWM Facilities

In order to assess future sediment accumulation in SWM facilities, it is important to have an accurate as-built survey of each new pond to confirm the original pond design volumes.

The developer should be responsible for completing a pond cleanout and a post pond clean out topographic survey, confirming the pond has been constructed as designed and with the pond volumes intended. It is recommended the post pond cleanout survey take place at the end of the maintenance period prior to assumption by the Township.

9.5.5 Alternative 17 – Low Impact Development Urban Road Section

Runoff from the majority of the developed areas in the Study Area, including all roadways is discharged uncontrolled to the receiving watercourses of Lake Simcoe. It is recommended for all new development and redevelopment of roads, water quality treatment for runoff be required whether existing quality SWM controls exist or not. This alternative would have the effect of continuing to improve the existing quality of runoff directed to the receiving watercourses and Lake Simcoe. LID practices can be incorporated into standard road sections where the existing soil, groundwater and bedrock conditions allow. Attached in Appendix G is the Township's Urban – Local Residential 20.0 m wide road standard section revised to incorporate an LID feature. The revised section requires minor adjustments to the location of the utilities in the boulevards while still remaining technically feasible. The revised section provides water quality treatment for 50% of the roadway, including filtering of sediment, nutrient uptake by vegetation, groundwater recharge and provides for reserve hydraulic capacity in the storm sewer. It is noted the storm sewer will continue to function as designed. Only temporary ponding is expected in the grassed swale since the perforated subdrain located beneath the grassed swale is intended to promote infiltration. It is noted the revised road section (included in Appendix G) allows for sidewalk on only one side of the road.

9.5.6 Alternative 18 – Joint Public & Private Awareness Programs

Runoff from the majority of Brechin and Lagoon City discharges uncontrolled to a tributary watercourse or Lake Simcoe directly. To assist in reducing the impacts of runoff produced during frequent storms joint public/private programs are recommended to promote rainwater harvesting and greywater reuse. A program promoting the use of rain barrels is recommended for individual households whereby individual property owners located within the settlement boundary limits are encouraged to purchase a rain barrel(s) from the Township, at a subsidized rate, for rainwater harvesting and re-use, in order to reduce the storm runoff volume and peak flow rate on an individual site basis. As part of the rain barrel campaign, public education related to other at-source SWM opportunities are to be introduced to the public including reducing fertilizer usage, rain gardens, roof downspout directed to pervious areas etc. Stormwater initiatives aimed at individual property owners are not only effective on a site by site basis, but have been shown to promote public education and awareness having positive effects on the community.

9.5.7 Alternative 19 – Township SWM Operation and Maintenance Program

Existing Certificates of Approval (C of As) and Environmental Compliance Approvals (ECAs) issued under Section 53 of the Water Resources Act require the owners of all SWM facilities to maintain the facilities and ensure they continue operating as originally designed over time.

After construction, the maintenance responsibilities of SWM facilities are often forgotten and when extensive pond maintenance is required financial resources are not available to complete the work. As indicated above, there are only three SWM facilities located in the Study Area, and only two which are owned and maintained by the Township. However, there is planned development located within the settlement boundaries and inspection and maintenance of all future SWM facilities will also be required. As a minimum, it is recommended for all future SWM facilities, an operation and maintenance manual detailing the specific maintenance requirements, be submitted by the SWM facility designer prior to final approval of the SWM facility. The manuals are to identify the frequent and infrequent maintenance responsibilities and are to be kept on file by the operating authority for reference.

An annual Township SWM facility maintenance program is recommended for the purposes of documenting SWM facility operating characteristics on an annual basis. Detailed annual field assessments are recommended to record:

- Sediment accumulation depth;
- Signs of erosion;
- Excessive debris;
- Excessive vegetation which may be obstruction flow, access, blocking inlets or outlets etc.;
- Prolonged ponding; and
- Damage to either the inlet / outlet.

Photos are to be logged during each visit and kept on file to monitor SWM facility features from year to year.

A proper SWM facility maintenance program, including annual records and ongoing analysis of data can be useful to confirm compliance with an existing C of A or ECA, assist with prioritizing SWM maintenance capital works projects (including outlet adjustments/retrofits, bank stabilization, sediment clean-outs etc.) and reduce liabilities and overall long term costs. An operation and maintenance program can be used to determine the frequency of maintenance for each SWM facility based on past records and to allocate long range budget resources as part of the Township's 5, 10 and 15-year capital budgets.

9.5.8 Alternative 20 – Phosphorus Reduction Strategies in Agricultural Areas

Actively farmed agricultural areas make up approximately 60% of the total Study Area and a majority of the overall existing and future phosphorus loading to Lake Simcoe. For this reason, it is appropriate to consider efforts on reducing phosphorus loadings outside of the settlement areas. There are a number of methods to reduce phosphorus loading from agricultural areas and which are described in the Lake Simcoe Climate Change Adaptation Strategy (Draft October 2013) including promoting the following:

- drainage and irrigation techniques to conserve water and minimize nutrient loss;
- promoting farmers to apply manure and other fertilizers in the spring after the spring freshet as opposed to the fall;
- sustainable management (i.e. crop rotation, low tillage, wind breaks, vegetated filter strips etc.); and
- environmental farm plans and plan updates.

The above techniques can be achieved through the implementation of pilot projects and programs such as the farm stewardship implementation program. Funding is available for rural retrofits and it is recommended the Township support and promote these programs with the farming community.

9.6 Evaluation of Alternatives

The Alternatives described above have been evaluated in each of the settlement areas and screened with respect to their impact on the physical, natural, social, cultural and economic environments. Table 15 assesses the SWM Alternatives in context with the Preliminary Criteria.

Table 15: Assessment of SWM Alternatives

Overleaf.

9.7 Evaluation Criteria and Weighting

Evaluation criteria were developed according to the MCEA guidelines recognizing a number of alternatives would be selected and that selection of one does not preclude the selection of another. The evaluation criteria for each alternative are summarized in the table below:

Table 15: Alternative Screening Table

Preliminary Criteria	Do Nothing	SWM Improvement Alternatives																			
		SWM Alternatives With Focus on Existing Development			SWM Alternatives With Focus on Future Development (Quantity Control)						SWM Alternatives With Focus on Future Development (Quality Control)			General SWM Improvement Alternatives							
		Alternative 1 – Existing SWM Facility Retrofit Opportunities	Alternative 2 – Improve Existing Condition Stormwater Runoff Using LIDs	Alternative 3 – Improve Existing Condition Uncontrolled Stormwater Using End of Pipe Controls	Alternative 4 – Standard Post to Pre Development Peak Flow Control	Alternative 5 – Peak Design Flow Targets	Alternative 6 – Centralized SWM Pond Locations	Alternative 7 – Extended Detention Over-Control	Alternative 8 – Water Balance and Infiltration Measures	Alternative 9 – Over-Control Infiltration Rates	Alternative 10 – MOE Enhanced Level Water Quality Control	Alternative 11 – LID At-Source Controls	Alternative 12 - LID Conveyance Controls	Alternative 13 – SWM System Design Rainfall to Account for Climate Change	Alternative 14 – Landscape Program Including Drought and Flood Tolerant Plant Species	Alternative 15 – Convert Roadside Ditches to Enhanced Grass Swales	Alternative 16 – As-Constructed Drawings for All New SWM Facilities	Alternative 17 – Low Impact Development Urban Road Section	Alternative 18 – Joint Public & Private Awareness Programs	Alternative 19 – Township SWM Operation and Maintenance Program	Alternative 20 – Phosphorus Reduction Strategies in Agricultural Areas
Land uses where strategy is to be applied	N/A	Existing SWM Facilities	Existing Development, Open Areas, Ditches etc.	Open Space Downstream of Existing Development	Future SWM Facility	Future SWM Facility	Future SWM Facility At Downstream Limit of Settlement Area	Future SWM Facilities	Future Development Lands	Future Development Lands	Future SWM Facilities	Future Development Lands	Future Development Lands	N/A	Existing & Future SWM Facilities, Ditches etc.	Existing Ditches	New SWM Facilities	Existing and new Roads	Individual Property Owners (Private Property)	Existing SWM facilities	Agricultural Areas
Peak flows	Negative	Positive	Neutral	Positive	Positive	Positive	Positive	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	Neutral	Positive	Positive	Positive	Neutral
Phosphorus Loading	Negative	Positive	Positive	Positive	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Positive	Positive	Positive	Neutral	Positive	Positive	Neutral	Positive	Positive	Positive	Positive
Infiltration	Negative	Neutral	Positive	Positive	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	Positive	Positive	Neutral	Positive	Positive	Neutral	Positive	Positive	Neutral	Neutral
Erosion Potential	Negative	Positive	Positive	Positive	Neutral	Neutral	Neutral	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Neutral	Positive	Positive	Positive	Neutral

Table 16: SWM Alternative Evaluation Criteria

Technical	Opportunity to reduce peak flows into Lake Simcoe
	Opportunities to decrease erosion of watercourses
	Opportunity to improve water quality
	Opportunity to reduce phosphorus loadings into Lake Simcoe
	Opportunities to mitigate changes in water balance
Natural Heritage Features	Provisions of direct and indirect fish habitat
	Potential to improve terrestrial habitats
	Impact to natural hazard features
Social Environment	Ability to improve public health and safety
	Impacts to private structures
	Impacts to public property
Cultural Environment	Impacts to built and cultural heritage landscape
	Impacts to archaeological resources
Economic Environment	Capital costs
	Operation and maintenance costs
	Risk management
	Impact on agricultural land use

The above evaluation criteria were applied to each proposed alternatives on an individual settlement area basis. This will help ensure the implementation of alternatives targets the specific constraints and opportunities of each area. The preferred alternatives are discussed in Section 10.

10 Preferred Alternative(s)

The recommendations provided herein are the preferred alternatives of this Master Plan process. The preferred alternatives are intended to guide SWM related to future development identified in the Township's Official Plan. The selection of the preferred alternatives for this CSWM-MP has been divided into two categories. A SWM plan has been developed for the Study Area as a whole and provides a general guideline for SWM practices for all future development. SWM Plans have also been prepared for each settlement area with respect to the list of alternatives which provide a more detailed SWM strategy intended for each settlement area specifically.

10.1 Overall SWM Plan

The overall SWM Plan includes a broad range of SWM alternatives and applies to all areas located in the Study Area and includes the following:

1. The SWM plan related to all future development and re-development is to consider a 15% increase in rainfall depth and intensity for the design of all future SWM systems.

2. The SWM plan related to all future development and re-development is to provide post to pre development peak flow control unless specified otherwise herein.

3. The SWM plan related to all future development and re-development is to provide MOECC Enhanced Level water quality control including a minimum of 24 hour extended detention of the greater of: 40 m^3/ha of contributing area or the total runoff volume produced by the 25 mm 4 hr Chicago design storm (for sites greater than 2 ha), unless specified otherwise herein.

4. The SWM plan related to all future development and re-development is to consider the use of LID practices where applicable, as stand-alone SWM systems or as part of a treatment train combined with other SWM practices. The conversion of existing roadside ditches into Enhanced Grass Swales is also recommended since these are a relatively low cost solution to increase water quality of runoff, including phosphorus reduction from existing developed areas.

5. All new roads and road reconstructions are to consider implementing the standardized LID road section included in Appendix F. Adaptations of the road section for other types of road sections and widths are recommended and should be reviewed with the Township during the initial planning stages of a project.

6. All new development and redevelopment is to consider the use of flood and drought tolerant plant species. Landscape plans specifying the use of such plants are required as part of each future development application involving SWM.

7. As-built surveys are required as part of all newly constructed SWM facilities for the purposes of confirming the design storage volumes exist and for determining sediment accumulation throughout the lifespan of the facility.

8. Operation and maintenance of the existing SWM facilities is currently completed by the Township. Due to the limited number of SWM facilities, Township staff can continue completing the necessary operation and maintenance tasks as part of the current Township operating budget, without the need for any additional staffing resources. However, developing a comprehensive operation and maintenance program as described in Section 9.5.7 is needed to provide clear guidance for Township operation and maintenance staff. A comprehensive operation and maintenance program is also useful for prioritizing and budgeting for SWM maintenance capital works projects (including outlet adjustments/retrofits, bank stabilization, sediment clean-outs etc.)

thereby reduce liabilities and overall long term costs. The proper operation and maintenance of SWM facilities is required in order to meet the short and long-term objectives of this CSWMMP.

9. Joint public/private programs are to be advance by the Township to improve water quality, reduce erosion and to promote public education and awareness on issues related to SWM.

10. The phosphorus analysis included herein has focussed on the settlement areas. However actively farmed agricultural areas constitute a majority of the existing and future phosphorus loading from the Study Area and the overall Ramara Creeks subwatershed to Lake Simcoe. For this reason, it is appropriate to implement efforts on reducing phosphorus loadings from these areas. A list of methods is included in Section 9.5.8 and can be realized through the implementation of pilot projects and programs such as the farm stewardship implementation program. Funding is available for rural retrofits and it is recommended the Township support these programs in cooperation with the farming community.

10.2 Settlement Area SWM Plans

10.2.1 Brechin

Centralized New SWM Pond Locations

The preferred alternative for Brechin includes three future centralized stormwater management facilities (SWMF). The recommended locations for the SWM facilities are: SWMF 1 - on the upstream side of the CN Rail Line north of Ramara Road 47, SWMF 2 - on the east side of Highway 12 between Concession Road 4 and Ramara Road 47 and SWMF 3 – west of SWM pond 2 upstream of the CN Rail Line. The need for additional SWM facilities due to grading and other site specific constraints will be reviewed in detail by the Township as part of the preliminary development application review process.

SWMF 1 will provide water quality and quantity control for the total undeveloped lands in the Brechin settlement area located north of Concession Road 4 (Catchment 205). Post to pre-development peak flow control as presented herein is sufficient to match the existing condition peak flow rates at the CN Rail line.

SWMF 2 and 3 will provide water quality and quantity control for the total undeveloped land in the Brechin settlement area located south of Concession Road 4, north of the industrial park including the Veltri Development (Catchments 213 & 222). A Draft Plan exists for the Veltri Development which consists of 32.3 ha of land including a wet SWM pond intended to service the 32.2 ha development. The Veltri Development represents approximately 71% of the total area in Catchment 213 and which is intended to be controlled by centralized SWMF 2. The location of the Veltri Development SWM facility is consistent with the preferred alternatives for the Study Area. However, final design of the Veltri Development SWM facility is to include allowances to accept uncontrolled flow from the lands to the east and to control runoff from these areas according to the unit flow rates developed for SWMF 2 and 3 which are presented in Table 5. SWMF 2 and 3 were originally contemplated as a single facility located at the CN Rail Line however the since the Veltri Development is Draft Plan Approved, it is logical to propose two SWM facilities thereby allowing the planning submissions for the Veltri Development to proceed as planned.

The development of the unit flow rates included herein is based on the best available information at this time of this report and is subject to revision as new information becomes available. Proposed adjustments to the unit flow rates by developers based on more accurate input data and modelling analyses will be reviewed by the Township and incorporated into the CSWM MP as appropriate.

Multiple land owners exist in the catchment areas draining to each SWM facility therefore cost sharing agreements will be required to allow upstream development to proceed. It is recommended discussions between all benefiting land owners take place early on in the development planning stages to allow logical progression of development without significant delays.

Brechin Public School SWM Pond Retrofit

The study confirmed the retrofit of the existing SWM pond located at the Brechin Public School as a project that would benefit the watershed. The retrofit should at a minimum provide MOECC Enhanced Level water quality treatment in addition to the quantity control function is currently provides. As part of the detailed retrofit design of the pond, extended detention is also recommended to reduce the potential for erosion in downstream areas as well as LID measures. This can be accomplished by modifications to the pond outlet and minor grading within and around the pond to create additional pond storage. Since the site is located on private lands, there is an opportunity for joint partnership between the Township, LSRCA and the Public School Board to construct the pond retrofit.

Water Budget

The water budget analysis for Brechin confirmed an annual infiltration target for new development of 1,831 m^3/ha as presented in Table 10. It is noted LID practices to support infiltration are only effective where site conditions permit. The future LID practice designs should consider the source of runoff to ensure there are no impacts to groundwater and/or nearby well users.

Individual water budget assessments completed at a higher level of detail are required as part of all future individual development applications.

Phosphorus Budget

The phosphorus budget analysis for Brechin included in Table 14 above confirmed a phosphorus loading increase of up to 40.4 % following full build-out compared to existing, while considering 63% phosphorus removal by traditional wet SWM facilities. A decrease in phosphorus loading of 10.7% is observed while considering 85% phosphorus removal by LID practices. These results echo the need to implement LID measures in Brechin either as stand-alone SWM practices (for small sites) or as part of a treatment train approach in combination with traditional wet SWM facilities.

A detailed phosphorus budget is required as part of each development application and must conform to the LSPP (4-8-DP) with the goal of no net increase in phosphorus from existing conditions.

A summary of the SWM Plan recommendations for future development in Brechin is summarized in Table 17.

Table 17: Brechin SWM Plan Summary Table

SWM Plan Criteria	Recommendation
Water Quality	Lot level and Conveyance LIDs (where feasible) & standard MOECC water quality treatment. 85% phosphorus removal for all future development
Water Quantity	A minimum of post to pre development peak flow control to MOECC criteria. Unit flow rates apply to all future development located in Catchments 213 and 222 (see Section 7.1.2)
Water Balance	Annual Infiltration target of 1,831 m^3/ha for all future development where site conditions permit
Erosion Control	Standard MOECC erosion control including 24 hr detention of runoff from 25 mm 4hr Chicago design storm (for sites greater than 2 ha)

10.2.2 Lagoon City

Centralized New SWM Pond Locations

The preferred alternative for Lagoon City includes consideration of two potential end-of-pipe SWM ponds. The recommended ponds locations are: SWMF 4 - adjacent to the Townships water treatment plant and SWMF 5 - east of Lakeshore Drive, south of Maple Trail. Both ponds are intended to service future Village Residential zoned lands that cannot outlet directly to Lake Simcoe and thus have the potential to cause flood impacts to lands downstream. Development on the lands occupied by the Township wastewater treatment plant is not expected to proceed in the near future however it has been included for completeness based on the zoning designation shown on the current Official Plan Land Use Plan.

SWMF 4 will provide water quality and quantity control for a 12.2 ha portion of land (Catchment 221) draining north and discharging into the Harrington Municipal Drain. Post to pre-development peak flow control as presented herein is sufficient to match the existing condition peak flow rates.

SWMF 5 will provide water quality and quantity control for the majority of undeveloped lands in the Lagoon City settlement area located south of Simcoe Road (Catchment 207). Post to pre-development peak flow control as presented herein is sufficient to match the existing condition peak flow rates immediately upstream of Lakeshore Drive.

Water Budget

The water budget analysis for Lagoon City confirmed an annual infiltration target for new development of 1,643 m^3/ha as presented in Table 10. It is noted LID practices to support infiltration are only effective where site conditions permit. Infiltration measures are strongly encouraged in existing areas classified as SGRA's, of which a portion of Catchment 207 is, with consideration for areas with highly vulnerable aquifers. Extra precautions should be taken for implementation of infiltration practices in these areas. Lagoon City is characterised as having muck type soils which are only semi-conducive to infiltration. Their use should be evaluated on a site by site basis.

Individual water budget assessments completed at a higher level of detail are required as part of all future individual development applications.

Phosphorus Budget

The phosphorus budget analysis for Lagoon City included in Table 14 above confirmed phosphorus loading increases following full build-out of 12.2% and 1.9% while considering 63% phosphorus removal by traditional wet SWM facilities and 85% phosphorous removal by LID practices respectively. These results indicate the need for LID measures in Lagoon City either as stand-alone SWM practices (for small sites) or as part of a treatment train approach in combination with traditional SWM facilities.

A detailed phosphorus budget is required as part of each development application and must conform to the LSPP (4-8-DP) with the goal of no net increase in phosphorus from existing conditions.

Notwithstanding the above, the use of LID practices in Lagoon City is highly recommended as a component of all new development and redevelopment due to the close proximity of the Lake. Water quality treatment of first flush type runoff by means of LID practices, which is not reflected in the calculations included in this study, will provide an added benefit to the quality of runoff discharging into Lake Simcoe.

A summary of the SWM Plan recommendations for future development in Lagoon City is summarized in Table 18.

Table 18: Lagoon City SWM Plan Summary Table

SWM Plan Criteria	Recommendation
Water Quality	Lot level and Conveyance LIDs (where feasible) & standard MOECC water quality treatment. 85% phosphorus removal for all future development
Water Quantity	A minimum of post to pre development peak flow control to MOECC criteria for all

	development that does not outlet directly to Lake Simcoe
Water Balance	Annual Infiltration Target of 1,643 m^3/ha for all future development where site conditions permit
Erosion Control	Standard MOECC erosion control including 24 hr detention of runoff from 25 mm 4hr Chicago design storm (for sites greater than 2 ha)

11 Implementation Plan

In order to ensure the preferred alternatives identified in the previous section are carried out, it is necessary to create a detailed implementation plan to outline implementation strategies, determine the responsibilities of various stakeholders, determine potential funding sources, and create a primary implementation schedule. The implementation plan places responsibility with the Township, as well as developers, residents and other government agencies.

The implementation of a portion of the preferred alternatives can be initiated immediately by the Township to improve existing SWM systems whereas the balance will be initiated as part of future development projects located in the settlement areas. These will be described in detail in the sections to follow:

11.1 Alternatives Available for Implementation Immediately

11.1.1 Brechin Public School Dry SWM Pond Retrofit

The Brechin Public School dry SWM pond is located on private lands and therefore implementation of the retrofit project requires collaboration with the Public School Board. As a first step, it is recommended the Township meet with the school board to openly discuss the project and the SWM improvement opportunity. The LSRCA should also be consulted for input related to the project and as a potential partner. If the project is supported by all parties, preliminary design of the retrofit can proceed following the criteria outlined in the Comprehensive SWM Master Plan Report. A list of possible retrofit opportunities include:

1. Modifications to the pond outlet to promote sedimentation and filtering of sediment prior to discharge from the facility;
2. Minor grading in the pond to create pond storage for erosion control and water quantity control as appropriate; and
3. Capture of untreated external flows for water quality treatment.

Preparing a cost estimates for the potential pond retrofits is pre-mature on the basis there are other factors which need to be resolved in advance.

11.1.2 Township-wide SWM Operation and Maintenance Program

As indicated in Section 10.1.8, a Township wide operation and maintenance program is recommended to meet the goal of this CSWMMP and can also be useful to prioritize and budget for SWM maintenance capital works projects (including outlet adjustments/retrofits, bank stabilization, sediment clean-outs etc.) and reduce liabilities and overall long term costs.

The Township has sufficient staffing resources available and is in the process of preparing a Township-wide operation and maintenance program to meet the criteria described in Section 9.5.7. The operation and maintenance program will include five existing SWM facilities throughout the Township, including the existing SWM facilities located in the study area, and will be expanded to include future SWM facilities as development proceeds.

Other preferred alternatives available for implementation immediately by the Township are Alternatives 9 and 10 described in Section 10.1 including:

- Joint public/private programs to achieve SWM goals and raise awareness; and
- Programs aimed at reducing phosphorus loading on Lake Simcoe from agricultural areas.

The costs associated with the above alternatives should be supplied by the Township. Alternate sources of funding are described in Section 11.1.3.

11.2 Alternatives to be Implemented at the Time of Future Development

The implementation of centralized SWM facilities described in Section 10.1.1 is a proactive measure intended to maintain the existing flow regimes and improve the water quality of future development runoff directed to the receiving watercourses and Lake Simcoe. Each facility is proposed to service a large undeveloped area and is only needed at the time when major development in the upstream lands is proposed. It is recommended the costs to design and construct the centralized facilities will be shared among the benefiting users. The need for centralized SWM facilities should be reviewed in detail by the Township and benefiting land owners when future development is being contemplated in the upstream area. The SWM facility proposed in Brechin on the east side of Highway 12 is currently draft plan approved. However, final design of this SWM facility should meet the preferred SWM criteria identified in the SWM-MP.

Other preferred alternatives to be implemented as part of all future development in the Settlement Areas are Alternatives 1-7 described in Section 10.1 including:

- 15% increase in rainfall depth and intensity for the design of all future SWM systems;
- Post to pre development peak flow control unless specified otherwise herein;

- MOECC Enhanced Level water quality control including a minimum of 24 hour extended detention of the greater of: 40 m3/ha of contributing area or the total runoff volume produced by the 25 mm storm, unless specified otherwise herein;
- LID practices for all future development and re-development where applicable;
- Consider implementing the standardized LID road section included in Appendix F;
- Landscape plans specifying the use of flood and drought tolerant plant species;
- As-built surveys are required as part of all newly constructed SWM facilities; and

The above alternatives are to be considered for implementation at the preliminary design stage of all future development and redevelopment. On this basis, the cost implications of each will vary on a project by project basis and will be incorporated into the overall project costs and born by the land owner.

The above recommended alternatives are to be implemented in combination with all other applicable MOECC, LSRCA, Township and LSPP SWM standards guidelines. The unit rate criteria for lands draining to the Donnelly Drain east of the CN Rail Line and at the Ramara Industrial Park SWM pond (as part of a SWM pond retrofit) are presented in Section 7.1.2. Typical post to pre development peak flow control was determined to be sufficient in all other centralized facilities.

The erosion control criteria was also reviewed in detail and it was determined a minimum 24 hour extended detention is also sufficient to maintain the existing form and function of the receiving channels.

11.3 Sources of Funding

Funding is needed in order to implement the SWM recommendations described above. It is expected the majority of the funds needed to implement the recommendations should be provided by the Township, however other sources should include:

- LSRCA;
- MOECC;
- Environmental Canada;
- MTO (for roadside ditch enhancements);
- Provincial Government (grants for sustainability and asset management); and
- Private Sector/ Developers.

A handful of potential funding sources are discussed below.

11.3.1 Lake Simcoe/South-Eastern Georgian Bay Clean-Up Fund

The Lake Simcoe/South-Eastern Georgian Bay Clean-Up Fund (LSGBCUF) is a program funded by Environment Canada, and was created in 2007. From 2001-2012 it was successful in accelerating the adoption of beneficial management practices in the watershed, reducing phosphorous loads from urban and rural sources, and improving information and monitoring for decision making. The Government of Canada renewed and expanded the program for 2012-2017 with a $29 million funding budget. The main objectives are:

- to improve environmental monitoring, assessment and scientific information required to measure the effectiveness of control strategies, and identify and assess alternative approaches to reducing phosphorous discharges;
- to conserve critical aquatic habitat and associated species through targeted aquatic habitat protection, restoration and creation projects;
- to reduce rural and urban non-point sources of phosphorous / nutrients, including implementation of BMPs for the management of soil, crops, livestock, and water use, septic systems and creating and rehabilitating wetlands and naturalizing watercourses to attenuate phosphorous discharges; and
- to reduce discharge of phosphorous from point sources including sewage, combined sewer overflows and urban stormwater systems including support to development and testing of innovative approaches to manage urban stormwater and wastewater.

The fund is open to applications from the following groups:

- Landowners;
- Environmental groups;
- Community groups (e.g. youth and seniors groups, community-based associations, service clubs);
- Small and medium sized business (e.g. developers, industries etc.);
- Aboriginal organizations (e.g. First Nations Councils, Métis Associations);
- Conservation Authorities;
- Stewardship Networks;
- Agriculture Associations;
- Non-governmental organizations;
- Educational institutions;

- Industry; and
- Provincial/territorial/municipal governments.

For more information on the program, refer to http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=85C54DAE-1#Purpose.

11.3.2 Landowner Environmental Assistance Program (LEAP)

LSRCA's Landowner Environmental Assistance Program (LEAP) provides landowners with funding and technical assistance for environmental projects on their land. LEAP is administered by the LSRCA and made possible by funding from municipal partners and the support of the York, Durham, and Simcoe chapters of the Ontario Federation of Agriculture. Examples of LEAP eligible projects related to potential SWM improvements include: improving streams, upgrading septic systems, managing manure, restricting livestock from watercourses, controlling cropland erosion etc. LSRCA stewardship technicians are available to answer questions regarding the funding available. For more information on the program, refer to http://www.lsrca.on.ca/leap/.

11.3.3 Lake Simcoe Phosphorus Offsetting Program (LSPOP)

The Lake Simcoe Phosphorus Offsetting Program (LSPOP) was initiated by the LSRCA to promote greater phosphorus reductions to offset the increase from future urban expansion and is a potential source of funding to be implemented in the near future. The offsetting measures consist of phosphorus reductions through the retrofit of existing stormwater discharges elsewhere in the subwatershed or adjacent subwatersheds. The primary funding source for specific retrofit projects (278 identified by the LSRCA to date) is the purchase cost that would be applied to the developer, to offset any increases in phosphorus loading (for sites larger than 0.5 ha) including an offset ratio, for new development. A phased approach has been proposed for the LSPOP with Phase 1 having a proposed duration of five years (2014-2018). For more information on the program, refer to http://www.lsrca.on.ca/programs/lspop.php

11.3.4 Ontario Soil and Crop Improvement Association (OSCIA)

The Ontario Soil and Crop Improvement Association offer cost-share programs for a wide variety of agricultural practices including environmental initiatives such as best management practices. At the present time, there are no related cost–share programs available however farmers are encouraged to contact OSCIA for information related to upcoming programs. OSCIA also offers frequent workshops and webinars for farmers including how to set up an Environmental Farm Plan, which is a voluntary environmental education and awareness program, to promote sustainable farming practices.

11.3.5 Green Municipal Fund

The Green Municipal Fund (GMF) is an initiative program run by the Federation of Canadian Municipalities (FCM) with the goal of funding municipal environmental initiatives including Plans, Studies and Projects. The GMF funds a variety of project including works related to water conservation, stormwater management, wastewater systems and septic systems. For more information on the program, refer to http://www.fcm.ca/home/programs/green-municipal-fund/about-gmf.htm.

11.3.6 Enbridge Savings by Design

Created by Enbridge Gas Distribution with integrated design support from Sustainable Buildings Canada and their network of sustainable experts, the Savings by Design program was developed to facilitate an easier transition to green housing innovation. This program is available for both residential and commercial developments. Enbridge and their support team assist in LID designs, which incorporate LID SWM controls, as well as other various energy saving designs. This program is ideal for residential developers. For more information, refer to http://residential.savingsbydesign.ca/incentives.html for the residential program, and http://commercial.savingsbydesign.ca/programoverview.html for the commercial program.

11.4 Policy Recommendations

It is recommended a number of additions/alterations be made to the Township's policies and guidelines in regards to stormwater management. The alterations/additions to these documents are as follows:

11.4.1 Township of Ramara Official Plan (July 31, 2003)

In recognizing the Township's Official Plan will be up for renewal in the near future, it is recommended the following be included in *Section 6.3 Stormwater Management*:

- In areas where soil/groundwater conditions permit, at-source infiltration measures (LID) installed at the lot level are recommended. In these areas, roof leaders and yard drainage should be disconnected and directed towards lawns, side and rear yard swales, boulevards, parks and other open spaces throughout the development where possible to promote infiltration;

- Road infiltration trenches and perforated pipe systems should be installed where soil/groundwater conditions permit;

- Enhanced grass swales should be implemented as conveyance channels where soil/groundwater conditions permit; and

- End-of Pipe SWM facility infiltration and exfiltration systems should be installed where soil and groundwater conditions permit to promote infiltration and reduce thermal impacts of the proposed SWM Facilities.

11.4.2 Township of Ramara Engineering Design Criteria and Standard Drawings (2014)

Section 4.2.2 Storm Water Management notes future development must adhere to existing Watershed Planning Studies and Master Drainage Plans. For clarity a direct reference to this CSWM MP should be incorporated into Section 4.2.2 related to the requirements for all future development located in the Study Area.

The preferred alternatives included herein were developed specifically for implementation within the Study Area however their use and effectiveness throughout the Township can be expected. For this reason, the Township may wish to amend the stormwater management criteria to incorporate the preferred alternatives of this CSWM MP as criteria to be applied throughout the entire Township.

12 Inspection and Maintenance of SWM Facilities

Intrinsic to meeting the objectives of the Master Plan will be the implementation of an inspection and maintenance schedule that will ensure the existing and future SWM facilities operate as designed to meet the objectives of the LSPP.

The Township is currently responsible for the operation and maintenance of two SWM facility locations in the Study Area including the Ramara Industrial Park Lands wet SWM facility and the Stormceptor 1000 water quality treatment unit and bio-swales located at the Township Administration Office. However, implementation of the Master Plan will increase the number of SWM facilities to be maintained by the Township, assuming the majority of future SWM facilities will be operated and maintained by the Township.

The majority of SWM facilities are designed and constructed by developers and ownership is transferred to the Municipality following development and the construction maintenance period. The liability and maintenance responsibilities are also transferred at this time. Private developments are typically owned and maintained by the owner of the property.

Section 53 of the Ontario Water Resources Act states the owner of a SWM facility is responsible for maintaining it in proper working condition. Environmental Compliance Approvals (ECA) are issued by the MOECC under section 53 of the Water Resources Act for new SWM facilities. Specifically, ECA’s outline the legal requirements for operation and maintenance and include:

1. The owner must maintain the SWMF retention volumes at all times;

2. The owner shall inspect the SWMF at least once a year, and if necessary, clean and maintain the SWMF to prevent excessive buildup of sediment and/or vegetation; and

3. The owner shall maintain a logbook to record inspections and maintenance operations undertaken and shall keep the logbook at a readily accessible location for inspection by the Ministry.

As described in Section 9.5.7, Alternative 19, an annual Township SWM facility operation and maintenance program is recommended for documenting the SWM facility operating characteristics of each SWM facility on an annual basis. The operation and maintenance program will be implemented during the construction phase of each SWM facility and will be maintained throughout the intended life in the manner intended and in compliance with the existing C of A's and ECA's thereby meeting the objectives of this Master Plan and the LSPP. A list of relevant annual field assessment data to be recorded is described in Section 9.5.7. Other details to be included in the operation and maintenance schedule will be confirmed in consultation with the Township to ensure the data collected will assist with prioritizing SWM maintenance capital works projects (including outlet adjustments/retrofits, bank stabilization, sediment clean-outs etc.) and reduce liabilities and overall long term maintenance costs. The operation and maintenance schedule will be used to allocate long range budget resources as part of the Township's 5, 10 and 15 year capital budgets.

As a final component of the overall operation and maintenance schedule, it is recommended this Master Plan be updated at minimum every five years to provide reporting on progress made in implementing the Master Plan.

Authored by: Jeremy Ash, B.Sc.Eng., P.Eng.
Manager – Ottawa Office

Reviewed by: Tim Collingwood, B.A.Sc., P.Eng.
Director, Manager – Orillia Office

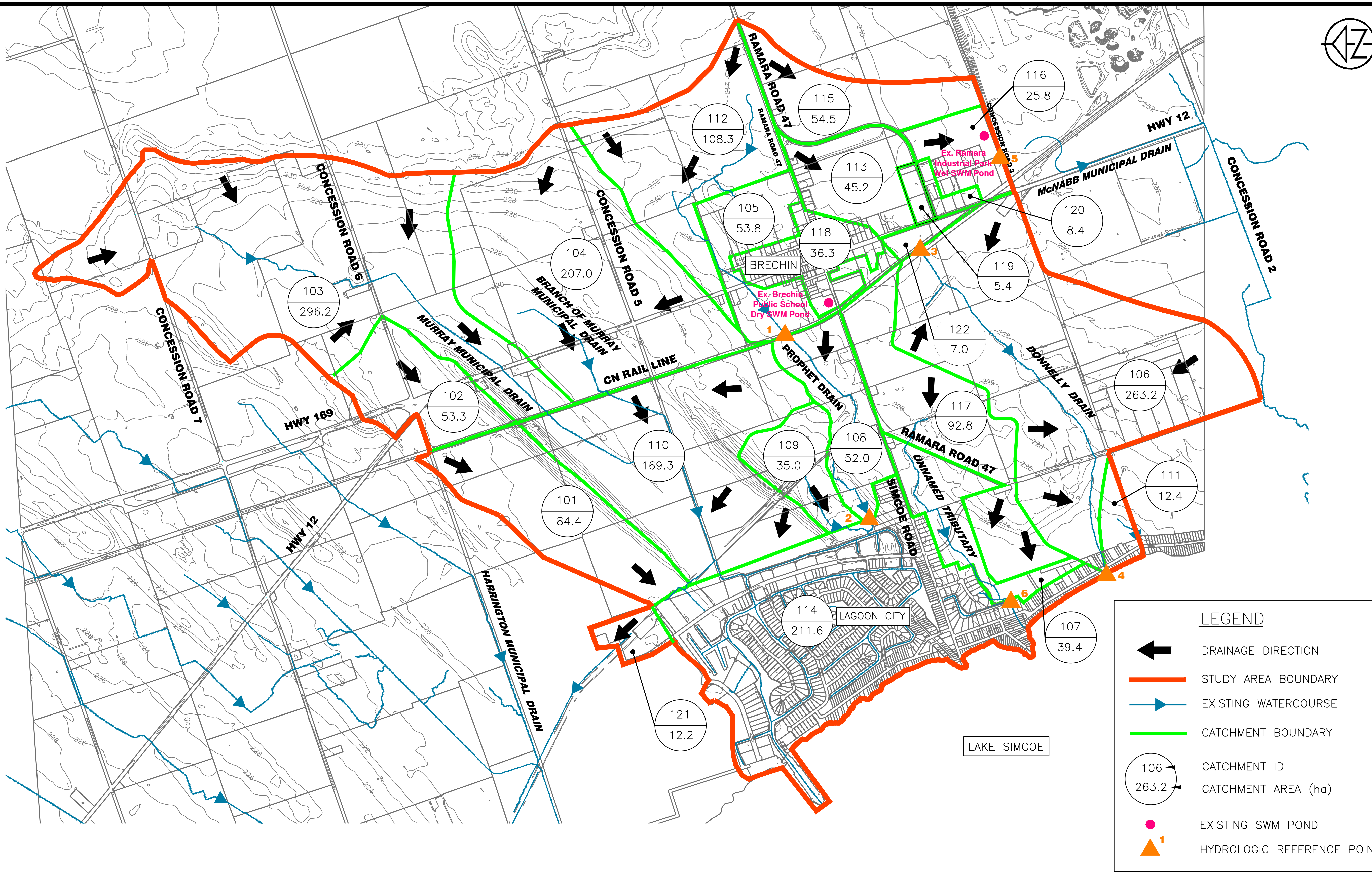
AERIAL PHOTOGRAPH FROM COUNTY OF SIMCOE (2008)
SETTLEMENT AREA BOUNDARIES AS DEFINED BY TOWNSHIP OF RAMARA OFFICIAL PLAN SCHEDULE 'A' (2006)

C.C.Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
STUDY AREA BOUNDARY

DWG. No. **FIG. 1**

SCALE: 1:25000 | DATE: SEPT 2015 | JOB NO. 312803



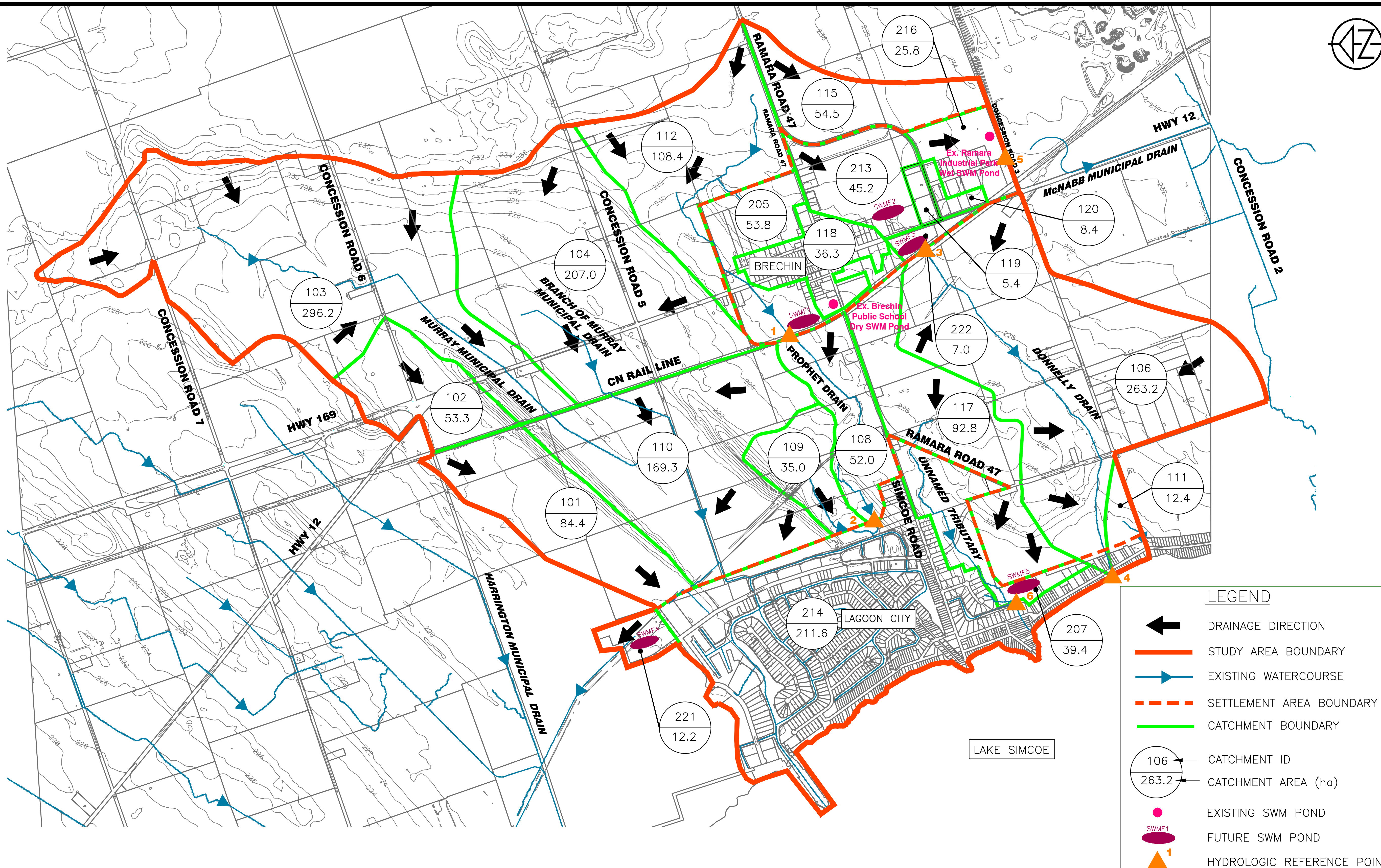
NOTES:
1. 2.0m CONTOUR DATA FROM COUNTY OF SIMCOE.

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
EXISTING CONDITIONS
DRAINAGE PLAN

DWG. No.
FIG. 2

SCALE: 1:25000 | DATE: SEPT 2015 | JOB NO. 312803



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NOTES:
1. 2.0m CONTOUR DATA FROM COUNTY OF SIMCOE.
2. SETTLEMENT AREA BOUNDARIES AS DEFINED BY TOWNSHIP OF RAMARA OFFICIAL PLAN SCHEDULE 'A' (2006)

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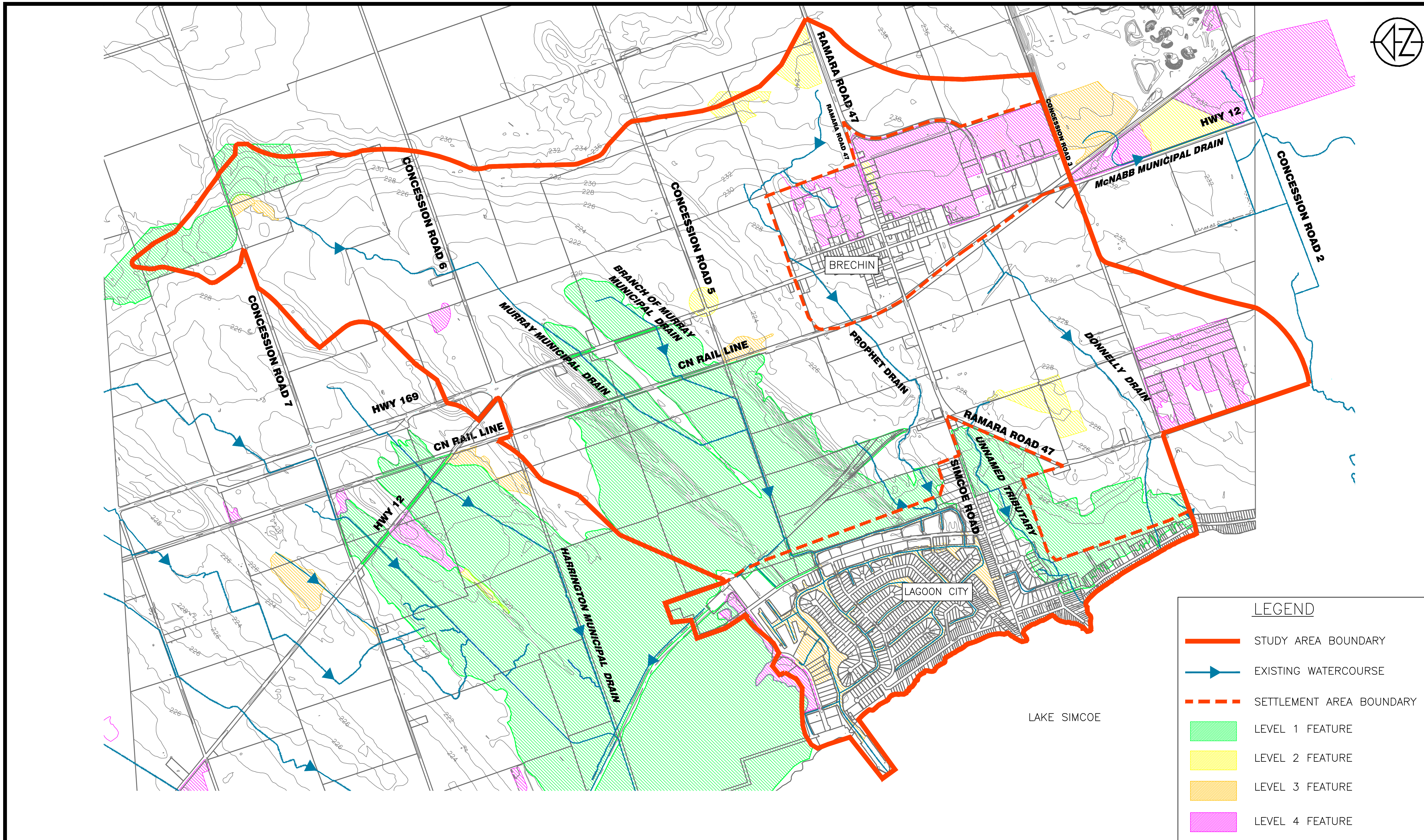
Collingwood Bracebridge Orillia Barrie

TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
FUTURE CONDITIONS DRAINAGE PLAN

SCALE: 1:25000 | DATE: SEPT 2015

DWG. No. **FIG. 3**

JOB NO. 312803



NOTES:

1. NATURAL HERITAGE FEATURE CLASSIFICATIONS AND DELINEATIONS SHOWN ARE FROM NATURAL HERITAGE SYSTEM FOR THE LAKE SIMCOE WATERSHED PHASE COMPONENTS AND POLICY TEMPLATES REPORT (LSRCA, 2007)

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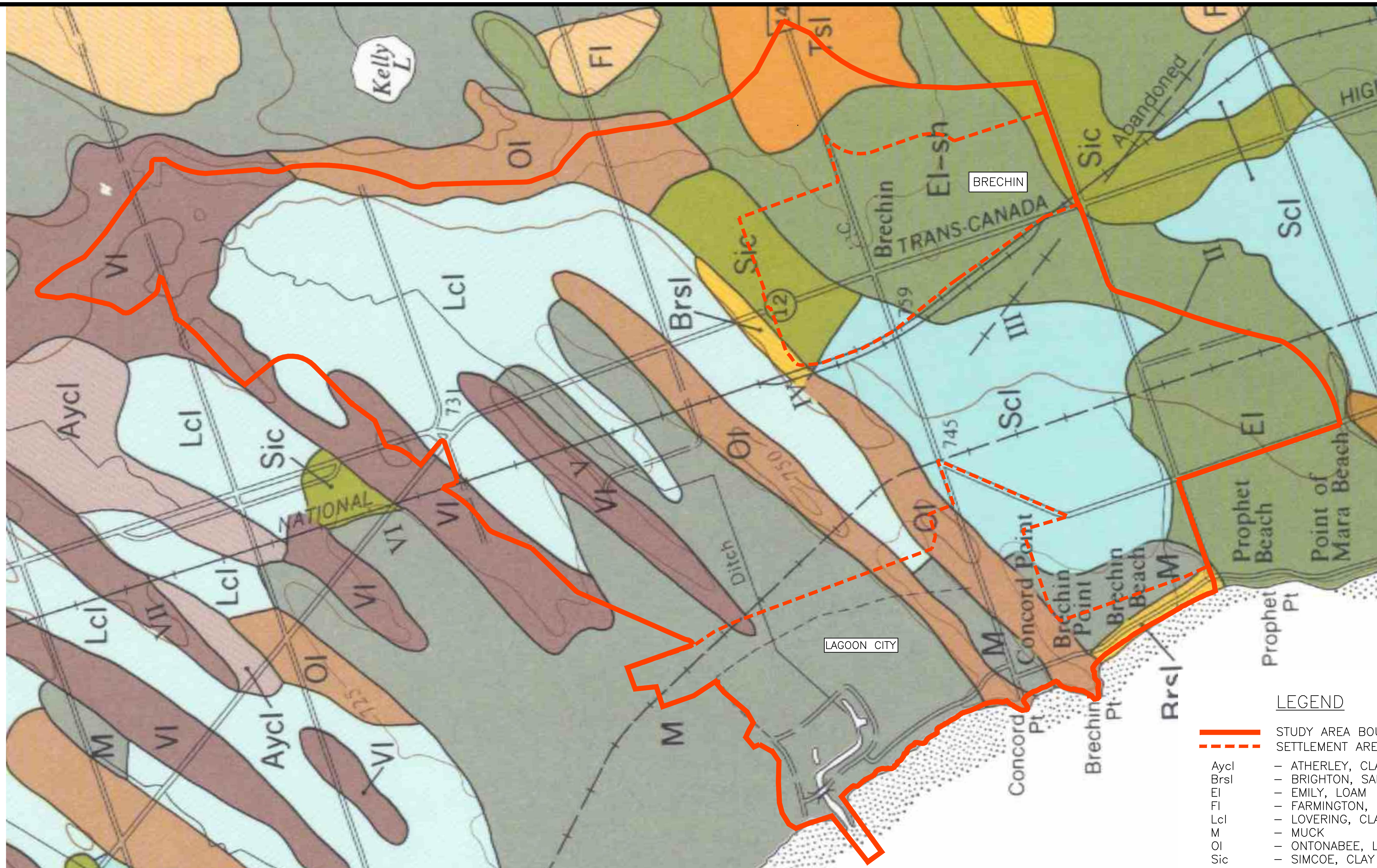
TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
NATURAL HERITAGE SYSTEM FEATURES

SCALE: 1:25000	DATE: SEPT 2015

DWG. No.
FIG. 4
JOB NO. 312803



LEGEND

- STUDY AREA BOUNDARY
- SETTLEMENT AREA BOUNDARY

Aycl	–	ATHERLEY, CLAY LOAM
Brsl	–	BRIGHTON, SANDY LOAM
El	–	EMILY, LOAM
Fl	–	FARMINGTON, LOAM
Lcl	–	LOVERING, CLAY LOAM
M	–	MUCK
Ol	–	ONTONABEE, LOAM
Sic	–	SIMCOE, CLAY LOAM
Scl	–	SMITHFIELD, CLAY LOAM
Tsl	–	TECUMSETH, SANDY LOAM
Vl	–	VASEY, LOAM

SOIL CLASSIFICATION SHOWN ARE FROM ONTARIO COUNTY SOIL SURVEY (NORTH HALF) (1956)

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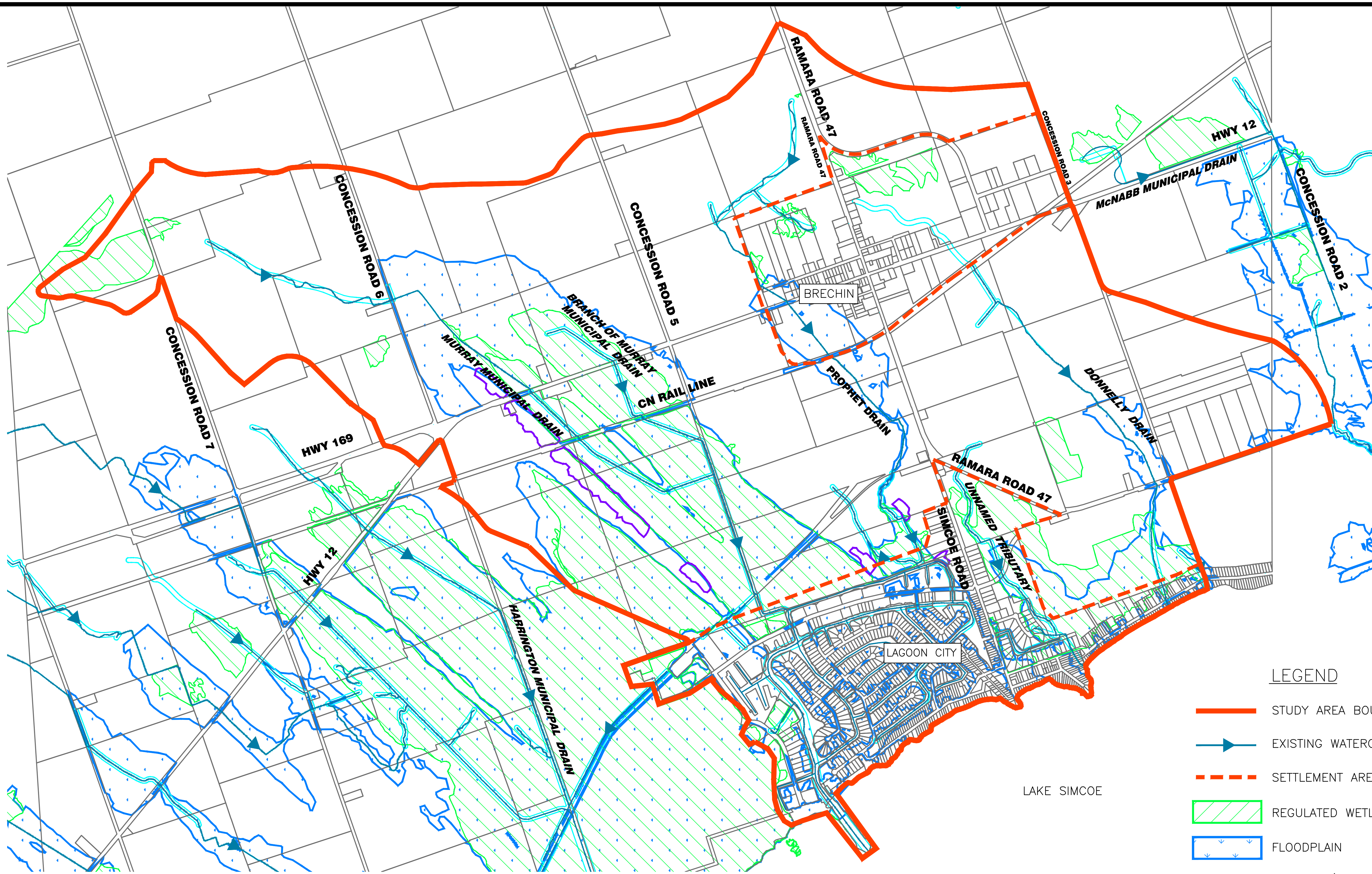
TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN

SOIL CLASSIFICATION

DWG. No. **FIG. 5**

SCALE: 1:25000 | DATE: SEPT 2015 | JOB NO. 312803



LEGEND

- STUDY AREA BOUNDARY
- EXISTING WATERCOURSE
- SETTLEMENT AREA BOUNDARY
- REGULATED WETLAND
- FLOODPLAIN
- EROSION (STEEP SLOPE)
- EROSION (MEANDERBELT)

Notes:
1. NATURAL HAZARD AREAS PROVIDED BY LSRCA, SEPTEMBER 2015.
2. THE WETLAND AREAS ARE AS IDENTIFIED BY MNRF.

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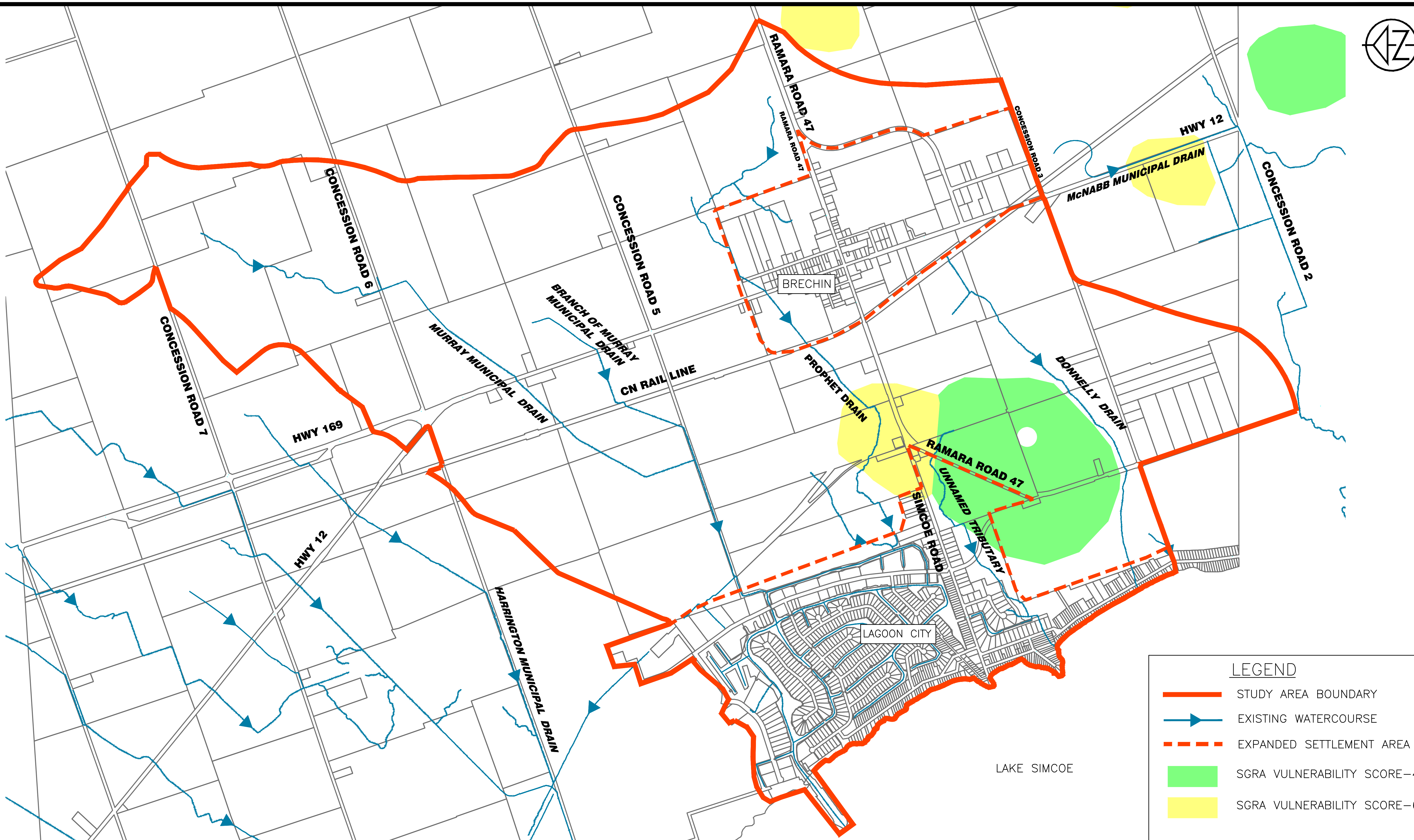
TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
NATURAL HAZARDS

DWG. No.
FIG. 6

SCALE: 1:25000 | DATE: SEPT 2015 | JOB NO. 312803



SIGNIFICANT GROUNDWATER RECHARGE AREA AND VULNERABILITY SCORES SHOWN ARE FROM APPROVED ASSESSMENT REPORT LAKE SIMCOE AND COUCHICHING BLACK RIVER SOURCE PROTECTION AREA PART 1: LAKE SIMCOE WATERSHED REPORT (LSRCA, 2011)

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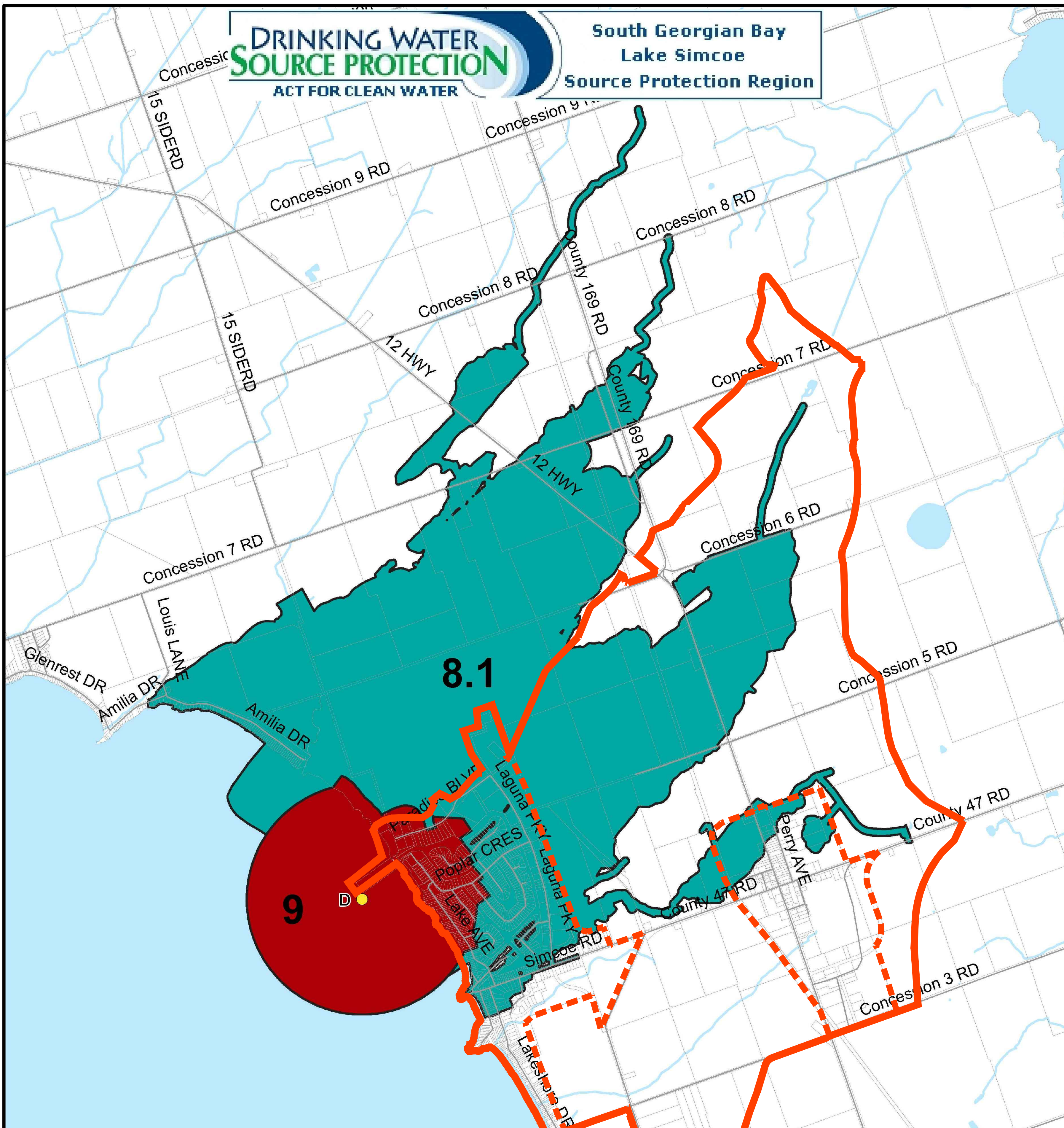
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN

SIGNIFICANT GROUNDWATER RECHARGE AREAS AND VULNERABILTY SCORES

DWG. No. **FIG. 7**

SCALE: 1:25000 | DATE: SEPT 2015 | JOB NO. 312803



Legend

- 9 — IPZ 1 AND VULNERABILITY SCORE
- 8.1 — IPZ 2 AND VULNERABILITY SCORE
- SURFACE WATER INTAKE (TYPE D)

N W E S

390 195 0 390 Metres

INTAKE PROTECTION ZONES AND VULNERABILITY SCORES - LAGOON CITY, RAMARA

DATE: JUNE 2010	SCALE: NTS
PROJECT: 0-071948.08	FILE. NO.:0-07194808F14.1-1

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.

GENIVAR Ontario

FIGURE **12c-1**

LEGEND

- STUDY AREA BOUNDARY
- SETTLEMENT AREA BOUNDARY

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Collingwood Bracebridge Orillia Barrie

TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
STUDY AREA WELLHEAD INTAKE PROTECTION AREA

SCALE: NTS	DATE: SEPT 2015	JOB NO. 312803

DWG. No. **FIG. 8**

NOTES:
1. THE WETLAND AREAS ARE AS IDENTIFIED BY THE MNRF (PROVIDED BY LSRCA, SEPTEMBER 2015)
2. AERIAL PHOTOGRAPH FROM COUNTY OF SIMCOE (2008)

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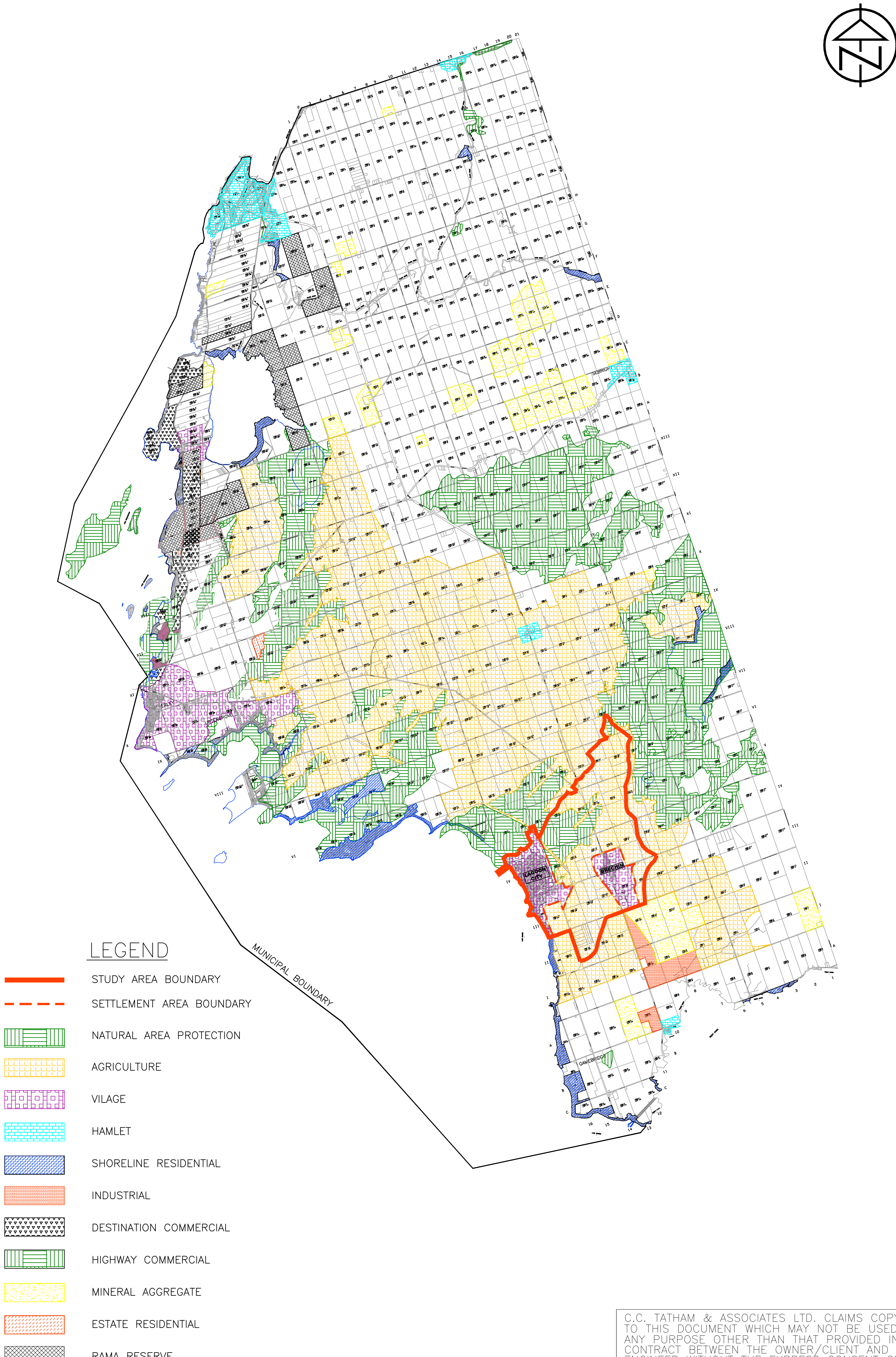
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
EXISTING LAND USES

DWG. No. **FIG. 9**

SCALE: 1:25000 | DATE: SEPT 2015 | JOB NO. 312803



NOTES:
1. DATA SHOWN IS FROM TOWNSHIP OF RAMARA OFFICIAL PLAN LAND USE PLAN DATED DECEMBER 2006.

C.C.Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
LAND USE PLAN

DWG. No. **FIG. 10**

SCALE: 1:125,000 | DATE: SEPT 2015 | JOB NO. 312803

NOTES:
1. LAND USE AREAS FROM TOWNSHIP OF RAMARA SCHEDULE 1–2 INTERIM SECONDARY PLAN DATED JULY 2003

C.C. Tatham & Associates Ltd.
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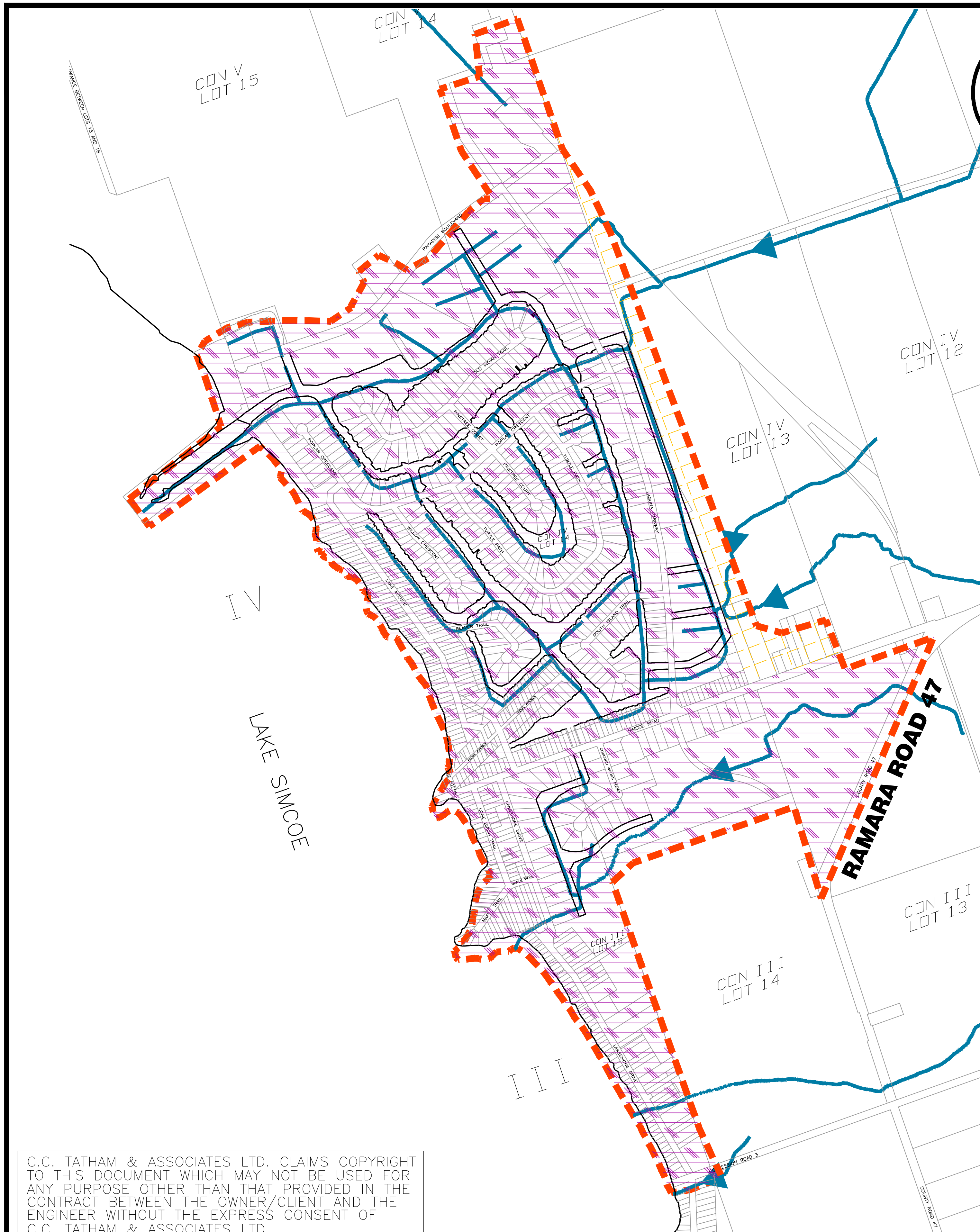
Collingwood Bracebridge Orillia Barrie

TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
INTERIM SECONDARY PLAN – BRECHIN VILLAGE

SCALE: 1:12,500	DATE: SEPT 2015	JOB NO. 312803

DWG. No.
FIG. 11



NOTES:
1. LAND USE AREAS FROM TOWNSHIP OF RAMARA SCHEDULE 1-3 INTERIM SECONDARY PLAN DATED JULY 2003

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

TOWNSHIP OF RAMARA
COMPREHENSIVE SWM MASTER PLAN
INTERIM SECONDARY PLAN – LAGOON CITY VILLAGE

DWG. No. **FIG. 12**

SCALE: 1:15,000 | DATE: SEPT 2015 | JOB NO. 312803

APPENDIX A:

MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT INFORMATION

TOWNSHIP OF RAMARA

"Proud History - Progressive Future"

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

NOTICE OF STUDY COMMENCEMENT & PUBLIC OPEN HOUSE

The Township of Ramara has initiated a Comprehensive Stormwater Management Master Plan (CSWM-MP) in accordance with the requirements of the Lake Simcoe Protection Plan (LSPP). The LSPP requires that all municipalities located in the Lake Simcoe watershed implement a CSWM-MP by June 2014. The underlying goal of the LSPP and CSWM-MP is to reduce phosphorous loadings to Lake Simcoe and improve the management of stormwater runoff from both existing and planned development.

This study is being executed in accordance with the planning and design process for Schedule 'B' projects as outlined in the Municipal Engineers Association *Municipal Class Environmental Assessment* document (October 2000, as amended in 2007 and 2011).

In particular, the CSWM-MP will be used to identify stormwater management improvement and retrofit opportunities, maintenance needs, and to make recommendations on design criteria and stormwater management approaches for future development in the settlement areas of Brechin and Lagoon City.

A Public Open House will be held at the Township Administration Office, 2297 Highway 12, Brechin on Thursday March 20, 2014, in the Council Chambers, from 3:00 p.m. to 5:00 p.m. to 6:00 p.m. to 8:00 p.m. to allow public and review agencies an opportunity to provide comments on the alternative solutions being proposed.

Subsequent to the Public Open House and a review of all concerns raised through public and agency comments, the Township will review the comments and recommend a preferred alternative(s). Those individuals and parties that requested to be kept informed of the Class EA process will be notified of the date that the preferred alternative(s) is presented to General Committee such that there is the opportunity for deputations to the next scheduled Council session, if required. Written comments and input are welcome. Comments and requests for information should be submitted to:

Deb McCabe, Planning Administrator
Township of Ramara
2297 Highway 12, P.O. Box 130
Brechin, Ontario
L0K 1B0
Tel: 705-484-5374
Fax: 705-484-0441
e-mail: dmccabe@ramara.ca

or

Tim Collingwood, B.A.Sc., P.Eng.
C.C. Tatham & Associates Ltd.
50 Andrew Street, Suite 100
Orillia, Ontario
L3V 7T5
Tel: 705-325-1753, ext 224
Fax: 705-325-7420
e-mail: tcollingwood@cctatham.com

This Notice issued February 20, 2014.

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre – March 20, 2014

SIGN-IN SHEET (please print)					
NAME	**STREET ADDRESS**	**TOWN/CITY**	**POSTAL CODE**	**AFFILIATION**	**EMAIL**
Joe Public	123 Your Street	Your Town	A1B 2C3	resident	joe@home.com
Steve Albanese		TORONTO	M5V 3E5	~~[illegible]~~ PLANNER	
K. Brenner		Orillia	L3V 6H6	[illegible]	
K Sipos					
MARIO. VELTRI.		BOWMANVILLE	L1C 3X2	PROPERTY OWNER	
RANDY PROVENCAL		BARRIE	L4N 5R7	Consultant Veltri Property	
[illegible]					
Bert Narrington		BRECHIN	L0K 1B0	RESIDENT	
SKIP BOGATTIG		BRECHIN	L0L 1B0	Resident	
John [illegible]		Brechin	L0K 1B0	"	
Erika [illegible]		Orillia	L3V 1P7	Resident	

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre
March 20, 2014

COMMENT SHEET (PLEASE PRINT)

ONEILL ST IS THE END OF THE STREETS TO THE TRACKS WHERE THE BIGGEST DRAINAGE PROBLEM IS

WATER WILL NOT GO PASSED THE TRACKS AND POOLS, THEN HEADS BACK UP ONEILL ST INTO ALL OF OUR BASEMENTS

THE DITCHES DONT DRAIN THEY NEED TO BE GRADED

AND THE HOUSE BESIDE 2240 BRECHIN MANOR IS PUMPING WATER CONSTANTLY ONTO MY PROPERTY

The information on this comment sheet is collected under the authority of the Environmental Assessment Act and will become public information. All comments will be included in the Class Environmental Assessment documentation to be made public at the conclusion of this project. Please check the space below if you wish your comments to be made anonymously.

Do you wish to be added to the project mailing list? You will be notified of the study conclusions. ☑ Yes ☐ No

☐ Please withhold my name and address from publication.

NAME: STEVE CANNON
STREET ADDRESS:
MAILING ADDRESS:
TOWN/CITY:
POSTAL CODE:
REPRESENTING:

Thank you for your input

Please hand to one of the project team members or email/mail/fax (by April 4, 2014) to:
Tim Collingwood, B.A.Sc., P. Eng., Director, Manager – Orillia Branch
C.C. Tatham & Associates Ltd.
50 Andrew Street South, Suite #100
Orillia, ON L3V 7T5 (fax) 705-325-7420
tcollingwood@cctatham.com

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre
March 20, 2014

COMMENT SHEET (PLEASE PRINT)

SEE ATTACHED COMMENTS

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Do you wish to be added to the project mailing list? You will be notified of the study conclusions. ☑ Yes ☐ No

☐ Please withhold my name and address from publication.

NAME: RANDY PROVENCAL (AECOM)
STREET ADDRESS:
MAILING ADDRESS:
TOWN/CITY:
POSTAL CODE:
REPRESENTING:

Thank you for your input

Please hand to one of the project team members or email/mail/fax (by April 4, 2014) to:
Tim Collingwood, B.A.Sc., P. Eng., Director, Manager – Orillia Branch
C.C. Tatham & Associates Ltd.
50 Andrew Street South, Suite #100
Orillia, ON L3V 7T5 (fax) 705-325-7420
tcollingwood@cctatham.com

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre

March 20, 2014

COMMENTS

- **The "Proposed Conditions Drainage Plan" shows a future SWM Facility (SWMF) to the west of Highway 12 to accommodate Catchment ID #213. This Catchment includes Draft Plan approved residential lands (RA-T-08-01) and a Commercial Block owned by Veltri & Son Limited. The approved Draft Plan includes a Stormwater Management Block within which a SWM Facility has been designed (Submissions provided to the Township) to accommodate both the residential and commercial lands. Why was this proposed SWM not identified on the "Proposed Conditions Drainage Plans" or in text associated with the Comprehensive Stormwater Management Plan?**

- **Will the proposed SWM Facility within the Draft Plan approved lands (RA-T-08-01) be included as an "optional SWMF location" given the lands has current status as part of the planning process?**

- **What process will the Veltri & Son Limited have to follow to satisfy current stormwater management draft plan conditions which are related to a proposed facility within the the (RA-T-08-01) Draft Plan and how does Veltri & Son Limited deal with timing requirements associated with the Draft Plan?**

- **Has the Owner of the property been notified of the proposed SWMF for Catchment 213?**

- **What planning mechanism's are in place or will be in place to establish a common stormwater facility to accommodate , in part, the Veltri Lands in a timely manner to coinicide with Draft Plan condition timelines for the Veltri Lands ?**

- **The "Proposed Conditions Drainage Plan" shows a "Donnelly Municipal Drain"extending from the CN rail line through to Lake Simcoe. Was this intended on being labled as a "Proposed Donnelly Municipal Drain"?**

- **Will recommendations be included within the Comprehensive Stormwater Management Plan for the establishment of a "Municipal Drain ? Will the recommendations include Township input.?**

- **As part of the Vetri & Son Limited Draft Plan (RA-T-08-01) dedications of land will be made to the Township for stormwater conveyance. Will the proposed Municipal Drain" (Identified as Donnelly) extend from the Highway 12 corridor across the lands**

located between Highway 12 and the CN Rail Line? This will provide for an uninterrupted drain for the Township from Highway 12 through to Lake Simcoe.

- **To what detail will implementation recommendations be included within the Comprehensive Stormwater Management Plan?**

- **Will there be the additional opportunities to review/comment on the proposed Comprehensive Stormwater Management Plan?**

- **We raise concerns that the progress and timing of satisfying Draft Plan Conditions of the Draft Approved Residential Land (RA-T-08-01) and the proposed Commercial Block owned by Veltri & Son Limited will be impacted by the proposed Stormwater Management Facility location associated with Catchment 213.**

AECOM, (Consultant for Veltri & Son Limited)

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre
March 20, 2014

COMMENT SHEET (PLEASE PRINT)

SEE ATTACHED COMMENTS

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Do you wish to be added to the project mailing list? You will be notified of the study conclusions. ☑ Yes ☐ No

☐ Please withhold my name and address from publication.

NAME: MARIO VELTRI
STREET ADDRESS:
MAILING ADDRESS:
TOWN/CITY:
POSTAL CODE:
REPRESENTING:

Thank you for your input

Please hand to one of the project team members or email/mail/fax (by April 4, 2014) to:
Tim Collingwood, B.A.Sc., P. Eng., Director, Manager – Orillia Branch
C.C. Tatham & Associates Ltd.
50 Andrew Street South, Suite #100
Orillia, ON L3V 7T5 (fax) 705-325-7420
tcollingwood@cctatham.com

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre

March 20, 2014

COMMENTS

- **The various proposed stormwater ponds, as part of the Comprehensive Stormwater Management Plan, drawing labled as “Proposed Conditions Drainage Plan” were all identified , at the meeting, to be located on lands owned by Talisker. A search on Google shows an overview of Lagoon City and states that a resort developer,Talisker, “ is working on a proposal for a big expansion” to Lagoon City. If this is correct then municipal officials in Brechin and Ramara must know of their plans. How does the proposed Comprehensive Stormwater Management Master Plan address the potential development by Talisker and how does their proposed development impact on my property (Veltri Property east of Highway 12)**

- **Has Talisker submitted a formal proposal for development? Have discussions taken place related to development and what is the nature of what is proposed?**

- **Has Talisker agreed to the various proposed pond locations?**

- **Has Talisker agreed to a municipal drain across their land located west of highway 12 and east of the CN Rail? (SWM Facilty location and property Owner “Talisker” identified at the public meeting)**

- **Will part of the reporting be a recommendation to establish a municipal drain downstream of my lands, Veltri Lands? We have contributed $7000 towards the establishment of a stormwater plan in the fall of 2013. I If improvements are required to establish a municipal drain what will my estimated cost be? What will be the timing of a proposed drain and when must the cost be paid ?**

Mario Veltri, Veltri & Son Limited

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre
March 20, 2014

COMMENT SHEET (PLEASE PRINT)

In the 205 Catchment area NW should remain in Agriculture, and have a complete 30' intervale tile drainage systematic system installed.

In the study boundray area systematic tile drainage ~~are~~ on all agricultural lands needs to be installed to reduce phosphourous loading.

In the Lake Simcoe watershed and study area it should be illegal to spread manure in late fall to proper conditions in the spring.

The settlement area boundrary needs to be maintained pernmanetly and never enlarged

In the ~~213~~ 213 catchment ~~area~~ the depth of soil existing needs to be measured and the stormwater pond area reduced it the soil is very shallow because the extra water from development area will be not that much more than what exists.

The information on this comment sheet is collected under the authority of the Environmental Assessment Act and will become public information. All comments will be included in the Class Environmental Assessment documentation to be made public at the conclusion of this project. Please check the space below if you wish your comments to be made anonymously.

See Over →

Do you wish to be added to the project mailing list? You will be notified of the study conclusions. ☑ Yes ☐ No

☐ Please withhold my name and address from publication.

NAME: Donald R. Mac Donald
STREET ADDRESS:
MAILING ADDRESS:
TOWN/CITY:
POSTAL CODE:
REPRESENTING:

Thank you for your input

Please hand to one of the project team members or email/mail/fax (by April 4, 2014) to:
Tim Collingwood, B.A.Sc., P. Eng., Director, Manager – Orillia Branch
C.C. Tatham & Associates Ltd.
50 Andrew Street South, Suite #100
Orillia, ON L3V 7T5 (fax) 705-325-7420
tcollingwood@cctatham.com

The use of infiltration tile systems needs to be incorporated for all stormwater.
The existing watercourse between concession 6 and 7 does not exist as it is tiled and runs underground mainly.

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre
March 20, 2014

COMMENT SHEET (PLEASE PRINT)

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Do you wish to be added to the project mailing list? You will be notified of the study conclusions. ☑ Yes ☐ No

☑ Please withhold my name and address from publication.

NAME: Don Goundrey
STREET ADDRESS:
MAILING ADDRESS:
TOWN/CITY:
POSTAL CODE:
REPRESENTING:

Thank you for your input

Please hand to one of the project team members or email/mail/fax (by April 4, 2014) to:
Tim Collingwood, B.A.Sc., P. Eng., Director, Manager – Orillia Branch
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TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre

March 20, 2014

COMMENTS AND RESPONSES

- **Oneill Street is the end of the streets to the tracks where the biggest drainage problem is.**

  The SWM-MP study is recommending a stormwater management facility immediately upstream of the CN Rail Line at the limit of the Brechin settlement boundary. A stormwater management facility at this location is expected to improve drainage in this area including reducing the potential for water to back up to Oneill Street.

- **Water will not go passed the tracks and pools then heads back up Oneill Street into all of our basements**

  See response to Comment #1 above.

- **The Ditches don't drain they need to be graded**

  Concerns related to the maintenance of ditches are to be directed to the Township Public Works Department.

- **The house beside 2240, Brechin Manor is pumping water constantly onto my property.**

  This concern should be directed to the Township Building Department.

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

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Public Information Centre

March 20, 2014

COMMENTS AND RESPONSES

- **The "Proposed Conditions Drainage Plan" shows a future SWM Facility (SWMF) to the west of Highway 12 to accommodate Catchment ID #213. This Catchment includes Draft Plan approved residential lands (RA-T-08-01) and a Commercial Block owned by Veltri & Son Limited. The approved Draft Plan includes a Stormwater Management Block within which a SWM Facility has been designed (Submissions provided to the Township) to accommodate both the residential and commercial lands. Why was this proposed SWM not identified on the "Proposed Conditions Drainage Plans" or in text associated with the Comprehensive Stormwater Management Plan?**

  The above comment has been considered and the SWMF originally proposed west of Highway 12 has been moved east of Highway 12 thereby respecting the status of the residential and commercial lands on the east side of Highway 12 which make up the majority of lands in Catchment 213. A second SWMF is recommended for the area west of Highway 12.

- **Will the proposed SWM Facility within the Draft Plan approved lands (RA-T-08-01) be included as an "optional SWMF location" given the lands has current status as part of the planning process?**

  The proposed SWM Facility within the Draft Plan approved lands will be the proposed SWMF for Catchment 213. Final design of the SWM facility will need to comply with the recommendations of the SWM-MP report.

- **What process will the Veltri & Son Limited have to follow to satisfy current stormwater management draft plan conditions which are related to a proposed facility within the the (RA-T-08-01) Draft Plan and how does Veltri & Son Limited deal with timing requirements associated with the Draft Plan?**

  SWM Draft Plan conditions can be completed at any time. As noted above, final design of the proposed SWM facility will need to consider the recommendations of the final SWM-MP document.

- **Has the Owner of the property been notified of the proposed SWMF for Catchment 213?**
  The Owner has been circulated the notice of Public Information Centre including access to public information. No specific notices have been issued to the Owner of the lands west of Highway 12 east of the railway tracks.

- **What planning mechanism's are in place or will be in place to establish a common stormwater facility to accommodate , in part, the Veltri Lands in a timely manner to coincide with Draft Plan condition timelines for the Veltri Lands ?**

  Since the location of the SWMF is now located on the Veltri lands, construction of the SWM facility is expected to proceed with the proposed residential and commercial developments.

- **The "Proposed Conditions Drainage Plan" shows a "Donnelly Municipal Drain"extending from the CN rail line through to Lake Simcoe. Was this intended on being labeled as a "Proposed Donnelly Municipal Drain"?**

  The Donnelly Drain is listed on the Ontario Ministry of Agriculture and Food website as the "Donnelly Municipal Drain D-5" however there are no by-laws on file at the Municipality to confirm the status of the drain. The Proposed Conditions Drainage Plan will be revised since the status of the drain cannot be confirmed at this time.

- **Will recommendations be included within the Comprehensive Stormwater Management Plan for the establishment of a "Municipal Drain ? Will the recommendations include Township input.?**

  A petition for a municipal drain can be initiated by any land owner. However at this time, the drain would extend across lands that are not proposed for development as per the Township's official plan. At this stage, it is not known whether or not outlet improvements are required to support the Veltri lands. This is to be evaluated by the developer's consultant in accordance with the Draft Plan Conditions. On this basis, proposing a municipal drain will not be a recommendation of the SWM-MP.

- **As part of the Vetri & Son Limited Draft Plan (RA-T-08-01) dedications of land will be made to the Township for stormwater conveyance. Will the proposed Municipal Drain" (Identified as Donnelly) extend from the Highway 12 corridor across the lands located between Highway 12 and the CN Rail Line? This will provide for an uninterrupted drain for the Township from Highway 12 through to Lake Simcoe.**

  A petition for a municipal drain is not being initiated by the Township at this time.

- **To what detail will implementation recommendations be included within the Comprehensive Stormwater Management Plan?**

  The SWM-MP will provide the framework for implementation of the proposed alternatives and recommendations. Details of the proposed alternatives and recommendations will be resolved by the Township prior to implementation.

- **Will there be the additional opportunities to review/comment on the proposed Comprehensive Stormwater Management Plan?**

The final SWM-MP document will be available to the public for a minimum of 30 days prior to adoption by council. Comments will be received during this period for consideration by council.

- **We raise concerns that the progress and timing of satisfying Draft Plan Conditions of the Draft Approved Residential Land (RA-T-08-01) and the proposed Commercial Block owned by Veltri & Son Limited will be impacted by the proposed Stormwater Management Facility location associated with Catchment 213.**

  As indicated above, the location of the SWMF for Catchment 213 has been relocated onto the Veltri lands thereby relieving concerns of having a SWMF to service the Veltri lands on another land owners property.

AECOM, (Consultant for Veltri & Son Limited)

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre

March 20, 2014

COMMENTS AND RESPONSES

- **The various proposed stormwater ponds, as part of the Comprehensive Stormwater Management Plan, drawing labled as "Proposed Conditions Drainage Plan" were all identified , at the meeting, to be located on lands owned by Talisker. A search on Google shows an overview of Lagoon City and states that a resort developer,Talisker, " is working on a proposal for a big expansion" to Lagoon City. If this is correct then municipal officials in Brechin and Ramara must know of their plans. How does the proposed Comprehensive Stormwater Management Master Plan address the potential development by Talisker and how does their proposed development impact on my property (Veltri Property east of Highway 12)**

  The Stormwater Management Master Plan is intended to address the servicing needs of existing and future development lands that are identified in the Township's Official plan. The lands in question are located outside of the settlement boundaries of both Brechin and Lagoon City.

- **Has Talisker submitted a formal proposal for development? Have discussions taken place related to development and what is the nature of what is proposed?**

  There has been no formal development proposal by talisker.

- **Has Talisker agreed to the various proposed pond locations?**

  The proposed ponds have been located in specific areas to most effectively control stormwater runoff from existing and future development lands including consideration of long term maintenance by the Municipality. The locations were first presented to the public for comment at the PIC.

- **Has Talisker agreed to a municipal drain across their land located west of highway 12 and east of the CN Rail? (SWM Facilty location and property Owner "Talisker" identified at the public meeting)**

  A municipal drain has not been petitioned west of Highway 12 and east of the CN Rail.

- **Will part of the reporting be a recommendation to establish a municipal drain downstream of my lands, Veltri Lands? We have contributed $7000 towards the establishment of a stormwater plan in the fall of 2013. I If improvements are required**

to establish a municipal drain what will my estimated cost be? What will be the timing of a proposed drain and when must the cost be paid ?

There is no proposal to establish a municipal drain.

Mario Veltri, Veltri & Son Limited

TOWNSHIP OF RAMARA
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Municipal Class EA

Public Information Centre

March 20, 2014

COMMENTS AND RESPONSES

- **In the 205 Catchment area NW should remain in agriculture and have a complete 30' interval tile drainage systematic system installed.**

  The land located in Catchment 205 is within the Brechin settlement boundary and designated for development as defined by the Township Official Plan.

- **In the study boundary area systematic tile drainage on all agricultural lands needs to be installed to reduce phosphorous loading.**

  The comparison of phosphorous loading from agricultural fields with and without tile drains is highly variable and depends on site specific conditions. This can be looked at on an individual site basis but is outside of the scope of this study.

- **In the Lake Simcoe watershed and study area it should be illegal to spread manure in late fall until proper conditions in the spring.**

  The application of manure in the fall can contribute to elevated phosphorous loading on Lake Simcoe in the Spring. Manure spread after the spring freshet in the spring has the potential to reduce such loadings to Lake Simcoe. Timing for application of manure in agricultural areas fall within Alternative 20 and was selected as a preferred alternative recommended in this SWM MP.

- **The settlement area boundary needs to be maintained permanently and never enlarged.**

  The settlement boundary limits used for this study are as per the Township's current Official Plan Land Use schedule 'A'. Any future adjustments to the settlement boundary limits are outside the scope of this study.

- **In the 213 catchment area the depth of soil existing needs to be measured and the stormwater pond area reduced if the soil is very shallow because the extra water from development area will not be that much more than what exists.**

  The stormwater pond in Catchment 213 will be designed considering existing soil conditions and a number of other parameters.

- **The use of infiltration tile systems needs to be incorporated for all stormwater.**

  Infiltration of stormwater runoff is an objective of the SWM-MP in order to maintain the existing water balance as much as possible.

- **The existing watercourse between Concession 6 and 7 does not exist as it is tiled and runs underground mainly.**

  We confirm the existing watercourse between Concession 6 and 7 is primarily conveyed underground via an existing tile drainage system. During periods of higher flows, runoff is expected to drain overland along the general alignment shown on the SWM-MP figures.

APPENDIX B:
BACKGROUND CORRESPONDENCE

C.C. Tatham & Associates Ltd.
Consulting Engineers

Collingwood Bracebridge Orillia Barrie

41 King Street, Unit 4
Barrie, Ontario L4N 6B5
Tel: (705) 733-9037
Fax: (705) 733-1520
Email: info@cctatham.com
Web: www.cctatham.com

MEMO

Date:	June 29, 2012	Pages: 5		CCTA File:	312803
To:	Tom Hogenbirk/Charles Burgess	Lake Simcoe Region Conservation Authority		Via:	email

From: Dan Hurley, B.A.Sc., P.Eng., LEED AP
Vice President, Manager - Water Resources Engineering

Tim Collingwood, B.A.Sc., P.Eng.
Director, Manager - Orillia Branch

Subject: Brechin Master Stormwater Management (SWM) Plan
Terms of Reference

We have been retained by the Township of Ramara to prepare a Master SWM Plan for the Lagoon City and Brechin settlement areas in accordance with the Minsitry of Environment (MOE) Lake Simcoe Protection Plan (LSPP) Policy 4.5-SA (June 2009). Prior to advancing past Step Two of this work plan; we have prepared the following Terms of Reference to outline the key project steps in accordance with the Lake Simcoe Region Conservation Authority (LSRCA) Comprehensive SWM Master Plan Guidelines (April 2011). Our work plan recognizes the intent of the LSPP and has been organized according to Steps 1-10 of the LSRCA guidelines.

At the onset of the project, we reviewed the background and prepared this work plan with the intent of meeting with the LSRCA on a pre-consultation basis to review the project and methodology in detail.

Our work plan has been broken down according to the LSRCA guidelines as follows:

<u>Step One - Scoping</u>

"Settlement Areas" are defined by the LSPP as urban areas and rural areas where development is concentrated and lands are designated in municipal official plans for development over the long term. At this stage we have identified two areas that we feel are characterized as settlement areas according to the LSPP definition. These include Lagoon City (including the growth area identified in the Official Plan) and Brechin proper. The settlement area boundaries are sketched on the attached plan.

Step Two – Determine the Study Area for the Settlement Area

The Brechin Master SWM Plan Study Area will encompass both settlement areas including identified growth areas and known development proposals. The Lagoon City settlement area will include the future Lagoon City Holdings 128 unit medium density condo development (draft plan approved) and the future Harrington 128 unit development (preliminary design stage). The remaining growth area, Concord Woods, has no development proposals however 579 units are assumed based on Official Plan designation.

The Brechin settlement area will include the future Veltri development (draft plan approved). The remaining growth area including Perry Avenue and Highway 12 have no development proposals however 329 units and 174 units respectively are assumed based on the Official Plan designation. The Brechin settlement area also includes approximately 35 hectares of industrial lands on Herrigan Drive which has no development proposals however these have also been assumed based on Official Plan designation.

The Study Area will include littoral zones and adjacent catchment areas which direct overland drainage or flow along ditches or swales into the settlement area.

Step Three – Develop a Characterization of the Study Area

We will evaluate background technical information including direction and policies provided in regional, county and provincial plans that apply to the Study Area. These include but are not limited to: the Lake Simcoe Protection Plan, the Growth Plan, the Provincial Policy Statement, master servicing plans, watershed and subwatershed plans, Source Water Protection Areas etc.

This step will also characterize the Study Area according to a broad range of factors detailed in the LSRCA guideline document including: the Study Area in a watershed context, planning and zoning , natural heritage, soil conditions, natural hazards, significant groundwater features and functions, surface water features and functions, wellhead and intake protection areas, existing SWM facilities, areas of known environmental degradation, existing land uses, area requiring remedial strategies, SWM retrofit opportunities, potential land use changes, transportation network and related facilities, utility corridors and data sources.

The majority of the above information will discussed with the LSRCA at the time of the pre consultation meeting with the intent of confirming whether or not more detailed studies will be required at this stage.

Step Four – Divide the Area into Management Units Where Appropriate

The Study Area is separated geographically into two settlement areas: Lagoon City and Brechin proper. At this stage, we anticipate a single management unit will be sufficient for analysing the overall Study Area. However, the need for two management units will be confirmed according to the information collected at the characterization of the Study Area (Step Three) stage.

Step Five – Evaluate the Cumulative Environmental Impact of Stormwater from Existing and Planned Development

Using the Study Area characterization developed in Step Three, we will develop several existing condition models including a water balance model, a hydrologic model, and a phosphorus loading model. The intent of these models will be to identify and minimize as much as is possible the potential impacts of stormwater, erosion and sedimentation and nutrient loading generated by existing and future planned development.

The level of detail for the water balance will be determined according to the information gathering as part of Step Three (as it relates to recharge areas) in consultation with the LSRCA.

For each settlement area we will utilize a unit area phosphorus loading spreadsheet (applicable for settlement areas <750 ha) for estimating phosphorus loads based on existing and proposed land use. We will consult with the LSRCA for appropriate selection of unit area loads.

We will prepare an existing condition hydrologic model for each settlement area to calculate peak flows for the 2-year through 100-year design storm events. Background information relating to existing development and SWM infrastructure will be incorporated into each model. All future planned development will also be modelled using the latest development proposals or assumed development based on Official Plan designation to identify the need for increased attenuation or storage requirements as part of future development.

An erosion analysis is also required for both existing and future conditions. The level of detail for the erosion analyses will be determiend through consultation with the LSRCA.

Step Six – Determine the Effectiveness of Existing Stormwater Management Systems

Lagoon City is comprised of open ditches and swales which outlet to a network of canals. The canals are hydraulically connected to Lake Simcoe. There are no water quality and/or quantity control facilities in Lagoon City.

Brechin proper is comprised of mostly open ditches with some storm sewer along Highway 12 and Ramara Road 47 which outlet to an open ditch along Ramara Road 47 and drain to Lake Simcoe. Several SWM facilities exist in Brechin Proper including two small SWM ponds located at the Brechin School and the Brechin industrial park. Using the available background information including as-built drawings, SWM reports, MOE C of A's etc., we will develop an inventory of each facility including location, age, original design capacity, treatment objectives (i.e quantity control only, quality and quantity) and maintenance history. This information will be provided in table format and data gaps will be identified.

We will complete a site visit to each facility location for visual inspections and photographic log purposes to ascertain how current facility operation matches with the design intent.

The need for a field survey of each existing SWM facility to compare against the original facility design will be discussed at the pre-consultation meeting.

Step Seven – Identify and Evaluate Stormwater Improvement and Retrofit Opportunities

We have reviewed the Lake Simcoe Basin Stormwater Management and Retrofit Opportunities Report (2007) however the ponds located within the Study Area were not discussed. Accordingly we will consult with the LSRCA whether or not any background studies which identify areas within the Study Area where stormwater is inadequately controlled including opportunities to retrofit or redesign existing SWM facilities.

Using the data collected in Step Six, we will thoroughly evaluate all the opportunities for SWM facility retrofits and determine the most effective treatment level possible for each existing pond location. For each potential existing SWM pond, retrofit cost estimates and the expected water quality treatment efficiency and phosphorus load reductions will be determined. This will allow the retrofits to be prioritized considering a number of factors including total phosphorus removal potential, total construction cost, public safety, long term maintenance and ease of implementation. This will be provided in table format. We will also consider the Climate Change Adaptation Strategy developed as per Policy 7.11 - SA of the LSPP as it relates to SWM.

Water quantity controls are specified to mitigate increased peak flow impacts on downstream receivers. Since Lake Simcoe is the direct receiver of runoff from Lagoon City, water quantity controls would not serve any purpose and should not be required. However, we will evaluate opportunities to provide water quality controls including the use of Low Impact Development (LID) measures.

Opportunities to provide water quality and quantity controls including the use of LIDs will be evaluated throughout Brechin proper.

We will discuss these with the LSRCA and incorporate any work completed to date related to retrofit opportunities.

Step Eight – Establish a Recommended Approach for Stormwater Management for the Study Area

Under this task the data and information collected from Steps 1-7 will be consolidated and prioritized to present an overall SWM strategy for identifying targets and objectives to guide the development of management approaches and techniques for future development and improvement of the existing stormwater infrastructure as per the relevant LSPP policies.

This will include broad management approaches for the management units within the Study Area and Identification of LID and phosphorous removal techniques to be promoted with new development. Also included will be identification of policies to be incorporated into the Official Plan to ensure the SWM strategy is incorporated as part of the overall municipal planning approach (if required).

In accordance with Phase 2 of the Municipal Class EA planning process the strategy will provide a statement of problems, opportunities and will identify other alternatives that have been considered in the development of the strategy and justify why the recommended approach was deemed to be preferable to these alternatives.

Step Nine – Develop an Implementation Plan for the Recommended Approaches

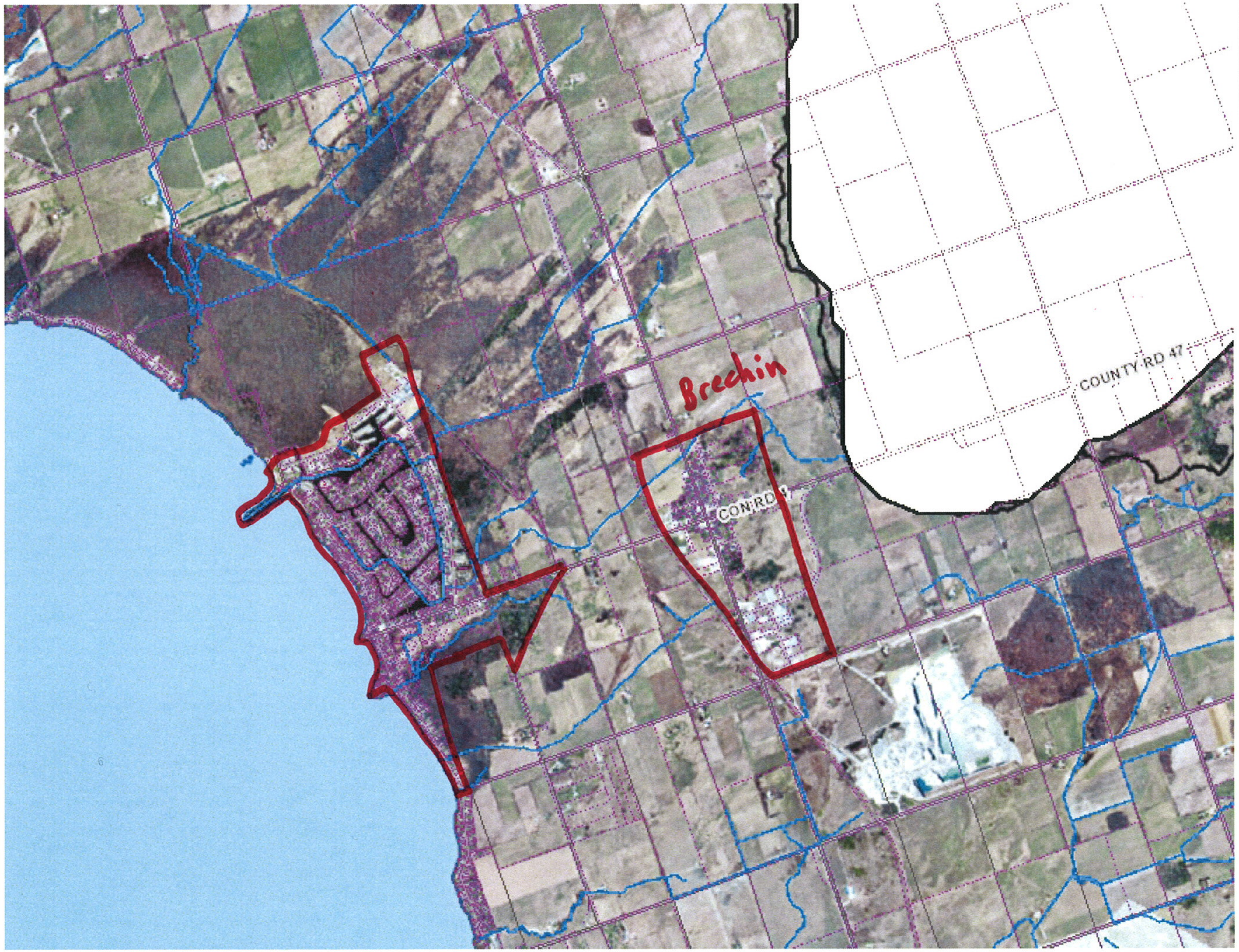
An implementation strategy for the recommended approach will be prepared. It will identify the responsibility, schedule and potential funding sources for upgrading and maintaing the SWM facilities as well as the mechanisms and requirements that developers will need to address related to SWM requirements as part of new development and or redevelopment including LID measures The implementation strategy will apply to the design and construction phases of development or redevelopment to assist in meeting policy DP-4.20 of the LSPP.

The implementation plan will also include responsibility, scheduling and potential funding sources for integration of new SWM practices into public open space planning, design and maintenance, and potential funding sources for stewardship programs for the development of public education programs.

Step Ten – Develop Programs for Inspection and Maintenance of Stomrwater Management Facilities

An inspection and maintenance program will be developed to verify and ensure the works specified in Steps 7-9 will be implemented during construction and be maintained throughout the intended life of the works in the manner intended. This will include developing an overall annual inspection and maintenance schedule.

Lake Simcoe Region Conservation Authority



Features

- LSRCA Watershed Mask
- Watercourse
- Lot and Concession
- LSRCA Boundary
- Lake Simcoe
- Lake Couchiching
- Hwy 400 Series
- Highways & Arterials
- Local Roads
- Lower Tier Municipalities

Printed On:
1/21/2011

Produced on Public Internet Mapping Site

Scale 1: 45,000

2,286	0	1,143	2,286	Meters

C.C. Tatham & Associates Ltd.
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Web: www.cctatham.com

MEETING MINUTES

Meeting Date: July 12, 2012 **Time:** 1:00 pm **CCTA File:** 312803

Location: CCTA Barrie Office Boardroom

Attendees:

Charles Burgess	Lake Simcoe Region Conservation Authority (LSRCA)
Tom Hogenbirk	Lake Simcoe Region Conservation Authority (LSRCA)
Jeremy Ash	C. C. Tatham & Associates Ltd. (CCTA)
Tim Collingwood	C. C. Tatham & Associates Ltd. (CCTA)

Purpose: Brechin Stormwater Management (SWM) Master Plan
Pre-Consultation Meeting

Meeting Item	Action
1. Introductions	
CCTA introduced the project team and had a brief discussion with the LSRCA related to other SWM master plans currently underway in the Lake Simcoe basin.	
2. Background Information	
LSRCA has provided CCTA with a list of available GIS layers applicable to the Township of Ramara.	
CCTA will review the available background information for the Township of Ramara and request additional information from the County of Simcoe and LSRCA where data gaps exist.	CCTA
The LSRCA confirmed a large portion of their information is available online and information requested from the LSRCA will be provided on a cost recovery basis.	
CCTA to prepare a background information request master list to send to the LSRCA.	CCTA
3. CCTA Terms of Reference	
CCTA discussed Steps 1-10 of the LSRCA Comprehensive SWM Master Plan Guidelines (April 2011) as per the Terms of Reference dated June 29, 2012.	
LSRCA and CCTA discussed the LSRCA SWM master plan matrix included in	

Meeting Item	Action
Schedule 2 of the Comprehensive SWM Master Plan Guideline document. This matrix clarifies the core requirements at each step.	
<u>Step 1 - Scoping</u>	
CCTA identified the two settlement areas according to the Lake Simcoe Protection Plan (LSPP) definition located in the Township of Ramara, namely Lagoon City and Brechin proper.	
<u>Step 2 – Determine the Study Area for the Settlement Area</u>	
CCTA proposed to have both settlement areas included as part of the overall Brechin SWM Master Plan Study Area due to their size and close proximity.	
LSRCA confirmed this is appropriate and explained multiple study areas are generally required for larger settlement areas with distinct characterizations.	
<u>Step 3 – Develop a Characterization of the Study Area</u>	
CCTA will utilize all of the available background information to characterize the Study Area according to the range of factors listed in the LSRCA SWM Master Plan Guidelines document. The characterizations will include direction and policies (i.e. LSPP, the Growth Plan, etc.) as well as physical watershed characteristics (i.e. natural hazards, soil conditions etc.).	CCTA
<u>Step 4 – Divide the Area into Management Units Where Appropriate</u>	
CCTA explained a single management unit for analysing the overall study area is expected. However, this will be confirmed upon completion of step three once the Study Area has been characterized.	
<u>Step 5 – Evaluate the Cumulative Environmental Impact of Stormwater from Existing and Planned Development</u>	
CCTA will be developing existing condition water balance, hydrologic, and phosphorus loading models. The LSRCA confirmed the expectations for each model as follows:	CCTA
The water balance model is to be completed as a desktop analysis using the available land use and soils information collected as part of step three.	
The hydrologic model is to be completed using Visual Otthymo or an equivalent model applicable to large drainage areas to calculate peak flows for the 2-year through 100-year design storm events. Areas draining to a SWM pond should be separated to appropriately model the peak flow attenuation effects of the SWM ponds. All future planned development will be modelled using the latest proposals	

Meeting Item	Action
or assumed development based on official plan designation.	
A continuous simulation model such as PC SWMM (or equivalent) will be considered if required for analysing existing and future development erosion analyses.	
The phosphorus loading model is to be completed as desktop analysis (i.e. spreadsheet) using unit area loadings for estimating existing and future land use loadings. CCTA discussed using the Berger 2010 report phosphorus unit area loading values which are applicable to the Lake Simcoe basin. LSRCA confirmed these values are applicable for use with this study. All phosphorus related questions should be directed to Rob Baldwin (LSRCA).	
LSRCA confirmed existing and future condition erosion analyses are required for each receiving watercourse where future development is proposed upstream. LSRCA confirmed the erosion analyses are also required for Municipal drains in order to prevent complicated cost sharing arrangements between property owners related to future maintenance or improvements to Municipal drains.	
The LSRCA expects a fluvial geomorphologist to conduct the erosion analyses.	
<u>Step 6 – Determine the Effectiveness of Existing Stormwater Management Systems</u>	
CCTA described the existing SWM infrastructure in Lagoon City and Brechin proper and will complete a site visit to each SWM pond for a visual inspection.	
LSRCA confirmed each SWM pond is to be analysed qualitatively based on the existing conditions observed on site. The purpose of the pond assessments is not to assess the maintenance requirements or priority of maintenance. On this basis an existing survey of each site is not required.	
<u>Step 7 – Identify and Evaluate Stormwater Improvement and Retrofit Opportunities</u>	
LSRCA confirmed they have no background information for the SWM ponds located in Ramara.	
Using the information gathered from Step 6, CCTA will determine whether or not the existing SWM ponds are deficient or built to current standards.	CCTA
LSRCA discussed the potential for phosphorus credit opportunities for improvements made to existing SWM ponds.	
LSRCA also confirmed a strong section of the SWM master plan should be dedicated to climate change and potential improvements to the existing SWM ponds in consideration of climate change. An example discussed at the meeting was of an existing SWM pond with an insufficient emergency overflow spillway to convey flows from more frequent storm events expected to occur as a result of climate change.	

Meeting Item	Action
Increasing the capacity of the overflow weir would be an example of a SWM pond improvement to handle the effects of climate change.	
LSRCA also discussed public education and awareness related to application of residential lawn fertilizers and pesticides etc. as a possible LID measure that could be incorporated in Lagoon City as a water quality improvement opportunity.	
Step 8 – Identify and Evaluate Stormwater Improvement and Retrofit Opportunities	
CCTA will consolidate the information from Steps 1-7 and present an overall SWM strategy identifying targets and objectives. In accordance with the Phase 2 Municipal Class EA planning process CCTA will provide a statement of problems, opportunities and identify alternatives considered in developing the preferred alternative.	CCTA
LSRCA requested a section in the SWM master plan dedicated to the Municipal Class EA process and how it was followed throughout the SWM master plan.	
Step 9 – Develop an Implementation Plan for the Recommended Approaches	
CCTA discussed the approach to developing an implementation plan for the preferred alternative including recommended policies, public education, recommended amendments to official plans, funding sources etc.	
Step 10 – Develop Programs for Inspection and Maintenance of Stormwater Management Ponds	
CCTA will prepare an overall inspection and maintenance program to ensure the works in Steps 7-9 are implemented during construction and maintained through the intended life of the works.	CCTA
4. General Discussion	
LSRCA discussed the importance of clear well thought out recommendations as the key to the SWM master document.	
LSRCA discussed that throughout the development of the SWM master plan the LSPP Section 4.5-SA should be examined by CCTA to confirm all of the requirements are being met.	
LSRCA discussed other SWM master plans they are aware of currently underway including the City of Barrie (annexed lands), Town of Aurora and Town of East Gwillimbury.	
LSRCA also noted Atherley/Uptergrove is considered a settlement area and thus requires a SWM master plan also. CCTA confirmed a SWM master plan for this	CCTA

Meeting Item	Action
settlement area will be prepared under separate cover. 5. Errors & Omissions Please report any errors or omissions to the author within seven days of receipt of these minutes otherwise they will be deemed correct.	

Respectfully submitted,
C. C. Tatham & Associates Ltd.

Jeremy Ash, B.Sc.Eng., P.Eng.
JA/TCC:ml

Distribution
All present, Rick Bates (Township of Ramara), Dan Hurley

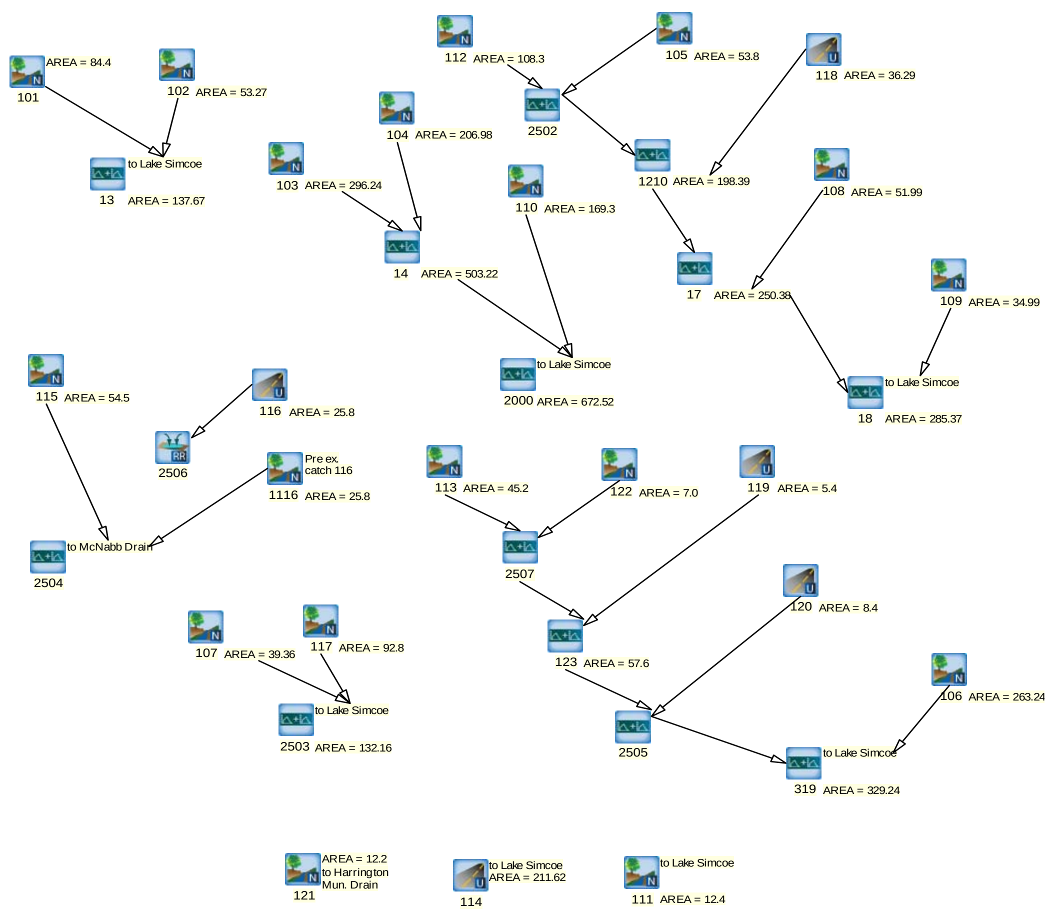
S:\2012\312803 - Brechin Master Drainage Plan\Word Documents\Meeting Minutes\MM - Minutes001 - Pre-Consultation Meeting with LSRCA.doc

APPENDIX C:
HYDROLOGIC MODEL DETAILED OUTPUT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Project:	Township of Ramara CSWMMP
Date:	Oct-15
File No.:	312803
Designed By:	JA
Checked By:	DJH
Subject:	Hydrologic Model Schematic

TOWNSHIP OF RAMARA SWM MASTER PLAN
HYDROLOGIC MODEL SCHEMATIC: EXISTING CONDITIONS



Nashyd	Route Pipe	Duhyd
Standhyd	Route Channel	Diverthyd
Addhyd	Route Reservoir	

C.C. Tatham & Associates Ltd. Consulting Engineers	Project:	Township of Ramara SWM Master Plan
Collingwood Bracebridge Orillia Barrie	File No.:	312803
	Date:	31-Jul-14
	Designed By:	JA
	Checked By:	DJH
	Subject:	Subwatershed Catchments

Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 101 **Area** 84.40 ha

WEIGHTED CN VALUE																									
Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
				Type	Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
M	MUCK	B	Muck	2	32.072	0.38	0	0	60	0.6414	0.02	69	0	0	65	0	0	80	0	0	100	31.431	0.98	50	50.38
VASL	VASEY	AB	Sand Loam	1	28.696	0.34	13.774	0.48	0.48	0	0	59	0	0	51	8.0349	0.28	80	0	0	100	6.887	0.24	50	34.6304
LVC	LOVERING	CD	Clay Loam or Clay	3	23.632	0.28	0	0	76	0	0	82	0	0	79	18.433	0.78	84	0	0	100	5.199	0.22	50	76.52
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**84.4**	**1**	**13.7741**	**0.1632**		**0.64144**	**0.0076**		**0**	**0**		**26.4678**	**0.3136**		**0**	**0**		**43.5166**	**0.5156**		**52.3**
																							CN (AMC III):		**71.6**

Time of Concentration Calculations

Initial Abstraction	**10.0524 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	232	m
Minimum Catchment Elevation	220	m
Catchment length	1950	m
Catchment Slope	1%	
Catchment Area	84.4	ha
Time of Concentration (Minutes)	**78.60**	
Time of Concentration (Hours)	**1.31**	
Time to Peak (2/3 x Time of Concentration)	**0.87**	

Time to Peak	**1.72 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	232	m
Minimum Catchment Elevation	220	m
Catchment length	1950	m
Catchment Slope	1%	
Catchment Area	84.4	ha
Time of Concentration (Minutes)	**155.11**	
Time of Concentration (Hours)	**2.59**	
Time to Peak (2/3 x Time of Concentration)	**1.72**	

Runoff Coefficient	**0.18**

Landuse Type	Soil Series				
	M	VASL	LVC	0	0
	2	1	3	#N/A	#N/A
Forest/Woodland	0.25	0.08	0.35	#N/A	#N/A
Cultivated	0.35	0.22	0.55	#N/A	#N/A
Pasture/Lawn	0.28	0.1	0.4	#N/A	#N/A
Impervious	0.95	0.95	0.95	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	0.05	#N/A	#N/A
Meadows	0.27	0.09	0.38	#N/A	#N/A
Soil Series Total	0.0546	0.112	0.44	#N/A	#N/A

Project:	Township of Ramara SWM Master Plan
File No.:	312803
Date:	31-Jul-14
Designed By:	JA
Checked By:	DJH
Subject:	Subwatershed Catchments

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 102 **Area** 53.27 ha

WEIGHTED CN VALUE

Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient Type	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
					Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
vasl	VASEY	AB	Sand Loam	1	17.0464	0.32	0	0	46	0	0	59	0	0	51	17.046	1	80	0	0	100	0	0	50	80
lvc	LOVERING	CD	Clay Loam or Clay	3	36.2236	0.68	0	0	76	0	0	82	0	0	79	36.224	1	80	0	0	100	0	0	50	80
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0	0	#N/A	0		#N/A	0		#N/A	0	0	#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0	0	#N/A	0		#N/A	0		#N/A	0	0	#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**53.27**	**1**	**0**	**0**		**0**	**0**		**0**	**0**		**53.27**	**1**		**0**	**0**		**0**	**0**		**80.0**
																							CN (AMC III):		**90.2**

Time of Concentration Calculations

Initial Abstraction	**7 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	232	m
Minimum Catchment Elevation	220	m
Catchment length	1230	m
Catchment Slope	1%	
Catchment Area	53.27	ha
Time of Concentration (Minutes)	**47.35**	
Time of Concentration (Hours)	**0.79**	
Time to Peak (2/3 x Time of Concentration)	**0.53**	

Time to Peak	**0.53 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	232	m
Minimum Catchment Elevation	220	m
Catchment length	1230	m
Catchment Slope	1%	
Catchment Area	53.27	ha
Time of Concentration (Minutes)	**75.57**	
Time of Concentration (Hours)	**1.26**	
Time to Peak (2/3 x Time of Concentration)	**0.84**	

Runoff Coefficient	**0.44**

Landuse Type	Soil Series				
	vasl	lvc	0	0	0
	1	3	#N/A	#N/A	#N/A
Forest/Woodland	0.08	0.35	#N/A	#N/A	#N/A
Cultivated	0.22	0.55	#N/A	#N/A	#N/A
Pasture/Lawn	0.1	0.4	#N/A	#N/A	#N/A
Impervious	0.95	0.95	#N/A	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	#N/A	#N/A	#N/A
Meadows	0.09	0.38	#N/A	#N/A	#N/A
Soil Series Total	0.22	0.55	#N/A	#N/A	#N/A

Project:	Township of Ramara SWM Master Plan
File No.:	312803
Date:	31-Jul-14
Designed By:	JA
Checked By:	DJH
Subject:	Subwatershed Catchments

C.C.Tatham & Associates Ltd.
Consulting Engineers

Collingwood Bracebridge Orillia Barrie

Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 103 **Area** 296.24 ha

WEIGHTED CN VALUE																										
Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
				Type	Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
vasl	VASEY	AB	Sand Loam	1	94.7968	0.32	0	0	46	0	0	59	0	0	51	78.681	0.83	80	0	0	100	16.115	0.17	50	74.9
m	MUCK	B	Muck	2	14.812	0.05	0	0	60	0	0	69	0	0	65	0	0	80	0	0	100	14.812	1	50	50
ol	OTONABEE	B	Loam or Silt Loam	2	14.812	0.05	0	0	60	0	0	69	0	0	65	14.812	1	74	0	0	100	0	0	50	74
lvc	LOVERING	CD	Clay Loam or Clay	3	171.8192	0.58	0	0	76	0	0	82	0	0	79	104.81	0.61	84	0	0	100	67.009	0.39	50	70.74
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**296.24**	**1**	**0**	**0**		**0**	**0**		**0**	**0**		**198.303**	**0.6694**		**0**	**0**		**97.9369**	**0.3306**		**71.2**
																							CN (AMC III):		**85.0**

Time of Concentration Calculations

Initial Abstraction	**8.653 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	220	m
Catchment length	4027.5	m
Catchment Slope	0%	
Catchment Area	296.24	ha
Time of Concentration (Minutes)	**156.29**	
Time of Concentration (Hours)	**2.60**	
Time to Peak (2/3 x Time of Concentration)	**1.74**	

Time to Peak	**2.53 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	220	m
Catchment length	4027.5	m
Catchment Slope	0%	
Catchment Area	296.24	ha
Time of Concentration (Minutes)	**228.09**	
Time of Concentration (Hours)	**3.80**	
Time to Peak (2/3 x Time of Concentration)	**2.53**	

Runoff Coefficient	**0.29**

Landuse Type	Soil Series				
	vasl	m	ol	lvc	0
	1	2	2	3	#N/A
Forest/Woodland	0.08	0.25	0.25	0.35	#N/A
Cultivated	0.22	0.35	0.35	0.55	#N/A
Pasture/Lawn	0.1	0.28	0.28	0.4	#N/A
Impervious	0.95	0.95	0.95	0.95	#N/A
Wetland/Lake/SWMF	0.05	0.05	0.05	0.05	#N/A
Meadows	0.09	0.27	0.27	0.38	#N/A
Soil Series Total	0.1911	0.05	0.35	0.355	#N/A

C.C. Tatham & Associates Ltd.
Consulting Engineers

Collingwood Bracebridge Orillia Barrie

Project:	Township of Ramara SWM Master Plan
File No.:	312803
Date:	31-Jul-14
Designed By:	JA
Checked By:	DJH
Subject:	Subwatershed Catchments

Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 104 **Area** 206.98 ha

WEIGHTED CN VALUE																									
Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
				Type	Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
sisc	SIMCOE	C	Clay Loam or Clay	3	2.0698	0.01	0	0	73	0	0	79	0	0	76	2.0698	1	80	0	0	100	0	0	50	80
brs	BRIGHTON	A	Sand	1	10.349	0.05	0	0	32	0	0	49	0	0	38	10.349	1	80	0	0	100	0	0	50	80
m	MUCK	B	Muck	2	22.7678	0.11	0	0	60	0	0	69	0	0	65	2.7321	0.12	74	0	0	100	20.036	0.88	50	52.88
ol	OTONABEE	B	Loam or Silt Loam	2	47.6054	0.23	0	0	60	0	0	69	0	0	65	44.273	0.93	74	0	0	100	3.3324	0.07	50	72.32
lvc	LOVERING	CD	Clay Loam or Clay	3	124.188	0.6	0	0	76	0	0	82	0	0	79	115.49	0.93	84	0	0	100	8.6932	0.07	50	81.62
				Totals	**206.98**	**1**	**0**	**0**		**0**	**0**		**0**	**0**		**174.92**	**0.8451**		**0**	**0**		**32.0612**	**0.1549**		**76.2**
																							CN (AMC III):		**88.1**

Time of Concentration Calculations

Initial Abstraction	**7.7745 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	240	m
Minimum Catchment Elevation	220	m
Catchment length	2137.5	m
Catchment Slope	1%	
Catchment Area	206.98	ha
Time of Concentration (Minutes)	**72.44**	
Time of Concentration (Hours)	**1.21**	
Time to Peak (2/3 x Time of Concentration)	**0.80**	

Time to Peak	**0.80 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	240	m
Minimum Catchment Elevation	220	m
Catchment length	2137.5	m
Catchment Slope	1%	
Catchment Area	206.98	ha
Time of Concentration (Minutes)	**106.21**	
Time of Concentration (Hours)	**1.77**	
Time to Peak (2/3 x Time of Concentration)	**1.18**	

Runoff Coefficient	**0.41**

Landuse Type	Soil Series				
	sisc	brs	m	ol	lvc
	3	1	2	2	3
Forest/Woodland	0.35	0.08	0.25	0.25	0.35
Cultivated	0.55	0.22	0.35	0.35	0.55
Pasture/Lawn	0.4	0.1	0.28	0.28	0.4
Impervious	0.95	0.95	0.95	0.95	0.95
Wetland/Lake/SWMF	0.05	0.05	0.05	0.05	0.05
Meadows	0.38	0.09	0.27	0.27	0.38
Soil Series Total	0.55	0.22	0.086	0.329	0.515

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	Checked By:	DJH
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Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 105 **Area** 53.80 ha

WEIGHTED CN VALUE																									
Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient Type	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
					Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
SMSC	SMITHFIELD	CD	Clay Loam or Clay	3	4.842	0.09	0	0	76	0	0	82	0	0	79	4.842	1	80	0	0	100	0	0	50	80
SISC	SIMCOE	C	Clay Loam or Clay	3	24.748	0.46	0	0	73	0	0	79	0	0	76	24.006	0.97	80	0	0	100	0.7424	0.03	50	79.1
BRS	BRIGHTON	A	Sand	1	0.538	0.01	0	0	32	0	0	49	0	0	38	0.538	1	62	0	0	100	0	0	50	62
EI	EMILY	B	Loam	2	23.672	0.44	6.6282	0.28	60	0	0	69	0	0	65	14.44	0.61	74	0	0	100	2.6039	0.11	50	67
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**53.8**	**1**	**6.62816**	**0.1232**		**0**	**0**		**0**	**0**		**43.8255**	**0.8146**		**0**	**0**		**3.34636**	**0.0622**		**73.9**
																							CN (AMC III):		**86.7**

Time of Concentration Calculations

Initial Abstraction	**7.6806 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	240	m
Minimum Catchment Elevation	228	m
Catchment length	1850	m
Catchment Slope	1%	
Catchment Area	53.8	ha
Time of Concentration (Minutes)	**77.19**	
Time of Concentration (Hours)	**1.29**	
Time to Peak (2/3 x Time of Concentration)	**0.86**	

Time to Peak	**0.86 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	240	m
Minimum Catchment Elevation	228	m
Catchment length	1850	m
Catchment Slope	1%	
Catchment Area	53.8	ha
Time of Concentration (Minutes)	**109.19**	
Time of Concentration (Hours)	**1.82**	
Time to Peak (2/3 x Time of Concentration)	**1.21**	

Runoff Coefficient	**0.42**

Landuse Type	Soil Series					
	SMSC	SISC	BRS	EI	0	0
	3	3	1	2	#N/A	#N/A
Forest/Woodland	0.35	0.35	0.08	0.25	#N/A	#N/A
Cultivated	0.55	0.55	0.22	0.35	#N/A	#N/A
Pasture/Lawn	0.4	0.4	0.1	0.28	#N/A	#N/A
Impervious	0.95	0.95	0.95	0.95	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	0.05	0.05	#N/A	#N/A
Meadows	0.38	0.38	0.09	0.27	#N/A	#N/A
Soil Series Total	0.55	0.535	0.22	0.289	#N/A	#N/A

C.C. Tatham & Associates Ltd.
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Collingwood Bracebridge Orillia Barrie

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Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 106 **Area** 263.24 ha

WEIGHTED CN VALUE

Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient Type	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
					Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
EL	EMILY	B	Loam	2	139.5172	0.53	0	0	60	0	0	69	0	0	65	139.52	1	80	0	0	100	0	0	50	80
M	MUCK	B	Muck	2	9.73988	0.037	0	0	60	0	0	69	0	0	65	0	0	80	0	0	100	9.7399	1	50	50
SMSC	SMITHFIELD	CD	Clay Loam or Clay	3	113.1932	0.43	0	0	76	0	0	82	0	0	79	106.4	0.94	84	0	0	100	6.7916	0.06	50	81.96
BRS	BRIGHTON	A	Sand	1	0.78972	0.003	0	0	32	0	0	49	0	0	38	0	0	62	0	0	100	0.7897	1	50	50
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**263.24**	**1**	**0**	**0**		**0**	**0**		**0**	**0**		**245.919**	**0.9342**		**0**	**0**		**17.3212**	**0.0658**		**79.6**
																							CN (AMC III):		**90.0**

Time of Concentration Calculations

Initial Abstraction	**7.329 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

Runoff Coefficient	**0.41**

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	234	m
Minimum Catchment Elevation	220	m
Catchment length	2940	m
Catchment Slope	0%	
Catchment Area	263.24	ha
Time of Concentration (Minutes)	**111.33**	
Time of Concentration (Hours)	**1.86**	
Time to Peak (2/3 x Time of Concentration)	**1.24**	

Time to Peak	**1.24 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	234	m
Minimum Catchment Elevation	220	m
Catchment length	2940	m
Catchment Slope	0%	
Catchment Area	263.24	ha
Time of Concentration (Minutes)	**155.55**	
Time of Concentration (Hours)	**2.59**	
Time to Peak (2/3 x Time of Concentration)	**1.73**	

Landuse Type	Soil Series				
	EL	M	SMSC	BRS	0
	2	2	3	1	#N/A
Forest/Woodland	0.25	0.25	0.35	0.08	#N/A
Cultivated	0.35	0.35	0.55	0.22	#N/A
Pasture/Lawn	0.28	0.28	0.4	0.1	#N/A
Impervious	0.95	0.95	0.95	0.95	#N/A
Wetland/Lake/SWMF	0.05	0.05	0.05	0.05	#N/A
Meadows	0.27	0.27	0.38	0.09	#N/A
Soil Series Total	0.35	0.05	0.52	0.05	#N/A

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Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 107 **Area** 39.36 ha

WEIGHTED CN VALUE

Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient Type	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
					Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
OI	OTONABEE	B	Loam or Silt Loam	2	8.6592	0.22	1.3855	0.16	60	1.2989	0.15	69	0	0	65	0	0	80	0	0	100	5.9748	0.69	50	54.45
SMSC	SMITHFIELD	CD	Clay Loam or Clay	3	20.8608	0.53	6.2582	0.3	76	0	0	82	0	0	79	1.043	0.05	80	0	0	100	13.56	0.65	50	59.3
M	MUCK	B	Muck	2	9.84	0.25	0	0	60	0	0	69	0	0	65	0	0	74	0	0	100	9.84	1	50	50
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**39.36**	**1**	**7.64371**	**0.1942**		**1.29888**	**0.033**		**0**	**0**		**1.04304**	**0.0265**		**0**	**0**		**29.3744**	**0.7463**		**55.9**
																							CN (AMC III):		**74.5**

Time of Concentration Calculations

Initial Abstraction	**11.2481 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	226	m
Minimum Catchment Elevation	219	m
Catchment length	1400	m
Catchment Slope	1%	
Catchment Area	39.36	ha
Time of Concentration (Minutes)	**63.49**	
Time of Concentration (Hours)	**1.06**	
Time to Peak (2/3 x Time of Concentration)	**0.71**	

Time to Peak	**1.66 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	226	m
Minimum Catchment Elevation	219	m
Catchment length	1400	m
Catchment Slope	1%	
Catchment Area	39.36	ha
Time of Concentration (Minutes)	**149.41**	
Time of Concentration (Hours)	**2.49**	
Time to Peak (2/3 x Time of Concentration)	**1.66**	

Runoff Coefficient	**0.13**

Landuse Type	Soil Series				
	OI	SMSC	M	0	0
	2	3	2	#N/A	#N/A
Forest/Woodland	0.25	0.35	0.25	#N/A	#N/A
Cultivated	0.35	0.55	0.35	#N/A	#N/A
Pasture/Lawn	0.28	0.4	0.28	#N/A	#N/A
Impervious	0.95	0.95	0.95	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	0.05	#N/A	#N/A
Meadows	0.27	0.38	0.27	#N/A	#N/A
Soil Series Total	0.1165	0.165	0.05	#N/A	#N/A

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C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 108 **Area** 51.99 ha

WEIGHTED CN VALUE																									
Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
				Type	Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
SMSC	SMITHFIELD	CD	Clay Loam or Clay	3	27.5547	0.53	0	0	76	0	0	82	0	0	79	27.555	1	80	0	0	100	0	0	50	80
OL	OTONABEE	B	Loam or Silt Loam	2	21.3159	0.41	0	0	60	0	0	69	0	0	65	19.184	0.9	80	0	0	100	2.1316	0.1	50	77
LVC	LOVERING	CD	Clay Loam or Clay	3	3.1194	0.06	0	0	76	0	0	82	0	0	79	1.5285	0.49	84	0	0	100	1.5909	0.51	50	66.66
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0	0	#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**51.99**	**1**	**0**	**0**		**0**	**0**		**0**	**0**		**48.2675**	**0.9284**		**0**	**0**		**3.72248**	**0.0716**		**78.0**
																							CN (AMC III):		**89.1**

Time of Concentration Calculations

Initial Abstraction	**7.358 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	230	m
Minimum Catchment Elevation	218	m
Catchment length	2062.5	m
Catchment Slope	1%	
Catchment Area	51.99	ha
Time of Concentration (Minutes)	**88.25**	
Time of Concentration (Hours)	**1.47**	
Time to Peak (2/3 x Time of Concentration)	**0.98**	

Time to Peak	**0.98 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	230	m
Minimum Catchment Elevation	218	m
Catchment length	2062.5	m
Catchment Slope	1%	
Catchment Area	51.99	ha
Time of Concentration (Minutes)	**116.77**	
Time of Concentration (Hours)	**1.95**	
Time to Peak (2/3 x Time of Concentration)	**1.30**	

Runoff Coefficient	**0.44**

Landuse Type	Soil Series				
	SMSC	OL	LVC	0	0
	3	2	3	#N/A	#N/A
Forest/Woodland	0.35	0.25	0.35	#N/A	#N/A
Cultivated	0.55	0.35	0.55	#N/A	#N/A
Pasture/Lawn	0.4	0.28	0.4	#N/A	#N/A
Impervious	0.95	0.95	0.95	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	0.05	#N/A	#N/A
Meadows	0.38	0.27	0.38	#N/A	#N/A
Soil Series Total	0.55	0.32	0.295	#N/A	#N/A

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Township of Ramara SWM Master Plan
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CONDITIONS

Catchment 109 **Area** 34.99 ha

WEIGHTED CN VALUE

Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient Type	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
					Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
OL	OTONABEE	B	Loam or Silt Loam	2	14.3459	0.41	4.0169	0.28	60	0	0	69	0	0	65	8.4641	0.59	80	0	0	100	1.865	0.13	50	70.5
LVC	LOVERING	CD	Clay Loam or Clay	3	20.6441	0.59	3.7159	0.18	76	0	0	82	0	0	79	15.07	0.73	80	0	0	100	1.858	0.09	50	76.58
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**34.99**	**1**	**7.73279**	**0.221**		**0**	**0**		**0**	**0**		**23.5343**	**0.6726**		**0**	**0**		**3.72294**	**0.1064**		**74.1**
																							CN (AMC III):		**86.8**

Time of Concentration Calculations

Initial Abstraction	**8.195 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	218	m
Catchment length	1185	m
Catchment Slope	2%	
Catchment Area	34.99	ha
Time of Concentration (Minutes)	**43.54**	
Time of Concentration (Hours)	**0.73**	
Time to Peak (2/3 x Time of Concentration)	**0.48**	

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	218	m
Catchment length	1185	m
Catchment Slope	2%	
Catchment Area	34.99	ha
Time of Concentration (Minutes)	**69.14**	
Time of Concentration (Hours)	**1.15**	
Time to Peak (2/3 x Time of Concentration)	**0.77**	

Runoff Coefficient	**0.39**

Landuse Type	Soil Series				
	OL	LVC	0	0	0
	2	3	#N/A	#N/A	#N/A
Forest/Woodland	0.25	0.35	#N/A	#N/A	#N/A
Cultivated	0.35	0.55	#N/A	#N/A	#N/A
Pasture/Lawn	0.28	0.4	#N/A	#N/A	#N/A
Impervious	0.95	0.95	#N/A	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	#N/A	#N/A	#N/A
Meadows	0.27	0.38	#N/A	#N/A	#N/A
Soil Series Total	0.283	0.469	#N/A	#N/A	#N/A

Time to Peak	**0.77 hrs**

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Township of Ramara SWM Master Plan
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CONDITIONS

Catchment 110 **Area** 169.30 ha

WEIGHTED CN VALUE																									
Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
				Type	Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
VASL	VASEY	AB	Sand Loam	1	16.93	0.1	0	0	46	4.7404	0.28	59	0	0	51	0	0	80	0	0	100	12.19	0.72	50	52.52
M	MUCK	B	Muck	2	88.036	0.52	3.5214	0.04	60	5.2822	0.06	69	0	0	65	0	0	80	0	0	100	79.232	0.9	50	51.54
LVC	LOVERING	CD	Clay Loam or Clay	3	30.474	0.18	3.0474	0.1	76	0	0	82	0	0	79	24.379	0.8	84	0	0	100	3.0474	0.1	50	79.8
OL	OTONABEE	B	Loam or Silt Loam	2	32.167	0.19	17.37	0.54	60	0	0	69	0	0	65	10.615	0.33	74	0	0	100	4.1817	0.13	50	63.32
BRS	BRIGHTON	A	Sand	1	1.693	0.01	0	0	32	0	0	49	0	0	38	1.693	1	62	0	0	100	0	0	50	62
				Totals	**169.3**	**1**	**23.939**	**0.1414**		**10.0226**	**0.0592**		**0**	**0**		**36.6873**	**0.2167**		**0**	**0**		**98.65**	**0.5827**		**59.1**
																							CN (AMC III):		**76.8**

Time of Concentration Calculations

Initial Abstraction	**10.2193 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	220	m
Catchment length	2100	m
Catchment Slope	1%	
Catchment Area	169.3	ha
Time of Concentration (Minutes)	**75.66**	
Time of Concentration (Hours)	**1.26**	
Time to Peak (2/3 x Time of Concentration)	**0.84**	

Time to Peak	**1.67 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	220	m
Catchment length	2100	m
Catchment Slope	1%	
Catchment Area	169.3	ha
Time of Concentration (Minutes)	**150.15**	
Time of Concentration (Hours)	**2.50**	
Time to Peak (2/3 x Time of Concentration)	**1.67**	

Runoff Coefficient	**0.18**

Landuse Type	Soil Series				
	VASL	M	LVC	OL	BRS
	1	2	3	2	1
Forest/Woodland	0.08	0.25	0.35	0.25	0.08
Cultivated	0.22	0.35	0.55	0.35	0.22
Pasture/Lawn	0.1	0.28	0.4	0.28	0.1
Impervious	0.95	0.95	0.95	0.95	0.95
Wetland/Lake/SWMF	0.05	0.05	0.05	0.05	0.05
Meadows	0.09	0.27	0.38	0.27	0.09
Soil Series Total	0.064	0.0718	0.48	0.257	0.22

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Collingwood Bracebridge Orillia Barrie

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Township of Ramara SWM Master Plan
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CONDITIONS

Catchment 111 **Area** 12.40 ha

WEIGHTED CN VALUE

Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient Type	Catchment Soil Characteristics Area	Percent	Forest/Woodland Area	Percent	CN	Pasture/Lawns Area	Percent	CN	Meadows Area	Percent	CN	Cultivated Area	Percent	CN	Impervious Area	Percent	CN	Wetland/Lakes/SWMF Area	Percent	CN	Average CN for Soil Type
EL	EMILY	B	Loam	2	4.092	0.33	0	0	60	0	0	69	0	0	65	3.7646	0.92	80	0	0	100	0.3274	0.08	50	77.6
M	MUCK	B	Muck	2	4.712	0.38	0	0	60	0	0	69	0	0	65	0	0	80	0	0	100	4.712	1	50	50
BRS	BRIGHTON	A	Sand	1	3.596	0.29	0	0	32	2.8049	0.78	49	0	0	38	0	0	62	0	0	100	0.7911	0.22	50	49.22
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**12.4**	**1**	**0**	**0**		**2.80488**	**0.2262**		**0**	**0**		**3.76464**	**0.3036**		**0**	**0**		**5.83048**	**0.4702**		**58.9**
																							CN (AMC III):		**76.7**

Time of Concentration Calculations

Initial Abstraction	**8.8986 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	224	m
Minimum Catchment Elevation	219	m
Catchment length	750	m
Catchment Slope	1%	
Catchment Area	12.4	ha

Time of Concentration (Minutes) **36.04**
Time of Concentration (Hours) **0.60**
Time to Peak (2/3 x Time of Concentration) **0.40**

Time to Peak	**1.07 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	224	m
Minimum Catchment Elevation	219	m
Catchment length	750	m
Catchment Slope	1%	
Catchment Area	12.4	ha

Time of Concentration (Minutes) **96.71**
Time of Concentration (Hours) **1.61**
Time to Peak (2/3 x Time of Concentration) **1.07**

Runoff Coefficient	**0.15**

Landuse Type	Soil Series				
	EL	M	BRS	0	0
	2	2	1	#N/A	#N/A
Forest/Woodland	0.25	0.25	0.08	#N/A	#N/A
Cultivated	0.35	0.35	0.22	#N/A	#N/A
Pasture/Lawn	0.28	0.28	0.1	#N/A	#N/A
Impervious	0.95	0.95	0.95	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	0.05	#N/A	#N/A
Meadows	0.27	0.27	0.09	#N/A	#N/A
Soil Series Total	0.326	0.05	0.089	#N/A	#N/A

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Township of Ramara SWM Master Plan
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CONDITIONS

Catchment 112 **Area** 108.30 ha

WEIGHTED CN VALUE																									
Soil Series	**Soil Series**	**Hydrologic Soil Group**	**Soil Texture**	**Runoff Coefficient**	**Catchment Soil Characteristics**		**Forest/Woodland**			**Pasture/Lawns**			**Meadows**			**Cultivated**			**Impervious**			**Wetland/Lakes/SWMF**			**Average CN for Soil Type**
				Type	**Area**	**Percent**	**Area**	**Percent**	**CN**	**Area**	**Percent**	**CN**	**Area**	**Percent**	**CN**	**Area**	**Percent**	**CN**	**Area**	**Percent**	**CN**	**Area**	**Percent**	**CN**	
SMSC	SMITHFIELD	CD	Clay Loam or Clay	3	1.083	0.01	0	0	76	0	0	82	0	0	79	1.083	1	80	0	0	100	0	0	50	80
SISC	SIMCOE	C	Clay Loam or Clay	3	31.407	0.29	8.1658	0.26	73	0	0	79	0	0	76	23.241	0.74	80	0	0	100	0	0	50	78.18
BRS	BRIGHTON	A	Sand	1	1.083	0.01	0	0	32	0	0	49	0	0	38	1.083	1	62	0	0	100	0	0	50	62
OL	OTONABEE	B	Loam or Silt Loam	2	17.328	0.16	0	0	60	0	0	69	0	0	65	17.328	1	74	0	0	100	0	0	50	74
EL	EMILY	B	Loam	2	31.407	0.29	6.2814	0.2	60	0	0	69	0	0	65	25.126	0.8	80	0	0	100	0	0	50	76
Tsl	TECUMSETH	AB	Sand	1	25.992	0.24	11.956	0.46	46	0	0	59	0	0	51	14.036	0.54	68	0	0	100	0	0	50	57.88
				Totals	**108.3**	**1**	**26.4035**	**0.2438**		**0**	**0**		**0**	**0**		**81.8965**	**0.7562**		**0**	**0**		**0**	**0**		**71.9**
																							CN (AMC III):		**85.5**

Time of Concentration Calculations

Initial Abstraction	**7.7314 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	240	m
Minimum Catchment Elevation	228	m
Catchment length	1215	m
Catchment Slope	1%	
Catchment Area	108.3	ha
Time of Concentration (Minutes)	**43.46**	
Time of Concentration (Hours)	**0.72**	
Time to Peak (2/3 x Time of Concentration)	**0.48**	

Time to Peak	**0.96 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	240	m
Minimum Catchment Elevation	228	m
Catchment length	1215	m
Catchment Slope	1%	
Catchment Area	108.3	ha
Time of Concentration (Minutes)	**86.58**	
Time of Concentration (Hours)	**1.44**	
Time to Peak (2/3 x Time of Concentration)	**0.96**	

Runoff Coefficient	**0.34**

Landuse Type	Soil Series					
	SMSC	SISC	BRS	OL	EL	Tsl
	3	3	1	2	2	1
Forest/Woodland	0.35	0.35	0.08	0.25	0.25	0.08
Cultivated	0.55	0.55	0.22	0.35	0.35	0.22
Pasture/Lawn	0.4	0.4	0.1	0.28	0.28	0.1
Impervious	0.95	0.95	0.95	0.95	0.95	0.95
Wetland/Lake/SWMF	0.05	0.05	0.05	0.05	0.05	0.05
Meadows	0.38	0.38	0.09	0.27	0.27	0.09
Soil Series Total	0.55	0.498	0.22	0.35	0.33	0.1556

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CONDITIONS

Catchment 113 **Area** 45.20 ha

WEIGHTED CN VALUE

Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient Type	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
					Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
EL	EMILY	B	Loam	2	45.2	1	6.78	0.15	60	0		69	0	0	65	28.928	0.64	80	0		100	9.492	0.21	50	70.7
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		80	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**45.2**	**1**	**6.78**	**0.15**		**0**	**0**		**0**	**0**		**28.928**	**0.64**		**0**	**0**		**9.492**	**0.21**		**70.7**
																							CN (AMC III):		**84.7**

Time of Concentration Calculations

Initial Abstraction	**8.5 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	238	m
Minimum Catchment Elevation	234	m
Catchment length	1140	m
Catchment Slope	0%	
Catchment Area	45.2	ha
Time of Concentration (Minutes)	**54.73**	
Time of Concentration (Hours)	**0.91**	
Time to Peak (2/3 x Time of Concentration)	**0.61**	

Time to Peak	**1.43 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	238	m
Minimum Catchment Elevation	234	m
Catchment length	1140	m
Catchment Slope	0%	
Catchment Area	45.2	ha
Time of Concentration (Minutes)	**128.77**	
Time of Concentration (Hours)	**2.15**	
Time to Peak (2/3 x Time of Concentration)	**1.43**	

Runoff Coefficient	**0.27**

Landuse Type	Soil Series				
	EL	0	0	0	0
	2	#N/A	#N/A	#N/A	#N/A
Forest/Woodland	0.25	#N/A	#N/A	#N/A	#N/A
Cultivated	0.35	#N/A	#N/A	#N/A	#N/A
Pasture/Lawn	0.28	#N/A	#N/A	#N/A	#N/A
Impervious	0.95	#N/A	#N/A	#N/A	#N/A
Wetland/Lake/SWMF	0.05	#N/A	#N/A	#N/A	#N/A
Meadows	0.27	#N/A	#N/A	#N/A	#N/A
Soil Series Total	0.272	#N/A	#N/A	#N/A	#N/A

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Collingwood Bracebridge Orillia Barrie

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CONDITIONS

Catchment 114 **Area** 211.62 ha (Total area excludes lagoons/Lake Simcoe)

WEIGHTED CN VALUE																									
Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
				Type	Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
VASL	VASEY	AB	Sand Loam	1	1.259139	0.01	0.831	0.66	46	0	0	59	0	0	51	0	0	80	0	0	100	0.3903	0.31	50	45.86
M	MUCK	B	Muck	2	153.7187	0.73	3.0744	0.02	60	58.413	0.38	69	0	0	65	4.6116	0.03	80	58.413	0.38	100	29.207	0.19	50	77.32
LVC	LOVERING	CD	Clay Loam or Clay	3	1.506734	0.01	0	0	76	0	0	82	0	0	79	0	0	84	0	0	100	1.5067	1	50	50
OL	OTONABEE	B	Loam or Silt Loam	2	50.07776	0.24	1.0016	0.02	60	22.535	0.45	69	0	0	65	0	0	74	22.535	0.45	100	4.0062	0.08	50	81.25
BRS	BRIGHTON	A	Sand	1	5.057718	0.02	0	0	32	2.5289	0.5	49	0	0	38	0	0	62	2.5289	0.5	100	0	0	50	74.5
				Totals	**211.62**	**1**	**4.90696**	**0.0231876**		**83.4769**	**0.3944662**		**0**	**0**		**4.61156**	**0.021792**		**83.4769**	**0.394466**		**35.11**	**0.16591**		**77.8**
																							CN (AMC III):		**89.0**

Time of Concentration Calculations

Initial Abstraction 5.1366 mm

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	220	m
Catchment length	2100	m
Catchment Slope	1%	
Catchment Area	211.62	ha
Time of Concentration (Minutes)	**73.99**	
Time of Concentration (Hours)	**1.23**	
Time to Peak (2/3 x Time of Concentration)	**0.82**	

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	220	m
Catchment length	2100	m
Catchment Slope	1%	
Catchment Area	211.62	ha
Time of Concentration (Minutes)	**97.38**	
Time of Concentration (Hours)	**1.62**	
Time to Peak (2/3 x Time of Concentration)	**1.08**	

Runoff Coefficient **0.50**

Landuse Type	Soil Series				
	VASL	M	LVC	OL	BRS
	1	2	3	2	1
Forest/Woodland	0.08	0.25	0.35	0.25	0.08
Cultivated	0.22	0.35	0.55	0.35	0.22
Pasture/Lawn	0.1	0.28	0.4	0.28	0.1
Impervious	0.95	0.95	0.95	0.95	0.95
Wetland/Lake/SWMF	0.05	0.05	0.05	0.05	0.05
Meadows	0.09	0.27	0.38	0.27	0.09
Soil Series Total	0.0683	0.4924	0.05	0.5625	0.525

Time to Peak **0.82 hrs**

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CONDITIONS

Catchment 115 **Area** 54.50 ha

WEIGHTED CN VALUE

Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient Type	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
					Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
Tisl	TIOGA	A	Sand Loam	1	14.17	0.26	0		32	0		49	0	0	38	14.17	1	80	0		100	0		50	80
Sisc	SIMCOE	C	Clay Loam or Clay	3	4.36	0.08	0		73	0		79	0		76	4.36	1	80	0		100	0		50	80
EL	EMILY	B	Loam	2	35.97	0.66	0		60	0		69	0		65	35.97	1	74	0		100	0		50	74
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**54.5**	**1**	**0**	**0**		**0**	**0**		**0**	**0**		**54.5**	**1**		**0**	**0**		**0**	**0**		**76.0**
																							CN (AMC III):		**88.0**

Time of Concentration Calculations

Initial Abstraction	**7 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	240	m
Minimum Catchment Elevation	233	m
Catchment length	1850	m
Catchment Slope	0.4%	
Catchment Area	54.5	ha
Time of Concentration (Minutes)	**85.87**	
Time of Concentration (Hours)	**1.43**	
Time to Peak (2/3 x Time of Concentration)	**0.95**	

Time to Peak	**1.65 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	240	m
Minimum Catchment Elevation	233	m
Catchment length	1850	m
Catchment Slope	0%	
Catchment Area	54.5	ha
Time of Concentration (Minutes)	**148.37**	
Time of Concentration (Hours)	**2.47**	
Time to Peak (2/3 x Time of Concentration)	**1.65**	

Runoff Coefficient	**0.33**

Landuse Type	Soil Series				
	Tisl	Sisc	EL	0	0
	1	3	2	#N/A	#N/A
Forest/Woodland	0.08	0.35	0.25	#N/A	#N/A
Cultivated	0.22	0.55	0.35	#N/A	#N/A
Pasture/Lawn	0.1	0.4	0.28	#N/A	#N/A
Impervious	0.95	0.95	0.95	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	0.05	#N/A	#N/A
Meadows	0.09	0.38	0.27	#N/A	#N/A
Soil Series Total	0.22	0.55	0.35	#N/A	#N/A

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Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 116 **Area** 25.80 ha

WEIGHTED CN VALUE

Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient Type	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
					Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
EL	EMILY	B	Loam	2	19.35	0.75	0		60	0		69	0		65	19.35	1	80	0		100	0		50	80
Sisc	SIMCOE	C	Clay Loam or Clay	3	6.45	0.25	0		73	0		79	0		76	6.45	1	80	0		100	0		50	80
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**25.8**	**1**	**0**	**0**		**0**	**0**		**0**	**0**		**25.8**	**1**		**0**	**0**		**0**	**0**		**80.0**
																							CN (AMC III):		**90.2**

Time of Concentration Calculations

Initial Abstraction	**7 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	232	m
Catchment length	550	m
Catchment Slope	0.7%	
Catchment Area	25.8	ha
Time of Concentration (Minutes)	**24.14**	
Time of Concentration (Hours)	**0.40**	
Time to Peak (2/3 x Time of Concentration)	**0.27**	

Time to Peak	**0.66 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	236	m
Minimum Catchment Elevation	232	m
Catchment length	550	m
Catchment Slope	1%	
Catchment Area	25.8	ha
Time of Concentration (Minutes)	**59.45**	
Time of Concentration (Hours)	**0.99**	
Time to Peak (2/3 x Time of Concentration)	**0.66**	

Runoff Coefficient	**0.40**

Landuse Type	Soil Series				
	EL	Sisc	0	0	0
	2	3	#N/A	#N/A	#N/A
Forest/Woodland	0.25	0.35	#N/A	#N/A	#N/A
Cultivated	0.35	0.55	#N/A	#N/A	#N/A
Pasture/Lawn	0.28	0.4	#N/A	#N/A	#N/A
Impervious	0.95	0.95	#N/A	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	#N/A	#N/A	#N/A
Meadows	0.27	0.38	#N/A	#N/A	#N/A
Soil Series Total	0.35	0.55	#N/A	#N/A	#N/A

C.C. Tatham & Associates Ltd. Consulting Engineers	Project:	Township of Ramara SWM Master Plan
Collingwood Bracebridge Orillia Barrie	File No.:	312803
	Date:	31-Jul-14
	Designed By:	JA
	Checked By:	DJH
	Subject:	Subwatershed Catchments

Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 117 **Area** 92.78 ha

WEIGHTED CN VALUE

Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
				Type	Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
EL	EMILY	B	Loam	2	3.7112	0.04	0		60	0		69	0		65	3.7112	1	80	0		100	0		50	80
smsc	SMITHFIELD	CD	Clay Loam or Clay	3	77.0074	0.83	3.8504	0.05	76	0		82	0		79	3.0803	0.04	80	0		100	70.077	0.91	50	52.5
m	MUCK	B	Muck	2	12.0614	0.13	0		60	0		69	0		65	0		74	0		100	12.061	1	50	50
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**92.78**	**1**	**3.85037**	**0.0415**		**0**	**0**		**0**	**0**		**6.7915**	**0.0732**		**0**	**0**		**82.1381**	**0.8853**		**53.3**
																							CN (AMC III):		**72.4**

Time of Concentration Calculations

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	233	m
Minimum Catchment Elevation	219	m
Catchment length	2300	m
Catchment Slope	0.6%	
Catchment Area	92.78	ha
Time of Concentration (Minutes)	**92.04**	
Time of Concentration (Hours)	**1.53**	
Time to Peak (2/3 x Time of Concentration)	**1.02**	

Time to Peak	**2.06 hrs**

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	233	m
Minimum Catchment Elevation	219	m
Catchment length	2300	m
Catchment Slope	1%	
Catchment Area	92.78	ha
Time of Concentration (Minutes)	**185.82**	
Time of Concentration (Hours)	**3.10**	
Time to Peak (2/3 x Time of Concentration)	**2.06**	

Initial Abstraction	**11.551 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

Runoff Coefficient	**0.09**

Landuse Type	Soil Series				
	EL	smsc	m	0	0
	2	3	2	#N/A	#N/A
Forest/Woodland	0.25	0.35	0.25	#N/A	#N/A
Cultivated	0.35	0.55	0.35	#N/A	#N/A
Pasture/Lawn	0.28	0.4	0.28	#N/A	#N/A
Impervious	0.95	0.95	0.95	#N/A	#N/A
Wetland/Lake/SWMF	0.05	0.05	0.05	#N/A	#N/A
Meadows	0.27	0.38	0.27	#N/A	#N/A
Soil Series Total	0.35	0.085	0.05	#N/A	#N/A

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 118

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.35			0.00	0.00
Cultivated Land, 5 -10% grade	0.45			0.00	0.00
Cultivated Land, 10 - 30% grade	0.65			0.00	0.00
Pasture Land, 0 - 5% grade	0.28			0.00	0.00
Pasture Land, 5 -10% grade	0.35			0.00	0.00
Pasture Land, 10 - 30% grade	0.40			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.25			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.30			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.35			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.50			0.00	0.00
Residential - Sinlge Family	0.40	50%	23.3	9.32	11.65
Residential - Multiple (i.e., semi, townhouse, apartment)	0.60			0.00	0.00
Industrial - Light	0.65			0.00	0.00
Industrial - Heavy	0.75			0.00	0.00
Commercial	0.70	85%	13.0	9.13	11.08
Unimproved Areas	0.20			0.00	0.00
Lawn, < 2% grade	0.11			0.00	0.00
Lawn, 2 - 7% grade	0.16			0.00	0.00
Lawn, > 7 % grade	0.25			0.00	0.00
Road Right-of-Way	0.70			0.00	0.00
Weighted Average			36.3	0.51	63%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 119

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.35			0.00	0.00
Cultivated Land, 5 -10% grade	0.45			0.00	0.00
Cultivated Land, 10 - 30% grade	0.65			0.00	0.00
Pasture Land, 0 - 5% grade	0.28			0.00	0.00
Pasture Land, 5 -10% grade	0.35			0.00	0.00
Pasture Land, 10 - 30% grade	0.40			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.25			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.30			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.35			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.50			0.00	0.00
Residential - Sinlge Family	0.40			0.00	0.00
Residential - Multiple (i.e., semi, townhouse, apartment)	0.60			0.00	0.00
Industrial - Light	0.65	75%	5.4	3.51	4.05
Industrial - Heavy	0.75			0.00	0.00
Commercial	0.70			0.00	0.00
Unimproved Areas	0.20			0.00	0.00
Lawn, < 2% grade	0.11			0.00	0.00
Lawn, 2 - 7% grade	0.16			0.00	0.00
Lawn, > 7 % grade	0.25			0.00	0.00
Road Right-of-Way	0.70			0.00	0.00
Weighted Average			5.4	0.65	75%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 120

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.35			0.00	0.00
Cultivated Land, 5 -10% grade	0.45			0.00	0.00
Cultivated Land, 10 - 30% grade	0.65			0.00	0.00
Pasture Land, 0 - 5% grade	0.28			0.00	0.00
Pasture Land, 5 -10% grade	0.35			0.00	0.00
Pasture Land, 10 - 30% grade	0.40			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.25			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.30			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.35			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.50			0.00	0.00
Residential - Sinlge Family	0.40			0.00	0.00
Residential - Multiple (i.e., semi, townhouse, apartment)	0.60			0.00	0.00
Industrial - Light	0.65	75%	8.4	5.46	6.30
Industrial - Heavy	0.75			0.00	0.00
Commercial	0.70			0.00	0.00
Unimproved Areas	0.20			0.00	0.00
Lawn, < 2% grade	0.11			0.00	0.00
Lawn, 2 - 7% grade	0.16			0.00	0.00
Lawn, > 7 % grade	0.25			0.00	0.00
Road Right-of-Way	0.70			0.00	0.00
Weighted Average			8.4	0.65	75%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Project:	Township of Ramara SWM Master Plan
File No.:	312803
Date:	31-Jul-14
Designed By:	JA
Checked By:	DJH
Subject:	Subwatershed Catchments

Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 121 **Area** 12.20 ha

WEIGHTED CN VALUE																									
Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
				Type	Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
M	MUCK	B	Muck	2	12.2	1	0	0	60	1.22	0.1	69	0		65	0		80	3.782	0.31	100	7.198	0.59	50	67.4
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		80	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**12.2**	**1**	**0**	**0**		**1.22**	**0.1**		**0**	**0**		**0**	**0**		**3.782**	**0.31**		**7.198**	**0.59**		**67.4**
																							CN (AMC III):		**82.6**

Time of Concentration Calculations

Initial Abstraction	**8.2 mm**

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	220	m
Minimum Catchment Elevation	219.5	m
Catchment length	300	m
Catchment Slope	0.2%	
Catchment Area	12.2	ha
Time of Concentration (Minutes)	**19.05**	
Time of Concentration (Hours)	**0.32**	
Time to Peak (2/3 x Time of Concentration)	**0.21**	

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	220	m
Minimum Catchment Elevation	219.5	m
Catchment length	300	m
Catchment Slope	0%	
Catchment Area	12.2	ha
Time of Concentration (Minutes)	**76.29**	
Time of Concentration (Hours)	**1.27**	
Time to Peak (2/3 x Time of Concentration)	**0.85**	

Runoff Coefficient	**0.35**

Landuse Type	Soil Series				
	M	0	0	0	0
	2	#N/A	#N/A	#N/A	#N/A
Forest/Woodland	0.25	#N/A	#N/A	#N/A	#N/A
Cultivated	0.35	#N/A	#N/A	#N/A	#N/A
Pasture/Lawn	0.28	#N/A	#N/A	#N/A	#N/A
Impervious	0.95	#N/A	#N/A	#N/A	#N/A
Wetland/Lake/SWMF	0.05	#N/A	#N/A	#N/A	#N/A
Meadows	0.27	#N/A	#N/A	#N/A	#N/A
Soil Series Total	0.352	#N/A	#N/A	#N/A	#N/A

Time to Peak	**0.85 hrs**

C.C. Tatham & Associates Ltd. Consulting Engineers — Collingwood Bracebridge Orillia Barrie		
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	Subject:	Subwatershed Catchments

Township of Ramara SWM Master Plan
CURVE NUMBER, INITIAL ABSTRACTION & TIME TO PEAK CALCULATIONS

CONDITIONS

Catchment 122 **Area** 7.00 ha

WEIGHTED CN VALUE																									
Soil Series	Soil Series	Hydrologic Soil Group	Soil Texture	Runoff Coefficient	Catchment Soil Characteristics		Forest/Woodland			Pasture/Lawns			Meadows			Cultivated			Impervious			Wetland/Lakes/SWMF			Average CN for Soil Type
				Type	Area	Percent	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	Area	Percent	CN	
EL	EMILY	B	Loam	2	7	1	0		60	0		69	0	0	65	7	1	80	0		100	0	0	50	80
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		80	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
	#N/A	#N/A	#N/A	#N/A	0		0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0		#N/A	0
				Totals	**7**	**1**	**0**	**0**		**0**	**0**		**0**	**0**		**7**	**1**		**0**	**0**		**0**	**0**		**80.0**
																							CN (AMC III):		**90.2**

Time of Concentration Calculations

Initial Abstraction	7 mm

Wetlands	12
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious	2

For Runoff Coefficients greater than 0.4

Bransby-Williams Formula

Maximum Catchment Elevation	234	m
Minimum Catchment Elevation	232	m
Catchment length	185	m
Catchment Slope	1%	
Catchment Area	7	ha
Time of Concentration (Minutes)	**8.55**	
Time of Concentration (Hours)	**0.14**	
Time to Peak (2/3 x Time of Concentration)	**0.09**	

Time to Peak	0.36 hrs

For Runoff Coefficients less than 0.4

Airport Method

Maximum Catchment Elevation	234	m
Minimum Catchment Elevation	232	m
Catchment length	185	m
Catchment Slope	1%	
Catchment Area	7	ha
Time of Concentration (Minutes)	**32.41**	
Time of Concentration (Hours)	**0.54**	
Time to Peak (2/3 x Time of Concentration)	**0.36**	

Runoff Coefficient	0.35

Landuse Type	Soil Series				
	EL	0	0	0	0
	2	#N/A	#N/A	#N/A	#N/A
Forest/Woodland	0.25	#N/A	#N/A	#N/A	#N/A
Cultivated	0.35	#N/A	#N/A	#N/A	#N/A
Pasture/Lawn	0.28	#N/A	#N/A	#N/A	#N/A
Impervious	0.95	#N/A	#N/A	#N/A	#N/A
Wetland/Lake/SWMF	0.05	#N/A	#N/A	#N/A	#N/A
Meadows	0.27	#N/A	#N/A	#N/A	#N/A
Soil Series Total	0.35	#N/A	#N/A	#N/A	#N/A

```
====================================================================================================

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
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                   *****  S U M M A R Y   O U T P U T  *****

  Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

  Output  filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci
  Summary filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci


DATE: 10/15/2015                           TIME: 2:17:33 PM

USER:


COMMENTS: ____________________________________________________________


  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      READ STORM                  6.0
      [ Ptot= 24.97 mm ]
      fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
      remark: 25 mm 4-hr Chicago storm
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .02  3.42   1.34  .05    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0101  1  5.0   84.40     .06  4.25    .91  .04    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0102  1  5.0   53.27     .38  2.58   3.96  .16    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0110  1  5.0  169.30     .15  4.25   1.14  .05    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0104  1  5.0  206.98     .84  3.00   3.06  .12    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0103  1  5.0  296.24     .37  5.00   2.22  .09    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0109  1  5.0   34.99     .13  2.92   2.66  .11    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0105  1  5.0   53.80     .19  3.00   2.79  .11    .000
      [CN=73.9         ]
      [ N = 3.0:Tp  .86]
*
  **  CALIB NASHYD       0112  1  5.0  108.30     .32  3.17   2.55  .10    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    1.83  2.00  13.21  .53    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD       0108  1  5.0   51.99     .21  3.17   3.46  .14    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD     0120  1  5.0    8.40     .65  1.92  16.00  .64    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .42  1.92  15.16  .61    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0113  1  5.0   45.20     .09  3.83   2.23  .09    .000
      [CN=70.7         ]
      [ N = 3.0:Tp 1.43]
*
  *   CALIB NASHYD       0122  1  5.0    7.00     .07  2.33   3.96  .16    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .36]
*
  *   CALIB NASHYD       0106  1  5.0  263.24     .98  3.50   3.77  .15    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .05  4.67    .76  .03    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB NASHYD       0107  1  5.0   39.36     .03  4.25    .87  .03    .000
      [CN=55.9         ]
      [ N = 3.0:Tp 1.66]
*
  *   CALIB NASHYD       1116  1  5.0   25.80     .16  2.75   3.96  .16    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50     .14  4.08   3.29  .13    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80     .75  2.00   9.06  .36    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62    5.07  2.08  10.22  .41    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20     .02  3.17   1.64  .07    .000
      [CN=63.4         ]
      [ N = 3.0:Tp  .95]
*
      ADD [0101 + 0102]  0013  3  5.0  137.67     .40  2.58   2.09  n/a    .000
*
      ADD [0104 + 0103]  0014  3  5.0  503.22    1.00  3.08   2.57  n/a    .000
*
      ADD [0105 + 0112]  2502  3  5.0  162.10     .51  3.08   2.63  n/a    .000
*
      ADD [2502 + 0118]  1210  3  5.0  198.39    1.87  2.00   4.56  n/a    .000
*
      ADD [1210 + 0108]  0017  3  5.0  250.38    1.89  2.00   4.34  n/a    .000
*
      ADD [0113 + 0122]  2507  3  5.0   52.20     .10  3.58   2.46  n/a    .000
*
      ADD [0117 + 0107]  2503  3  5.0  132.16     .07  4.50    .79  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30     .25  3.08   3.51  n/a    .000
*
      RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .02  8.25   8.97  n/a    .000
      {ST=   .17 ha.m }
*
      ADD [0110 + 0014]  2000  3  5.0  672.52    1.11  3.25   2.21  n/a    .000
*
      ADD [0109 + 0017]  0018  3  5.0  285.37    1.90  2.00   4.13  n/a    .000
*
      ADD [0119 + 2507]  0123  3  5.0   57.60     .44  1.92   3.65  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00    1.08  1.92   5.22  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24    1.13  3.50   4.06  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   2 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      READ STORM                 12.0
      [ Ptot= 33.30 mm ]
      fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
      remark: * Orillia Chicago 2 Year, 4 Hour Storm
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .04  3.33   2.95  .09    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
```

```
 ** CALIB NASHYD      0101  1  5.0   84.40     .14  4.25   2.13  .06    .000
    [CN=52.3        ]
    [ N = 3.0:Tp 1.72]
*
 ** CALIB NASHYD      0102  1  5.0   53.27     .77  2.58   7.70  .23    .000
    [CN=80.0        ]
    [ N = 3.0:Tp  .53]
*
 ** CALIB NASHYD      0110  1  5.0  169.30     .36  4.17   2.68  .08    .000
    [CN=59.1        ]
    [ N = 3.0:Tp 1.67]
*
 ** CALIB NASHYD      0104  1  5.0  206.98    1.76  3.00   6.20  .19    .000
    [CN=76.2        ]
    [ N = 3.0:Tp  .80]
*
 ** CALIB NASHYD      0103  1  5.0  296.24     .79  5.00   4.75  .14    .000
    [CN=71.2        ]
    [ N = 3.0:Tp 2.53]
*
 ** CALIB NASHYD      0109  1  5.0   34.99     .27  2.92   5.53  .17    .000
    [CN=74.1        ]
    [ N = 3.0:Tp  .77]
*
 ** CALIB NASHYD      0105  1  5.0   53.80     .40  3.08   5.68  .17    .000
    [CN=73.9        ]
    [ N = 3.0:Tp  .86]
*
 ** CALIB NASHYD      0112  1  5.0  108.30     .68  3.17   5.24  .16    .000
    [CN=71.9        ]
    [ N = 3.0:Tp  .96]
*
 ** CALIB STANDHYD    0118  1  5.0   36.29    2.38  2.08  19.05  .57    .000
    [I%=42.0:S%= 2.00]
*
 ** CALIB NASHYD      0108  1  5.0   51.99     .43  3.17   6.88  .21    .000
    [CN=78.0        ]
    [ N = 3.0:Tp  .98]
*
 ** CALIB STANDHYD    0120  1  5.0    8.40     .83  2.00  22.82  .69    .000
    [I%=50.0:S%= 2.00]
*
 *  CALIB STANDHYD    0119  1  5.0    5.40     .52  2.00  21.55  .65    .000
    [I%=50.0:S%= 2.00]
*
 *  CALIB NASHYD      0113  1  5.0   45.20     .19  3.83   4.73  .14    .000
    [CN=70.7        ]
    [ N = 3.0:Tp 1.43]
*
 *  CALIB NASHYD      0122  1  5.0    7.00     .13  2.42   7.70  .23    .000
    [CN=80.0        ]
    [ N = 3.0:Tp  .36]
*
 *  CALIB NASHYD      0106  1  5.0  263.24    1.95  3.50   7.42  .22    .000
    [CN=79.6        ]
    [ N = 3.0:Tp 1.24]
*
 *  CALIB NASHYD      0117  1  5.0   92.80     .12  4.58   1.93  .06    .000
    [CN=53.3        ]
    [ N = 3.0:Tp 2.06]
*
 *  CALIB NASHYD      0107  1  5.0   39.36     .07  4.17   2.18  .07    .000
    [CN=55.9        ]
    [ N = 3.0:Tp 1.66]
*
 *  CALIB NASHYD      1116  1  5.0   25.80     .32  2.75   7.70  .23    .000
    [CN=80.0        ]
    [ N = 3.0:Tp  .66]
*
 *  CALIB NASHYD      0115  1  5.0   54.50     .28  4.00   6.49  .20    .000
    [CN=76.0        ]
    [ N = 3.0:Tp 1.65]
*
 *  CALIB STANDHYD    0116  1  5.0   25.80    1.00  2.00  13.64  .41    .000
    [I%=25.0:S%= 1.00]
*
 *  CALIB STANDHYD    0114  1  5.0  211.62    7.19  2.17  15.48  .46    .000
    [I%=26.0:S%= 1.00]
*
 *  CALIB NASHYD      0121  1  5.0   12.20     .05  3.17   3.56  .11    .000
    [CN=63.4        ]
    [ N = 3.0:Tp  .95]
*
    ADD [0101 + 0102]  0013  3  5.0  137.67     .81  2.67   4.29  n/a    .000
*
    ADD [0104 + 0103]  0014  3  5.0  503.22    2.10  3.17   5.35  n/a    .000
*
    ADD [0105 + 0112]  2502  3  5.0  162.10    1.07  3.08   5.39  n/a    .000
*
    ADD [2502 + 0118]  1210  3  5.0  198.39    2.52  2.08   7.88  n/a    .000
*
    ADD [1210 + 0108]  0017  3  5.0  250.38    2.58  2.08   7.68  n/a    .000
*
```

```
    ADD [0113 + 0122]  2507  3  5.0   52.20     .22  3.58   5.13  n/a    .000
*
    ADD [0117 + 0107]  2503  3  5.0  132.16     .19  4.42   2.00  n/a    .000
*
    ADD [1116 + 0115]  2504  3  5.0   80.30     .50  3.08   6.88  n/a    .000
*
    RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .03  8.00  13.56  n/a    .000
    {ST=   .27 ha.m }
*
    ADD [0110 + 0014]  2000  3  5.0  672.52    2.36  3.25   4.68  n/a    .000
*
    ADD [0109 + 0017]  0018  3  5.0  285.37    2.62  2.08   7.41  n/a    .000
*
    ADD [0119 + 2507]  0123  3  5.0   57.60     .57  2.00   6.67  n/a    .000
*
    ADD [0120 + 0123]  2505  3  5.0   66.00    1.40  2.00   8.72  n/a    .000
*
    ADD [2505 + 0106]  0319  3  5.0  329.24    2.25  3.50   7.68  n/a    .000
*
 ****************************
 ** SIMULATION NUMBER:   3 **
 ****************************

 W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                min     ha     cms   hrs     mm          cms

    START @   .00 hrs
    --------------------
    READ STORM                 12.0
    [ Ptot= 44.71 mm ]
    fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
    remark: * Orillia Chicago 5 Year, 4 Hour Storm
*
 ** CALIB NASHYD      0111  1  5.0   12.40     .08  3.33   6.02  .13    .000
    [CN=58.9        ]
    [ N = 3.0:Tp 1.07]
*
 ** CALIB NASHYD      0101  1  5.0   84.40     .30  4.17   4.52  .10    .000
    [CN=52.3        ]
    [ N = 3.0:Tp 1.72]
*
 ** CALIB NASHYD      0102  1  5.0   53.27    1.44  2.58  14.05  .31    .000
    [CN=80.0        ]
    [ N = 3.0:Tp  .53]
*
 ** CALIB NASHYD      0110  1  5.0  169.30     .76  4.08   5.66  .13    .000
    [CN=59.1        ]
    [ N = 3.0:Tp 1.67]
*
 ** CALIB NASHYD      0104  1  5.0  206.98    3.40  2.92  11.72  .26    .000
    [CN=76.2        ]
    [ N = 3.0:Tp  .80]
*
 ** CALIB NASHYD      0103  1  5.0  296.24    1.56  4.92   9.35  .21    .000
    [CN=71.2        ]
    [ N = 3.0:Tp 2.53]
*
 ** CALIB NASHYD      0109  1  5.0   34.99     .53  2.92  10.64  .24    .000
    [CN=74.1        ]
    [ N = 3.0:Tp  .77]
*
 ** CALIB NASHYD      0105  1  5.0   53.80     .77  3.00  10.81  .24    .000
    [CN=73.9        ]
    [ N = 3.0:Tp  .86]
*
 ** CALIB NASHYD      0112  1  5.0  108.30    1.32  3.17  10.04  .22    .000
    [CN=71.9        ]
    [ N = 3.0:Tp  .96]
*
 ** CALIB STANDHYD    0118  1  5.0   36.29    3.69  2.00  27.67  .62    .000
    [I%=42.0:S%= 2.00]
*
 ** CALIB NASHYD      0108  1  5.0   51.99     .80  3.17  12.78  .29    .000
    [CN=78.0        ]
    [ N = 3.0:Tp  .98]
*
 *  CALIB STANDHYD    0120  1  5.0    8.40    1.19  2.00  32.65  .73    .000
    [I%=50.0:S%= 2.00]
*
 *  CALIB STANDHYD    0119  1  5.0    5.40     .75  2.00  30.83  .69    .000
    [I%=50.0:S%= 2.00]
*
 *  CALIB NASHYD      0113  1  5.0   45.20     .38  3.75   9.27  .21    .000
    [CN=70.7        ]
    [ N = 3.0:Tp 1.43]
*
 *  CALIB NASHYD      0122  1  5.0    7.00     .25  2.33  14.05  .31    .000
    [CN=80.0        ]
    [ N = 3.0:Tp  .36]
*
 *  CALIB NASHYD      0106  1  5.0  263.24    3.63  3.42  13.66  .31    .000
    [CN=79.6        ]
    [ N = 3.0:Tp 1.24]
```

```
 *
   *   CALIB NASHYD       0117  1  5.0   92.80     .27  4.50   4.29  .10    .000
       [CN=53.3         ]
       [ N = 3.0:Tp 2.06]
 *
   *   CALIB NASHYD       0107  1  5.0   39.36     .15  4.08   4.78  .11    .000
       [CN=55.9         ]
       [ N = 3.0:Tp 1.66]
 *
   *   CALIB NASHYD       1116  1  5.0   25.80     .59  2.75  14.05  .31    .000
       [CN=80.0         ]
       [ N = 3.0:Tp  .66]
 *
   *   CALIB NASHYD       0115  1  5.0   54.50     .53  4.00  12.06  .27    .000
       [CN=76.0         ]
       [ N = 3.0:Tp 1.65]
 *
   *   CALIB STANDHYD     0116  1  5.0   25.80    1.39  2.00  20.73  .46    .000
       [I%=25.0:S%= 1.00]
 *
   *   CALIB STANDHYD     0114  1  5.0  211.62   11.68  2.17  23.52  .53    .000
       [I%=26.0:S%= 1.00]
 *
   *   CALIB NASHYD       0121  1  5.0   12.20     .11  3.17   7.14  .16    .000
       [CN=63.4         ]
       [ N = 3.0:Tp  .95]
 *
       ADD [0101 + 0102]  0013  3  5.0  137.67    1.54  2.58   8.21  n/a    .000
 *
       ADD [0104 + 0103]  0014  3  5.0  503.22    4.06  3.08  10.32  n/a    .000
 *
       ADD [0105 + 0112]  2502  3  5.0  162.10    2.09  3.08  10.30  n/a    .000
 *
       ADD [2502 + 0118]  1210  3  5.0  198.39    3.86  2.00  13.47  n/a    .000
 *
       ADD [1210 + 0108]  0017  3  5.0  250.38    3.92  2.00  13.33  n/a    .000
 *
       ADD [0113 + 0122]  2507  3  5.0   52.20     .42  3.50   9.91  n/a    .000
 *
       ADD [0117 + 0107]  2503  3  5.0  132.16     .41  4.33   4.43  n/a    .000
 *
       ADD [1116 + 0115]  2504  3  5.0   80.30     .93  3.00  12.70  n/a    .000
 *
       RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .05  7.58  20.65  n/a    .000
       {ST=   .42 ha.m }
 *
       ADD [0110 + 0014]  2000  3  5.0  672.52    4.63  3.17   9.15  n/a    .000
 *
       ADD [0109 + 0017]  0018  3  5.0  285.37    3.98  2.00  13.00  n/a    .000
 *
       ADD [0119 + 2507]  0123  3  5.0   57.60     .86  2.00  11.87  n/a    .000
 *
       ADD [0120 + 0123]  2505  3  5.0   66.00    2.05  2.00  14.52  n/a    .000
 *
       ADD [2505 + 0106]  0319  3  5.0  329.24    4.16  3.42  13.83  n/a    .000
 *
   ****************************
   ** SIMULATION NUMBER:   4 **
   ****************************

   W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                    min     ha     cms   hrs     mm          cms

       START @   .00 hrs
       --------------------
       READ STORM                12.0
       [ Ptot= 63.42 mm ]
       fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
       remark: *Orillia Chicago 25 Year, 4 Hour Storm
 *
   **  CALIB NASHYD       0111  1  5.0   12.40     .18  3.25  12.83  .20    .000
       [CN=58.9         ]
       [ N = 3.0:Tp 1.07]
 *
   **  CALIB NASHYD       0101  1  5.0   84.40     .66  4.08  10.01  .16    .000
       [CN=52.3         ]
       [ N = 3.0:Tp 1.72]
 *
   **  CALIB NASHYD       0102  1  5.0   53.27    2.73  2.58  26.55  .42    .000
       [CN=80.0         ]
       [ N = 3.0:Tp  .53]
 *
   **  CALIB NASHYD       0110  1  5.0  169.30    1.66  4.00  12.37  .20    .000
       [CN=59.1         ]
       [ N = 3.0:Tp 1.67]
 *
   **  CALIB NASHYD       0104  1  5.0  206.98    6.71  2.92  22.93  .36    .000
       [CN=76.2         ]
       [ N = 3.0:Tp  .80]
 *
   **  CALIB NASHYD       0103  1  5.0  296.24    3.17  4.83  19.02  .30    .000
       [CN=71.2         ]
       [ N = 3.0:Tp 2.53]
```

```
 *
   **  CALIB NASHYD       0109  1  5.0   34.99    1.07  2.83  21.18  .33    .000
       [CN=74.1         ]
       [ N = 3.0:Tp  .77]
 *
   **  CALIB NASHYD       0105  1  5.0   53.80    1.53  3.00  21.35  .34    .000
       [CN=73.9         ]
       [ N = 3.0:Tp  .86]
 *
   **  CALIB NASHYD       0112  1  5.0  108.30    2.66  3.08  20.02  .32    .000
       [CN=71.9         ]
       [ N = 3.0:Tp  .96]
 *
   **  CALIB STANDHYD     0118  1  5.0   36.29    5.90  2.00  42.91  .68    .000
       [I%=42.0:S%= 2.00]
 *
   **  CALIB NASHYD       0108  1  5.0   51.99    1.55  3.08  24.59  .39    .000
       [CN=78.0         ]
       [ N = 3.0:Tp  .98]
 *
   *   CALIB STANDHYD     0120  1  5.0    8.40    1.94  2.00  49.54  .78    .000
       [I%=50.0:S%= 2.00]
 *
   *   CALIB STANDHYD     0119  1  5.0    5.40    1.21  2.00  46.94  .74    .000
       [I%=50.0:S%= 2.00]
 *
   *   CALIB NASHYD       0113  1  5.0   45.20     .77  3.67  18.83  .30    .000
       [CN=70.7         ]
       [ N = 3.0:Tp 1.43]
 *
   *   CALIB NASHYD       0122  1  5.0    7.00     .47  2.33  26.54  .42    .000
       [CN=80.0         ]
       [ N = 3.0:Tp  .36]
 *
   *   CALIB NASHYD       0106  1  5.0  263.24    6.94  3.42  25.99  .41    .000
       [CN=79.6         ]
       [ N = 3.0:Tp 1.24]
 *
   *   CALIB NASHYD       0117  1  5.0   92.80     .61  4.50   9.79  .15    .000
       [CN=53.3         ]
       [ N = 3.0:Tp 2.06]
 *
   *   CALIB NASHYD       0107  1  5.0   39.36     .34  4.08  10.76  .17    .000
       [CN=55.9         ]
       [ N = 3.0:Tp 1.66]
 *
   *   CALIB NASHYD       1116  1  5.0   25.80    1.13  2.67  26.55  .42    .000
       [CN=80.0         ]
       [ N = 3.0:Tp  .66]
 *
   *   CALIB NASHYD       0115  1  5.0   54.50    1.03  3.92  23.30  .37    .000
       [CN=76.0         ]
       [ N = 3.0:Tp 1.65]
 *
   *   CALIB STANDHYD     0116  1  5.0   25.80    1.98  2.00  33.83  .53    .000
       [I%=25.0:S%= 1.00]
 *
   *   CALIB STANDHYD     0114  1  5.0  211.62   19.91  2.08  38.09  .60    .000
       [I%=26.0:S%= 1.00]
 *
   *   CALIB NASHYD       0121  1  5.0   12.20     .22  3.08  14.92  .24    .000
       [CN=63.4         ]
       [ N = 3.0:Tp  .95]
 *
       ADD [0101 + 0102]  0013  3  5.0  137.67    2.97  2.58  16.41  n/a    .000
 *
       ADD [0104 + 0103]  0014  3  5.0  503.22    8.06  3.08  20.63  n/a    .000
 *
       ADD [0105 + 0112]  2502  3  5.0  162.10    4.18  3.08  20.46  n/a    .000
 *
       ADD [2502 + 0118]  1210  3  5.0  198.39    6.34  2.00  24.57  n/a    .000
 *
       ADD [1210 + 0108]  0017  3  5.0  250.38    6.50  2.00  24.57  n/a    .000
 *
       ADD [0113 + 0122]  2507  3  5.0   52.20     .85  3.50  19.87  n/a    .000
 *
       ADD [0117 + 0107]  2503  3  5.0  132.16     .94  4.33  10.08  n/a    .000
 *
       ADD [1116 + 0115]  2504  3  5.0   80.30    1.78  3.00  24.34  n/a    .000
 *
       RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .27  4.92  33.75  n/a    .000
       {ST=   .55 ha.m }
 *
       ADD [0110 + 0014]  2000  3  5.0  672.52    9.32  3.17  18.55  n/a    .000
 *
       ADD [0109 + 0017]  0018  3  5.0  285.37    7.50  2.92  24.15  n/a    .000
 *
       ADD [0119 + 2507]  0123  3  5.0   57.60    1.45  2.00  22.40  n/a    .000
 *
       ADD [0120 + 0123]  2505  3  5.0   66.00    3.39  2.00  25.86  n/a    .000
 *
       ADD [2505 + 0106]  0319  3  5.0  329.24    7.96  3.42  25.96  n/a    .000
 *
```

```
 ****************************
 ** SIMULATION NUMBER:   5 **
 ****************************

 W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                 min     ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     READ STORM                 12.0
     [ Ptot= 78.51 mm ]
     fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
     remark: *Orillia Chicago 100 Year, 4 Hour Storm
*
 **  CALIB NASHYD       0111  1  5.0   12.40     .27  3.25  19.63  .25    .000
     [CN=58.9         ]
     [ N = 3.0:Tp 1.07]
*
 **  CALIB NASHYD       0101  1  5.0   84.40    1.03  4.08  15.64  .20    .000
     [CN=52.3         ]
     [ N = 3.0:Tp 1.72]
*
 **  CALIB NASHYD       0102  1  5.0   53.27    3.93  2.50  37.87  .48    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .53]
*
 **  CALIB NASHYD       0110  1  5.0  169.30    2.58  4.00  19.12  .24    .000
     [CN=59.1         ]
     [ N = 3.0:Tp 1.67]
*
 **  CALIB NASHYD       0104  1  5.0  206.98    9.85  2.83  33.32  .42    .000
     [CN=76.2         ]
     [ N = 3.0:Tp  .80]
*
 **  CALIB NASHYD       0103  1  5.0  296.24    4.72  4.83  28.24  .36    .000
     [CN=71.2         ]
     [ N = 3.0:Tp 2.53]
*
 **  CALIB NASHYD       0109  1  5.0   34.99    1.59  2.83  31.07  .40    .000
     [CN=74.1         ]
     [ N = 3.0:Tp  .77]
*
 **  CALIB NASHYD       0105  1  5.0   53.80    2.27  2.92  31.24  .40    .000
     [CN=73.9         ]
     [ N = 3.0:Tp  .86]
*
 **  CALIB NASHYD       0112  1  5.0  108.30    3.95  3.08  29.46  .38    .000
     [CN=71.9         ]
     [ N = 3.0:Tp  .96]
*
 **  CALIB STANDHYD     0118  1  5.0   36.29    7.73  2.00  55.86  .71    .000
     [I%=42.0:S%= 2.00]
*
 **  CALIB NASHYD       0108  1  5.0   51.99    2.26  3.08  35.42  .45    .000
     [CN=78.0         ]
     [ N = 3.0:Tp  .98]
*
  *  CALIB STANDHYD     0120  1  5.0    8.40    2.50  2.00  63.59  .81    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     0119  1  5.0    5.40    1.56  2.00  60.46  .77    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB NASHYD       0113  1  5.0   45.20    1.14  3.67  27.96  .36    .000
     [CN=70.7         ]
     [ N = 3.0:Tp 1.43]
*
  *  CALIB NASHYD       0122  1  5.0    7.00     .67  2.33  37.87  .48    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .36]
*
  *  CALIB NASHYD       0106  1  5.0  263.24    9.99  3.42  37.20  .47    .000
     [CN=79.6         ]
     [ N = 3.0:Tp 1.24]
*
  *  CALIB NASHYD       0117  1  5.0   92.80     .96  4.42  15.47  .20    .000
     [CN=53.3         ]
     [ N = 3.0:Tp 2.06]
*
  *  CALIB NASHYD       0107  1  5.0   39.36     .53  4.00  16.88  .22    .000
     [CN=55.9         ]
     [ N = 3.0:Tp 1.66]
*
  *  CALIB NASHYD       1116  1  5.0   25.80    1.63  2.67  37.88  .48    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .66]
*
  *  CALIB NASHYD       0115  1  5.0   54.50    1.49  3.92  33.70  .43    .000
     [CN=76.0         ]
     [ N = 3.0:Tp 1.65]
*
  *  CALIB STANDHYD     0116  1  5.0   25.80    2.49  2.00  45.35  .58    .000
     [I%=25.0:S%= 1.00]
*
  *  CALIB STANDHYD     0114  1  5.0  211.62   29.90  2.17  50.68  .65    .000
     [I%=26.0:S%= 1.00]
*
  *  CALIB NASHYD       0121  1  5.0   12.20     .34  3.08  22.57  .29    .000
     [CN=63.4         ]
     [ N = 3.0:Tp  .95]
*
     ADD [0101 + 0102]  0013  3  5.0  137.67    4.31  2.58  24.24  n/a    .000
*
     ADD [0104 + 0103]  0014  3  5.0  503.22   11.87  3.00  30.33  n/a    .000
*
     ADD [0105 + 0112]  2502  3  5.0  162.10    6.19  3.00  30.05  n/a    .000
*
     ADD [2502 + 0118]  1210  3  5.0  198.39    8.49  2.00  34.77  n/a    .000
*
     ADD [1210 + 0108]  0017  3  5.0  250.38    9.33  2.92  34.91  n/a    .000
*
     ADD [0113 + 0122]  2507  3  5.0   52.20    1.27  3.42  29.29  n/a    .000
*
     ADD [0117 + 0107]  2503  3  5.0  132.16    1.48  4.25  15.89  n/a    .000
*
     ADD [1116 + 0115]  2504  3  5.0   80.30    2.57  3.00  35.04  n/a    .000
*
     RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .45  4.50  45.26  n/a    .000
     {ST=   .68 ha.m }
*
     ADD [0110 + 0014]  2000  3  5.0  672.52   13.84  3.17  27.51  n/a    .000
*
     ADD [0109 + 0017]  0018  3  5.0  285.37   10.92  2.92  34.44  n/a    .000
*
     ADD [0119 + 2507]  0123  3  5.0   57.60    1.94  2.00  32.21  n/a    .000
*
     ADD [0120 + 0123]  2505  3  5.0   66.00    4.44  2.00  36.21  n/a    .000
*
     ADD [2505 + 0106]  0319  3  5.0  329.24   11.47  3.33  37.00  n/a    .000
*
 FINISH

=============================================================================================================
```

```
=====================================================================================================

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO

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                   *****  S U M M A R Y   O U T P U T  *****

  Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

  Output  filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci
  Summary filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci


DATE: 10/15/2015                           TIME: 2:14:42 PM

USER:


COMMENTS: ____________________________________________________________


  ****************************
  ** SIMULATION NUMBER:   1 **  2 yr 12 hr SCS
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                   min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                   5.0
      [ Ptot= 41.33 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .05  7.33   5.02  .12    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0101  1  5.0   84.40     .18  8.25   3.73  .09    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0102  1  5.0   53.27     .93  6.58  12.05  .29    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0110  1  5.0  169.30     .46  8.17   4.68  .11    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0104  1  5.0  206.98    2.18  6.92   9.96  .24    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0103  1  5.0  296.24    1.02  9.25   7.87  .19    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0109  1  5.0   34.99     .34  6.92   9.00  .22    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0105  1  5.0   53.80     .49  7.00   9.17  .22    .000
      [CN=73.9         ]
      [ N = 3.0:Tp  .86]
*
  **  CALIB NASHYD       0112  1  5.0  108.30     .84  7.08   8.50  .21    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    2.06  6.08  25.05  .61    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD       0108  1  5.0   51.99     .52  7.17  10.91  .26    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
```

```
  **  CALIB STANDHYD     0120  1  5.0    8.40     .67  6.00  29.69  .72    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .43  6.00  28.03  .68    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0113  1  5.0   45.20     .24  7.75   7.81  .19    .000
      [CN=70.7         ]
      [ N = 3.0:Tp 1.43]
*
  *   CALIB NASHYD       0122  1  5.0    7.00     .16  6.33  12.05  .29    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .36]
*
  *   CALIB NASHYD       0106  1  5.0  263.24    2.36  7.42  11.68  .28    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .16  8.75   3.50  .08    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB NASHYD       0107  1  5.0   39.36     .09  8.25   3.91  .09    .000
      [CN=55.9         ]
      [ N = 3.0:Tp 1.66]
*
  *   CALIB NASHYD       1116  1  5.0   25.80     .39  6.75  12.05  .29    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50     .34  8.00  10.29  .25    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80     .76  6.08  18.55  .45    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62    7.54  6.25  22.58  .55    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20     .07  7.17   5.97  .14    .000
      [CN=63.4         ]
      [ N = 3.0:Tp  .95]
*
      ADD [0101 + 0102]  0013  3  5.0  137.67     .99  6.58   6.95  n/a    .000
*
      ADD [0104 + 0103]  0014  3  5.0  503.22    2.59  7.08   8.73  n/a    .000
*
      ADD [0105 + 0112]  2502  3  5.0  162.10    1.33  7.08   8.72  n/a    .000
*
      ADD [2502 + 0118]  1210  3  5.0  198.39    2.38  6.17  11.71  n/a    .000
*
      ADD [1210 + 0108]  0017  3  5.0  250.38    2.51  6.17  11.54  n/a    .000
*
      ADD [0113 + 0122]  2507  3  5.0   52.20     .27  7.50   8.37  n/a    .000
*
      ADD [0117 + 0107]  2503  3  5.0  132.16     .24  8.58   3.63  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30     .60  7.00  10.85  n/a    .000
*
      RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .04 13.33  18.46  n/a    .000
      {ST=   .35 ha.m }
*
      ADD [0110 + 0014]  2000  3  5.0  672.52    2.92  7.17   7.71  n/a    .000
*
      ADD [0109 + 0017]  0018  3  5.0  285.37    2.62  6.17  11.23  n/a    .000
*
      ADD [0119 + 2507]  0123  3  5.0   57.60     .52  6.08  10.22  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00    1.18  6.08  12.69  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24    2.72  7.42  11.89  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   2 **  5 yr 12 hr SCS
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                   min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                   5.0
      [ Ptot= 56.11 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .10  7.25   9.93  .18    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0101  1  5.0   84.40     .38  8.17   7.65  .14    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
```

```
  ** CALIB NASHYD      0102  1  5.0   53.27    1.70  6.58  21.41  .38    .000
     [CN=80.0        ]
     [ N = 3.0:Tp  .53]
*
  ** CALIB NASHYD      0110  1  5.0  169.30     .96  8.08   9.51  .17    .000
     [CN=59.1        ]
     [ N = 3.0:Tp 1.67]
*
  ** CALIB NASHYD      0104  1  5.0  206.98    4.14  6.92  18.28  .33    .000
     [CN=76.2        ]
     [ N = 3.0:Tp  .80]
*
  ** CALIB NASHYD      0103  1  5.0  296.24    1.98  9.08  14.97  .27    .000
     [CN=71.2        ]
     [ N = 3.0:Tp 2.53]
*
  ** CALIB NASHYD      0109  1  5.0   34.99     .66  6.83  16.79  .30    .000
     [CN=74.1        ]
     [ N = 3.0:Tp  .77]
*
  ** CALIB NASHYD      0105  1  5.0   53.80     .94  6.92  16.97  .30    .000
     [CN=73.9        ]
     [ N = 3.0:Tp  .86]
*
  ** CALIB NASHYD      0112  1  5.0  108.30    1.62  7.08  15.85  .28    .000
     [CN=71.9        ]
     [ N = 3.0:Tp  .96]
*
  ** CALIB STANDHYD    0118  1  5.0   36.29    3.21  6.08  36.82  .66    .000
     [I%=42.0:S%= 2.00]
*
  ** CALIB NASHYD      0108  1  5.0   51.99     .97  7.08  19.71  .35    .000
     [CN=78.0        ]
     [ N = 3.0:Tp  .98]
*
   * CALIB STANDHYD    0120  1  5.0    8.40     .99  6.00  42.85  .76    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB STANDHYD    0119  1  5.0    5.40     .62  6.00  40.54  .72    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB NASHYD      0113  1  5.0   45.20     .46  7.67  14.83  .26    .000
     [CN=70.7        ]
     [ N = 3.0:Tp 1.43]
*
   * CALIB NASHYD      0122  1  5.0    7.00     .29  6.33  21.41  .38    .000
     [CN=80.0        ]
     [ N = 3.0:Tp  .36]
*
   * CALIB NASHYD      0106  1  5.0  263.24    4.36  7.42  20.91  .37    .000
     [CN=79.6        ]
     [ N = 3.0:Tp 1.24]
*
   * CALIB NASHYD      0117  1  5.0   92.80     .35  8.67   7.42  .13    .000
     [CN=53.3        ]
     [ N = 3.0:Tp 2.06]
*
   * CALIB NASHYD      0107  1  5.0   39.36     .19  8.08   8.19  .15    .000
     [CN=55.9        ]
     [ N = 3.0:Tp 1.66]
*
   * CALIB NASHYD      1116  1  5.0   25.80     .71  6.67  21.41  .38    .000
     [CN=80.0        ]
     [ N = 3.0:Tp  .66]
*
   * CALIB NASHYD      0115  1  5.0   54.50     .64  7.92  18.65  .33    .000
     [CN=76.0        ]
     [ N = 3.0:Tp 1.65]
*
   * CALIB STANDHYD    0116  1  5.0   25.80    1.11  6.00  28.53  .51    .000
     [I%=25.0:S%= 1.00]
*
   * CALIB STANDHYD    0114  1  5.0  211.62   12.80  6.25  34.42  .61    .000
     [I%=26.0:S%= 1.00]
*
   * CALIB NASHYD      0121  1  5.0   12.20     .13  7.08  11.62  .21    .000
     [CN=63.4        ]
     [ N = 3.0:Tp  .95]
*
     ADD [0101 + 0102]  0013  3  5.0  137.67    1.85  6.58  12.98  n/a    .000
*
     ADD [0104 + 0103]  0014  3  5.0  503.22    4.96  7.00  16.33  n/a    .000
*
     ADD [0105 + 0112]  2502  3  5.0  162.10    2.55  7.00  16.22  n/a    .000
*
     ADD [2502 + 0118]  1210  3  5.0  198.39    3.97  6.17  19.99  n/a    .000
*
     ADD [1210 + 0108]  0017  3  5.0  250.38    4.26  6.17  19.93  n/a    .000
*
     ADD [0113 + 0122]  2507  3  5.0   52.20     .52  7.42  15.71  n/a    .000
*
     ADD [0117 + 0107]  2503  3  5.0  132.16     .53  8.42   7.65  n/a    .000
*
```

```
     ADD [1116 + 0115]  2504  3  5.0   80.30    1.12  7.00  19.54  n/a    .000
*
     RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .14 10.50  28.44  n/a    .000
     {ST=   .48 ha.m }
*
     ADD [0110 + 0014]  2000  3  5.0  672.52    5.68  7.17  14.61  n/a    .000
*
     ADD [0109 + 0017]  0018  3  5.0  285.37    4.76  6.75  19.55  n/a    .000
*
     ADD [0119 + 2507]  0123  3  5.0   57.60     .82  6.08  18.04  n/a    .000
*
     ADD [0120 + 0123]  2505  3  5.0   66.00    1.79  6.08  21.19  n/a    .000
*
     ADD [2505 + 0106]  0319  3  5.0  329.24    5.00  7.42  20.97  n/a    .000
*
 ****************************
 ** SIMULATION NUMBER:   3 **  10 yr 12 hr SCS
 ****************************

 W/E COMMAND            HYD ID   DT     AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                min      ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     MASS STORM                 5.0
     [ Ptot= 65.89 mm ]
*
  ** CALIB NASHYD      0111  1  5.0   12.40     .15  7.25  13.87  .21    .000
     [CN=58.9        ]
     [ N = 3.0:Tp 1.07]
*
  ** CALIB NASHYD      0101  1  5.0   84.40     .54  8.08  10.86  .16    .000
     [CN=52.3        ]
     [ N = 3.0:Tp 1.72]
*
  ** CALIB NASHYD      0102  1  5.0   53.27    2.28  6.50  28.33  .43    .000
     [CN=80.0        ]
     [ N = 3.0:Tp  .53]
*
  ** CALIB NASHYD      0110  1  5.0  169.30    1.37  8.00  13.40  .20    .000
     [CN=59.1        ]
     [ N = 3.0:Tp 1.67]
*
  ** CALIB NASHYD      0104  1  5.0  206.98    5.64  6.83  24.55  .37    .000
     [CN=76.2        ]
     [ N = 3.0:Tp  .80]
*
  ** CALIB NASHYD      0103  1  5.0  296.24    2.74  9.08  20.45  .31    .000
     [CN=71.2        ]
     [ N = 3.0:Tp 2.53]
*
  ** CALIB NASHYD      0109  1  5.0   34.99     .90  6.83  22.72  .34    .000
     [CN=74.1        ]
     [ N = 3.0:Tp  .77]
*
  ** CALIB NASHYD      0105  1  5.0   53.80    1.29  6.92  22.89  .35    .000
     [CN=73.9        ]
     [ N = 3.0:Tp  .86]
*
  ** CALIB NASHYD      0112  1  5.0  108.30    2.23  7.08  21.49  .33    .000
     [CN=71.9        ]
     [ N = 3.0:Tp  .96]
*
  ** CALIB STANDHYD    0118  1  5.0   36.29    3.90  6.08  44.99  .68    .000
     [I%=42.0:S%= 2.00]
*
  ** CALIB NASHYD      0108  1  5.0   51.99    1.31  7.08  26.29  .40    .000
     [CN=78.0        ]
     [ N = 3.0:Tp  .98]
*
   * CALIB STANDHYD    0120  1  5.0    8.40    1.21  6.00  51.82  .79    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB STANDHYD    0119  1  5.0    5.40     .76  6.00  49.12  .75    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB NASHYD      0113  1  5.0   45.20     .64  7.67  20.25  .31    .000
     [CN=70.7        ]
     [ N = 3.0:Tp 1.43]
*
   * CALIB NASHYD      0122  1  5.0    7.00     .39  6.33  28.33  .43    .000
     [CN=80.0        ]
     [ N = 3.0:Tp  .36]
*
   * CALIB NASHYD      0106  1  5.0  263.24    5.86  7.33  27.75  .42    .000
     [CN=79.6        ]
     [ N = 3.0:Tp 1.24]
*
   * CALIB NASHYD      0117  1  5.0   92.80     .51  8.58  10.65  .16    .000
     [CN=53.3        ]
     [ N = 3.0:Tp 2.06]
*
   * CALIB NASHYD      0107  1  5.0   39.36     .28  8.08  11.69  .18    .000
```

```
      [CN=55.9         ]
      [ N = 3.0:Tp 1.66]
*
  *   CALIB NASHYD       1116  1  5.0   25.80     .95  6.67  28.34  .43    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50     .86  7.92  24.93  .38    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80    1.34  6.00  35.66  .54    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62   17.50  6.25  42.70  .65    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20     .19  7.08  16.09  .24    .000
      [CN=63.4         ]
      [ N = 3.0:Tp  .95]
*
      ADD [0101 + 0102]  0013  3  5.0  137.67    2.49  6.58  17.62  n/a    .000
*
      ADD [0104 + 0103]  0014  3  5.0  503.22    6.79  7.00  22.14  n/a    .000
*
      ADD [0105 + 0112]  2502  3  5.0  162.10    3.50  7.00  21.95  n/a    .000
*
      ADD [2502 + 0118]  1210  3  5.0  198.39    4.73  6.17  26.17  n/a    .000
*
      ADD [1210 + 0108]  0017  3  5.0  250.38    5.47  6.83  26.19  n/a    .000
*
      ADD [0113 + 0122]  2507  3  5.0   52.20     .71  7.42  21.33  n/a    .000
*
      ADD [0117 + 0107]  2503  3  5.0  132.16     .77  8.42  10.96  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30    1.51  7.00  26.03  n/a    .000
*
      RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .24  9.67  35.58  n/a    .000
      {ST=   .53 ha.m }
*
      ADD [0110 + 0014]  2000  3  5.0  672.52    7.82  7.08  19.94  n/a    .000
*
      ADD [0109 + 0017]  0018  3  5.0  285.37    6.37  6.83  25.77  n/a    .000
*
      ADD [0119 + 2507]  0123  3  5.0   57.60    1.05  6.08  23.94  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00    2.24  6.08  27.49  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24    6.72  7.33  27.70  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   4 **  25 yr 12 hr SCS
  ****************************

  W/E COMMAND             HYD ID   DT    AREA    Qpeak Tpeak   R.V. R.C.    Qbase
                                   min     ha     cms   hrs     mm           cms

      START @   .00 hrs
      --------------------
      MASS STORM                   5.0
      [ Ptot= 78.27 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .21  7.17  19.51  .25    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0101  1  5.0   84.40     .78  8.08  15.54  .20    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    3.06  6.50  37.69  .48    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0110  1  5.0  169.30    1.97  8.00  19.00  .24    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0104  1  5.0  206.98    7.71  6.83  33.15  .42    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0103  1  5.0  296.24    3.79  9.00  28.09  .36    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0109  1  5.0   34.99    1.24  6.83  30.91  .39    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0105  1  5.0   53.80    1.77  6.92  31.07  .40    .000
      [CN=73.9         ]
      [ N = 3.0:Tp  .86]
```

```
*
  **  CALIB NASHYD       0112  1  5.0  108.30    3.07  7.08  29.30  .37    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    5.19  6.08  55.65  .71    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD       0108  1  5.0   51.99    1.77  7.08  35.24  .45    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    1.49  6.00  63.36  .81    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .94  6.00  60.24  .77    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0113  1  5.0   45.20     .89  7.58  27.81  .36    .000
      [CN=70.7         ]
      [ N = 3.0:Tp 1.43]
*
  *   CALIB NASHYD       0122  1  5.0    7.00     .53  6.33  37.68  .48    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .36]
*
  *   CALIB NASHYD       0106  1  5.0  263.24    7.89  7.33  37.02  .47    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .74  8.50  15.37  .20    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB NASHYD       0107  1  5.0   39.36     .40  8.00  16.78  .21    .000
      [CN=55.9         ]
      [ N = 3.0:Tp 1.66]
*
  *   CALIB NASHYD       1116  1  5.0   25.80    1.27  6.67  37.69  .48    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    1.17  7.83  33.53  .43    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80    1.64  6.00  45.16  .58    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62   21.75  6.25  53.53  .68    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20     .26  7.08  22.44  .29    .000
      [CN=63.4         ]
      [ N = 3.0:Tp  .95]
*
      ADD [0101 + 0102]  0013  3  5.0  137.67    3.37  6.58  24.11  n/a    .000
*
      ADD [0104 + 0103]  0014  3  5.0  503.22    9.33  7.00  30.17  n/a    .000
*
      ADD [0105 + 0112]  2502  3  5.0  162.10    4.82  7.00  29.89  n/a    .000
*
      ADD [2502 + 0118]  1210  3  5.0  198.39    6.42  6.17  34.60  n/a    .000
*
      ADD [1210 + 0108]  0017  3  5.0  250.38    7.33  6.92  34.73  n/a    .000
*
      ADD [0113 + 0122]  2507  3  5.0   52.20     .99  7.42  29.13  n/a    .000
*
      ADD [0117 + 0107]  2503  3  5.0  132.16    1.13  8.33  15.79  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30    2.04  6.92  34.87  n/a    .000
*
      RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .35  9.08  45.08  n/a    .000
      {ST=   .61 ha.m }
*
      ADD [0110 + 0014]  2000  3  5.0  672.52   10.83  7.08  27.36  n/a    .000
*
      ADD [0109 + 0017]  0018  3  5.0  285.37    8.57  6.83  34.27  n/a    .000
*
      ADD [0119 + 2507]  0123  3  5.0   57.60    1.36  6.08  32.05  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00    2.82  6.08  36.04  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24    9.06  7.33  36.82  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   5 **  50 yr 12 hr SCS
  ****************************

  W/E COMMAND             HYD ID   DT    AREA    Qpeak Tpeak   R.V. R.C.    Qbase
                                   min     ha     cms   hrs     mm           cms

      START @   .00 hrs
```

```
     --------------------
     MASS STORM                    5.0
     [ Ptot= 87.35 mm ]
*
  ** CALIB NASHYD       0111  1  5.0   12.40     .26  7.17  24.07  .28    .000
     [CN=58.9         ]
     [ N = 3.0:Tp 1.07]
*
  ** CALIB NASHYD       0101  1  5.0   84.40     .98  8.08  19.36  .22    .000
     [CN=52.3         ]
     [ N = 3.0:Tp 1.72]
*
  ** CALIB NASHYD       0102  1  5.0   53.27    3.66  6.50  44.88  .51    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .53]
*
  ** CALIB NASHYD       0110  1  5.0  169.30    2.46  8.00  23.53  .27    .000
     [CN=59.1         ]
     [ N = 3.0:Tp 1.67]
*
  ** CALIB NASHYD       0104  1  5.0  206.98    9.31  6.83  39.83  .46    .000
     [CN=76.2         ]
     [ N = 3.0:Tp  .80]
*
  ** CALIB NASHYD       0103  1  5.0  296.24    4.62  9.00  34.10  .39    .000
     [CN=71.2         ]
     [ N = 3.0:Tp 2.53]
*
  ** CALIB NASHYD       0109  1  5.0   34.99    1.51  6.83  37.31  .43    .000
     [CN=74.1         ]
     [ N = 3.0:Tp  .77]
*
  ** CALIB NASHYD       0105  1  5.0   53.80    2.14  6.92  37.46  .43    .000
     [CN=73.9         ]
     [ N = 3.0:Tp  .86]
*
  ** CALIB NASHYD       0112  1  5.0  108.30    3.73  7.00  35.44  .41    .000
     [CN=71.9         ]
     [ N = 3.0:Tp  .96]
*
  ** CALIB STANDHYD     0118  1  5.0   36.29    5.99  6.08  63.65  .73    .000
     [I%=42.0:S%= 2.00]
*
  ** CALIB NASHYD       0108  1  5.0   51.99    2.13  7.00  42.17  .48    .000
     [CN=78.0         ]
     [ N = 3.0:Tp  .98]
*
   * CALIB STANDHYD     0120  1  5.0    8.40    1.82  6.00  71.94  .82    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB STANDHYD     0119  1  5.0    5.40    1.14  6.00  68.54  .78    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB NASHYD       0113  1  5.0   45.20    1.09  7.58  33.77  .39    .000
     [CN=70.7         ]
     [ N = 3.0:Tp 1.43]
*
   * CALIB NASHYD       0122  1  5.0    7.00     .63  6.33  44.88  .51    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .36]
*
   * CALIB NASHYD       0106  1  5.0  263.24    9.46  7.33  44.15  .51    .000
     [CN=79.6         ]
     [ N = 3.0:Tp 1.24]
*
   * CALIB NASHYD       0117  1  5.0   92.80     .93  8.50  19.24  .22    .000
     [CN=53.3         ]
     [ N = 3.0:Tp 2.06]
*
   * CALIB NASHYD       0107  1  5.0   39.36     .51  8.00  20.92  .24    .000
     [CN=55.9         ]
     [ N = 3.0:Tp 1.66]
*
   * CALIB NASHYD       1116  1  5.0   25.80    1.52  6.67  44.88  .51    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .66]
*
   * CALIB NASHYD       0115  1  5.0   54.50    1.41  7.83  40.21  .46    .000
     [CN=76.0         ]
     [ N = 3.0:Tp 1.65]
*
   * CALIB STANDHYD     0116  1  5.0   25.80    1.86  6.00  52.40  .60    .000
     [I%=25.0:S%= 1.00]
*
   * CALIB STANDHYD     0114  1  5.0  211.62   25.49  6.25  61.66  .71    .000
     [I%=26.0:S%= 1.00]
*
   * CALIB NASHYD       0121  1  5.0   12.20     .32  7.08  27.52  .32    .000
     [CN=63.4         ]
     [ N = 3.0:Tp  .95]
*
     ADD [0101 + 0102]  0013  3  5.0  137.67    4.05  6.58  29.24  n/a    .000
*
```

```
     ADD [0104 + 0103]  0014  3  5.0  503.22   11.32  7.00  36.46  n/a    .000
*
     ADD [0105 + 0112]  2502  3  5.0  162.10    5.86  7.00  36.11  n/a    .000
*
     ADD [2502 + 0118]  1210  3  5.0  198.39    7.58  6.17  41.15  n/a    .000
*
     ADD [1210 + 0108]  0017  3  5.0  250.38    8.82  6.92  41.36  n/a    .000
*
     ADD [0113 + 0122]  2507  3  5.0   52.20    1.20  7.33  35.26  n/a    .000
*
     ADD [0117 + 0107]  2503  3  5.0  132.16    1.42  8.33  19.74  n/a    .000
*
     ADD [1116 + 0115]  2504  3  5.0   80.30    2.45  6.92  41.71  n/a    .000
*
     RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .44  8.83  52.31  n/a    .000
     {ST=   .67 ha.m }
*
     ADD [0110 + 0014]  2000  3  5.0  672.52   13.20  7.08  33.21  n/a    .000
*
     ADD [0109 + 0017]  0018  3  5.0  285.37   10.32  6.83  40.86  n/a    .000
*
     ADD [0119 + 2507]  0123  3  5.0   57.60    1.66  6.08  38.38  n/a    .000
*
     ADD [0120 + 0123]  2505  3  5.0   66.00    3.42  6.08  42.65  n/a    .000
*
     ADD [2505 + 0106]  0319  3  5.0  329.24   10.86  7.33  43.85  n/a    .000
*
 ****************************
 ** SIMULATION NUMBER:   6 **  100 yr 12 hr SCS
 ****************************

 W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                min     ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     MASS STORM                    5.0
     [ Ptot= 96.54 mm ]
*
  ** CALIB NASHYD       0111  1  5.0   12.40     .32  7.17  29.00  .30    .000
     [CN=58.9         ]
     [ N = 3.0:Tp 1.07]
*
  ** CALIB NASHYD       0101  1  5.0   84.40    1.20  8.00  23.54  .24    .000
     [CN=52.3         ]
     [ N = 3.0:Tp 1.72]
*
  ** CALIB NASHYD       0102  1  5.0   53.27    4.29  6.50  52.38  .54    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .53]
*
  ** CALIB NASHYD       0110  1  5.0  169.30    2.99  7.92  28.44  .29    .000
     [CN=59.1         ]
     [ N = 3.0:Tp 1.67]
*
  ** CALIB NASHYD       0104  1  5.0  206.98   11.01  6.83  46.85  .49    .000
     [CN=76.2         ]
     [ N = 3.0:Tp  .80]
*
  ** CALIB NASHYD       0103  1  5.0  296.24    5.51  8.92  40.48  .42    .000
     [CN=71.2         ]
     [ N = 3.0:Tp 2.53]
*
  ** CALIB NASHYD       0109  1  5.0   34.99    1.79  6.83  44.06  .46    .000
     [CN=74.1         ]
     [ N = 3.0:Tp  .77]
*
  ** CALIB NASHYD       0105  1  5.0   53.80    2.54  6.92  44.20  .46    .000
     [CN=73.9         ]
     [ N = 3.0:Tp  .86]
*
  ** CALIB NASHYD       0112  1  5.0  108.30    4.44  7.00  41.93  .43    .000
     [CN=71.9         ]
     [ N = 3.0:Tp  .96]
*
  ** CALIB STANDHYD     0118  1  5.0   36.29    6.83  6.08  71.87  .74    .000
     [I%=42.0:S%= 2.00]
*
  ** CALIB NASHYD       0108  1  5.0   51.99    2.51  7.00  49.42  .51    .000
     [CN=78.0         ]
     [ N = 3.0:Tp  .98]
*
   * CALIB STANDHYD     0120  1  5.0    8.40    2.08  6.00  80.68  .84    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB STANDHYD     0119  1  5.0    5.40    1.30  6.00  77.03  .80    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB NASHYD       0113  1  5.0   45.20    1.30  7.58  40.10  .42    .000
     [CN=70.7         ]
     [ N = 3.0:Tp 1.43]
*
   * CALIB NASHYD       0122  1  5.0    7.00     .73  6.33  52.38  .54    .000
```

```
      [CN=80.0         ]
      [ N = 3.0:Tp  .36]
*
  *   CALIB NASHYD       0106  1  5.0  263.24   11.10  7.33  51.60  .53    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB NASHYD       0117  1  5.0   92.80    1.14  8.50  23.46  .24    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB NASHYD       0107  1  5.0   39.36     .62  7.92  25.44  .26    .000
      [CN=55.9         ]
      [ N = 3.0:Tp 1.66]
*
  *   CALIB NASHYD       1116  1  5.0   25.80    1.78  6.67  52.39  .54    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    1.67  7.83  47.23  .49    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80    2.09  6.00  59.91  .62    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62   32.02  6.17  70.00  .73    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20     .39  7.00  32.97  .34    .000
      [CN=63.4         ]
      [ N = 3.0:Tp  .95]
*
      ADD [0101 + 0102]  0013  3  5.0  137.67    4.76  6.58  34.70  n/a    .000
*
      ADD [0104 + 0103]  0014  3  5.0  503.22   13.42  7.00  43.10  n/a    .000
*
      ADD [0105 + 0112]  2502  3  5.0  162.10    6.96  7.00  42.69  n/a    .000
*
      ADD [2502 + 0118]  1210  3  5.0  198.39    8.80  6.17  48.03  n/a    .000
*
      ADD [1210 + 0108]  0017  3  5.0  250.38   10.39  6.92  48.32  n/a    .000
*
      ADD [0113 + 0122]  2507  3  5.0   52.20    1.43  7.33  41.74  n/a    .000
*
      ADD [0117 + 0107]  2503  3  5.0  132.16    1.74  8.25  24.05  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30    2.88  6.92  48.89  n/a    .000
*
      RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .54  8.58  59.82  n/a    .000
      {ST=   .74 ha.m }
*
      ADD [0110 + 0014]  2000  3  5.0  672.52   15.71  7.08  39.41  n/a    .000
*
      ADD [0109 + 0017]  0018  3  5.0  285.37   12.18  6.83  47.79  n/a    .000
*
      ADD [0119 + 2507]  0123  3  5.0   57.60    1.94  6.08  45.05  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00    3.95  6.08  49.59  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24   12.75  7.33  51.20  n/a    .000
*
 FINISH
===========================================================================================================
```

```
===========================================================================================================

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO

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                   *****  S U M M A R Y   O U T P U T  *****

  Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

  Output  filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci
  Summary filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci

DATE: 10/15/2015                           TIME: 2:10:16 PM

USER:

COMMENTS: ____________________________________________________________

  ****************************
  ** SIMULATION NUMBER:   1 ** 2yr 24 hr SCS Type II
  ****************************

  W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                  5.0
      [ Ptot= 46.51 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .06 13.00   6.57  .14    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    1.00 12.33  15.13  .33    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0101  1  5.0   84.40     .20 13.92   4.96  .11    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0103  1  5.0  296.24    1.10 14.83  10.15  .22    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0104  1  5.0  206.98    2.37 12.67  12.67  .27    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0110  1  5.0  169.30     .51 13.83   6.20  .13    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0108  1  5.0   51.99     .56 12.83  13.79  .30    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    2.08 11.83  29.05  .63    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD       0112  1  5.0  108.30     .91 12.83  10.87  .23    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB NASHYD       0105  1  5.0   53.80     .53 12.75  11.70  .25    .000
      [CN=73.9         ]
      [ N = 3.0:Tp  .86]
*
  **  CALIB NASHYD       0109  1  5.0   34.99     .37 12.58  11.53  .25    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0106  1  5.0  263.24    2.56 13.17  14.71  .32    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  **  CALIB NASHYD       0122  1  5.0    7.00     .17 12.08  15.12  .33    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .36]
*
  **  CALIB NASHYD       0113  1  5.0   45.20     .26 13.42  10.06  .22    .000
      [CN=70.7         ]
      [ N = 3.0:Tp 1.43]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .44 11.75  32.30  .70    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40     .69 11.75  34.20  .74    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0107  1  5.0   39.36     .10 13.83   5.25  .11    .000
      [CN=55.9         ]
      [ N = 3.0:Tp 1.66]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .18 14.42   4.72  .10    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB NASHYD       1116  1  5.0   25.80     .41 12.42  15.13  .33    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50     .37 13.67  13.02  .28    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80     .77 11.83  21.89  .47    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62    7.18 12.00  24.82  .53    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20     .07 12.83   7.77  .17    .000
      [CN=63.4         ]
      [ N = 3.0:Tp  .95]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67    1.07 12.33   8.89  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22    2.82 12.75  11.19  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52    3.20 12.92   9.93  n/a    .000
*
      ADD [0112 + 0105]  2502  3  5.0  162.10    1.44 12.83  11.15  n/a    .000
*
      ADD [0122 + 0113]  2507  3  5.0   52.20     .29 13.25  10.74  n/a    .000
*
      ADD [2507 + 0119]  0123  3  5.0   57.60     .55 11.83  12.76  n/a    .000
*
      ADD [0123 + 0120]  2505  3  5.0   66.00    1.23 11.83  15.49  n/a    .000
*
      ADD [0107 + 0117]  2503  3  5.0  132.16     .27 14.17   4.88  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30     .66 12.75  13.69  n/a    .000
*
      RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .04 20.83  21.80  n/a    .000
      {ST=   .37 ha.m }
*
      ADD [0118 + 2502]  1210  3  5.0  198.39    2.50 11.92  14.42  n/a    .000
*
      ADD [0106 + 2505]  0319  3  5.0  329.24    2.94 13.17  14.87  n/a    .000
*
      ADD [0108 + 1210]  0017  3  5.0  250.38    2.67 11.92  14.29  n/a    .000
*
      ADD [0017 + 0109]  0018  3  5.0  285.37    2.82 12.50  13.95  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   2 **  5 yr 24 hr SCS Type II
  ****************************

  W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                  5.0
      [ Ptot= 60.36 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .10 13.00  11.55  .19    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    1.65 12.25  24.32  .40    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
```

```
 ** CALIB NASHYD      0101  1  5.0   84.40    .37 13.83   8.97  .15    .000
    [CN=52.3        ]
    [ N = 3.0:Tp 1.72]
*
 ** CALIB NASHYD      0103  1  5.0  296.24   1.93 14.75  17.25  .29    .000
    [CN=71.2        ]
    [ N = 3.0:Tp 2.53]
*
 ** CALIB NASHYD      0104  1  5.0  206.98   4.03 12.58  20.91  .35    .000
    [CN=76.2        ]
    [ N = 3.0:Tp  .80]
*
 ** CALIB NASHYD      0110  1  5.0  169.30    .95 13.75  11.11  .18    .000
    [CN=59.1        ]
    [ N = 3.0:Tp 1.67]
*
 ** CALIB NASHYD      0108  1  5.0   51.99    .94 12.83  22.47  .37    .000
    [CN=78.0        ]
    [ N = 3.0:Tp  .98]
*
 ** CALIB STANDHYD    0118  1  5.0   36.29   3.06 11.83  40.29  .67    .000
    [I%=42.0:S%= 2.00]
*
 ** CALIB NASHYD      0112  1  5.0  108.30   1.58 12.83  18.20  .30    .000
    [CN=71.9        ]
    [ N = 3.0:Tp  .96]
*
 ** CALIB NASHYD      0105  1  5.0   53.80    .92 12.67  19.44  .32    .000
    [CN=73.9        ]
    [ N = 3.0:Tp  .86]
*
 ** CALIB NASHYD      0109  1  5.0   34.99    .64 12.58  19.27  .32    .000
    [CN=74.1        ]
    [ N = 3.0:Tp  .77]
*
 ** CALIB NASHYD      0106  1  5.0  263.24   4.25 13.17  23.78  .39    .000
    [CN=79.6        ]
    [ N = 3.0:Tp 1.24]
*
 ** CALIB NASHYD      0122  1  5.0    7.00    .29 12.08  24.32  .40    .000
    [CN=80.0        ]
    [ N = 3.0:Tp  .36]
*
 ** CALIB NASHYD      0113  1  5.0   45.20    .45 13.42  17.08  .28    .000
    [CN=70.7        ]
    [ N = 3.0:Tp 1.43]
*
  * CALIB STANDHYD    0119  1  5.0    5.40    .60 11.75  44.19  .73    .000
    [I%=50.0:S%= 2.00]
*
  * CALIB STANDHYD    0120  1  5.0    8.40    .95 11.75  46.67  .77    .000
    [I%=50.0:S%= 2.00]
*
  * CALIB NASHYD      0107  1  5.0   39.36    .19 13.75   9.63  .16    .000
    [CN=55.9        ]
    [ N = 3.0:Tp 1.66]
*
  * CALIB NASHYD      0117  1  5.0   92.80    .34 14.33   8.74  .14    .000
    [CN=53.3        ]
    [ N = 3.0:Tp 2.06]
*
  * CALIB NASHYD      1116  1  5.0   25.80    .69 12.42  24.32  .40    .000
    [CN=80.0        ]
    [ N = 3.0:Tp  .66]
*
  * CALIB NASHYD      0115  1  5.0   54.50    .63 13.67  21.28  .35    .000
    [CN=76.0        ]
    [ N = 3.0:Tp 1.65]
*
  * CALIB STANDHYD    0116  1  5.0   25.80   1.07 11.75  31.54  .52    .000
    [I%=25.0:S%= 1.00]
*
  * CALIB STANDHYD    0114  1  5.0  211.62  11.35 12.00  35.56  .59    .000
    [I%=26.0:S%= 1.00]
*
  * CALIB NASHYD      0121  1  5.0   12.20    .13 12.83  13.48  .22    .000
    [CN=63.4        ]
    [ N = 3.0:Tp  .95]
*
    ADD [0102 + 0101]  0013  3  5.0  137.67   1.80 12.33  14.91  n/a    .000
*
    ADD [0103 + 0104]  0014  3  5.0  503.22   4.87 12.75  18.75  n/a    .000
*
    ADD [0014 + 0110]  2000  3  5.0  672.52   5.58 12.83  16.83  n/a    .000
*
    ADD [0112 + 0105]  2502  3  5.0  162.10   2.49 12.75  18.61  n/a    .000
*
    ADD [0122 + 0113]  2507  3  5.0   52.20    .51 13.17  18.05  n/a    .000
*
    ADD [2507 + 0119]  0123  3  5.0   57.60    .82 11.83  20.50  n/a    .000
*
    ADD [0123 + 0120]  2505  3  5.0   66.00   1.76 11.83  23.83  n/a    .000
*
```

```
    ADD [0107 + 0117]  2503  3  5.0  132.16    .52 14.08   9.01  n/a    .000
*
    ADD [1116 + 0115]  2504  3  5.0   80.30   1.09 12.75  22.25  n/a    .000
*
    RESRVR [ 2 : 0116] 2506  1  5.0   25.80    .13 16.50  31.45  n/a    .000
    {ST=   .48 ha.m }
*
    ADD [0118 + 2502]  1210  3  5.0  198.39   3.91 11.92  22.58  n/a    .000
*
    ADD [0106 + 2505]  0319  3  5.0  329.24   4.89 13.08  23.79  n/a    .000
*
    ADD [0108 + 1210]  0017  3  5.0  250.38   4.21 11.92  22.55  n/a    .000
*
    ADD [0017 + 0109]  0018  3  5.0  285.37   4.64 12.58  22.15  n/a    .000
*
 ****************************
 ** SIMULATION NUMBER:   3 **  10 yr 24 hr SCS Type II
 ****************************

 W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                min     ha     cms   hrs     mm          cms

    START @   .00 hrs
    --------------------
    MASS STORM                  5.0
    [ Ptot= 69.52 mm ]
*
 ** CALIB NASHYD      0111  1  5.0   12.40    .14 13.00  15.42  .22    .000
    [CN=58.9        ]
    [ N = 3.0:Tp 1.07]
*
 ** CALIB NASHYD      0102  1  5.0   53.27   2.13 12.25  30.96  .45    .000
    [CN=80.0        ]
    [ N = 3.0:Tp  .53]
*
 ** CALIB NASHYD      0101  1  5.0   84.40    .51 13.83  12.14  .17    .000
    [CN=52.3        ]
    [ N = 3.0:Tp 1.72]
*
 ** CALIB NASHYD      0103  1  5.0  296.24   2.57 14.75  22.57  .33    .000
    [CN=71.2        ]
    [ N = 3.0:Tp 2.53]
*
 ** CALIB NASHYD      0104  1  5.0  206.98   5.27 12.58  26.96  .39    .000
    [CN=76.2        ]
    [ N = 3.0:Tp  .80]
*
 ** CALIB NASHYD      0110  1  5.0  169.30   1.29 13.75  14.94  .22    .000
    [CN=59.1        ]
    [ N = 3.0:Tp 1.67]
*
 ** CALIB NASHYD      0108  1  5.0   51.99   1.22 12.83  28.80  .41    .000
    [CN=78.0        ]
    [ N = 3.0:Tp  .98]
*
 ** CALIB STANDHYD    0118  1  5.0   36.29   3.67 11.83  48.02  .69    .000
    [I%=42.0:S%= 2.00]
*
 ** CALIB NASHYD      0112  1  5.0  108.30   2.08 12.83  23.66  .34    .000
    [CN=71.9        ]
    [ N = 3.0:Tp  .96]
*
 ** CALIB NASHYD      0105  1  5.0   53.80   1.20 12.67  25.18  .36    .000
    [CN=73.9        ]
    [ N = 3.0:Tp  .86]
*
 ** CALIB NASHYD      0109  1  5.0   34.99    .84 12.58  25.01  .36    .000
    [CN=74.1        ]
    [ N = 3.0:Tp  .77]
*
 ** CALIB NASHYD      0106  1  5.0  263.24   5.49 13.08  30.36  .44    .000
    [CN=79.6        ]
    [ N = 3.0:Tp 1.24]
*
 ** CALIB NASHYD      0122  1  5.0    7.00    .37 12.08  30.96  .45    .000
    [CN=80.0        ]
    [ N = 3.0:Tp  .36]
*
 ** CALIB NASHYD      0113  1  5.0   45.20    .60 13.42  22.35  .32    .000
    [CN=70.7        ]
    [ N = 3.0:Tp 1.43]
*
  * CALIB STANDHYD    0119  1  5.0    5.40    .72 11.75  52.30  .75    .000
    [I%=50.0:S%= 2.00]
*
  * CALIB STANDHYD    0120  1  5.0    8.40   1.13 11.75  55.12  .79    .000
    [I%=50.0:S%= 2.00]
*
  * CALIB NASHYD      0107  1  5.0   39.36    .26 13.75  13.08  .19    .000
    [CN=55.9        ]
    [ N = 3.0:Tp 1.66]
*
  * CALIB NASHYD      0117  1  5.0   92.80    .47 14.25  11.94  .17    .000
```

```
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB NASHYD       1116  1  5.0   25.80     .88 12.42  30.96  .45    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50     .81 13.58  27.34  .39    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80    1.27 11.75  38.35  .55    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62   15.11 12.00  43.05  .62    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20     .17 12.83  17.85  .26    .000
      [CN=63.4         ]
      [ N = 3.0:Tp  .95]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67    2.33 12.33  19.42  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22    6.40 12.75  24.38  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52    7.39 12.83  22.00  n/a    .000
*
      ADD [0112 + 0105]  2502  3  5.0  162.10    3.28 12.75  24.17  n/a    .000
*
      ADD [0122 + 0113]  2507  3  5.0   52.20     .67 13.17  23.51  n/a    .000
*
      ADD [2507 + 0119]  0123  3  5.0   57.60    1.01 11.83  26.20  n/a    .000
*
      ADD [0123 + 0120]  2505  3  5.0   66.00    2.14 11.83  29.88  n/a    .000
*
      ADD [0107 + 0117]  2503  3  5.0  132.16     .73 14.08  12.28  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30    1.42 12.75  28.50  n/a    .000
*
      RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .21 15.42  38.26  n/a    .000
      {ST=   .52 ha.m }
*
      ADD [0118 + 2502]  1210  3  5.0  198.39    4.52 11.92  28.53  n/a    .000
*
      ADD [0106 + 2505]  0319  3  5.0  329.24    6.31 13.08  30.26  n/a    .000
*
      ADD [0108 + 1210]  0017  3  5.0  250.38    5.12 12.58  28.59  n/a    .000
*
      ADD [0017 + 0109]  0018  3  5.0  285.37    5.97 12.58  28.15  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   4 **  25 yr 24 hr SCS Type II
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                   min    ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                   5.0
      [ Ptot= 81.07 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .19 12.92  20.85  .26    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    2.76 12.25  39.82  .49    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0101  1  5.0   84.40     .71 13.75  16.65  .21    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0103  1  5.0  296.24    3.43 14.67  29.86  .37    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0104  1  5.0  206.98    6.94 12.58  35.12  .43    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0110  1  5.0  169.30    1.79 13.67  20.33  .25    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0108  1  5.0   51.99    1.60 12.83  37.29  .46    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    4.79 11.83  58.04  .72    .000
      [I%=42.0:S%= 2.00]
*
```

```
  **  CALIB NASHYD       0112  1  5.0  108.30    2.77 12.75  31.11  .38    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB NASHYD       0105  1  5.0   53.80    1.59 12.67  32.96  .41    .000
      [CN=73.9         ]
      [ N = 3.0:Tp  .86]
*
  **  CALIB NASHYD       0109  1  5.0   34.99    1.12 12.58  32.80  .40    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0106  1  5.0  263.24    7.15 13.08  39.13  .48    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  **  CALIB NASHYD       0122  1  5.0    7.00     .48 12.08  39.81  .49    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .36]
*
  **  CALIB NASHYD       0113  1  5.0   45.20     .81 13.33  29.56  .37    .000
      [CN=70.7         ]
      [ N = 3.0:Tp 1.43]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .87 11.75  62.72  .77    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    1.37 11.75  65.92  .81    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0107  1  5.0   39.36     .37 13.67  17.98  .22    .000
      [CN=55.9         ]
      [ N = 3.0:Tp 1.66]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .67 14.25  16.49  .20    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB NASHYD       1116  1  5.0   25.80    1.14 12.42  39.82  .49    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    1.07 13.58  35.50  .44    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80    1.52 11.75  47.31  .58    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62   18.22 11.92  52.81  .65    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20     .24 12.75  23.93  .30    .000
      [CN=63.4         ]
      [ N = 3.0:Tp  .95]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67    3.05 12.33  25.62  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22    8.49 12.75  32.02  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52    9.86 12.83  29.08  n/a    .000
*
      ADD [0112 + 0105]  2502  3  5.0  162.10    4.35 12.75  31.72  n/a    .000
*
      ADD [0122 + 0113]  2507  3  5.0   52.20     .90 13.08  30.94  n/a    .000
*
      ADD [2507 + 0119]  0123  3  5.0   57.60    1.27 11.83  33.92  n/a    .000
*
      ADD [0123 + 0120]  2505  3  5.0   66.00    2.63 11.83  37.99  n/a    .000
*
      ADD [0107 + 0117]  2503  3  5.0  132.16    1.02 14.00  16.94  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30    1.85 12.67  36.89  n/a    .000
*
      RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .30 14.92  47.22  n/a    .000
      {ST=   .58 ha.m }
*
      ADD [0118 + 2502]  1210  3  5.0  198.39    5.96 11.92  36.54  n/a    .000
*
      ADD [0106 + 2505]  0319  3  5.0  329.24    8.22 13.08  38.90  n/a    .000
*
      ADD [0108 + 1210]  0017  3  5.0  250.38    6.63 12.67  36.69  n/a    .000
*
      ADD [0017 + 0109]  0018  3  5.0  285.37    7.75 12.58  36.21  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   5 **  50 yr 24 hr SCS Type II
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                   min    ha     cms   hrs     mm          cms

      START @   .00 hrs
```

```
     --------------------
     MASS STORM                   5.0
     [ Ptot= 89.74 mm ]
*
 **  CALIB NASHYD       0111  1  5.0   12.40     .23 12.92  25.27  .28    .000
     [CN=58.9         ]
     [ N = 3.0:Tp 1.07]
*
 **  CALIB NASHYD       0102  1  5.0   53.27    3.26 12.25  46.74  .52    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .53]
*
 **  CALIB NASHYD       0101  1  5.0   84.40     .87 13.75  20.38  .23    .000
     [CN=52.3         ]
     [ N = 3.0:Tp 1.72]
*
 **  CALIB NASHYD       0103  1  5.0  296.24    4.13 14.67  35.67  .40    .000
     [CN=71.2         ]
     [ N = 3.0:Tp 2.53]
*
 **  CALIB NASHYD       0104  1  5.0  206.98    8.26 12.58  41.56  .46    .000
     [CN=76.2         ]
     [ N = 3.0:Tp  .80]
*
 **  CALIB NASHYD       0110  1  5.0  169.30    2.19 13.67  24.73  .28    .000
     [CN=59.1         ]
     [ N = 3.0:Tp 1.67]
*
 **  CALIB NASHYD       0108  1  5.0   51.99    1.89 12.75  43.96  .49    .000
     [CN=78.0         ]
     [ N = 3.0:Tp  .98]
*
 **  CALIB STANDHYD     0118  1  5.0   36.29    5.47 11.83  65.70  .73    .000
     [I%=42.0:S%= 2.00]
*
 **  CALIB NASHYD       0112  1  5.0  108.30    3.32 12.75  37.04  .41    .000
     [CN=71.9         ]
     [ N = 3.0:Tp  .96]
*
 **  CALIB NASHYD       0105  1  5.0   53.80    1.90 12.67  39.12  .44    .000
     [CN=73.9         ]
     [ N = 3.0:Tp  .86]
*
 **  CALIB NASHYD       0109  1  5.0   34.99    1.34 12.58  38.97  .43    .000
     [CN=74.1         ]
     [ N = 3.0:Tp  .77]
*
 **  CALIB NASHYD       0106  1  5.0  263.24    8.44 13.08  45.99  .51    .000
     [CN=79.6         ]
     [ N = 3.0:Tp 1.24]
*
 **  CALIB NASHYD       0122  1  5.0    7.00     .56 12.08  46.73  .52    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .36]
*
 **  CALIB NASHYD       0113  1  5.0   45.20     .97 13.33  35.33  .39    .000
     [CN=70.7         ]
     [ N = 3.0:Tp 1.43]
*
  *  CALIB STANDHYD     0119  1  5.0    5.40    1.04 11.75  70.66  .79    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     0120  1  5.0    8.40    1.55 11.75  74.11  .83    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB NASHYD       0107  1  5.0   39.36     .45 13.67  22.02  .25    .000
     [CN=55.9         ]
     [ N = 3.0:Tp 1.66]
*
  *  CALIB NASHYD       0117  1  5.0   92.80     .83 14.17  20.27  .23    .000
     [CN=53.3         ]
     [ N = 3.0:Tp 2.06]
*
  *  CALIB NASHYD       1116  1  5.0   25.80    1.35 12.42  46.74  .52    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .66]
*
  *  CALIB NASHYD       0115  1  5.0   54.50    1.27 13.58  41.94  .47    .000
     [CN=76.0         ]
     [ N = 3.0:Tp 1.65]
*
  *  CALIB STANDHYD     0116  1  5.0   25.80    1.72 11.75  54.26  .61    .000
     [I%=25.0:S%= 1.00]
*
  *  CALIB STANDHYD     0114  1  5.0  211.62   21.25 12.00  60.31  .67    .000
     [I%=26.0:S%= 1.00]
*
  *  CALIB NASHYD       0121  1  5.0   12.20     .29 12.75  28.85  .32    .000
     [CN=63.4         ]
     [ N = 3.0:Tp  .95]
*
     ADD [0102 + 0101]  0013  3  5.0  137.67    3.61 12.33  30.58  n/a    .000
*
     ADD [0103 + 0104]  0014  3  5.0  503.22   10.15 12.75  38.10  n/a    .000
*
     ADD [0014 + 0110]  2000  3  5.0  672.52   11.85 12.83  34.73  n/a    .000
*
     ADD [0112 + 0105]  2502  3  5.0  162.10    5.20 12.75  37.73  n/a    .000
*
     ADD [0122 + 0113]  2507  3  5.0   52.20    1.08 13.08  36.86  n/a    .000
*
     ADD [2507 + 0119]  0123  3  5.0   57.60    1.54 11.83  40.02  n/a    .000
*
     ADD [0123 + 0120]  2505  3  5.0   66.00    3.07 11.83  44.36  n/a    .000
*
     ADD [0107 + 0117]  2503  3  5.0  132.16    1.26 14.00  20.79  n/a    .000
*
     ADD [1116 + 0115]  2504  3  5.0   80.30    2.19 12.67  43.48  n/a    .000
*
     RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .38 14.67  54.17  n/a    .000
     {ST=   .63 ha.m }
*
     ADD [0118 + 2502]  1210  3  5.0  198.39    6.94 11.92  42.85  n/a    .000
*
     ADD [0106 + 2505]  0319  3  5.0  329.24    9.71 13.08  45.67  n/a    .000
*
     ADD [0108 + 1210]  0017  3  5.0  250.38    7.86 12.67  43.08  n/a    .000
*
     ADD [0017 + 0109]  0018  3  5.0  285.37    9.20 12.58  42.57  n/a    .000
*
 ****************************
 ** SIMULATION NUMBER:   6 **  100 yr 24 hr SCS Type II
 ****************************

 W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                 min     ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     MASS STORM                   5.0
     [ Ptot= 98.31 mm ]
*
 **  CALIB NASHYD       0111  1  5.0   12.40     .27 12.92  29.92  .30    .000
     [CN=58.9         ]
     [ N = 3.0:Tp 1.07]
*
 **  CALIB NASHYD       0102  1  5.0   53.27    3.76 12.25  53.77  .55    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .53]
*
 **  CALIB NASHYD       0101  1  5.0   84.40    1.05 13.75  24.32  .25    .000
     [CN=52.3         ]
     [ N = 3.0:Tp 1.72]
*
 **  CALIB NASHYD       0103  1  5.0  296.24    4.85 14.67  41.67  .42    .000
     [CN=71.2         ]
     [ N = 3.0:Tp 2.53]
*
 **  CALIB NASHYD       0104  1  5.0  206.98    9.62 12.58  48.15  .49    .000
     [CN=76.2         ]
     [ N = 3.0:Tp  .80]
*
 **  CALIB NASHYD       0110  1  5.0  169.30    2.62 13.67  29.36  .30    .000
     [CN=59.1         ]
     [ N = 3.0:Tp 1.67]
*
 **  CALIB NASHYD       0108  1  5.0   51.99    2.20 12.75  50.76  .52    .000
     [CN=78.0         ]
     [ N = 3.0:Tp  .98]
*
 **  CALIB STANDHYD     0118  1  5.0   36.29    6.16 11.83  73.38  .75    .000
     [I%=42.0:S%= 2.00]
*
 **  CALIB NASHYD       0112  1  5.0  108.30    3.88 12.75  43.14  .44    .000
     [CN=71.9         ]
     [ N = 3.0:Tp  .96]
*
 **  CALIB NASHYD       0105  1  5.0   53.80    2.22 12.67  45.45  .46    .000
     [CN=73.9         ]
     [ N = 3.0:Tp  .86]
*
 **  CALIB NASHYD       0109  1  5.0   34.99    1.56 12.58  45.31  .46    .000
     [CN=74.1         ]
     [ N = 3.0:Tp  .77]
*
 **  CALIB NASHYD       0106  1  5.0  263.24    9.76 13.08  52.97  .54    .000
     [CN=79.6         ]
     [ N = 3.0:Tp 1.24]
*
 **  CALIB NASHYD       0122  1  5.0    7.00     .65 12.08  53.76  .55    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .36]
*
 **  CALIB NASHYD       0113  1  5.0   45.20    1.14 13.33  41.27  .42    .000
     [CN=70.7         ]
     [ N = 3.0:Tp 1.43]
```

```
*
  *   CALIB STANDHYD     0119  1  5.0    5.40    1.19 11.75  78.58  .80    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    1.88 11.75  82.27  .84    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0107  1  5.0   39.36     .54 13.67  26.29  .27    .000
      [CN=55.9         ]
      [ N = 3.0:Tp 1.66]
*
  *   CALIB NASHYD       0117  1  5.0   92.80    1.00 14.17  24.26  .25    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB NASHYD       1116  1  5.0   25.80    1.56 12.42  53.77  .55    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    1.47 13.58  48.53  .49    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80    1.91 11.75  61.29  .62    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62   24.26 12.00  67.86  .69    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20     .34 12.75  33.99  .35    .000
      [CN=63.4         ]
      [ N = 3.0:Tp  .95]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67    4.19 12.33  35.72  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22   11.86 12.75  44.34  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52   13.90 12.83  40.57  n/a    .000
*
      ADD [0112 + 0105]  2502  3  5.0  162.10    6.09 12.75  43.91  n/a    .000
*
      ADD [0122 + 0113]  2507  3  5.0   52.20    1.26 13.08  42.95  n/a    .000
*
      ADD [2507 + 0119]  0123  3  5.0   57.60    1.77 11.83  46.29  n/a    .000
*
      ADD [0123 + 0120]  2505  3  5.0   66.00    3.62 11.83  50.87  n/a    .000
*
      ADD [0107 + 0117]  2503  3  5.0  132.16    1.52 14.00  24.87  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30    2.54 12.67  50.21  n/a    .000
*
      RESRVR [ 2 : 0116] 2506  1  5.0   25.80     .45 14.50  61.21  n/a    .000
      {ST=   .69 ha.m }
*
      ADD [0118 + 2502]  1210  3  5.0  198.39    7.95 11.92  49.30  n/a    .000
*
      ADD [0106 + 2505]  0319  3  5.0  329.24   11.23 13.08  52.55  n/a    .000
*
      ADD [0108 + 1210]  0017  3  5.0  250.38    9.12 12.67  49.60  n/a    .000
*
      ADD [0017 + 0109]  0018  3  5.0  285.37   10.68 12.58  49.08  n/a    .000
*
 FINISH
=============================================================================================================
```

```
===========================================================================================================

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
```



```
                   *****  S U M M A R Y   O U T P U T  *****

  Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

  Output  filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci
  Summary filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci


DATE: 10/15/2015                           TIME: 2:23:30 PM

USER:


COMMENTS: ____________________________________________________________


  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      READ STORM                  12.0
      [ Ptot=212.00 mm ]
      fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
      remark: * REGIONAL DESIGN STORM - HAZEL
*
  **  CALIB NASHYD       0111  1  5.0   12.40    1.14 11.25 147.18  .69    .000
      [CN=76.7        ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    6.61 10.33 180.67  .85    .000
      [CN=90.2        ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0101  1  5.0   84.40    5.98 11.83 134.78  .64    .000
      [CN=71.6        ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0103  1  5.0  296.24   20.08 12.42 166.57  .79    .000
      [CN=85.0        ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0104  1  5.0  206.98   22.77 10.92 174.83  .82    .000
      [CN=88.1        ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0110  1  5.0  169.30   12.94 11.75 146.21  .69    .000
      [CN=76.8        ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0108  1  5.0   51.99    5.48 11.08 177.62  .84    .000
      [CN=89.1        ]
      [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    4.91 10.00 180.69  .85    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD       0112  1  5.0  108.30   11.20 11.08 168.70  .80    .000
      [CN=85.5        ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB NASHYD       0105  1  5.0   53.80    5.77 11.00 171.58  .81    .000
      [CN=86.7        ]
      [ N = 3.0:Tp  .86]
*
  **  CALIB NASHYD       0109  1  5.0   34.99    3.85 10.83 171.33  .81    .000
      [CN=86.8        ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0106  1  5.0  263.24   25.74 11.33 179.90  .85    .000
      [CN=90.0        ]
      [ N = 3.0:Tp 1.24]
*
  **  CALIB STANDHYD     0120  1  5.0    8.40    1.20 10.00 193.34  .91    .000
      [I%=50.0:S%= 2.00]
*
  **  CALIB NASHYD       0122  1  5.0    7.00     .95 10.08 180.64  .85    .000
      [CN=90.2        ]
      [ N = 3.0:Tp  .36]
*
  **  CALIB NASHYD       0113  1  5.0   45.20    4.01 11.50 166.06  .78    .000
      [CN=84.7        ]
      [ N = 3.0:Tp 1.43]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .76 10.00 187.83  .89    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0107  1  5.0   39.36    2.93 11.75 140.04  .66    .000
      [CN=74.5        ]
      [ N = 3.0:Tp 1.66]
*
  *   CALIB NASHYD       0117  1  5.0   92.80    6.04 12.17 135.12  .64    .000
      [CN=72.4        ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB NASHYD       1116  1  5.0   25.80    3.02 10.50 180.67  .85    .000
      [CN=90.2        ]
      [ N = 3.0:Tp  .66]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    4.67 11.67 175.37  .83    .000
      [CN=88.0        ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0116  1  5.0   25.80    2.32 11.00 163.27  .77    .000
      [I%=25.0:S%= 1.00]
*
  *   CALIB STANDHYD     0114  1  5.0  211.62   28.04 10.08 191.66  .90    .000
      [I%=26.0:S%= 1.00]
*
  *   CALIB NASHYD       0121  1  5.0   12.20    1.27 11.00 161.42  .76    .000
      [CN=82.6        ]
      [ N = 3.0:Tp  .85]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67   11.17 11.08 152.54  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22   39.08 11.25 169.97  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52   51.43 11.33 163.99  n/a    .000
*
      ADD [0112 + 0105]  2502  3  5.0  162.10   16.97 11.08 169.65  n/a    .000
*
      ADD [0122 + 0113]  2507  3  5.0   52.20    4.58 11.17 168.02  n/a    .000
*
      ADD [2507 + 0119]  0123  3  5.0   57.60    5.06 11.00 169.87  n/a    .000
*
      ADD [0107 + 0117]  2503  3  5.0  132.16    8.93 12.00 136.58  n/a    .000
*
      ADD [1116 + 0115]  2504  3  5.0   80.30    7.24 11.17 177.07  n/a    .000
*
      ADD [0118 + 2502]  1210  3  5.0  198.39   20.64 11.00 171.67  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00    5.93 11.00 172.86  n/a    .000
*
      ADD [0108 + 1210]  0017  3  5.0  250.38   26.09 11.00 172.91  n/a    .000
*
      ADD [0106 + 2505]  0319  3  5.0  329.24   31.03 11.17 178.49  n/a    .000
*
      ADD [0017 + 0109]  0018  3  5.0  285.37   29.93 11.00 172.71  n/a    .000
*
 FINISH

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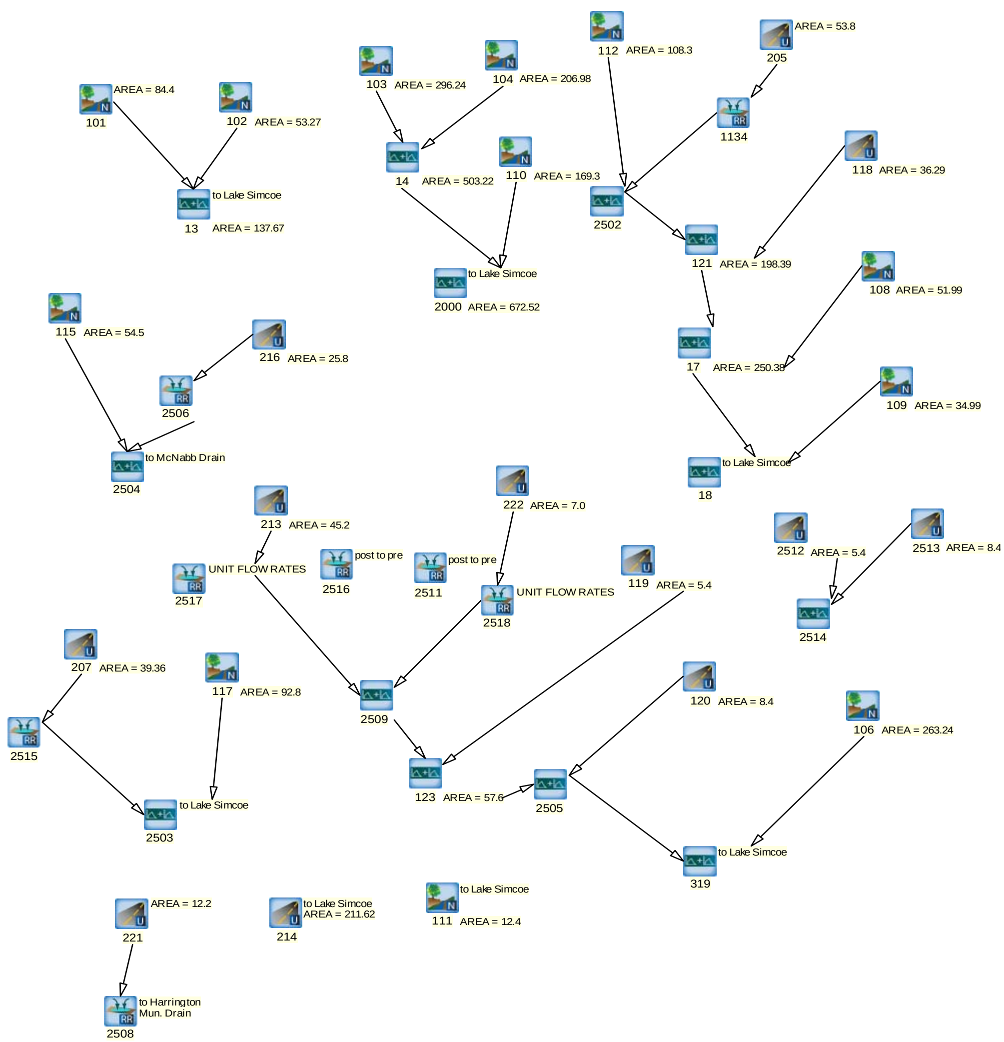
C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Project:	Township of Ramara CSWMMP
Date:	Oct-15
File No.:	312803
Designed By:	JA
Checked By:	DJH
Subject:	Hydrologic Model Schematic

TOWNSHIP OF RAMARA SWM MASTER PLAN
HYDROLOGIC MODEL SCHEMATIC: FUTURE CONDITIONS



Nashyd	Route Pipe	Duhyd
Standhyd	Route Channel	Diverthyd
Addhyd	Route Reservoir	

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 205

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.35			0.00	0.00
Cultivated Land, 5 -10% grade	0.45			0.00	0.00
Cultivated Land, 10 - 30% grade	0.65			0.00	0.00
Pasture Land, 0 - 5% grade	0.28			0.00	0.00
Pasture Land, 5 -10% grade	0.35			0.00	0.00
Pasture Land, 10 - 30% grade	0.40			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.25			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.30			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.35			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.50			0.00	0.00
Residential - Sinlge Family	0.40	50%	46.3	18.52	23.15
Residential - Multiple (i.e., semi, townhouse, apartment)	0.60			0.00	0.00
Industrial - Light	0.65			0.00	0.00
Industrial - Heavy	0.75			0.00	0.00
Commercial	0.70	85%	7.5	5.25	6.38
Unimproved Areas	0.20			0.00	0.00
Lawn, < 2% grade	0.11			0.00	0.00
Lawn, 2 - 7% grade	0.16			0.00	0.00
Lawn, > 7 % grade	0.25			0.00	0.00
Road Right-of-Way	0.70			0.00	0.00
Weighted Average			53.8	0.44	55%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 207

Runoff Coeffcient "C" Reference No.: 6
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.55			0.00	0.00
Cultivated Land, 5 -10% grade	0.60			0.00	0.00
Cultivated Land, 10 - 30% grade	0.70			0.00	0.00
Pasture Land, 0 - 5% grade	0.40			0.00	0.00
Pasture Land, 5 -10% grade	0.45			0.00	0.00
Pasture Land, 10 - 30% grade	0.55			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.35			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.42			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.52			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.60			0.00	0.00
Residential - Sinlge Family	0.50	50%	39.4	19.68	19.68
Residential - Multiple (i.e., semi, townhouse, apartment)	0.70			0.00	0.00
Industrial - Light	0.75			0.00	0.00
Industrial - Heavy	0.85			0.00	0.00
Commercial	0.80			0.00	0.00
Unimproved Areas	0.30			0.00	0.00
Lawn, < 2% grade	0.17			0.00	0.00
Lawn, 2 - 7% grade	0.22			0.00	0.00
Lawn, > 7 % grade	0.35			0.00	0.00
Road Right-of-Way	0.80			0.00	0.00
Weighted Average			39.4	0.50	50%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 213

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.35	0%	8.2	2.87	0.00
Cultivated Land, 5 -10% grade	0.45			0.00	0.00
Cultivated Land, 10 - 30% grade	0.65			0.00	0.00
Pasture Land, 0 - 5% grade	0.28			0.00	0.00
Pasture Land, 5 -10% grade	0.35			0.00	0.00
Pasture Land, 10 - 30% grade	0.40			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.25			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.30			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.35			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.50			0.00	0.00
Residential - Sinlge Family	0.40	50%	29.6	11.82	14.78
Residential - Multiple (i.e., semi, townhouse, apartment)	0.60			0.00	0.00
Industrial - Light	0.65	0.75	2.0	1.30	1.50
Industrial - Heavy	0.75			0.00	0.00
Commercial	0.70	85%	5.4	3.78	4.59
Unimproved Areas	0.20			0.00	0.00
Lawn, < 2% grade	0.11			0.00	0.00
Lawn, 2 - 7% grade	0.16			0.00	0.00
Lawn, > 7 % grade	0.25			0.00	0.00
Road Right-of-Way	0.70			0.00	0.00
Weighted Average			45.2	0.44	46%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 214

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.35	0%	12.6	4.41	0.00
Cultivated Land, 5 -10% grade	0.45			0.00	0.00
Cultivated Land, 10 - 30% grade	0.65			0.00	0.00
Pasture Land, 0 - 5% grade	0.28			0.00	0.00
Pasture Land, 5 -10% grade	0.35			0.00	0.00
Pasture Land, 10 - 30% grade	0.40			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.25			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.30			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.35			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.50			0.00	0.00
Residential - Sinlge Family	0.40	50%	199.0	79.61	99.51
Residential - Multiple (i.e., semi, townhouse, apartment)	0.60			0.00	0.00
Industrial - Light	0.65			0.00	0.00
Industrial - Heavy	0.75			0.00	0.00
Commercial	0.70			0.00	0.00
Unimproved Areas	0.20			0.00	0.00
Lawn, < 2% grade	0.11			0.00	0.00
Lawn, 2 - 7% grade	0.16			0.00	0.00
Lawn, > 7 % grade	0.25			0.00	0.00
Road Right-of-Way	0.70			0.00	0.00
Weighted Average			211.6	0.40	47%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 216

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.35			0.00	0.00
Cultivated Land, 5 -10% grade	0.45			0.00	0.00
Cultivated Land, 10 - 30% grade	0.65			0.00	0.00
Pasture Land, 0 - 5% grade	0.28			0.00	0.00
Pasture Land, 5 -10% grade	0.35			0.00	0.00
Pasture Land, 10 - 30% grade	0.40			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.25			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.30			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.35			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.50			0.00	0.00
Residential - Sinlge Family	0.40			0.00	0.00
Residential - Multiple (i.e., semi, townhouse, apartment)	0.60			0.00	0.00
Industrial - Light	0.65	0.75	25.8	16.77	19.35
Industrial - Heavy	0.75			0.00	0.00
Commercial	0.70			0.00	0.00
Unimproved Areas	0.20			0.00	0.00
Lawn, < 2% grade	0.11			0.00	0.00
Lawn, 2 - 7% grade	0.16			0.00	0.00
Lawn, > 7 % grade	0.25			0.00	0.00
Road Right-of-Way	0.70			0.00	0.00
Weighted Average			25.8	0.65	75%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 221

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.35			0.00	0.00
Cultivated Land, 5 -10% grade	0.45			0.00	0.00
Cultivated Land, 10 - 30% grade	0.65			0.00	0.00
Pasture Land, 0 - 5% grade	0.28			0.00	0.00
Pasture Land, 5 -10% grade	0.35			0.00	0.00
Pasture Land, 10 - 30% grade	0.40			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.25			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.30			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.35			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.50			0.00	0.00
Residential - Sinlge Family	0.40	50%	12.2	4.88	6.10
Residential - Multiple (i.e., semi, townhouse, apartment)	0.60			0.00	0.00
Industrial - Light	0.65			0.00	0.00
Industrial - Heavy	0.75			0.00	0.00
Commercial	0.70			0.00	0.00
Unimproved Areas	0.20			0.00	0.00
Lawn, < 2% grade	0.11			0.00	0.00
Lawn, 2 - 7% grade	0.16			0.00	0.00
Lawn, > 7 % grade	0.25			0.00	0.00
Road Right-of-Way	0.70			0.00	0.00
Weighted Average			12.2	0.40	50%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA

STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENT/% IMPERVIOUSNESS - CATCHMENT 222

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	% Impervious	Total Area (Ha)	A x C	A x % Imp.
Cultivated Land, 0 - 5% grade	0.35			0.00	0.00
Cultivated Land, 5 -10% grade	0.45			0.00	0.00
Cultivated Land, 10 - 30% grade	0.65			0.00	0.00
Pasture Land, 0 - 5% grade	0.28			0.00	0.00
Pasture Land, 5 -10% grade	0.35			0.00	0.00
Pasture Land, 10 - 30% grade	0.40			0.00	0.00
Woodlot or Cutover, 0 - 5% grade	0.25			0.00	0.00
Woodlot or Cutover, 5 -10% grade	0.30			0.00	0.00
Woodlot or Cutover, 10 -30% grade	0.35			0.00	0.00
Lakes and Wetlands	0.05			0.00	0.00
Impervious Areas (i.e., buildings, roads, parking lots, etc.)	0.95			0.00	0.00
Gravel (not to be used for proposed parking or storage areas)	0.50			0.00	0.00
Residential - Sinlge Family	0.40			0.00	0.00
Residential - Multiple (i.e., semi, townhouse, apartment)	0.60			0.00	0.00
Industrial - Light	0.65	0.75	4.8	3.12	3.60
Industrial - Heavy	0.75			0.00	0.00
Commercial	0.70	85%	2.2	1.54	1.87
Unimproved Areas	0.20			0.00	0.00
Lawn, < 2% grade	0.11			0.00	0.00
Lawn, 2 - 7% grade	0.16			0.00	0.00
Lawn, > 7 % grade	0.25			0.00	0.00
Road Right-of-Way	0.70			0.00	0.00
Weighted Average			7.0	0.67	78%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

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=========================================================================================================

       V   V   I    SSSSS  U   U    A    L
       V   V   I    SS     U   U   A A   L
        V V    I     SS    U   U  AAAAA  L
        V V    I      SS   U   U  A   A  L
         VV    I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
```

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```
                   *****  S U M M A R Y   O U T P U T  *****

  Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

  Output  filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci
  Summary filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci

DATE: 10/15/2015                           TIME: 2:17:58 PM

USER:

COMMENTS: ____________________________________________________________

  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************

  W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                 min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      READ STORM                 6.0
      [ Ptot= 24.97 mm ]
      fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
      remark: 25 mm 4-hr Chicago storm
*
  **  CALIB NASHYD      0111  1  5.0   12.40     .02  3.42   1.34  .05    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD      0102  1  5.0   53.27     .38  2.58   3.96  .16    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD      0101  1  5.0   84.40     .06  4.25    .91  .04    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD      0103  1  5.0  296.24     .37  5.00   2.22  .09    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD      0104  1  5.0  206.98     .84  3.00   3.06  .12    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD      0110  1  5.0  169.30     .15  4.25   1.14  .05    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD      0108  1  5.0   51.99     .21  3.17   3.46  .14    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD    0118  1  5.0   36.29    1.83  2.00  13.21  .53    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB STANDHYD    0205  1  5.0   53.80    2.28  2.00  12.24  .49    .000
      [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD      0112  1  5.0  108.30     .32  3.17   2.55  .10    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB NASHYD      0109  1  5.0   34.99     .13  2.92   2.66  .11    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD      0106  1  5.0  263.24     .98  3.50   3.77  .15    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  **  CALIB STANDHYD    0120  1  5.0    8.40     .65  1.92  16.00  .64    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD    0119  1  5.0    5.40     .42  1.92  15.16  .61    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD    0213  1  5.0   45.20    1.63  2.00  10.39  .42    .000
      [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD    0222  1  5.0    7.00     .59  1.92  17.23  .69    .000
      [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD    0216  1  5.0   25.80    1.72  2.00  16.64  .67    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD      0115  1  5.0   54.50     .14  4.08   3.29  .13    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD    0207  1  5.0   39.36    1.57  2.00  10.04  .40    .000
      [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD      0117  1  5.0   92.80     .05  4.67    .76  .03    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD    0214  1  5.0  211.62    5.98  2.08  11.44  .46    .000
      [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD    0221  1  5.0   12.20     .60  1.92  10.33  .41    .000
      [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD    2512  1  5.0    5.40     .42  1.92  15.16  .61    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD    2513  1  5.0    8.40     .65  1.92  16.00  .64    .000
      [I%=50.0:S%= 2.00]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67     .40  2.58   2.09  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22    1.00  3.08   2.57  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52    1.11  3.25   2.21  n/a    .000
*
      RESRVR [ 2 : 0205] 1134  1  5.0   53.80     .07  4.33  12.20  n/a    .000
      {ST=   .60 ha.m }
*
      ADD [1134 + 0112]  2502  3  5.0  162.10     .39  3.17   5.75  n/a    .000
*
      RESRVR [ 2 : 0213] 2516  1  5.0   45.20     .05  4.33  10.34  n/a    .000
      {ST=   .43 ha.m }
*
      RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .01  4.08  16.92  n/a    .000
      {ST=   .11 ha.m }
*
      RESRVR [ 2 : 0216] 2506  1  5.0   25.80     .05  4.17  16.56  n/a    .000
      {ST=   .39 ha.m }
*
      ADD [2506 + 0115]  2504  3  5.0   80.30     .19  4.08   7.55  n/a    .000
*
      RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .04  4.25   9.99  n/a    .000
      {ST=   .36 ha.m }
*
      ADD [2515 + 0117]  2503  3  5.0  132.16     .09  4.58   3.51  n/a    .000
*
      RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .01  4.25  10.15  n/a    .000
      {ST=   .11 ha.m }
*
      ADD [2512 + 2513]  2514  3  5.0   13.80    1.07  1.92  15.67  n/a    .000
*
      ADD [0118 + 2502]  0121  3  5.0  198.39    1.88  2.00   7.12  n/a    .000
*
      ADD [2516 + 2511]  2509  3  5.0   52.20     .06  4.25  11.22  n/a    .000
*
      ADD [0108 + 0121]  0017  3  5.0  250.38    1.90  2.00   6.36  n/a    .000
*
      ADD [0119 + 2509]  0123  3  5.0   57.60     .44  1.92  11.59  n/a    .000
*
      ADD [0017 + 0109]  0018  3  5.0  285.37    1.91  2.00   5.91  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00    1.09  1.92  12.15  n/a    .000
*
      ADD [0106 + 2505]  0319  3  5.0  329.24    1.10  1.92   5.45  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   2 **
  ****************************
```

```
 W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                 min     ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     READ STORM                 12.0
     [ Ptot= 33.30 mm ]
     fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
     remark: * Orillia Chicago 2 Year, 4 Hour Storm
*
 **  CALIB NASHYD       0111  1  5.0   12.40     .04  3.33   2.95  .09    .000
     [CN=58.9         ]
     [ N = 3.0:Tp 1.07]
*
 **  CALIB NASHYD       0102  1  5.0   53.27     .77  2.58   7.70  .23    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .53]
*
 **  CALIB NASHYD       0101  1  5.0   84.40     .14  4.25   2.13  .06    .000
     [CN=52.3         ]
     [ N = 3.0:Tp 1.72]
*
 **  CALIB NASHYD       0103  1  5.0  296.24     .79  5.00   4.75  .14    .000
     [CN=71.2         ]
     [ N = 3.0:Tp 2.53]
*
 **  CALIB NASHYD       0104  1  5.0  206.98    1.76  3.00   6.20  .19    .000
     [CN=76.2         ]
     [ N = 3.0:Tp  .80]
*
 **  CALIB NASHYD       0110  1  5.0  169.30     .36  4.17   2.68  .08    .000
     [CN=59.1         ]
     [ N = 3.0:Tp 1.67]
*
 **  CALIB NASHYD       0108  1  5.0   51.99     .43  3.17   6.88  .21    .000
     [CN=78.0         ]
     [ N = 3.0:Tp  .98]
*
 **  CALIB STANDHYD     0118  1  5.0   36.29    2.38  2.08  19.05  .57    .000
     [I%=42.0:S%= 2.00]
*
 **  CALIB STANDHYD     0205  1  5.0   53.80    2.99  2.08  17.89  .54    .000
     [I%=37.0:S%= 2.00]
*
 **  CALIB NASHYD       0112  1  5.0  108.30     .68  3.17   5.24  .16    .000
     [CN=71.9         ]
     [ N = 3.0:Tp  .96]
*
 **  CALIB NASHYD       0109  1  5.0   34.99     .27  2.92   5.53  .17    .000
     [CN=74.1         ]
     [ N = 3.0:Tp  .77]
*
 **  CALIB NASHYD       0106  1  5.0  263.24    1.95  3.50   7.42  .22    .000
     [CN=79.6         ]
     [ N = 3.0:Tp 1.24]
*
 **  CALIB STANDHYD     0120  1  5.0    8.40     .83  2.00  22.82  .69    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     0119  1  5.0    5.40     .52  2.00  21.55  .65    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     0213  1  5.0   45.20    2.13  2.08  15.35  .46    .000
     [I%=31.0:S%= 2.00]
*
  *  CALIB STANDHYD     0222  1  5.0    7.00     .75  2.00  24.47  .73    .000
     [I%=52.0:S%= 2.00]
*
  *  CALIB STANDHYD     0216  1  5.0   25.80    2.32  2.00  23.73  .71    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB NASHYD       0115  1  5.0   54.50     .28  4.00   6.49  .20    .000
     [CN=76.0         ]
     [ N = 3.0:Tp 1.65]
*
  *  CALIB STANDHYD     0207  1  5.0   39.36    1.91  2.08  14.38  .43    .000
     [I%=35.0:S%= 2.00]
*
  *  CALIB NASHYD       0117  1  5.0   92.80     .12  4.58   1.93  .06    .000
     [CN=53.3         ]
     [ N = 3.0:Tp 2.06]
*
  *  CALIB STANDHYD     0214  1  5.0  211.62    8.33  2.17  17.05  .51    .000
     [I%=31.0:S%= 1.00]
*
  *  CALIB STANDHYD     0221  1  5.0   12.20     .72  2.00  15.12  .45    .000
     [I%=35.0:S%= 1.00]
*
  *  CALIB STANDHYD     2512  1  5.0    5.40     .52  2.00  21.55  .65    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     2513  1  5.0    8.40     .83  2.00  22.82  .69    .000
     [I%=50.0:S%= 2.00]

*
     ADD [0102 + 0101]  0013  3  5.0  137.67     .81  2.67   4.29  n/a    .000
*
     ADD [0103 + 0104]  0014  3  5.0  503.22    2.10  3.17   5.35  n/a    .000
*
     ADD [0014 + 0110]  2000  3  5.0  672.52    2.36  3.25   4.68  n/a    .000
*
     RESRVR [ 2 : 0205] 1134  1  5.0   53.80     .40  3.33  17.85  n/a    .000
     {ST=   .76 ha.m }
*
     ADD [1134 + 0112]  2502  3  5.0  162.10    1.07  3.25   9.42  n/a    .000
*
     RESRVR [ 2 : 0213] 2516  1  5.0   45.20     .19  3.83  15.30  n/a    .000
     {ST=   .58 ha.m }
*
     RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .11  2.75  24.16  n/a    .000
     {ST=   .13 ha.m }
*
     RESRVR [ 2 : 0216] 2506  1  5.0   25.80     .27  3.00  23.65  n/a    .000
     {ST=   .49 ha.m }
*
     ADD [2506 + 0115]  2504  3  5.0   80.30     .50  3.42  12.01  n/a    .000
*
     RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .07  4.25  14.32  n/a    .000
     {ST=   .51 ha.m }
*
     ADD [2515 + 0117]  2503  3  5.0  132.16     .19  4.50   5.62  n/a    .000
*
     RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .05  3.83  14.95  n/a    .000
     {ST=   .15 ha.m }
*
     ADD [2512 + 2513]  2514  3  5.0   13.80    1.35  2.00  22.32  n/a    .000
*
     ADD [0118 + 2502]  0121  3  5.0  198.39    2.50  2.08  11.18  n/a    .000
*
     ADD [2516 + 2511]  2509  3  5.0   52.20     .25  3.25  16.49  n/a    .000
*
     ADD [0108 + 0121]  0017  3  5.0  250.38    2.55  2.08  10.29  n/a    .000
*
     ADD [0119 + 2509]  0123  3  5.0   57.60     .55  2.00  16.96  n/a    .000
*
     ADD [0017 + 0109]  0018  3  5.0  285.37    2.60  2.08   9.71  n/a    .000
*
     ADD [0120 + 0123]  2505  3  5.0   66.00    1.38  2.00  17.71  n/a    .000
*
     ADD [0106 + 2505]  0319  3  5.0  329.24    2.27  3.42   9.48  n/a    .000
*
 ****************************
 ** SIMULATION NUMBER:   3 **
 ****************************

 W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                 min     ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     READ STORM                 12.0
     [ Ptot= 44.71 mm ]
     fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
     remark: * Orillia Chicago 5 Year, 4 Hour Storm
*
 **  CALIB NASHYD       0111  1  5.0   12.40     .08  3.33   6.02  .13    .000
     [CN=58.9         ]
     [ N = 3.0:Tp 1.07]
*
 **  CALIB NASHYD       0102  1  5.0   53.27    1.44  2.58  14.05  .31    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .53]
*
 **  CALIB NASHYD       0101  1  5.0   84.40     .30  4.17   4.52  .10    .000
     [CN=52.3         ]
     [ N = 3.0:Tp 1.72]
*
 **  CALIB NASHYD       0103  1  5.0  296.24    1.56  4.92   9.35  .21    .000
     [CN=71.2         ]
     [ N = 3.0:Tp 2.53]
*
 **  CALIB NASHYD       0104  1  5.0  206.98    3.40  2.92  11.72  .26    .000
     [CN=76.2         ]
     [ N = 3.0:Tp  .80]
*
 **  CALIB NASHYD       0110  1  5.0  169.30     .76  4.08   5.66  .13    .000
     [CN=59.1         ]
     [ N = 3.0:Tp 1.67]
*
 **  CALIB NASHYD       0108  1  5.0   51.99     .80  3.17  12.78  .29    .000
     [CN=78.0         ]
     [ N = 3.0:Tp  .98]
*
 **  CALIB STANDHYD     0118  1  5.0   36.29    3.69  2.00  27.67  .62    .000
     [I%=42.0:S%= 2.00]
*
 **  CALIB STANDHYD     0205  1  5.0   53.80    4.69  2.08  26.31  .59    .000
```

```
     [I%=37.0:S%= 2.00]
*
 **  CALIB NASHYD       0112  1  5.0  108.30    1.32  3.17  10.04  .22    .000
     [CN=71.9          ]
     [ N = 3.0:Tp  .96]
*
 **  CALIB NASHYD       0109  1  5.0   34.99     .53  2.92  10.64  .24    .000
     [CN=74.1          ]
     [ N = 3.0:Tp  .77]
*
 **  CALIB NASHYD       0106  1  5.0  263.24    3.63  3.42  13.66  .31    .000
     [CN=79.6          ]
     [ N = 3.0:Tp 1.24]
*
  *  CALIB STANDHYD     0120  1  5.0    8.40    1.19  2.00  32.65  .73    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     0119  1  5.0    5.40     .75  2.00  30.83  .69    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     0213  1  5.0   45.20    3.42  2.00  22.88  .51    .000
     [I%=31.0:S%= 2.00]
*
  *  CALIB STANDHYD     0222  1  5.0    7.00    1.07  2.00  34.81  .78    .000
     [I%=52.0:S%= 2.00]
*
  *  CALIB STANDHYD     0216  1  5.0   25.80    3.54  2.00  33.90  .76    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB NASHYD       0115  1  5.0   54.50     .53  4.00  12.06  .27    .000
     [CN=76.0          ]
     [ N = 3.0:Tp 1.65]
*
  *  CALIB STANDHYD     0207  1  5.0   39.36    3.05  2.00  20.87  .47    .000
     [I%=35.0:S%= 2.00]
*
  *  CALIB NASHYD       0117  1  5.0   92.80     .27  4.50   4.29  .10    .000
     [CN=53.3          ]
     [ N = 3.0:Tp 2.06]
*
  *  CALIB STANDHYD     0214  1  5.0  211.62   13.25  2.17  25.49  .57    .000
     [I%=31.0:S%= 1.00]
*
  *  CALIB STANDHYD     0221  1  5.0   12.20    1.03  2.00  22.41  .50    .000
     [I%=35.0:S%= 1.00]
*
  *  CALIB STANDHYD     2512  1  5.0    5.40     .75  2.00  30.83  .69    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     2513  1  5.0    8.40    1.19  2.00  32.65  .73    .000
     [I%=50.0:S%= 2.00]
*
     ADD [0102 + 0101]  0013  3  5.0  137.67    1.54  2.58   8.21  n/a    .000
*
     ADD [0103 + 0104]  0014  3  5.0  503.22    4.06  3.08  10.32  n/a    .000
*
     ADD [0014 + 0110]  2000  3  5.0  672.52    4.63  3.17   9.15  n/a    .000
*
     RESRVR [ 2 : 0205] 1134  1  5.0   53.80     .77  3.00  26.27  n/a    .000
     {ST=  1.02 ha.m }
*
     ADD [1134 + 0112]  2502  3  5.0  162.10    2.09  3.08  15.43  n/a    .000
*
     RESRVR [ 2 : 0213] 2516  1  5.0   45.20     .37  3.42  22.83  n/a    .000
     {ST=   .80 ha.m }
*
     RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .25  2.50  34.49  n/a    .000
     {ST=   .16 ha.m }
*
     RESRVR [ 2 : 0216] 2506  1  5.0   25.80     .60  2.67  33.82  n/a    .000
     {ST=   .62 ha.m }
*
     ADD [2506 + 0115]  2504  3  5.0   80.30     .99  3.42  19.05  n/a    .000
*
     RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .15  4.08  20.81  n/a    .000
     {ST=   .71 ha.m }
*
     ADD [2515 + 0117]  2503  3  5.0  132.16     .41  4.42   9.21  n/a    .000
*
     RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .11  3.25  22.24  n/a    .000
     {ST=   .21 ha.m }
*
     ADD [2512 + 2513]  2514  3  5.0   13.80    1.94  2.00  31.94  n/a    .000
*
     ADD [0118 + 2502]  0121  3  5.0  198.39    3.83  2.00  17.67  n/a    .000
*
     ADD [2516 + 2511]  2509  3  5.0   52.20     .57  2.83  24.39  n/a    .000
*
     ADD [0108 + 0121]  0017  3  5.0  250.38    3.89  2.00  16.65  n/a    .000
*
     ADD [0119 + 2509]  0123  3  5.0   57.60     .80  2.00  25.00  n/a    .000
*
     ADD [0017 + 0109]  0018  3  5.0  285.37    3.95  2.00  15.91  n/a    .000
```

```
*
     ADD [0120 + 0123]  2505  3  5.0   66.00    1.99  2.00  25.97  n/a    .000
*
     ADD [0106 + 2505]  0319  3  5.0  329.24    4.24  3.33  16.12  n/a    .000
*
 ****************************
 ** SIMULATION NUMBER:   4 **
 ****************************

 W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     READ STORM                12.0
     [ Ptot= 63.42 mm ]
     fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
     remark: *Orillia Chicago 25 Year, 4 Hour Storm
*
 **  CALIB NASHYD       0111  1  5.0   12.40     .18  3.25  12.83  .20    .000
     [CN=58.9          ]
     [ N = 3.0:Tp 1.07]
*
 **  CALIB NASHYD       0102  1  5.0   53.27    2.73  2.58  26.55  .42    .000
     [CN=80.0          ]
     [ N = 3.0:Tp  .53]
*
 **  CALIB NASHYD       0101  1  5.0   84.40     .66  4.08  10.01  .16    .000
     [CN=52.3          ]
     [ N = 3.0:Tp 1.72]
*
 **  CALIB NASHYD       0103  1  5.0  296.24    3.17  4.83  19.02  .30    .000
     [CN=71.2          ]
     [ N = 3.0:Tp 2.53]
*
 **  CALIB NASHYD       0104  1  5.0  206.98    6.71  2.92  22.93  .36    .000
     [CN=76.2          ]
     [ N = 3.0:Tp  .80]
*
 **  CALIB NASHYD       0110  1  5.0  169.30    1.66  4.00  12.37  .20    .000
     [CN=59.1          ]
     [ N = 3.0:Tp 1.67]
*
 **  CALIB NASHYD       0108  1  5.0   51.99    1.55  3.08  24.59  .39    .000
     [CN=78.0          ]
     [ N = 3.0:Tp  .98]
*
 **  CALIB STANDHYD     0118  1  5.0   36.29    5.90  2.00  42.91  .68    .000
     [I%=42.0:S%= 2.00]
*
 **  CALIB STANDHYD     0205  1  5.0   53.80    7.87  2.00  41.31  .65    .000
     [I%=37.0:S%= 2.00]
*
 **  CALIB NASHYD       0112  1  5.0  108.30    2.66  3.08  20.02  .32    .000
     [CN=71.9          ]
     [ N = 3.0:Tp  .96]
*
 **  CALIB NASHYD       0109  1  5.0   34.99    1.07  2.83  21.18  .33    .000
     [CN=74.1          ]
     [ N = 3.0:Tp  .77]
*
 **  CALIB NASHYD       0106  1  5.0  263.24    6.94  3.42  25.99  .41    .000
     [CN=79.6          ]
     [ N = 3.0:Tp 1.24]
*
  *  CALIB STANDHYD     0120  1  5.0    8.40    1.94  2.00  49.54  .78    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     0119  1  5.0    5.40    1.21  2.00  46.94  .74    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB STANDHYD     0213  1  5.0   45.20    5.71  2.00  36.57  .58    .000
     [I%=31.0:S%= 2.00]
*
  *  CALIB STANDHYD     0222  1  5.0    7.00    1.74  2.00  52.34  .83    .000
     [I%=52.0:S%= 2.00]
*
  *  CALIB STANDHYD     0216  1  5.0   25.80    5.34  2.00  51.24  .81    .000
     [I%=50.0:S%= 2.00]
*
  *  CALIB NASHYD       0115  1  5.0   54.50    1.03  3.92  23.30  .37    .000
     [CN=76.0          ]
     [ N = 3.0:Tp 1.65]
*
  *  CALIB STANDHYD     0207  1  5.0   39.36    4.65  2.00  32.64  .51    .000
     [I%=35.0:S%= 2.00]
*
  *  CALIB NASHYD       0117  1  5.0   92.80     .61  4.50   9.79  .15    .000
     [CN=53.3          ]
     [ N = 3.0:Tp 2.06]
*
  *  CALIB STANDHYD     0214  1  5.0  211.62   24.14  2.08  40.61  .64    .000
     [I%=31.0:S%= 1.00]
```

```
*
  *   CALIB STANDHYD     0221  1  5.0   12.20    1.58  2.00  35.71  .56    .000
      [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD     2512  1  5.0    5.40    1.21  2.00  46.94  .74    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     2513  1  5.0    8.40    1.94  2.00  49.54  .78    .000
      [I%=50.0:S%= 2.00]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67    2.97  2.58  16.41  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22    8.06  3.08  20.63  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52    9.32  3.17  18.55  n/a    .000
*
      RESRVR [ 2 : 0205] 1134  1  5.0   53.80    1.49  2.83  41.27  n/a    .000
      {ST=  1.50 ha.m }
*
      ADD [1134 + 0112]  2502  3  5.0  162.10    4.11  3.00  27.07  n/a    .000
*
      RESRVR [ 2 : 0213] 2516  1  5.0   45.20     .76  3.08  36.52  n/a    .000
      {ST=  1.21 ha.m }
*
      RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .46  2.33  52.03  n/a    .000
      {ST=   .22 ha.m }
*
      RESRVR [ 2 : 0216] 2506  1  5.0   25.80    1.11  2.58  51.15  n/a    .000
      {ST=   .88 ha.m }
*
      ADD [2506 + 0115]  2504  3  5.0   80.30    1.80  3.33  32.25  n/a    .000
*
      RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .34  3.67  32.59  n/a    .000
      {ST=  1.06 ha.m }
*
      ADD [2515 + 0117]  2503  3  5.0  132.16     .93  4.25  16.58  n/a    .000
*
      RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .23  3.00  35.54  n/a    .000
      {ST=   .31 ha.m }
*
      ADD [2512 + 2513]  2514  3  5.0   13.80    3.15  2.00  48.52  n/a    .000
*
      ADD [0118 + 2502]  0121  3  5.0  198.39    6.36  2.00  29.97  n/a    .000
*
      ADD [2516 + 2511]  2509  3  5.0   52.20    1.13  2.67  38.60  n/a    .000
*
      ADD [0108 + 0121]  0017  3  5.0  250.38    6.52  2.00  28.85  n/a    .000
*
      ADD [0119 + 2509]  0123  3  5.0   57.60    1.52  2.00  39.39  n/a    .000
*
      ADD [0017 + 0109]  0018  3  5.0  285.37    7.45  2.83  27.91  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00    3.46  2.00  40.68  n/a    .000
*
      ADD [0106 + 2505]  0319  3  5.0  329.24    8.10  3.33  28.93  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   5 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      READ STORM                 12.0
      [ Ptot= 78.51 mm ]
      fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
      remark: *Orillia Chicago 100 Year, 4 Hour Storm
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .27  3.25  19.63  .25    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    3.93  2.50  37.87  .48    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0101  1  5.0   84.40    1.03  4.08  15.64  .20    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0103  1  5.0  296.24    4.72  4.83  28.24  .36    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0104  1  5.0  206.98    9.85  2.83  33.32  .42    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0110  1  5.0  169.30    2.58  4.00  19.12  .24    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
```

```
*
  **  CALIB NASHYD       0108  1  5.0   51.99    2.26  3.08  35.42  .45    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    7.73  2.00  55.86  .71    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB STANDHYD     0205  1  5.0   53.80   10.44  2.00  54.13  .69    .000
      [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD       0112  1  5.0  108.30    3.95  3.08  29.46  .38    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB NASHYD       0109  1  5.0   34.99    1.59  2.83  31.07  .40    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0106  1  5.0  263.24    9.99  3.42  37.20  .47    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    2.50  2.00  63.59  .81    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40    1.56  2.00  60.46  .77    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0213  1  5.0   45.20    7.64  2.00  48.49  .62    .000
      [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD     0222  1  5.0    7.00    2.22  2.00  66.78  .85    .000
      [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD     0216  1  5.0   25.80    7.50  2.00  65.56  .84    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    1.49  3.92  33.70  .43    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0207  1  5.0   39.36    6.35  2.00  42.97  .55    .000
      [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .96  4.42  15.47  .20    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD     0214  1  5.0  211.62   32.68  2.08  53.54  .68    .000
      [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD     0221  1  5.0   12.20    2.20  2.00  47.32  .60    .000
      [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD     2512  1  5.0    5.40    1.56  2.00  60.46  .77    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     2513  1  5.0    8.40    2.50  2.00  63.59  .81    .000
      [I%=50.0:S%= 2.00]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67    4.31  2.58  24.24  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22   11.87  3.00  30.33  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52   13.84  3.17  27.51  n/a    .000
*
      RESRVR [ 2 : 0205] 1134  1  5.0   53.80    2.19  2.75  54.09  n/a    .000
      {ST=  1.92 ha.m }
*
      ADD [1134 + 0112]  2502  3  5.0  162.10    6.03  3.00  37.63  n/a    .000
*
      RESRVR [ 2 : 0213] 2516  1  5.0   45.20    1.14  3.00  48.44  n/a    .000
      {ST=  1.57 ha.m }
*
      RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .64  2.33  66.47  n/a    .000
      {ST=   .27 ha.m }
*
      RESRVR [ 2 : 0216] 2506  1  5.0   25.80    1.58  2.50  65.48  n/a    .000
      {ST=  1.10 ha.m }
*
      ADD [2506 + 0115]  2504  3  5.0   80.30    2.53  3.25  43.91  n/a    .000
*
      RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .53  3.33  42.91  n/a    .000
      {ST=  1.35 ha.m }
*
      ADD [2515 + 0117]  2503  3  5.0  132.16    1.45  4.25  23.64  n/a    .000
*
      RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .34  2.83  47.14  n/a    .000
      {ST=   .40 ha.m }
*
      ADD [2512 + 2513]  2514  3  5.0   13.80    4.06  2.00  62.36  n/a    .000
*
```

```
     ADD [0118 + 2502]  0121  3  5.0  198.39    8.81  2.00  40.97  n/a    .000
*
     ADD [2516 + 2511]  2509  3  5.0   52.20    1.65  2.67  50.86  n/a    .000
*
     ADD [0108 + 0121]  0017  3  5.0  250.38    9.22  2.83  39.82  n/a    .000
*
     ADD [0119 + 2509]  0123  3  5.0   57.60    2.18  2.00  51.76  n/a    .000
*
     ADD [0017 + 0109]  0018  3  5.0  285.37   10.81  2.83  38.74  n/a    .000
*
     ADD [0120 + 0123]  2505  3  5.0   66.00    4.68  2.00  53.26  n/a    .000
*
     ADD [0106 + 2505]  0319  3  5.0  329.24   11.64  3.33  40.42  n/a    .000
*
 FINISH
============================================================================================================
```

```
====================================================================================================

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
```

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```
                   *****  S U M M A R Y   O U T P U T  *****

  Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

  Output  filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci
  Summary filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci


DATE: 10/15/2015                           TIME: 2:15:06 PM

USER:


COMMENTS: ____________________________________________________________


  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                   min    ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                   5.0
      [ Ptot= 41.33 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40    .05  7.33   5.02  .12    .000
      [CN=58.9          ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    .93  6.58  12.05  .29    .000
      [CN=80.0          ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0101  1  5.0   84.40    .18  8.25   3.73  .09    .000
      [CN=52.3          ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0103  1  5.0  296.24   1.02  9.25   7.87  .19    .000
      [CN=71.2          ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0104  1  5.0  206.98   2.18  6.92   9.96  .24    .000
      [CN=76.2          ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0110  1  5.0  169.30    .46  8.17   4.68  .11    .000
      [CN=59.1          ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0108  1  5.0   51.99    .52  7.17  10.91  .26    .000
      [CN=78.0          ]
      [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29   2.06  6.08  25.05  .61    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB STANDHYD     0205  1  5.0   53.80   2.71  6.17  23.74  .57    .000
      [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD       0112  1  5.0  108.30    .84  7.08   8.50  .21    .000
      [CN=71.9          ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB NASHYD       0109  1  5.0   34.99    .34  6.92   9.00  .22    .000
      [CN=74.1          ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0106  1  5.0  263.24   2.36  7.42  11.68  .28    .000
      [CN=79.6          ]
      [ N = 3.0:Tp 1.24]
*
  **  CALIB STANDHYD     0120  1  5.0    8.40    .67  6.00  29.69  .72    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40    .43  6.00  28.03  .68    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0213  1  5.0   45.20   1.93  6.17  20.57  .50    .000
      [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD     0222  1  5.0    7.00    .61  6.00  31.71  .77    .000
      [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD     0216  1  5.0   25.80   1.96  6.08  30.85  .75    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    .34  8.00  10.29  .25    .000
      [CN=76.0          ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0207  1  5.0   39.36   1.69  6.08  18.88  .46    .000
      [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD       0117  1  5.0   92.80    .16  8.75   3.50  .08    .000
      [CN=53.3          ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD     0214  1  5.0  211.62   7.99  6.25  22.91  .55    .000
      [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD     0221  1  5.0   12.20    .58  6.00  20.18  .49    .000
      [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD     2512  1  5.0    5.40    .43  6.00  28.03  .68    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     2513  1  5.0    8.40    .67  6.00  29.69  .72    .000
      [I%=50.0:S%= 2.00]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67    .99  6.58   6.95  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22   2.59  7.08   8.73  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52   2.92  7.17   7.71  n/a    .000
*
      RESRVR [ 2 : 0205] 1134  1  5.0   53.80    .48  7.25  23.70  n/a    .000
      {ST=   .82 ha.m }
*
      ADD [1134 + 0112]  2502  3  5.0  162.10   1.31  7.17  13.54  n/a    .000
*
      RESRVR [ 2 : 0213] 2516  1  5.0   45.20    .23  7.83  20.52  n/a    .000
      {ST=   .63 ha.m }
*
      RESRVR [ 2 : 0222] 2511  1  5.0    7.00    .15  6.58  31.39  n/a    .000
      {ST=   .14 ha.m }
*
      RESRVR [ 2 : 0216] 2506  1  5.0   25.80    .37  6.92  30.76  n/a    .000
      {ST=   .51 ha.m }
*
      ADD [2506 + 0115]  2504  3  5.0   80.30    .63  7.25  16.87  n/a    .000
*
      RESRVR [ 2 : 0207] 2515  1  5.0   39.36    .09  9.50  18.83  n/a    .000
      {ST=   .57 ha.m }
*
      ADD [2515 + 0117]  2503  3  5.0  132.16    .25  8.83   8.07  n/a    .000
*
      RESRVR [ 2 : 0221] 2508  1  5.0   12.20    .07  7.58  20.00  n/a    .000
      {ST=   .16 ha.m }
*
      ADD [2512 + 2513]  2514  3  5.0   13.80   1.10  6.00  29.04  n/a    .000
*
      ADD [0118 + 2502]  0121  3  5.0  198.39   2.28  6.17  15.65  n/a    .000
*
      ADD [2516 + 2511]  2509  3  5.0   52.20    .33  6.83  21.98  n/a    .000
*
      ADD [0108 + 0121]  0017  3  5.0  250.38   2.42  6.17  14.66  n/a    .000
*
      ADD [0119 + 2509]  0123  3  5.0   57.60    .46  6.00  22.54  n/a    .000
*
      ADD [0017 + 0109]  0018  3  5.0  285.37   2.58  6.75  13.97  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00   1.13  6.00  23.45  n/a    .000
*
      ADD [0106 + 2505]  0319  3  5.0  329.24   2.75  7.42  14.04  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   2 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                   min    ha     cms   hrs     mm          cms
```

```
      START @   .00 hrs
      --------------------
      MASS STORM                 5.0
      [ Ptot= 56.11 mm ]
 *
   ** CALIB NASHYD      0111  1  5.0   12.40     .10  7.25   9.93  .18    .000
      [CN=58.9        ]
      [ N = 3.0:Tp 1.07]
 *
   ** CALIB NASHYD      0102  1  5.0   53.27    1.70  6.58  21.41  .38    .000
      [CN=80.0        ]
      [ N = 3.0:Tp  .53]
 *
   ** CALIB NASHYD      0101  1  5.0   84.40     .38  8.17   7.65  .14    .000
      [CN=52.3        ]
      [ N = 3.0:Tp 1.72]
 *
   ** CALIB NASHYD      0103  1  5.0  296.24    1.98  9.08  14.97  .27    .000
      [CN=71.2        ]
      [ N = 3.0:Tp 2.53]
 *
   ** CALIB NASHYD      0104  1  5.0  206.98    4.14  6.92  18.28  .33    .000
      [CN=76.2        ]
      [ N = 3.0:Tp  .80]
 *
   ** CALIB NASHYD      0110  1  5.0  169.30     .96  8.08   9.51  .17    .000
      [CN=59.1        ]
      [ N = 3.0:Tp 1.67]
 *
   ** CALIB NASHYD      0108  1  5.0   51.99     .97  7.08  19.71  .35    .000
      [CN=78.0        ]
      [ N = 3.0:Tp  .98]
 *
   ** CALIB STANDHYD    0118  1  5.0   36.29    3.21  6.08  36.82  .66    .000
      [I%=42.0:S%= 2.00]
 *
   ** CALIB STANDHYD    0205  1  5.0   53.80    4.35  6.17  35.30  .63    .000
      [I%=37.0:S%= 2.00]
 *
   ** CALIB NASHYD      0112  1  5.0  108.30    1.62  7.08  15.85  .28    .000
      [CN=71.9        ]
      [ N = 3.0:Tp  .96]
 *
   ** CALIB NASHYD      0109  1  5.0   34.99     .66  6.83  16.79  .30    .000
      [CN=74.1        ]
      [ N = 3.0:Tp  .77]
 *
   ** CALIB NASHYD      0106  1  5.0  263.24    4.36  7.42  20.91  .37    .000
      [CN=79.6        ]
      [ N = 3.0:Tp 1.24]
 *
   *  CALIB STANDHYD    0120  1  5.0    8.40     .99  6.00  42.85  .76    .000
      [I%=50.0:S%= 2.00]
 *
   *  CALIB STANDHYD    0119  1  5.0    5.40     .62  6.00  40.54  .72    .000
      [I%=50.0:S%= 2.00]
 *
   *  CALIB STANDHYD    0213  1  5.0   45.20    3.15  6.17  31.05  .55    .000
      [I%=31.0:S%= 2.00]
 *
   *  CALIB STANDHYD    0222  1  5.0    7.00     .89  6.00  45.42  .81    .000
      [I%=52.0:S%= 2.00]
 *
   *  CALIB STANDHYD    0216  1  5.0   25.80    3.00  6.08  44.39  .79    .000
      [I%=50.0:S%= 2.00]
 *
   *  CALIB NASHYD      0115  1  5.0   54.50     .64  7.92  18.65  .33    .000
      [CN=76.0        ]
      [ N = 3.0:Tp 1.65]
 *
   *  CALIB STANDHYD    0207  1  5.0   39.36    2.53  6.08  27.89  .50    .000
      [I%=35.0:S%= 2.00]
 *
   *  CALIB NASHYD      0117  1  5.0   92.80     .35  8.67   7.42  .13    .000
      [CN=53.3        ]
      [ N = 3.0:Tp 2.06]
 *
   *  CALIB STANDHYD    0214  1  5.0  211.62   13.18  6.25  34.55  .62    .000
      [I%=31.0:S%= 1.00]
 *
   *  CALIB STANDHYD    0221  1  5.0   12.20     .88  6.00  30.34  .54    .000
      [I%=35.0:S%= 1.00]
 *
   *  CALIB STANDHYD    2512  1  5.0    5.40     .62  6.00  40.54  .72    .000
      [I%=50.0:S%= 2.00]
 *
   *  CALIB STANDHYD    2513  1  5.0    8.40     .99  6.00  42.85  .76    .000
      [I%=50.0:S%= 2.00]
 *
      ADD [0102 + 0101]  0013  3  5.0  137.67    1.85  6.58  12.98  n/a    .000
 *
      ADD [0103 + 0104]  0014  3  5.0  503.22    4.96  7.00  16.33  n/a    .000
```

```
 *
      ADD [0014 + 0110]  2000  3  5.0  672.52    5.68  7.17  14.61  n/a    .000
 *
      RESRVR [ 2 : 0205] 1134  1  5.0   53.80     .93  6.92  35.26  n/a    .000
      {ST=  1.13 ha.m }
 *
      ADD [1134 + 0112]  2502  3  5.0  162.10    2.54  7.08  22.29  n/a    .000
 *
      RESRVR [ 2 : 0213] 2516  1  5.0   45.20     .46  7.25  31.00  n/a    .000
      {ST=   .89 ha.m }
 *
      RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .29  6.42  45.11  n/a    .000
      {ST=   .17 ha.m }
 *
      RESRVR [ 2 : 0216] 2506  1  5.0   25.80     .71  6.67  44.30  n/a    .000
      {ST=   .68 ha.m }
 *
      ADD [2506 + 0115]  2504  3  5.0   80.30    1.17  7.33  26.89  n/a    .000
 *
      RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .19  8.25  27.83  n/a    .000
      {ST=   .79 ha.m }
 *
      ADD [2515 + 0117]  2503  3  5.0  132.16     .54  8.58  13.50  n/a    .000
 *
      RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .13  7.08  30.17  n/a    .000
      {ST=   .23 ha.m }
 *
      ADD [2512 + 2513]  2514  3  5.0   13.80    1.61  6.00  41.94  n/a    .000
 *
      ADD [0118 + 2502]  0121  3  5.0  198.39    3.92  6.17  24.95  n/a    .000
 *
      ADD [2516 + 2511]  2509  3  5.0   52.20     .69  6.83  32.89  n/a    .000
 *
      ADD [0108 + 0121]  0017  3  5.0  250.38    4.27  6.25  23.86  n/a    .000
 *
      ADD [0119 + 2509]  0123  3  5.0   57.60     .83  6.17  33.61  n/a    .000
 *
      ADD [0017 + 0109]  0018  3  5.0  285.37    4.77  6.75  22.99  n/a    .000
 *
      ADD [0120 + 0123]  2505  3  5.0   66.00    1.77  6.08  34.79  n/a    .000
 *
      ADD [0106 + 2505]  0319  3  5.0  329.24    5.12  7.33  23.69  n/a    .000
 *
  ****************************
  ** SIMULATION NUMBER:   3 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                 5.0
      [ Ptot= 65.89 mm ]
 *
   ** CALIB NASHYD      0111  1  5.0   12.40     .15  7.25  13.87  .21    .000
      [CN=58.9        ]
      [ N = 3.0:Tp 1.07]
 *
   ** CALIB NASHYD      0102  1  5.0   53.27    2.28  6.50  28.33  .43    .000
      [CN=80.0        ]
      [ N = 3.0:Tp  .53]
 *
   ** CALIB NASHYD      0101  1  5.0   84.40     .54  8.08  10.86  .16    .000
      [CN=52.3        ]
      [ N = 3.0:Tp 1.72]
 *
   ** CALIB NASHYD      0103  1  5.0  296.24    2.74  9.08  20.45  .31    .000
      [CN=71.2        ]
      [ N = 3.0:Tp 2.53]
 *
   ** CALIB NASHYD      0104  1  5.0  206.98    5.64  6.83  24.55  .37    .000
      [CN=76.2        ]
      [ N = 3.0:Tp  .80]
 *
   ** CALIB NASHYD      0110  1  5.0  169.30    1.37  8.00  13.40  .20    .000
      [CN=59.1        ]
      [ N = 3.0:Tp 1.67]
 *
   ** CALIB NASHYD      0108  1  5.0   51.99    1.31  7.08  26.29  .40    .000
      [CN=78.0        ]
      [ N = 3.0:Tp  .98]
 *
   ** CALIB STANDHYD    0118  1  5.0   36.29    3.90  6.08  44.99  .68    .000
      [I%=42.0:S%= 2.00]
 *
   ** CALIB STANDHYD    0205  1  5.0   53.80    5.44  6.17  43.37  .66    .000
      [I%=37.0:S%= 2.00]
 *
   ** CALIB NASHYD      0112  1  5.0  108.30    2.23  7.08  21.49  .33    .000
      [CN=71.9        ]
      [ N = 3.0:Tp  .96]
 *
```

```
  **  CALIB NASHYD       0109  1  5.0   34.99     .90  6.83  22.72  .34    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0106  1  5.0  263.24    5.86  7.33  27.75  .42    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    1.21  6.00  51.82  .79    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .76  6.00  49.12  .75    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0213  1  5.0   45.20    3.99  6.17  38.48  .58    .000
      [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD     0222  1  5.0    7.00    1.08  6.00  54.68  .83    .000
      [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD     0216  1  5.0   25.80    3.67  6.08  53.56  .81    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0115  1  5.0   54.50     .86  7.92  24.93  .38    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0207  1  5.0   39.36    3.23  6.08  34.29  .52    .000
      [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .51  8.58  10.65  .16    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD     0214  1  5.0  211.62   17.69  6.25  42.68  .65    .000
      [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD     0221  1  5.0   12.20    1.09  6.00  37.56  .57    .000
      [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD     2512  1  5.0    5.40     .76  6.00  49.12  .75    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     2513  1  5.0    8.40    1.21  6.00  51.82  .79    .000
      [I%=50.0:S%= 2.00]
*
      ADD [0102 + 0101]  0013  3  5.0  137.67    2.49  6.58  17.62  n/a    .000
*
      ADD [0103 + 0104]  0014  3  5.0  503.22    6.79  7.00  22.14  n/a    .000
*
      ADD [0014 + 0110]  2000  3  5.0  672.52    7.82  7.08  19.94  n/a    .000
*
      RESRVR [ 2 : 0205] 1134  1  5.0   53.80    1.26  6.83  43.33  n/a    .000
      {ST=  1.35 ha.m }
*
      ADD [1134 + 0112]  2502  3  5.0  162.10    3.47  7.00  28.73  n/a    .000
*
      RESRVR [ 2 : 0213] 2516  1  5.0   45.20     .64  7.17  38.43  n/a    .000
      {ST=  1.08 ha.m }
*
      RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .39  6.42  54.37  n/a    .000
      {ST=   .20 ha.m }
*
      RESRVR [ 2 : 0216] 2506  1  5.0   25.80     .94  6.58  53.48  n/a    .000
      {ST=   .80 ha.m }
*
      ADD [2506 + 0115]  2504  3  5.0   80.30    1.55  7.25  34.10  n/a    .000
*
      RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .28  8.08  34.23  n/a    .000
      {ST=   .95 ha.m }
*
      ADD [2515 + 0117]  2503  3  5.0  132.16     .78  8.50  17.67  n/a    .000
*
      RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .19  7.00  37.39  n/a    .000
      {ST=   .28 ha.m }
*
      ADD [2512 + 2513]  2514  3  5.0   13.80    1.97  6.00  50.76  n/a    .000
*
      ADD [0118 + 2502]  0121  3  5.0  198.39    4.84  6.17  31.71  n/a    .000
*
      ADD [2516 + 2511]  2509  3  5.0   52.20     .94  6.75  40.56  n/a    .000
*
      ADD [0108 + 0121]  0017  3  5.0  250.38    5.45  6.83  30.58  n/a    .000
*
      ADD [0119 + 2509]  0123  3  5.0   57.60    1.16  6.17  41.37  n/a    .000
*
      ADD [0017 + 0109]  0018  3  5.0  285.37    6.35  6.83  29.62  n/a    .000
*
      ADD [0120 + 0123]  2505  3  5.0   66.00    2.29  6.08  42.70  n/a    .000
*
      ADD [0106 + 2505]  0319  3  5.0  329.24    6.86  7.33  30.75  n/a    .000
*
  ****************************
```

```
  ** SIMULATION NUMBER:   4 **
  ****************************

  W/E COMMAND             HYD ID   DT     AREA    Qpeak Tpeak    R.V. R.C.    Qbase
                                  min      ha      cms   hrs      mm           cms

      START @   .00 hrs
      --------------------
      MASS STORM                  5.0
      [ Ptot= 78.27 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .21  7.17  19.51  .25    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    3.06  6.50  37.69  .48    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0101  1  5.0   84.40     .78  8.08  15.54  .20    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0103  1  5.0  296.24    3.79  9.00  28.09  .36    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0104  1  5.0  206.98    7.71  6.83  33.15  .42    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0110  1  5.0  169.30    1.97  8.00  19.00  .24    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0108  1  5.0   51.99    1.77  7.08  35.24  .45    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    5.19  6.08  55.65  .71    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB STANDHYD     0205  1  5.0   53.80    6.89  6.17  53.92  .69    .000
      [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD       0112  1  5.0  108.30    3.07  7.08  29.30  .37    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB NASHYD       0109  1  5.0   34.99    1.24  6.83  30.91  .39    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD       0106  1  5.0  263.24    7.89  7.33  37.02  .47    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    1.49  6.00  63.36  .81    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .94  6.00  60.24  .77    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0213  1  5.0   45.20    4.92  6.08  48.29  .62    .000
      [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD     0222  1  5.0    7.00    1.43  6.00  66.55  .85    .000
      [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD     0216  1  5.0   25.80    4.53  6.08  65.33  .83    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    1.17  7.83  33.53  .43    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0207  1  5.0   39.36    3.98  6.08  42.80  .55    .000
      [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .74  8.50  15.37  .20    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD     0214  1  5.0  211.62   22.21  6.17  53.33  .68    .000
      [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD     0221  1  5.0   12.20    1.36  6.00  47.13  .60    .000
      [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD     2512  1  5.0    5.40     .94  6.00  60.24  .77    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     2513  1  5.0    8.40    1.49  6.00  63.36  .81    .000
```

```
     [I%=50.0:S%= 2.00]
*
     ADD [0102 + 0101]  0013  3  5.0  137.67    3.37  6.58  24.11  n/a    .000
*
     ADD [0103 + 0104]  0014  3  5.0  503.22    9.33  7.00  30.17  n/a    .000
*
     ADD [0014 + 0110]  2000  3  5.0  672.52   10.83  7.08  27.36  n/a    .000
*
     RESRVR [ 2 : 0205] 1134  1  5.0   53.80    1.71  6.83  53.88  n/a    .000
     {ST=  1.64 ha.m }
*
     ADD [1134 + 0112]  2502  3  5.0  162.10    4.74  7.00  37.46  n/a    .000
*
     RESRVR [ 2 : 0213] 2516  1  5.0   45.20     .88  7.00  48.24  n/a    .000
     {ST=  1.33 ha.m }
*
     RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .52  6.33  66.24  n/a    .000
     {ST=   .24 ha.m }
*
     RESRVR [ 2 : 0216] 2506  1  5.0   25.80    1.25  6.58  65.25  n/a    .000
     {ST=   .94 ha.m }
*
     ADD [2506 + 0115]  2504  3  5.0   80.30    2.05  7.25  43.72  n/a    .000
*
     RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .40  7.50  42.74  n/a    .000
     {ST=  1.15 ha.m }
*
     ADD [2515 + 0117]  2503  3  5.0  132.16    1.12  8.42  23.52  n/a    .000
*
     RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .26  6.92  46.95  n/a    .000
     {ST=   .34 ha.m }
*
     ADD [2512 + 2513]  2514  3  5.0   13.80    2.43  6.00  62.14  n/a    .000
*
     ADD [0118 + 2502]  0121  3  5.0  198.39    6.63  6.17  40.79  n/a    .000
*
     ADD [2516 + 2511]  2509  3  5.0   52.20    1.29  6.67  50.66  n/a    .000
*
     ADD [0108 + 0121]  0017  3  5.0  250.38    7.28  6.83  39.64  n/a    .000
*
     ADD [0119 + 2509]  0123  3  5.0   57.60    1.65  6.17  51.56  n/a    .000
*
     ADD [0017 + 0109]  0018  3  5.0  285.37    8.52  6.83  38.57  n/a    .000
*
     ADD [0120 + 0123]  2505  3  5.0   66.00    3.06  6.08  53.06  n/a    .000
*
     ADD [0106 + 2505]  0319  3  5.0  329.24    9.21  7.25  40.23  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   5 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                   min     ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     MASS STORM                   5.0
     [ Ptot= 87.35 mm ]
*
  ** CALIB NASHYD       0111  1  5.0   12.40     .26  7.17  24.07  .28    .000
     [CN=58.9         ]
     [ N = 3.0:Tp 1.07]
*
  ** CALIB NASHYD       0102  1  5.0   53.27    3.66  6.50  44.88  .51    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .53]
*
  ** CALIB NASHYD       0101  1  5.0   84.40     .98  8.08  19.36  .22    .000
     [CN=52.3         ]
     [ N = 3.0:Tp 1.72]
*
  ** CALIB NASHYD       0103  1  5.0  296.24    4.62  9.00  34.10  .39    .000
     [CN=71.2         ]
     [ N = 3.0:Tp 2.53]
*
  ** CALIB NASHYD       0104  1  5.0  206.98    9.31  6.83  39.83  .46    .000
     [CN=76.2         ]
     [ N = 3.0:Tp  .80]
*
  ** CALIB NASHYD       0110  1  5.0  169.30    2.46  8.00  23.53  .27    .000
     [CN=59.1         ]
     [ N = 3.0:Tp 1.67]
*
  ** CALIB NASHYD       0108  1  5.0   51.99    2.13  7.00  42.17  .48    .000
     [CN=78.0         ]
     [ N = 3.0:Tp  .98]
*
  ** CALIB STANDHYD     0118  1  5.0   36.29    5.99  6.08  63.65  .73    .000
     [I%=42.0:S%= 2.00]
*
  ** CALIB STANDHYD     0205  1  5.0   53.80    8.36  6.08  61.86  .71    .000
     [I%=37.0:S%= 2.00]
```

```
*
  ** CALIB NASHYD       0112  1  5.0  108.30    3.73  7.00  35.44  .41    .000
     [CN=71.9         ]
     [ N = 3.0:Tp  .96]
*
  ** CALIB NASHYD       0109  1  5.0   34.99    1.51  6.83  37.31  .43    .000
     [CN=74.1         ]
     [ N = 3.0:Tp  .77]
*
  ** CALIB NASHYD       0106  1  5.0  263.24    9.46  7.33  44.15  .51    .000
     [CN=79.6         ]
     [ N = 3.0:Tp 1.24]
*
   * CALIB STANDHYD     0120  1  5.0    8.40    1.82  6.00  71.94  .82    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB STANDHYD     0119  1  5.0    5.40    1.14  6.00  68.54  .78    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB STANDHYD     0213  1  5.0   45.20    6.21  6.08  55.74  .64    .000
     [I%=31.0:S%= 2.00]
*
   * CALIB STANDHYD     0222  1  5.0    7.00    1.63  6.00  75.32  .86    .000
     [I%=52.0:S%= 2.00]
*
   * CALIB STANDHYD     0216  1  5.0   25.80    5.17  6.08  74.05  .85    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB NASHYD       0115  1  5.0   54.50    1.41  7.83  40.21  .46    .000
     [CN=76.0         ]
     [ N = 3.0:Tp 1.65]
*
   * CALIB STANDHYD     0207  1  5.0   39.36    4.59  6.08  49.30  .56    .000
     [I%=35.0:S%= 2.00]
*
   * CALIB NASHYD       0117  1  5.0   92.80     .93  8.50  19.24  .22    .000
     [CN=53.3         ]
     [ N = 3.0:Tp 2.06]
*
   * CALIB STANDHYD     0214  1  5.0  211.62   25.94  6.17  61.35  .70    .000
     [I%=31.0:S%= 1.00]
*
   * CALIB STANDHYD     0221  1  5.0   12.20    1.67  6.08  54.40  .62    .000
     [I%=35.0:S%= 1.00]
*
   * CALIB STANDHYD     2512  1  5.0    5.40    1.14  6.00  68.54  .78    .000
     [I%=50.0:S%= 2.00]
*
   * CALIB STANDHYD     2513  1  5.0    8.40    1.82  6.00  71.94  .82    .000
     [I%=50.0:S%= 2.00]
*
     ADD [0102 + 0101]  0013  3  5.0  137.67    4.05  6.58  29.24  n/a    .000
*
     ADD [0103 + 0104]  0014  3  5.0  503.22   11.32  7.00  36.46  n/a    .000
*
     ADD [0014 + 0110]  2000  3  5.0  672.52   13.20  7.08  33.21  n/a    .000
*
     RESRVR [ 2 : 0205] 1134  1  5.0   53.80    2.07  6.75  61.82  n/a    .000
     {ST=  1.86 ha.m }
*
     ADD [1134 + 0112]  2502  3  5.0  162.10    5.73  6.92  44.19  n/a    .000
*
     RESRVR [ 2 : 0213] 2516  1  5.0   45.20    1.09  6.92  55.69  n/a    .000
     {ST=  1.52 ha.m }
*
     RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .61  6.33  75.01  n/a    .000
     {ST=   .27 ha.m }
*
     RESRVR [ 2 : 0216] 2506  1  5.0   25.80    1.49  6.50  73.97  n/a    .000
     {ST=  1.05 ha.m }
*
     ADD [2506 + 0115]  2504  3  5.0   80.30    2.43  7.17  51.06  n/a    .000
*
     RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .50  7.33  49.24  n/a    .000
     {ST=  1.30 ha.m }
*
     ADD [2515 + 0117]  2503  3  5.0  132.16    1.41  8.33  28.17  n/a    .000
*
     RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .32  6.83  54.23  n/a    .000
     {ST=   .39 ha.m }
*
     ADD [2512 + 2513]  2514  3  5.0   13.80    2.96  6.00  70.61  n/a    .000
*
     ADD [0118 + 2502]  0121  3  5.0  198.39    8.07  6.17  47.75  n/a    .000
*
     ADD [2516 + 2511]  2509  3  5.0   52.20    1.58  6.67  58.28  n/a    .000
*
     ADD [0108 + 0121]  0017  3  5.0  250.38    8.82  6.17  46.59  n/a    .000
*
     ADD [0119 + 2509]  0123  3  5.0   57.60    2.00  6.08  59.24  n/a    .000
*
     ADD [0017 + 0109]  0018  3  5.0  285.37   10.25  6.83  45.46  n/a    .000
*
```

```
     ADD [0120 + 0123]  2505  3  5.0   66.00    3.77  6.08  60.86  n/a    .000
*
     ADD [0106 + 2505]  0319  3  5.0  329.24   11.03  7.25  47.50  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   6 **
  ****************************

  W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                 min     ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     MASS STORM                  5.0
     [ Ptot= 96.54 mm ]
*
  **  CALIB NASHYD      0111  1  5.0   12.40     .32  7.17  29.00  .30    .000
     [CN=58.9          ]
     [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD      0102  1  5.0   53.27    4.29  6.50  52.38  .54    .000
     [CN=80.0          ]
     [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD      0101  1  5.0   84.40    1.20  8.00  23.54  .24    .000
     [CN=52.3          ]
     [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD      0103  1  5.0  296.24    5.51  8.92  40.48  .42    .000
     [CN=71.2          ]
     [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD      0104  1  5.0  206.98   11.01  6.83  46.85  .49    .000
     [CN=76.2          ]
     [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD      0110  1  5.0  169.30    2.99  7.92  28.44  .29    .000
     [CN=59.1          ]
     [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD      0108  1  5.0   51.99    2.51  7.00  49.42  .51    .000
     [CN=78.0          ]
     [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD    0118  1  5.0   36.29    6.83  6.08  71.87  .74    .000
     [I%=42.0:S%= 2.00]
*
  **  CALIB STANDHYD    0205  1  5.0   53.80    9.57  6.08  70.02  .73    .000
     [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD      0112  1  5.0  108.30    4.44  7.00  41.93  .43    .000
     [CN=71.9          ]
     [ N = 3.0:Tp  .96]
*
  **  CALIB NASHYD      0109  1  5.0   34.99    1.79  6.83  44.06  .46    .000
     [CN=74.1          ]
     [ N = 3.0:Tp  .77]
*
  **  CALIB NASHYD      0106  1  5.0  263.24   11.10  7.33  51.60  .53    .000
     [CN=79.6          ]
     [ N = 3.0:Tp 1.24]
*
  *   CALIB STANDHYD    0120  1  5.0    8.40    2.08  6.00  80.68  .84    .000
     [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD    0119  1  5.0    5.40    1.30  6.00  77.03  .80    .000
     [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD    0213  1  5.0   45.20    7.15  6.08  63.44  .66    .000
     [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD    0222  1  5.0    7.00    1.84  6.00  84.24  .87    .000
     [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD    0216  1  5.0   25.80    5.88  6.08  82.92  .86    .000
     [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD      0115  1  5.0   54.50    1.67  7.83  47.23  .49    .000
     [CN=76.0          ]
     [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD    0207  1  5.0   39.36    5.56  6.08  56.06  .58    .000
     [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD      0117  1  5.0   92.80    1.14  8.50  23.46  .24    .000
     [CN=53.3          ]
     [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD    0214  1  5.0  211.62   32.18  6.17  69.58  .72    .000
     [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD    0221  1  5.0   12.20    1.92  6.08  61.94  .64    .000
     [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD    2512  1  5.0    5.40    1.30  6.00  77.03  .80    .000
     [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD    2513  1  5.0    8.40    2.08  6.00  80.68  .84    .000
     [I%=50.0:S%= 2.00]
*
     ADD [0102 + 0101]  0013  3  5.0  137.67    4.76  6.58  34.70  n/a    .000
*
     ADD [0103 + 0104]  0014  3  5.0  503.22   13.42  7.00  43.10  n/a    .000
*
     ADD [0014 + 0110]  2000  3  5.0  672.52   15.71  7.08  39.41  n/a    .000
*
     RESRVR [ 2 : 0205] 1134  1  5.0   53.80    2.54  6.67  69.98  n/a    .000
     {ST=  2.07 ha.m }
*
     ADD [1134 + 0112]  2502  3  5.0  162.10    6.83  6.92  51.24  n/a    .000
*
     RESRVR [ 2 : 0213] 2516  1  5.0   45.20    1.29  6.92  63.39  n/a    .000
     {ST=  1.72 ha.m }
*
     RESRVR [ 2 : 0222] 2511  1  5.0    7.00     .72  6.25  83.93  n/a    .000
     {ST=   .29 ha.m }
*
     RESRVR [ 2 : 0216] 2506  1  5.0   25.80    1.73  6.50  82.84  n/a    .000
     {ST=  1.17 ha.m }
*
     ADD [2506 + 0115]  2504  3  5.0   80.30    2.83  7.17  58.67  n/a    .000
*
     RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .61  7.25  56.01  n/a    .000
     {ST=  1.46 ha.m }
*
     ADD [2515 + 0117]  2503  3  5.0  132.16    1.71  8.33  33.16  n/a    .000
*
     RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .39  6.75  61.76  n/a    .000
     {ST=   .44 ha.m }
*
     ADD [2512 + 2513]  2514  3  5.0   13.80    3.38  6.00  79.25  n/a    .000
*
     ADD [0118 + 2502]  0121  3  5.0  198.39    9.39  6.17  55.02  n/a    .000
*
     ADD [2516 + 2511]  2509  3  5.0   52.20    1.86  6.58  66.15  n/a    .000
*
     ADD [0108 + 0121]  0017  3  5.0  250.38   10.37  6.75  53.85  n/a    .000
*
     ADD [0119 + 2509]  0123  3  5.0   57.60    2.36  6.17  67.17  n/a    .000
*
     ADD [0017 + 0109]  0018  3  5.0  285.37   12.16  6.75  52.65  n/a    .000
*
     ADD [0120 + 0123]  2505  3  5.0   66.00    4.36  6.08  68.89  n/a    .000
*
     ADD [0106 + 2505]  0319  3  5.0  329.24   12.93  7.25  55.07  n/a    .000
*
 FINISH

===========================================================================================================
```

```
=========================================================================================================

       V   V   I   SSSSS  U   U    A    L
       V   V   I   SS     U   U   A A   L
        V V    I    SS    U   U  AAAAA  L
        V V    I     SS   U   U  A   A  L
         VV    I   SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO

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                   *****  S U M M A R Y   O U T P U T  *****

  Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

  Output  filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci
  Summary filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci


DATE: 10/15/2015                           TIME: 2:10:57 PM

USER:

COMMENTS: ____________________________________________________________


  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************

  W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                 min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                 5.0
      [ Ptot= 46.51 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .06 13.00   6.57  .14    .000
      [CN=58.9        ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0101  1  5.0   84.40     .20 13.92   4.96  .11    .000
      [CN=52.3        ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    1.00 12.33  15.13  .33    .000
      [CN=80.0        ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0110  1  5.0  169.30     .51 13.83   6.20  .13    .000
      [CN=59.1        ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0104  1  5.0  206.98    2.37 12.67  12.67  .27    .000
      [CN=76.2        ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0103  1  5.0  296.24    1.10 14.83  10.15  .22    .000
      [CN=71.2        ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0109  1  5.0   34.99     .37 12.58  11.53  .25    .000
      [CN=74.1        ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB STANDHYD     0205  1  5.0   53.80    2.77 11.92  27.66  .60    .000
      [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD       0112  1  5.0  108.30     .91 12.83  10.87  .23    .000
      [CN=71.9        ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    2.08 11.83  29.05  .63    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD       0108  1  5.0   51.99     .56 12.83  13.79  .30    .000
      [CN=78.0        ]
      [ N = 3.0:Tp  .98]
*
   *  CALIB STANDHYD     0119  1  5.0    5.40     .44 11.75  32.30  .70    .000
```

```
      [I%=50.0:S%= 2.00]
*
   *  CALIB STANDHYD     0222  1  5.0    7.00     .62 11.75  36.42  .78    .000
      [I%=52.0:S%= 2.00]
*
   *  CALIB STANDHYD     0213  1  5.0   45.20    1.99 11.92  24.10  .52    .000
      [I%=31.0:S%= 2.00]
*
   *  CALIB STANDHYD     0120  1  5.0    8.40     .69 11.75  34.20  .74    .000
      [I%=50.0:S%= 2.00]
*
   *  CALIB NASHYD       0106  1  5.0  263.24    2.56 13.17  14.71  .32    .000
      [CN=79.6        ]
      [ N = 3.0:Tp 1.24]
*
   *  CALIB NASHYD       0115  1  5.0   54.50     .37 13.67  13.02  .28    .000
      [CN=76.0        ]
      [ N = 3.0:Tp 1.65]
*
   *  CALIB STANDHYD     0216  1  5.0   25.80    1.98 11.83  35.50  .76    .000
      [I%=50.0:S%= 2.00]
*
   *  CALIB STANDHYD     0207  1  5.0   39.36    1.71 11.83  21.91  .47    .000
      [I%=35.0:S%= 2.00]
*
   *  CALIB NASHYD       0117  1  5.0   92.80     .18 14.42   4.72  .10    .000
      [CN=53.3        ]
      [ N = 3.0:Tp 2.06]
*
   *  CALIB STANDHYD     0214  1  5.0  211.62    8.55 12.00  26.85  .58    .000
      [I%=31.0:S%= 1.00]
*
   *  CALIB STANDHYD     0221  1  5.0   12.20     .60 11.75  23.60  .51    .000
      [I%=35.0:S%= 1.00]
*
   *  CALIB STANDHYD     2513  1  5.0    8.40     .69 11.75  34.20  .74    .000
      [I%=50.0:S%= 2.00]
*
   *  CALIB STANDHYD     2512  1  5.0    5.40     .44 11.75  32.30  .70    .000
      [I%=50.0:S%= 2.00]
*
      ADD [0101 + 0102]  0013  3  5.0  137.67    1.07 12.33   8.89  n/a    .000
*
      ADD [0104 + 0103]  0014  3  5.0  503.22    2.82 12.75  11.19  n/a    .000
*
      RESRVR [ 2 : 0205] 1134  1  5.0   53.80     .51 12.92  27.62  n/a    .000
      {ST=   .84 ha.m }
*
      ADD [1134 + 0112]  2502  3  5.0  162.10    1.42 12.83  16.43  n/a    .000
*
      ADD [2502 + 0118]  0121  3  5.0  198.39    2.38 11.92  18.74  n/a    .000
*
      ADD [0121 + 0108]  0017  3  5.0  250.38    2.55 11.92  17.71  n/a    .000
*
      RESRVR [ 2 : 0222] 2518  1  5.0    7.00     .17 12.25  36.11  n/a    .000
      {ST=   .14 ha.m }
*
      RESRVR [ 2 : 0213] 2517  1  5.0   45.20     .21 13.58  24.05  n/a    .000
      {ST=   .66 ha.m }
*
      RESRVR [ 2 : 0216] 2506  1  5.0   25.80     .41 12.58  35.41  n/a    .000
      {ST=   .52 ha.m }
*
      RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .10 14.50  21.86  n/a    .000
      {ST=   .58 ha.m }
*
      ADD [2515 + 0117]  2503  3  5.0  132.16     .27 14.42   9.83  n/a    .000
*
      RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .07 13.17  23.42  n/a    .000
      {ST=   .17 ha.m }
*
      ADD [2513 + 2512]  2514  3  5.0   13.80    1.12 11.75  33.46  n/a    .000
*
      ADD [0110 + 0014]  2000  3  5.0  672.52    3.20 12.92   9.93  n/a    .000
*
      ADD [0109 + 0017]  0018  3  5.0  285.37    2.78 12.50  16.95  n/a    .000
*
      ADD [2518 + 2517]  2509  3  5.0   52.20     .35 12.42  25.66  n/a    .000
*
      ADD [0115 + 2506]  2504  3  5.0   80.30     .69 12.92  20.21  n/a    .000
*
      ADD [0119 + 2509]  0123  3  5.0   57.60     .48 11.75  26.29  n/a    .000
*
      ADD [0123 + 0120]  2505  3  5.0   66.00    1.16 11.75  27.29  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24    2.93 13.08  17.23  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   2 **
  ****************************

  W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                 min     ha     cms   hrs     mm          cms
```

```
     START @   .00 hrs
     --------------------
     MASS STORM                  5.0
     [ Ptot= 60.36 mm ]
 *
  ** CALIB NASHYD       0111  1  5.0   12.40     .10 13.00  11.55  .19    .000
     [CN=58.9        ]
     [ N = 3.0:Tp 1.07]
 *
  ** CALIB NASHYD       0101  1  5.0   84.40     .37 13.83   8.97  .15    .000
     [CN=52.3        ]
     [ N = 3.0:Tp 1.72]
 *
  ** CALIB NASHYD       0102  1  5.0   53.27    1.65 12.25  24.32  .40    .000
     [CN=80.0        ]
     [ N = 3.0:Tp  .53]
 *
  ** CALIB NASHYD       0110  1  5.0  169.30     .95 13.75  11.11  .18    .000
     [CN=59.1        ]
     [ N = 3.0:Tp 1.67]
 *
  ** CALIB NASHYD       0104  1  5.0  206.98    4.03 12.58  20.91  .35    .000
     [CN=76.2        ]
     [ N = 3.0:Tp  .80]
 *
  ** CALIB NASHYD       0103  1  5.0  296.24    1.93 14.75  17.25  .29    .000
     [CN=71.2        ]
     [ N = 3.0:Tp 2.53]
 *
  ** CALIB NASHYD       0109  1  5.0   34.99     .64 12.58  19.27  .32    .000
     [CN=74.1        ]
     [ N = 3.0:Tp  .77]
 *
  ** CALIB STANDHYD     0205  1  5.0   53.80    4.20 11.92  38.72  .64    .000
     [I%=37.0:S%= 2.00]
 *
  ** CALIB NASHYD       0112  1  5.0  108.30    1.58 12.83  18.20  .30    .000
     [CN=71.9        ]
     [ N = 3.0:Tp  .96]
 *
  ** CALIB STANDHYD     0118  1  5.0   36.29    3.06 11.83  40.29  .67    .000
     [I%=42.0:S%= 2.00]
 *
  ** CALIB NASHYD       0108  1  5.0   51.99     .94 12.83  22.47  .37    .000
     [CN=78.0        ]
     [ N = 3.0:Tp  .98]
 *
   * CALIB STANDHYD     0119  1  5.0    5.40     .60 11.75  44.19  .73    .000
     [I%=50.0:S%= 2.00]
 *
   * CALIB STANDHYD     0222  1  5.0    7.00     .85 11.75  49.37  .82    .000
     [I%=52.0:S%= 2.00]
 *
   * CALIB STANDHYD     0213  1  5.0   45.20    3.05 11.92  34.19  .57    .000
     [I%=31.0:S%= 2.00]
 *
   * CALIB STANDHYD     0120  1  5.0    8.40     .95 11.75  46.67  .77    .000
     [I%=50.0:S%= 2.00]
 *
   * CALIB NASHYD       0106  1  5.0  263.24    4.25 13.17  23.78  .39    .000
     [CN=79.6        ]
     [ N = 3.0:Tp 1.24]
 *
   * CALIB NASHYD       0115  1  5.0   54.50     .63 13.67  21.28  .35    .000
     [CN=76.0        ]
     [ N = 3.0:Tp 1.65]
 *
   * CALIB STANDHYD     0216  1  5.0   25.80    2.90 11.83  48.30  .80    .000
     [I%=50.0:S%= 2.00]
 *
   * CALIB STANDHYD     0207  1  5.0   39.36    2.43 11.83  30.59  .51    .000
     [I%=35.0:S%= 2.00]
 *
   * CALIB NASHYD       0117  1  5.0   92.80     .34 14.33   8.74  .14    .000
     [CN=53.3        ]
     [ N = 3.0:Tp 2.06]
 *
   * CALIB STANDHYD     0214  1  5.0  211.62   12.52 12.00  38.00  .63    .000
     [I%=31.0:S%= 1.00]
 *
   * CALIB STANDHYD     0221  1  5.0   12.20     .86 11.75  33.39  .55    .000
     [I%=35.0:S%= 1.00]
 *
   * CALIB STANDHYD     2513  1  5.0    8.40     .95 11.75  46.67  .77    .000
     [I%=50.0:S%= 2.00]
 *
   * CALIB STANDHYD     2512  1  5.0    5.40     .60 11.75  44.19  .73    .000
     [I%=50.0:S%= 2.00]
 *
     ADD [0101 + 0102]  0013  3  5.0  137.67    1.80 12.33  14.91  n/a    .000
 *
     ADD [0104 + 0103]  0014  3  5.0  503.22    4.87 12.75  18.75  n/a    .000
```

```
 *
     RESRVR [ 2 : 0205] 1134  1  5.0   53.80     .90 12.67  38.68  n/a    .000
     {ST=  1.11 ha.m }
 *
     ADD [1134 + 0112]  2502  3  5.0  162.10    2.47 12.75  25.00  n/a    .000
 *
     ADD [2502 + 0118]  0121  3  5.0  198.39    3.87 11.92  27.79  n/a    .000
 *
     ADD [0121 + 0108]  0017  3  5.0  250.38    4.22 12.00  26.69  n/a    .000
 *
     RESRVR [ 2 : 0222] 2518  1  5.0    7.00     .20 12.33  49.06  n/a    .000
     {ST=   .18 ha.m }
 *
     RESRVR [ 2 : 0213] 2517  1  5.0   45.20     .28 13.58  34.14  n/a    .000
     {ST=   .94 ha.m }
 *
     RESRVR [ 2 : 0216] 2506  1  5.0   25.80     .68 12.42  48.22  n/a    .000
     {ST=   .67 ha.m }
 *
     RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .18 13.83  30.53  n/a    .000
     {ST=   .78 ha.m }
 *
     ADD [2515 + 0117]  2503  3  5.0  132.16     .52 14.25  15.23  n/a    .000
 *
     RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .13 12.83  33.22  n/a    .000
     {ST=   .23 ha.m }
 *
     ADD [2513 + 2512]  2514  3  5.0   13.80    1.55 11.75  45.70  n/a    .000
 *
     ADD [0110 + 0014]  2000  3  5.0  672.52    5.58 12.83  16.83  n/a    .000
 *
     ADD [0109 + 0017]  0018  3  5.0  285.37    4.63 12.50  25.78  n/a    .000
 *
     ADD [2518 + 2517]  2509  3  5.0   52.20     .46 12.92  36.14  n/a    .000
 *
     ADD [0115 + 2506]  2504  3  5.0   80.30    1.15 13.08  29.93  n/a    .000
 *
     ADD [0119 + 2509]  0123  3  5.0   57.60     .80 11.83  36.90  n/a    .000
 *
     ADD [0123 + 0120]  2505  3  5.0   66.00    1.74 11.83  38.14  n/a    .000
 *
     ADD [2505 + 0106]  0319  3  5.0  329.24    4.84 13.08  26.66  n/a    .000
 *
 ****************************
 ** SIMULATION NUMBER:   3 **
 ****************************

 W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha    cms   hrs     mm           cms

     START @   .00 hrs
     --------------------
     MASS STORM                  5.0
     [ Ptot= 69.52 mm ]
 *
  ** CALIB NASHYD       0111  1  5.0   12.40     .14 13.00  15.42  .22    .000
     [CN=58.9        ]
     [ N = 3.0:Tp 1.07]
 *
  ** CALIB NASHYD       0101  1  5.0   84.40     .51 13.83  12.14  .17    .000
     [CN=52.3        ]
     [ N = 3.0:Tp 1.72]
 *
  ** CALIB NASHYD       0102  1  5.0   53.27    2.13 12.25  30.96  .45    .000
     [CN=80.0        ]
     [ N = 3.0:Tp  .53]
 *
  ** CALIB NASHYD       0110  1  5.0  169.30    1.29 13.75  14.94  .22    .000
     [CN=59.1        ]
     [ N = 3.0:Tp 1.67]
 *
  ** CALIB NASHYD       0104  1  5.0  206.98    5.27 12.58  26.96  .39    .000
     [CN=76.2        ]
     [ N = 3.0:Tp  .80]
 *
  ** CALIB NASHYD       0103  1  5.0  296.24    2.57 14.75  22.57  .33    .000
     [CN=71.2        ]
     [ N = 3.0:Tp 2.53]
 *
  ** CALIB NASHYD       0109  1  5.0   34.99     .84 12.58  25.01  .36    .000
     [CN=74.1        ]
     [ N = 3.0:Tp  .77]
 *
  ** CALIB STANDHYD     0205  1  5.0   53.80    5.11 11.92  46.37  .67    .000
     [I%=37.0:S%= 2.00]
 *
  ** CALIB NASHYD       0112  1  5.0  108.30    2.08 12.83  23.66  .34    .000
     [CN=71.9        ]
     [ N = 3.0:Tp  .96]
 *
  ** CALIB STANDHYD     0118  1  5.0   36.29    3.67 11.83  48.02  .69    .000
     [I%=42.0:S%= 2.00]
 *
```

```
  **  CALIB NASHYD       0108  1  5.0   51.99    1.22 12.83  28.80  .41    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .72 11.75  52.30  .75    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0222  1  5.0    7.00    1.01 11.75  58.08  .84    .000
      [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD     0213  1  5.0   45.20    3.75 11.92  41.26  .59    .000
      [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    1.13 11.75  55.12  .79    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0106  1  5.0  263.24    5.49 13.08  30.36  .44    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB NASHYD       0115  1  5.0   54.50     .81 13.58  27.34  .39    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0216  1  5.0   25.80    3.46 11.83  56.93  .82    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0207  1  5.0   39.36    3.02 11.83  36.69  .53    .000
      [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .47 14.25  11.94  .17    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD     0214  1  5.0  211.62   16.40 12.00  45.71  .66    .000
      [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD     0221  1  5.0   12.20    1.03 11.75  40.27  .58    .000
      [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD     2513  1  5.0    8.40    1.13 11.75  55.12  .79    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     2512  1  5.0    5.40     .72 11.75  52.30  .75    .000
      [I%=50.0:S%= 2.00]
*
      ADD [0101 + 0102]  0013  3  5.0  137.67    2.33 12.33  19.42  n/a    .000
*
      ADD [0104 + 0103]  0014  3  5.0  503.22    6.40 12.75  24.38  n/a    .000
*
      RESRVR [ 2 : 0205] 1134  1  5.0   53.80    1.18 12.58  46.33  n/a    .000
      {ST=  1.30 ha.m }
*
      ADD [1134 + 0112]  2502  3  5.0  162.10    3.25 12.75  31.18  n/a    .000
*
      ADD [2502 + 0118]  0121  3  5.0  198.39    4.62 11.92  34.26  n/a    .000
*
      ADD [0121 + 0108]  0017  3  5.0  250.38    5.11 12.58  33.13  n/a    .000
*
      RESRVR [ 2 : 0222] 2518  1  5.0    7.00     .21 12.33  57.77  n/a    .000
      {ST=   .22 ha.m }
*
      RESRVR [ 2 : 0213] 2517  1  5.0   45.20     .33 13.58  41.21  n/a    .000
      {ST=  1.14 ha.m }
*
      RESRVR [ 2 : 0216] 2506  1  5.0   25.80     .88 12.33  56.85  n/a    .000
      {ST=   .77 ha.m }
*
      RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .25 13.58  36.63  n/a    .000
      {ST=   .91 ha.m }
*
      ADD [2515 + 0117]  2503  3  5.0  132.16     .72 14.17  19.29  n/a    .000
*
      RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .17 12.75  40.09  n/a    .000
      {ST=   .27 ha.m }
*
      ADD [2513 + 2512]  2514  3  5.0   13.80    1.85 11.75  54.01  n/a    .000
*
      ADD [0110 + 0014]  2000  3  5.0  672.52    7.39 12.83  22.00  n/a    .000
*
      ADD [0109 + 0017]  0018  3  5.0  285.37    5.95 12.58  32.13  n/a    .000
*
      ADD [2518 + 2517]  2509  3  5.0   52.20     .53 12.92  43.43  n/a    .000
*
      ADD [0115 + 2506]  2504  3  5.0   80.30    1.46 13.00  36.82  n/a    .000
*
      ADD [0119 + 2509]  0123  3  5.0   57.60    1.00 11.83  44.26  n/a    .000
*
      ADD [0123 + 0120]  2505  3  5.0   66.00    2.13 11.83  45.64  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24    6.17 13.08  33.42  n/a    .000
*
  ****************************
```

```
  ** SIMULATION NUMBER:   4 **
  ****************************

  W/E COMMAND            HYD ID   DT    AREA    Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha      cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                  5.0
      [ Ptot= 81.07 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .19 12.92  20.85  .26    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0101  1  5.0   84.40     .71 13.75  16.65  .21    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    2.76 12.25  39.82  .49    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0110  1  5.0  169.30    1.79 13.67  20.33  .25    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0104  1  5.0  206.98    6.94 12.58  35.12  .43    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0103  1  5.0  296.24    3.43 14.67  29.86  .37    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0109  1  5.0   34.99    1.12 12.58  32.80  .40    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB STANDHYD     0205  1  5.0   53.80    6.31 11.92  56.29  .69    .000
      [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD       0112  1  5.0  108.30    2.77 12.75  31.11  .38    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    4.79 11.83  58.04  .72    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD       0108  1  5.0   51.99    1.60 12.83  37.29  .46    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .87 11.75  62.72  .77    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0222  1  5.0    7.00    1.22 11.75  69.17  .85    .000
      [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD     0213  1  5.0   45.20    4.67 11.92  50.51  .62    .000
      [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    1.37 11.75  65.92  .81    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0106  1  5.0  263.24    7.15 13.08  39.13  .48    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    1.07 13.58  35.50  .44    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0216  1  5.0   25.80    4.18 11.83  67.94  .84    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0207  1  5.0   39.36    3.66 11.83  44.72  .55    .000
      [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD       0117  1  5.0   92.80     .67 14.25  16.49  .20    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD     0214  1  5.0  211.62   19.95 11.92  55.72  .69    .000
      [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD     0221  1  5.0   12.20    1.25 11.75  49.29  .61    .000
      [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD     2513  1  5.0    8.40    1.37 11.75  65.92  .81    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     2512  1  5.0    5.40     .87 11.75  62.72  .77    .000
```

```
     [I%=50.0:S%= 2.00]
*
     ADD [0101 + 0102]  0013  3  5.0  137.67    3.05 12.33  25.62  n/a    .000
*
     ADD [0104 + 0103]  0014  3  5.0  503.22    8.49 12.75  32.02  n/a    .000
*
     RESRVR [ 2 : 0205] 1134  1  5.0   53.80    1.55 12.58  56.24  n/a    .000
     {ST=  1.54 ha.m }
*
     ADD [1134 + 0112]  2502  3  5.0  162.10    4.29 12.75  39.45  n/a    .000
*
     ADD [2502 + 0118]  0121  3  5.0  198.39    6.16 11.92  42.85  n/a    .000
*
     ADD [0121 + 0108]  0017  3  5.0  250.38    6.73 11.92  41.70  n/a    .000
*
     RESRVR [ 2 : 0222] 2518  1  5.0    7.00     .24 12.33  68.86  n/a    .000
     {ST=   .26 ha.m }
*
     RESRVR [ 2 : 0213] 2517  1  5.0   45.20     .40 13.58  50.46  n/a    .000
     {ST=  1.41 ha.m }
*
     RESRVR [ 2 : 0216] 2506  1  5.0   25.80    1.14 12.33  67.86  n/a    .000
     {ST=   .90 ha.m }
*
     RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .35 13.33  44.67  n/a    .000
     {ST=  1.08 ha.m }
*
     ADD [2515 + 0117]  2503  3  5.0  132.16    1.00 14.08  24.89  n/a    .000
*
     RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .24 12.67  49.11  n/a    .000
     {ST=   .32 ha.m }
*
     ADD [2513 + 2512]  2514  3  5.0   13.80    2.24 11.75  64.67  n/a    .000
*
     ADD [0110 + 0014]  2000  3  5.0  672.52    9.86 12.83  29.08  n/a    .000
*
     ADD [0109 + 0017]  0018  3  5.0  285.37    7.71 12.58  40.61  n/a    .000
*
     ADD [2518 + 2517]  2509  3  5.0   52.20     .62 13.00  52.93  n/a    .000
*
     ADD [0115 + 2506]  2504  3  5.0   80.30    1.88 13.00  45.90  n/a    .000
*
     ADD [0119 + 2509]  0123  3  5.0   57.60    1.24 11.83  53.84  n/a    .000
*
     ADD [0123 + 0120]  2505  3  5.0   66.00    2.60 11.83  55.38  n/a    .000
*
     ADD [2505 + 0106]  0319  3  5.0  329.24    7.94 13.08  42.39  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   5 **
  ****************************

  W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                 min     ha     cms   hrs     mm          cms

     START @   .00 hrs
     --------------------
     MASS STORM                  5.0
     [ Ptot= 89.74 mm ]
*
  **  CALIB NASHYD      0111  1  5.0   12.40     .23 12.92  25.27  .28    .000
     [CN=58.9         ]
     [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD      0101  1  5.0   84.40     .87 13.75  20.38  .23    .000
     [CN=52.3         ]
     [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD      0102  1  5.0   53.27    3.26 12.25  46.74  .52    .000
     [CN=80.0         ]
     [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD      0110  1  5.0  169.30    2.19 13.67  24.73  .28    .000
     [CN=59.1         ]
     [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD      0104  1  5.0  206.98    8.26 12.58  41.56  .46    .000
     [CN=76.2         ]
     [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD      0103  1  5.0  296.24    4.13 14.67  35.67  .40    .000
     [CN=71.2         ]
     [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD      0109  1  5.0   34.99    1.34 12.58  38.97  .43    .000
     [CN=74.1         ]
     [ N = 3.0:Tp  .77]
*
  **  CALIB STANDHYD    0205  1  5.0   53.80    7.24 11.92  63.89  .71    .000
     [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD      0112  1  5.0  108.30    3.32 12.75  37.04  .41    .000
     [CN=71.9         ]
     [ N = 3.0:Tp  .96]
*
  **  CALIB STANDHYD    0118  1  5.0   36.29    5.47 11.83  65.70  .73    .000
     [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD      0108  1  5.0   51.99    1.89 12.75  43.96  .49    .000
     [CN=78.0         ]
     [ N = 3.0:Tp  .98]
*
  *   CALIB STANDHYD    0119  1  5.0    5.40    1.04 11.75  70.66  .79    .000
     [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD    0222  1  5.0    7.00    1.50 11.75  77.55  .87    .000
     [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD    0213  1  5.0   45.20    5.63 11.83  57.65  .64    .000
     [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD    0120  1  5.0    8.40    1.55 11.75  74.11  .83    .000
     [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD      0106  1  5.0  263.24    8.44 13.08  45.99  .51    .000
     [CN=79.6         ]
     [ N = 3.0:Tp 1.24]
*
  *   CALIB NASHYD      0115  1  5.0   54.50    1.27 13.58  41.94  .47    .000
     [CN=76.0         ]
     [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD    0216  1  5.0   25.80    4.73 11.83  76.26  .85    .000
     [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD    0207  1  5.0   39.36    4.19 11.83  50.97  .57    .000
     [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD      0117  1  5.0   92.80     .83 14.17  20.27  .23    .000
     [CN=53.3         ]
     [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD    0214  1  5.0  211.62   23.02 11.92  63.39  .71    .000
     [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD    0221  1  5.0   12.20    1.43 11.75  56.27  .63    .000
     [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD    2513  1  5.0    8.40    1.55 11.75  74.11  .83    .000
     [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD    2512  1  5.0    5.40    1.04 11.75  70.66  .79    .000
     [I%=50.0:S%= 2.00]
*
     ADD [0101 + 0102]  0013  3  5.0  137.67    3.61 12.33  30.58  n/a    .000
*
     ADD [0104 + 0103]  0014  3  5.0  503.22   10.15 12.75  38.10  n/a    .000
*
     RESRVR [ 2 : 0205] 1134  1  5.0   53.80    1.86 12.50  63.85  n/a    .000
     {ST=  1.73 ha.m }
*
     ADD [1134 + 0112]  2502  3  5.0  162.10    5.13 12.75  45.94  n/a    .000
*
     ADD [2502 + 0118]  0121  3  5.0  198.39    7.22 11.92  49.55  n/a    .000
*
     ADD [0121 + 0108]  0017  3  5.0  250.38    7.91 11.92  48.39  n/a    .000
*
     RESRVR [ 2 : 0222] 2518  1  5.0    7.00     .52 12.08  77.24  n/a    .000
     {ST=   .28 ha.m }
*
     RESRVR [ 2 : 0213] 2517  1  5.0   45.20     .94 12.67  57.60  n/a    .000
     {ST=  1.50 ha.m }
*
     RESRVR [ 2 : 0216] 2506  1  5.0   25.80    1.35 12.25  76.18  n/a    .000
     {ST=   .99 ha.m }
*
     RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .44 13.17  50.92  n/a    .000
     {ST=  1.21 ha.m }
*
     ADD [2515 + 0117]  2503  3  5.0  132.16    1.24 14.00  29.39  n/a    .000
*
     RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .29 12.58  56.09  n/a    .000
     {ST=   .36 ha.m }
*
     ADD [2513 + 2512]  2514  3  5.0   13.80    2.60 11.75  72.76  n/a    .000
*
     ADD [0110 + 0014]  2000  3  5.0  672.52   11.85 12.83  34.73  n/a    .000
*
     ADD [0109 + 0017]  0018  3  5.0  285.37    9.16 12.58  47.23  n/a    .000
*
     ADD [2518 + 2517]  2509  3  5.0   52.20    1.17 12.67  60.24  n/a    .000
*
     ADD [0115 + 2506]  2504  3  5.0   80.30    2.20 13.00  52.94  n/a    .000
*
     ADD [0119 + 2509]  0123  3  5.0   57.60    1.47 11.83  61.21  n/a    .000
*
```

```
      ADD [0123 + 0120]  2505  3  5.0   66.00    3.01 11.75  62.85  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24    9.71 13.00  49.37  n/a    .000
*
  ****************************
  ** SIMULATION NUMBER:   6 **
  ****************************

  W/E COMMAND            HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      MASS STORM                  5.0
      [ Ptot= 98.31 mm ]
*
  **  CALIB NASHYD       0111  1  5.0   12.40     .27 12.92  29.92  .30    .000
      [CN=58.9         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0101  1  5.0   84.40    1.05 13.75  24.32  .25    .000
      [CN=52.3         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    3.76 12.25  53.77  .55    .000
      [CN=80.0         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0110  1  5.0  169.30    2.62 13.67  29.36  .30    .000
      [CN=59.1         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0104  1  5.0  206.98    9.62 12.58  48.15  .49    .000
      [CN=76.2         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0103  1  5.0  296.24    4.85 14.67  41.67  .42    .000
      [CN=71.2         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0109  1  5.0   34.99    1.56 12.58  45.31  .46    .000
      [CN=74.1         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB STANDHYD     0205  1  5.0   53.80    8.57 11.83  71.52  .73    .000
      [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD       0112  1  5.0  108.30    3.88 12.75  43.14  .44    .000
      [CN=71.9         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    6.16 11.83  73.38  .75    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD       0108  1  5.0   51.99    2.20 12.75  50.76  .52    .000
      [CN=78.0         ]
      [ N = 3.0:Tp  .98]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40    1.19 11.75  78.58  .80    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0222  1  5.0    7.00    1.67 11.75  85.87  .87    .000
      [I%=52.0:S%= 2.00]
*
  *   CALIB STANDHYD     0213  1  5.0   45.20    6.40 11.83  64.86  .66    .000
      [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    1.88 11.75  82.27  .84    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0106  1  5.0  263.24    9.76 13.08  52.97  .54    .000
      [CN=79.6         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    1.47 13.58  48.53  .49    .000
      [CN=76.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0216  1  5.0   25.80    5.32 11.83  84.54  .86    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0207  1  5.0   39.36    4.72 11.83  57.31  .58    .000
      [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD       0117  1  5.0   92.80    1.00 14.17  24.26  .25    .000
      [CN=53.3         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD     0214  1  5.0  211.62   28.38 11.92  71.09  .72    .000
      [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD     0221  1  5.0   12.20    1.74 11.83  63.32  .64    .000
      [I%=35.0:S%= 1.00]
*
  *   CALIB STANDHYD     2513  1  5.0    8.40    1.88 11.75  82.27  .84    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     2512  1  5.0    5.40    1.19 11.75  78.58  .80    .000
      [I%=50.0:S%= 2.00]
*
      ADD [0101 + 0102]  0013  3  5.0  137.67    4.19 12.33  35.72  n/a    .000
*
      ADD [0104 + 0103]  0014  3  5.0  503.22   11.86 12.75  44.34  n/a    .000
*
      RESRVR [ 2 : 0205] 1134  1  5.0   53.80    2.18 12.42  71.48  n/a    .000
      {ST=  1.92 ha.m }
*
      ADD [1134 + 0112]  2502  3  5.0  162.10    5.96 12.67  52.55  n/a    .000
*
      ADD [2502 + 0118]  0121  3  5.0  198.39    8.49 11.92  56.36  n/a    .000
*
      ADD [0121 + 0108]  0017  3  5.0  250.38    9.31 11.92  55.19  n/a    .000
*
      RESRVR [ 2 : 0222] 2518  1  5.0    7.00     .62 12.08  85.56  n/a    .000
      {ST=   .29 ha.m }
*
      RESRVR [ 2 : 0213] 2517  1  5.0   45.20    1.14 12.67  64.81  n/a    .000
      {ST=  1.63 ha.m }
*
      RESRVR [ 2 : 0216] 2506  1  5.0   25.80    1.56 12.25  84.45  n/a    .000
      {ST=  1.09 ha.m }
*
      RESRVR [ 2 : 0207] 2515  1  5.0   39.36     .53 13.08  57.26  n/a    .000
      {ST=  1.35 ha.m }
*
      ADD [2515 + 0117]  2503  3  5.0  132.16    1.49 14.00  34.09  n/a    .000
*
      RESRVR [ 2 : 0221] 2508  1  5.0   12.20     .34 12.50  63.15  n/a    .000
      {ST=   .40 ha.m }
*
      ADD [2513 + 2512]  2514  3  5.0   13.80    3.07 11.75  80.83  n/a    .000
*
      ADD [0110 + 0014]  2000  3  5.0  672.52   13.90 12.83  40.57  n/a    .000
*
      ADD [0109 + 0017]  0018  3  5.0  285.37   10.62 12.50  53.98  n/a    .000
*
      ADD [2518 + 2517]  2509  3  5.0   52.20    1.59 12.25  67.59  n/a    .000
*
      ADD [0115 + 2506]  2504  3  5.0   80.30    2.53 12.92  60.07  n/a    .000
*
      ADD [0119 + 2509]  0123  3  5.0   57.60    1.82 12.25  68.62  n/a    .000
*
      ADD [0123 + 0120]  2505  3  5.0   66.00    3.52 11.75  70.36  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24   11.29 13.00  56.46  n/a    .000
*
 FINISH

=============================================================================================================
```

```
=============================================================================================================

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
```



```
                   *****  S U M M A R Y   O U T P U T  *****

  Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

  Output  filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci
  Summary filename: C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 -
Brechin and Lagoon Ci


DATE: 10/15/2015                           TIME: 2:25:06 PM

USER:


COMMENTS: ____________________________________________________________


  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      READ STORM                 12.0
      [ Ptot=212.00 mm ]
      fname : C:\Users\jash\Desktop\Project Files\312803 - Brechin Master SWM Plan\October 2015 Submission\VO2 - B
      remark: * REGIONAL DESIGN STORM - HAZEL
*
  **  CALIB NASHYD       0111  1  5.0   12.40    1.14 11.25 147.18  .69    .000
      [CN=76.7         ]
      [ N = 3.0:Tp 1.07]
*
  **  CALIB NASHYD       0101  1  5.0   84.40    5.98 11.83 134.78  .64    .000
      [CN=71.6         ]
      [ N = 3.0:Tp 1.72]
*
  **  CALIB NASHYD       0102  1  5.0   53.27    6.61 10.33 180.67  .85    .000
      [CN=90.2         ]
      [ N = 3.0:Tp  .53]
*
  **  CALIB NASHYD       0110  1  5.0  169.30   12.94 11.75 146.21  .69    .000
      [CN=76.8         ]
      [ N = 3.0:Tp 1.67]
*
  **  CALIB NASHYD       0104  1  5.0  206.98   22.77 10.92 174.83  .82    .000
      [CN=88.1         ]
      [ N = 3.0:Tp  .80]
*
  **  CALIB NASHYD       0103  1  5.0  296.24   20.08 12.42 166.57  .79    .000
      [CN=85.0         ]
      [ N = 3.0:Tp 2.53]
*
  **  CALIB NASHYD       0109  1  5.0   34.99    3.85 10.83 171.33  .81    .000
      [CN=86.8         ]
      [ N = 3.0:Tp  .77]
*
  **  CALIB STANDHYD     0205  1  5.0   53.80    7.56 10.00 193.91  .91    .000
      [I%=37.0:S%= 2.00]
*
  **  CALIB NASHYD       0112  1  5.0  108.30   11.20 11.08 168.70  .80    .000
      [CN=85.5         ]
      [ N = 3.0:Tp  .96]
*
  **  CALIB STANDHYD     0118  1  5.0   36.29    4.91 10.00 180.69  .85    .000
      [I%=42.0:S%= 2.00]
*
  **  CALIB NASHYD       0108  1  5.0   51.99    5.48 11.08 177.62  .84    .000
      [CN=89.1         ]
      [ N = 3.0:Tp  .98]
*
  **  CALIB STANDHYD     0222  1  5.0    7.00    1.01 10.00 196.06  .92    .000
      [I%=52.0:S%= 2.00]
*
  **  CALIB STANDHYD     0213  1  5.0   45.20    6.26 10.00 187.86  .89    .000
      [I%=31.0:S%= 2.00]
*
  *   CALIB STANDHYD     0119  1  5.0    5.40     .76 10.00 187.83  .89    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB STANDHYD     0120  1  5.0    8.40    1.20 10.00 193.34  .91    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0106  1  5.0  263.24   25.74 11.33 179.90  .85    .000
      [CN=90.0         ]
      [ N = 3.0:Tp 1.24]
*
  *   CALIB STANDHYD     0216  1  5.0   25.80    3.70 10.00 196.46  .93    .000
      [I%=50.0:S%= 2.00]
*
  *   CALIB NASHYD       0115  1  5.0   54.50    4.67 11.67 175.37  .83    .000
      [CN=88.0         ]
      [ N = 3.0:Tp 1.65]
*
  *   CALIB STANDHYD     0207  1  5.0   39.36    5.24 10.00 176.25  .83    .000
      [I%=35.0:S%= 2.00]
*
  *   CALIB NASHYD       0117  1  5.0   92.80    6.04 12.17 135.12  .64    .000
      [CN=72.4         ]
      [ N = 3.0:Tp 2.06]
*
  *   CALIB STANDHYD     0214  1  5.0  211.62   28.28 10.08 194.13  .92    .000
      [I%=31.0:S%= 1.00]
*
  *   CALIB STANDHYD     0221  1  5.0   12.20    1.69 10.00 186.81  .88    .000
      [I%=35.0:S%= 1.00]
*
      ADD [0101 + 0102]  0013  3  5.0  137.67   11.17 11.08 152.54  n/a    .000
*
      ADD [0104 + 0103]  0014  3  5.0  503.22   39.08 11.25 169.97  n/a    .000
*
      ADD [0205 + 0112]  2502  3  5.0  162.10   16.85 11.00 177.06  n/a    .000
*
      ADD [2502 + 0118]  0121  3  5.0  198.39   20.55 11.00 177.73  n/a    .000
*
      ADD [0121 + 0108]  0017  3  5.0  250.38   26.00 11.00 177.71  n/a    .000
*
      ADD [0222 + 0213]  2508  3  5.0   52.20    7.27 10.00 188.96  n/a    .000
*
      ADD [2508 + 0119]  0123  3  5.0   57.60    8.03 10.00 188.85  n/a    .000
*
      ADD [0123 + 0120]  2505  3  5.0   66.00    9.23 10.00 189.42  n/a    .000
*
      ADD [2505 + 0106]  0319  3  5.0  329.24   31.83 11.00 181.81  n/a    .000
*
      ADD [0216 + 0115]  2504  3  5.0   80.30    6.94 11.00 182.15  n/a    .000
*
      ADD [0207 + 0117]  2503  3  5.0  132.16    8.91 11.00 147.37  n/a    .000
*
      ADD [0110 + 0014]  2000  3  5.0  672.52   51.43 11.33 163.99  n/a    .000
*
      ADD [0109 + 0017]  0018  3  5.0  285.37   29.84 11.00 176.92  n/a    .000
*
 FINISH

=============================================================================================================
```

APPENDIX D:

WATER BALANCE CALCULATIONS

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
WATER BUDGET/PHOSPHORUS ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

EXISTING CONDITION LAGOON CITY SETTLEMENT AREA, COMBINED CATCHMENTS 107, 114, 121

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Total Area (Ha)	Runoff Coeffcient "C"	% Impervious
Cultivated Land, 0 - 5% grade	5.7	0.35	0%
Cultivated Land, 5 -10% grade		0.45	
Cultivated Land, 10 - 30% grade		0.65	
Pasture Land, 0 - 5% grade	1.3	0.28	0%
Pasture Land, 5 -10% grade		0.35	
Pasture Land, 10 - 30% grade		0.40	
Woodlot or Cutover, 0 - 5% grade	12.6	0.25	0%
Woodlot or Cutover, 5 -10% grade		0.30	
Woodlot or Cutover, 10 -30% grade		0.35	
Lakes and Wetlands	71.7	0.05	0%
Impervious Areas (i.e., buildings, roads, parking lots, etc.)		0.95	
Gravel (not to be used for proposed parking or storage areas)		0.50	
Residential - Sinlge Family	167.0	0.40	50%
Residential - Multiple (i.e., semi, townhouse, apartment)		0.60	
Industrial - Light	5.0	0.65	75%
Industrial - Heavy		0.75	
Commercial		0.70	
Unimproved Areas		0.20	
Lawn, < 2% grade		0.11	
Lawn, 2 - 7% grade		0.16	
Lawn, > 7 % grade		0.25	
Road Right-of-Way		0.70	
	263.30	0.30	33%

Note: Land use areas determined from available mapping and aerial photography
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
WATER BUDGET/PHOSPHORUS ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

FUTURE LAGOON CITY SETTLEMENT AREA, COMBINED CATCHMENTS 207, 214, 221

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Total Area (Ha)	Runoff Coeffcient "C"	% Impervious
Cultivated Land, 0 - 5% grade	12.6	0.35	0%
Cultivated Land, 5 -10% grade		0.45	
Cultivated Land, 10 - 30% grade		0.65	
Pasture Land, 0 - 5% grade		0.28	
Pasture Land, 5 -10% grade		0.35	
Pasture Land, 10 - 30% grade		0.40	
Woodlot or Cutover, 0 - 5% grade		0.25	
Woodlot or Cutover, 5 -10% grade		0.30	
Woodlot or Cutover, 10 -30% grade		0.35	
Lakes and Wetlands		0.05	
Impervious Areas (i.e., buildings, roads, parking lots, etc.)		0.95	
Gravel (not to be used for proposed parking or storage areas)		0.50	
Residential - Sinlge Family	250.7	0.40	50%
Residential - Multiple (i.e., semi, townhouse, apartment)		0.60	
Industrial - Light		0.65	
Industrial - Heavy		0.75	
Commercial		0.70	
Unimproved Areas		0.20	
Lawn, < 2% grade		0.11	
Lawn, 2 - 7% grade		0.16	
Lawn, > 7 % grade		0.25	
Road Right-of-Way		0.70	
	263.30	0.40	48%

Note: Land use areas determined from Township of Ramara Schedule I-3 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
WATER BUDGET/PHOSPHORUS ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

EXISTING BRECHIN SETTLEMENT AREA, COMBINED CATCHMENTS 118, 105, 113, 119, 120, 116

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Total Area (Ha)	Runoff Coeffcient "C"	% Impervious
Cultivated Land, 0 - 5% grade	92.7	0.35	0%
Cultivated Land, 5 -10% grade		0.45	
Cultivated Land, 10 - 30% grade		0.65	
Pasture Land, 0 - 5% grade		0.28	
Pasture Land, 5 -10% grade		0.35	
Pasture Land, 10 - 30% grade		0.40	
Woodlot or Cutover, 0 - 5% grade	13.4	0.25	0%
Woodlot or Cutover, 5 -10% grade		0.30	
Woodlot or Cutover, 10 -30% grade		0.35	
Lakes and Wetlands	12.8	0.05	0%
Impervious Areas (i.e., buildings, roads, parking lots, etc.)		0.95	
Gravel (not to be used for proposed parking or storage areas)		0.50	
Residential - Sinlge Family	23.3	0.40	50%
Residential - Multiple (i.e., semi, townhouse, apartment)		0.60	
Industrial - Light	26.7	0.65	75%
Industrial - Heavy		0.75	
Commercial	13.0	0.70	85%
Unimproved Areas		0.20	
Lawn, < 2% grade		0.11	
Lawn, 2 - 7% grade		0.16	
Lawn, > 7 % grade		0.25	
Road Right-of-Way		0.70	
	181.94000	0.40	24%

Note: Land use areas determined from available mapping and aerial photography
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
WATER BUDGET/PHOSPHORUS ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

FUTURE BRECHIN SETTLEMENT AREA, COMBINED CATCHMENTS 118, 205, 213, 119, 120, 216

Runoff Coeffcient "C" Reference No.: 4
(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Total Area (Ha)	Runoff Coeffcient "C"	% Impervious
Cultivated Land, 0 - 5% grade	8.2	0.35	0%
Cultivated Land, 5 -10% grade		0.45	
Cultivated Land, 10 - 30% grade		0.65	
Pasture Land, 0 - 5% grade		0.28	
Pasture Land, 5 -10% grade		0.35	
Pasture Land, 10 - 30% grade		0.40	
Woodlot or Cutover, 0 - 5% grade		0.25	
Woodlot or Cutover, 5 -10% grade		0.30	
Woodlot or Cutover, 10 -30% grade		0.35	
Lakes and Wetlands		0.05	
Impervious Areas (i.e., buildings, roads, parking lots, etc.)		0.95	
Gravel (not to be used for proposed parking or storage areas)		0.50	
Residential - Sinlge Family	99.2	0.40	50%
Residential - Multiple (i.e., semi, townhouse, apartment)		0.60	
Industrial - Light	46.4	0.65	75%
Industrial - Heavy		0.75	
Commercial	28.1	0.70	85%
Unimproved Areas		0.20	
Lawn, < 2% grade		0.11	
Lawn, 2 - 7% grade		0.16	
Lawn, > 7 % grade		0.25	
Road Right-of-Way		0.70	
	181.9	0.51	60%

Note: Land use areas determined from Township of Ramara Schedule I-2 Interim Secondary Plan - Brechin Village
Watershed soils group determined from Soils Survey of Simcoe County .
Runoff Coefficients adapted from Design Charts 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual. " MTO. (1997)
% Impervious values from LSRCA Technical Guidelines for Stormwater Management Submissions, April 2013
Institutional land use assumed to have the same RC and % imperviousness as commercial land use.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

LAGOON CITY SETTLEMENT AREA
EXISTING CONDITIONS

Runoff Coefficient:	0.30
Thornthwaite Coefficient	1.087

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-8.0	113.8	0.0	0	0.8	0	0	114
February	-6.8	71.8	0.0	0	0.8	0	0	72
March	-1.7	66.4	0.0	0	1.0	0	0	66
April	5.5	72.6	1.1	27	1.1	30	30	42
May	12.4	96.6	4.0	74.9	1.3	95	95	1
June	18.4	96.0	7.2	116	1.3	148	96	0
July	20.8	80.1	8.6	133	1.3	173	80	0
August	19.9	84.9	8.1	117	1.2	140	85	0
September	15.5	85.7	5.6	77	1.0	80	80	6
October	8.7	84.6	2.3	37	1.0	35	35	50
November	2.5	103.1	0.4	8	0.8	7	7	96
December	-3.6	100.0	0.0	0	0.8	0	0	100
Total		1055.7	37.2	589.8		708.7	508.2	547.5

TOTAL WATER SURPLUS 547.5

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

LAGOON CITY SETTLEMENT AREA
FUTURE CONDITIONS

Runoff Coefficient: 0.40
Thornthwaite Coefficient 1.087

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-8.0	113.8	0.0	0	0.8	0	0	114
February	-6.8	71.8	0.0	0	0.8	0	0	72
March	-1.7	66.4	0.0	0	1.0	0	0	66
April	5.5	72.6	1.1	27	1.1	30	30	42
May	12.4	96.6	4.0	74.9	1.3	95	95	1
June	18.4	96.0	7.2	116	1.3	148	96	0
July	20.8	80.1	8.6	133	1.3	173	80	0
August	19.9	84.9	8.1	117	1.2	140	85	0
September	15.5	85.7	5.6	77	1.0	80	80	6
October	8.7	84.6	2.3	37	1.0	35	35	50
November	2.5	103.1	0.4	8	0.8	7	7	96
December	-3.6	100.0	0.0	0	0.8	0	0	100
Total		1055.7	37.2	589.8		708.7	508.2	547.5

TOTAL WATER SURPLUS 547.5

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

BRECHIN SETTLEMENT AREA
EXISTING CONDITIONS

Runoff Coefficient: 0.40
Thornthwaite Coefficient 1.087

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-8.0	113.8	0.0	0	0.8	0	0	114
February	-6.8	71.8	0.0	0	0.8	0	0	72
March	-1.7	66.4	0.0	0	1.0	0	0	66
April	5.5	72.6	1.1	27	1.1	30	30	42
May	12.4	96.6	4.0	74.9	1.3	95	95	1
June	18.4	96.0	7.2	116	1.3	148	96	0
July	20.8	80.1	8.6	133	1.3	173	80	0
August	19.9	84.9	8.1	117	1.2	140	85	0
September	15.5	85.7	5.6	77	1.0	80	80	6
October	8.7	84.6	2.3	37	1.0	35	35	50
November	2.5	103.1	0.4	8	0.8	7	7	96
December	-3.6	100.0	0.0	0	0.8	0	0	100
Total		1055.7	37.2	589.8		708.7	508.2	547.5

TOTAL WATER SURPLUS 547.5

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS

Runoff Coefficient: 0.51
Thornthwaite Coefficient 1.087

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-8.0	113.8	0.0	0	0.8	0	0	114
February	-6.8	71.8	0.0	0	0.8	0	0	72
March	-1.7	66.4	0.0	0	1.0	0	0	66
April	5.5	72.6	1.1	27	1.1	30	30	42
May	12.4	96.6	4.0	74.9	1.3	95	95	1
June	18.4	96.0	7.2	116	1.3	148	96	0
July	20.8	80.1	8.6	133	1.3	173	80	0
August	19.9	84.9	8.1	117	1.2	140	85	0
September	15.5	85.7	5.6	77	1.0	80	80	6
October	8.7	84.6	2.3	37	1.0	35	35	50
November	2.5	103.1	0.4	8	0.8	7	7	96
December	-3.6	100.0	0.0	0	0.8	0	0	100
Total		1055.7	37.2	589.8		708.7	508.2	547.5

TOTAL WATER SURPLUS 547.5

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

C.C. Tatham & Associates Ltd. Consulting Engineers Collingwood Bracebridge Orillia Barrie	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
	File No.:	312803	Designed:	JSN
	Subject:	Lagoon City Water Budget	Checked:	JA

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	176.4	86.9	263.30	136.92	126.38	263.30
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.50	-	-
Run-Off Coefficient	0.50	1.00	-	0.50	1.00	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Outputs						
Precipitation surplus (mm/yr)	547.5	844.5	645.5	547.5	844.5	690.1
Net surplus (mm/yr)	547.5	844.5	645.5	547.5	844.5	690.1
Evapotranspiration (mm/yr)	508.2	211.1	410.2	508.2	211.1	365.6
Inflitration (mm/yr)	273.7	0.0	183.4	273.7	0.0	142.3
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	273.7	0.0	183.4	273.7	0.0	142.3
Run-off Pervious Areas (mm/yr)	273.7	0.0	183.4	273.7	0.0	142.3
Run-off Impervious Areas (mm/yr)	0.0	844.5	278.7	0.0	844.5	405.4
Total Run-off (mm/yr)	273.7	844.5	462.1	273.7	844.5	547.7
Total Outputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Inputs						
Precipitation (m3/yr)	1,862,348	917,276	2,779,625	1,445,405	1,334,220	2,779,625
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,862,348	917,276	2,779,625	1,445,405	1,334,220	2,779,625
Outputs						
Precipitation surplus (m3/yr)	965,825	733,821	1,699,646	749,596	1,067,376	1,816,972
Net surplus (m3/yr)	965,825	733,821	1,699,646	749,596	1,067,376	1,816,972
Evapotranspiration (m3/yr)	896,523	183,455	1,079,978	695,809	266,844	962,653
Inflitration (m3/yr)	482,913	0	482,913	374,798	0	374,798
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	482,913	0	482,913	374,798	0	374,798
Run-off Pervious Areas (m3/yr)	482,913	0	482,913	374,798	0	374,798
Run-off Impervious Areas (m3/yr)	0	733,821	733,821	0	1,067,376	1,067,376
Total Run-off (m3/yr)	482,913	733,821	1,216,734	374,798	1,067,376	1,442,174
Total Outputs (m3/yr)	1,862,348	917,276	2,779,625	1,445,405	1,334,220	2,779,625

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

C.C. Tatham & Associates Ltd. Consulting Engineers — Collingwood Bracebridge Orillia Barrie	Project:	Brechin and Lagoon City CSWMMP	Date:	Date:	Oct-15
	File No.:	312803	Designed:	Designed:	JSN
	Subject:	Brechin Water Budget	Checked:	Checked:	JA

Catchment Designation	Pre-Development				Post-Development		
	Pervious	Impervious	Total		Pervious	Impervious	Total
Catchment Area (ha)	138.20	43.70	181.90		72.80	109.10	181.90
Inflitration Factors							
Topography Infiltration Factor	0.15	0.15	-		0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-		0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-		0.15	-	-
MOE Infiltration Factor	0.50	-	-		0.50	-	-
Actual Infiltration Factor	0.50	-	-		0.50	-	-
Run-Off Coefficient	0.50	1.00	-		0.50	1.00	-
Runoff from Impervious Surfaces	0.00	0.80	-		0.00	0.80	-
Inputs							
Precipitation (mm/yr)	1055.7	1055.7	1055.7		1055.7	1055.7	1055.7
Run-on (mm/yr)	0.0	0.0	0.0		0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0		0.0	0.0	0.0
Total Inputs (mm/yr)	1055.7	1055.7	1055.7		1055.7	1055.7	1055.7
Outputs							
Precipitation surplus (mm/yr)	547.5	844.5	618.9		547.5	844.5	725.7
Net surplus (mm/yr)	547.5	844.5	618.9		547.5	844.5	725.7
Evapotranspiration (mm/yr)	508.2	211.1	436.8		508.2	211.1	330.0
Inflitration (mm/yr)	273.7	0.0	208.0		273.7	0.0	109.6
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0		0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0		0.0	0.0	0.0
Total Infiltration (mm/yr)	273.7	0.0	208.0		273.7	0.0	109.6
Run-off Pervious Areas (mm/yr)	273.7	0.0	208.0		273.7	0.0	109.6
Run-off Impervious Areas (mm/yr)	0.0	844.5	202.9		0.0	844.5	506.5
Total Run-off (mm/yr)	273.7	844.5	410.9		273.7	844.5	616.1
Total Outputs (mm/yr)	1055.7	1055.7	1055.7		1055.7	1055.7	1055.7
Inputs							
Precipitation (m3/yr)	1,458,960	461,335	1,920,295		768,540	1,151,755	1,920,295
Run-on (m3/yr)	0	0	0		0	0	0
Other Inputs (m3/yr)	0	0	0		0	0	0
Total Inputs (m3/yr)	1,458,960	461,335	1,920,295		768,540	1,151,755	1,920,295
Outputs							
Precipitation surplus (m3/yr)	756,625	369,068	1,125,694		398,570	921,404	1,319,974
Net surplus (m3/yr)	756,625	369,068	1,125,694		398,570	921,404	1,319,974
Evapotranspiration (m3/yr)	702,334	92,267	794,601		369,971	230,351	600,322
Inflitration (m3/yr)	378,313	0	378,313		199,285	0	199,285
Infiltration of Pervious Runoff (m3/yr)	0	0	0		0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0		0	0	0
Total Infiltration (m3/yr)	378,313	0	378,313		199,285	0	199,285
Run-off Pervious Areas (m3/yr)	378,313	0	378,313		199,285	0	199,285
Run-off Impervious Areas (m3/yr)	0	369,068	369,068		0	921,404	921,404
Total Run-off (m3/yr)	378,313	369,068	747,381		199,285	921,404	1,120,689
Total Outputs (m3/yr)	1,458,960	461,335	1,920,295		768,540	1,151,755	1,920,295

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 2

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.145
Preciptation change	(+0%)
Temperature change	(+1C)

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-7.0	113.8	0.0	0	0.8	0	0	114
February	-5.8	71.8	0.0	0	0.8	0	0	72
March	-0.7	66.4	0.0	0	1.0	0	0	66
April	6.5	72.6	1.5	30	1.1	33	33	39
May	13.4	96.6	4.5	78.4	1.3	100	97	0
June	19.4	96.0	7.8	120	1.3	154	96	0
July	21.8	80.1	9.3	139	1.3	180	80	0
August	20.9	84.9	8.7	122	1.2	146	85	0
September	16.5	85.7	6.1	80	1.0	83	83	2
October	9.7	84.6	2.7	39	1.0	37	37	47
November	3.5	103.1	0.6	10	0.8	8	8	95
December	-2.6	100.0	0.0	0	0.8	0	0	100
Total		1055.7	41.1	618.9		742.6	520.2	535.5

TOTAL WATER SURPLUS 535.5

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 3

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.207
Preciptation change	(+0%)
Temperature change	(+2C)

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-6.0	113.8	0.0	0	0.8	0	0	114
February	-4.8	71.8	0.0	0	0.8	0	0	72
March	0.3	66.4	0.0	1	1.0	1	1	66
April	7.5	72.6	1.8	33	1.1	37	37	36
May	14.4	96.6	5.0	82.0	1.3	104	97	0
June	20.4	96.0	8.4	125	1.3	161	96	0
July	22.8	80.1	9.9	145	1.3	188	80	0
August	21.9	84.9	9.3	127	1.2	152	85	0
September	17.5	85.7	6.7	84	1.0	87	86	0
October	10.7	84.6	3.2	42	1.0	39	39	45
November	4.5	103.1	0.9	12	0.8	10	10	93
December	-1.6	100.0	0.0	0	0.8	0	0	100
Total		1055.7	45.2	650.0		778.9	530.1	525.6

TOTAL WATER SURPLUS 525.6

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 4

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.343
Preciptation change	(+0%)
Temperature change	(+4C)

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-4.0	113.8	0.0	0	0.8	0	0	114
February	-2.8	71.8	0.0	0	0.8	0	0	72
March	2.3	66.4	0.3	5	1.0	5	5	61
April	9.5	72.6	2.6	38	1.1	42	42	30
May	16.4	96.6	6.1	89.8	1.3	114	97	0
June	22.4	96.0	9.7	137	1.3	175	96	0
July	24.8	80.1	11.3	159	1.3	206	80	0
August	23.9	84.9	10.7	139	1.2	167	85	0
September	19.5	85.7	7.9	91	1.0	95	86	0
October	12.7	84.6	4.1	46	1.0	44	44	41
November	6.5	103.1	1.5	16	0.8	13	13	90
December	0.4	100.0	0.0	0	0.8	0	0	100
Total		1055.7	54.1	721.1		862.0	548.0	507.7

TOTAL WATER SURPLUS 507.7

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 5

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.087
Preciptation change	(-10%)
Temperature change	(+0C)

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-8.0	102.4	0.0	0	0.8	0	0	102
February	-6.8	64.6	0.0	0	0.8	0	0	65
March	-1.7	59.7	0.0	0	1.0	0	0	60
April	5.5	65.4	1.1	27	1.1	30	30	35
May	12.4	86.9	4.0	74.9	1.3	95	87	0
June	18.4	86.4	7.2	116	1.3	148	86	0
July	20.8	72.1	8.6	133	1.3	173	72	0
August	19.9	76.4	8.1	117	1.2	140	76	0
September	15.5	77.1	5.6	77	1.0	80	77	0
October	8.7	76.2	2.3	37	1.0	35	35	41
November	2.5	92.8	0.4	8	0.8	7	7	86
December	-3.6	90.0	0.0	0	0.8	0	0	90
Total		950.1	37.2	589.8		708.7	471.0	479.1

TOTAL WATER SURPLUS 479.1

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 6

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.145
Preciptation change	(-10%)
Temperature change	(+1C)

Month	Temperature (°C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-7.0	102.4	0.0	0	0.8	0	0	102
February	-5.8	64.6	0.0	0	0.8	0	0	65
March	-0.7	59.7	0.0	0	1.0	0	0	60
April	6.5	65.4	1.5	30	1.1	33	33	32
May	13.4	86.9	4.5	78.4	1.3	100	87	0
June	19.4	86.4	7.8	120	1.3	154	86	0
July	21.8	72.1	9.3	139	1.3	180	72	0
August	20.9	76.4	8.7	122	1.2	146	76	0
September	16.5	77.1	6.1	80	1.0	83	77	0
October	9.7	76.2	2.7	39	1.0	37	37	39
November	3.5	92.8	0.6	10	0.8	8	8	84
December	-2.6	90.0	0.0	0	0.8	0	0	90
Total		950.1	41.1	618.9		742.6	478.2	471.9

TOTAL WATER SURPLUS 471.9

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 7

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.207
Preciptation change	(-10%)
Temperature change	(+2C)

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-6.0	102.4	0.0	0	0.8	0	0	102
February	-4.8	64.6	0.0	0	0.8	0	0	65
March	0.3	59.7	0.0	1	1.0	1	1	59
April	7.5	65.4	1.8	33	1.1	37	37	29
May	14.4	86.9	5.0	82.0	1.3	104	87	0
June	20.4	86.4	8.4	125	1.3	161	86	0
July	22.8	72.1	9.9	145	1.3	188	72	0
August	21.9	76.4	9.3	127	1.2	152	76	0
September	17.5	77.1	6.7	84	1.0	87	77	0
October	10.7	76.2	3.2	42	1.0	39	39	37
November	4.5	92.8	0.9	12	0.8	10	10	83
December	-1.6	90.0	0.0	0	0.8	0	0	90
Total		950.1	45.2	650.0		778.9	485.8	464.4

TOTAL WATER SURPLUS 464.4

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 8

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.343
Preciptation change	(-10%)
Temperature change	(+4C)

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-4.0	102.4	0.0	0	0.8	0	0	102
February	-2.8	64.6	0.0	0	0.8	0	0	65
March	2.3	59.7	0.3	5	1.0	5	5	54
April	9.5	65.4	2.6	38	1.1	42	42	23
May	16.4	86.9	6.1	89.8	1.3	114	87	0
June	22.4	86.4	9.7	137	1.3	175	86	0
July	24.8	72.1	11.3	159	1.3	206	72	0
August	23.9	76.4	10.7	139	1.2	167	76	0
September	19.5	77.1	7.9	91	1.0	95	77	0
October	12.7	76.2	4.1	46	1.0	44	44	32
November	6.5	92.8	1.5	16	0.8	13	13	80
December	0.4	90.0	0.0	0	0.8	0	0	90
Total		950.1	54.1	721.1		862.0	503.6	446.5

TOTAL WATER SURPLUS 446.5

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 9

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.087
Preciptation change	(+10%)
Temperature change	(+0C)

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-8.0	125.2	0.0	0	0.8	0	0	125
February	-6.8	78.9	0.0	0	0.8	0	0	79
March	-1.7	73.0	0.0	0	1.0	0	0	73
April	5.5	79.9	1.1	27	1.1	30	30	50
May	12.4	106.2	4.0	74.9	1.3	95	95	11
June	18.4	105.6	7.2	116	1.3	148	106	0
July	20.8	88.1	8.6	133	1.3	173	88	0
August	19.9	93.4	8.1	117	1.2	140	93	0
September	15.5	94.3	5.6	77	1.0	80	80	14
October	8.7	93.1	2.3	37	1.0	35	35	58
November	2.5	113.4	0.4	8	0.8	7	7	107
December	-3.6	110.0	0.0	0	0.8	0	0	110
Total		1161.3	37.2	589.8		708.7	534.3	626.9

TOTAL WATER SURPLUS 626.9

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 10

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.145
Preciptation change	(+10%)
Temperature change	(+1C)

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-7.0	125.2	0.0	0	0.8	0	0	125
February	-5.8	78.9	0.0	0	0.8	0	0	79
March	-0.7	73.0	0.0	0	1.0	0	0	73
April	6.5	79.9	1.5	30	1.1	33	33	46
May	13.4	106.2	4.5	78.4	1.3	100	100	7
June	19.4	105.6	7.8	120	1.3	154	106	0
July	21.8	88.1	9.3	139	1.3	180	88	0
August	20.9	93.4	8.7	122	1.2	146	93	0
September	16.5	94.3	6.1	80	1.0	83	83	11
October	9.7	93.1	2.7	39	1.0	37	37	56
November	3.5	113.4	0.6	10	0.8	8	8	105
December	-2.6	110.0	0.0	0	0.8	0	0	110
Total		1161.3	41.1	618.9		742.6	549.3	612.0

TOTAL WATER SURPLUS 612.0

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 11

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.207
Preciptation change	(+10%)
Temperature change	(+2C)

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-6.0	125.2	0.0	0	0.8	0	0	125
February	-4.8	78.9	0.0	0	0.8	0	0	79
March	0.3	73.0	0.0	1	1.0	1	1	72
April	7.5	79.9	1.8	33	1.1	37	37	43
May	14.4	106.2	5.0	82.0	1.3	104	104	2
June	20.4	105.6	8.4	125	1.3	161	106	0
July	22.8	88.1	9.9	145	1.3	188	88	0
August	21.9	93.4	9.3	127	1.2	152	93	0
September	17.5	94.3	6.7	84	1.0	87	87	7
October	10.7	93.1	3.2	42	1.0	39	39	54
November	4.5	113.4	0.9	12	0.8	10	10	103
December	-1.6	110.0	0.0	0	0.8	0	0	110
Total		1161.3	45.2	650.0		778.9	565.0	596.2

TOTAL WATER SURPLUS 596.2

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

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BRECHIN SETTLEMENT AREA
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO 12

Runoff Coefficient:	0.51
Thornthwaite Coefficient	1.343
Preciptation change	(+10%)
Temperature change	(+4C)

Month	Temperature (^oC)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)
January	-4.0	125.2	0.0	0	0.8	0	0	125
February	-2.8	78.9	0.0	0	0.8	0	0	79
March	2.3	73.0	0.3	5	1.0	5	5	68
April	9.5	79.9	2.6	38	1.1	42	42	38
May	16.4	106.2	6.1	89.8	1.3	114	106	0
June	22.4	105.6	9.7	137	1.3	175	106	0
July	24.8	88.1	11.3	159	1.3	206	88	0
August	23.9	93.4	10.7	139	1.2	167	93	0
September	19.5	94.3	7.9	91	1.0	95	94	0
October	12.7	93.1	4.1	46	1.0	44	44	49
November	6.5	113.4	1.5	16	0.8	13	13	100
December	0.4	110.0	0.0	0	0.8	0	0	110
Total		1161.3	54.1	721.1		862.0	592.3	569.0

TOTAL WATER SURPLUS 569.0

Note:
1) Source - Orillia Brain Climate Normal Data for 1992 - 2006 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
C.C. Tatham & Associates Ltd. Consulting Engineers Collingwood Bracebridge Orillia Barrie	File No.:	312803	Designed:	JSN
	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 1

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Outputs						
Precipitation surplus (mm/yr)	547.5	844.5	617.3	547.5	844.5	698.4
Net surplus (mm/yr)	547.5	844.5	617.3	547.5	844.5	698.4
Evapotranspiration (mm/yr)	508.2	211.1	438.4	508.2	211.1	357.3
Inflitration (mm/yr)	273.7	0.0	209.4	269.4	0.0	132.6
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	273.7	0.0	209.4	269.4	0.0	132.6
Run-off Pervious Areas (mm/yr)	273.7	0.0	209.4	278.1	0.0	136.8
Run-off Impervious Areas (mm/yr)	0.0	844.5	198.5	0.0	844.5	429.0
Total Run-off (mm/yr)	273.7	844.5	407.9	278.1	844.5	565.8
Total Outputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Inputs						
Precipitation (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717
Outputs						
Precipitation surplus (m3/yr)	761,996	361,121	1,123,117	490,146	780,477	1,270,623
Net surplus (m3/yr)	761,996	361,121	1,123,117	490,146	780,477	1,270,623
Evapotranspiration (m3/yr)	707,320	90,280	797,600	454,975	195,119	650,095
Inflitration (m3/yr)	380,998	0	380,998	241,184	0	241,184
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	380,998	0	380,998	241,184	0	241,184
Run-off Pervious Areas (m3/yr)	380,998	0	380,998	248,961	0	248,961
Run-off Impervious Areas (m3/yr)	0	361,121	361,121	0	780,477	780,477
Total Run-off (m3/yr)	380,998	361,121	742,119	248,961	780,477	1,029,438
Total Outputs (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
C.C. Tatham & Associates Ltd. Consulting Engineers Collingwood Bracebridge Orillia Barrie	File No.:	312803	Designed:	JSN
	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 2

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Outputs						
Precipitation surplus (mm/yr)	535.5	844.5	608.1	535.5	844.5	692.5
Net surplus (mm/yr)	535.5	844.5	608.1	535.5	844.5	692.5
Evapotranspiration (mm/yr)	520.2	211.1	447.6	520.2	211.1	363.2
Inflitration (mm/yr)	267.8	0.0	204.8	263.5	0.0	129.7
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	267.8	0.0	204.8	263.5	0.0	129.7
Run-off Pervious Areas (mm/yr)	267.8	0.0	204.8	272.0	0.0	133.8
Run-off Impervious Areas (mm/yr)	0.0	844.5	198.5	0.0	844.5	429.0
Total Run-off (mm/yr)	267.8	844.5	403.3	272.0	844.5	562.8
Total Outputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Inputs						
Precipitation (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717
Outputs						
Precipitation surplus (m3/yr)	745,316	361,121	1,106,437	479,416	780,477	1,259,893
Net surplus (m3/yr)	745,316	361,121	1,106,437	479,416	780,477	1,259,893
Evapotranspiration (m3/yr)	724,000	90,280	814,280	465,705	195,119	660,824
Inflitration (m3/yr)	372,658	0	372,658	235,905	0	235,905
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	372,658	0	372,658	235,905	0	235,905
Run-off Pervious Areas (m3/yr)	372,658	0	372,658	243,511	0	243,511
Run-off Impervious Areas (m3/yr)	0	361,121	361,121	0	780,477	780,477
Total Run-off (m3/yr)	372,658	361,121	733,779	243,511	780,477	1,023,989
Total Outputs (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

C.C. Tatham & Associates Ltd. Consulting Engineers Collingwood Bracebridge Orillia Barrie	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
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	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 3

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Outputs						
Precipitation surplus (mm/yr)	525.6	844.5	600.5	525.6	844.5	687.6
Net surplus (mm/yr)	525.6	844.5	600.5	525.6	844.5	687.6
Evapotranspiration (mm/yr)	530.1	211.1	455.1	530.1	211.1	368.1
Inflitration (mm/yr)	262.8	0.0	201.0	258.6	0.0	127.3
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	262.8	0.0	201.0	258.6	0.0	127.3
Run-off Pervious Areas (mm/yr)	262.8	0.0	201.0	267.0	0.0	131.4
Run-off Impervious Areas (mm/yr)	0.0	844.5	198.5	0.0	844.5	429.0
Total Run-off (mm/yr)	262.8	844.5	399.5	267.0	844.5	560.3
Total Outputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Inputs						
Precipitation (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717
Outputs						
Precipitation surplus (m3/yr)	731,517	361,121	1,092,638	470,540	780,477	1,251,017
Net surplus (m3/yr)	731,517	361,121	1,092,638	470,540	780,477	1,251,017
Evapotranspiration (m3/yr)	737,799	90,280	828,079	474,581	195,119	669,700
Inflitration (m3/yr)	365,759	0	365,759	231,537	0	231,537
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	365,759	0	365,759	231,537	0	231,537
Run-off Pervious Areas (m3/yr)	365,759	0	365,759	239,003	0	239,003
Run-off Impervious Areas (m3/yr)	0	361,121	361,121	0	780,477	780,477
Total Run-off (m3/yr)	365,759	361,121	726,880	239,003	780,477	1,019,480
Total Outputs (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
C.C. Tatham & Associates Ltd. Consulting Engineers Collingwood Bracebridge Orillia Barrie	File No.:	312803	Designed:	JSN
	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 4

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Outputs						
Precipitation surplus (mm/yr)	507.7	844.5	586.9	507.7	844.5	678.8
Net surplus (mm/yr)	507.7	844.5	586.9	507.7	844.5	678.8
Evapotranspiration (mm/yr)	548.0	211.1	468.8	548.0	211.1	376.9
Inflitration (mm/yr)	253.9	0.0	194.2	249.8	0.0	122.9
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	253.9	0.0	194.2	249.8	0.0	122.9
Run-off Pervious Areas (mm/yr)	253.9	0.0	194.2	257.9	0.0	126.9
Run-off Impervious Areas (mm/yr)	0.0	844.5	198.5	0.0	844.5	429.0
Total Run-off (mm/yr)	253.9	844.5	392.7	257.9	844.5	555.9
Total Outputs (mm/yr)	1055.7	1055.7	1055.7	1055.7	1055.7	1055.7
Inputs						
Precipitation (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717
Outputs						
Precipitation surplus (m3/yr)	706,656	361,121	1,067,777	454,549	780,477	1,235,026
Net surplus (m3/yr)	706,656	361,121	1,067,777	454,549	780,477	1,235,026
Evapotranspiration (m3/yr)	762,660	90,280	852,940	490,572	195,119	685,692
Inflitration (m3/yr)	353,328	0	353,328	223,668	0	223,668
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	353,328	0	353,328	223,668	0	223,668
Run-off Pervious Areas (m3/yr)	353,328	0	353,328	230,880	0	230,880
Run-off Impervious Areas (m3/yr)	0	361,121	361,121	0	780,477	780,477
Total Run-off (m3/yr)	353,328	361,121	714,449	230,880	780,477	1,011,358
Total Outputs (m3/yr)	1,469,316	451,401	1,920,717	945,121	975,596	1,920,717

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

C.C. Tatham & Associates Ltd. Consulting Engineers — Collingwood, Bracebridge, Orillia, Barrie				
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	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 5

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Outputs						
Precipitation surplus (mm/yr)	479.1	760.1	545.2	479.1	760.1	621.8
Net surplus (mm/yr)	479.1	760.1	545.2	479.1	760.1	621.8
Evapotranspiration (mm/yr)	471.0	190.0	405.0	471.0	190.0	328.3
Inflitration (mm/yr)	239.6	0.0	183.3	235.8	0.0	116.0
Inflitration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Inflitration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	239.6	0.0	183.3	235.8	0.0	116.0
Run-off Pervious Areas (mm/yr)	239.6	0.0	183.3	243.4	0.0	119.8
Run-off Impervious Areas (mm/yr)	0.0	760.1	178.6	0.0	760.1	386.1
Total Run-off (mm/yr)	239.6	760.1	361.9	243.4	760.1	505.8
Total Outputs (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Inputs						
Precipitation (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646
Outputs						
Precipitation surplus (m3/yr)	666,864	325,009	991,873	428,953	702,429	1,131,382
Net surplus (m3/yr)	666,864	325,009	991,873	428,953	702,429	1,131,382
Evapotranspiration (m3/yr)	655,521	81,252	736,773	421,656	175,607	597,264
Inflitration (m3/yr)	333,432	0	333,432	211,073	0	211,073
Inflitration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Inflitration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	333,432	0	333,432	211,073	0	211,073
Run-off Pervious Areas (m3/yr)	333,432	0	333,432	217,879	0	217,879
Run-off Impervious Areas (m3/yr)	0	325,009	325,009	0	702,429	702,429
Total Run-off (m3/yr)	333,432	325,009	658,441	217,879	702,429	920,309
Total Outputs (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

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Climate Change Scenario 6

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Outputs						
Precipitation surplus (mm/yr)	471.9	760.1	539.6	471.9	760.1	618.3
Net surplus (mm/yr)	471.9	760.1	539.6	471.9	760.1	618.3
Evapotranspiration (mm/yr)	478.2	190.0	410.5	478.2	190.0	331.8
Inflitration (mm/yr)	235.9	0.0	180.5	232.2	0.0	114.3
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	235.9	0.0	180.5	232.2	0.0	114.3
Run-off Pervious Areas (mm/yr)	235.9	0.0	180.5	239.7	0.0	117.9
Run-off Impervious Areas (mm/yr)	0.0	760.1	178.6	0.0	760.1	386.1
Total Run-off (mm/yr)	235.9	760.1	359.1	239.7	760.1	504.0
Total Outputs (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Inputs						
Precipitation (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646
Outputs						
Precipitation surplus (m3/yr)	656,793	325,009	981,802	422,475	702,429	1,124,904
Net surplus (m3/yr)	656,793	325,009	981,802	422,475	702,429	1,124,904
Evapotranspiration (m3/yr)	665,591	81,252	746,843	428,134	175,607	603,741
Inflitration (m3/yr)	328,397	0	328,397	207,886	0	207,886
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	328,397	0	328,397	207,886	0	207,886
Run-off Pervious Areas (m3/yr)	328,397	0	328,397	214,589	0	214,589
Run-off Impervious Areas (m3/yr)	0	325,009	325,009	0	702,429	702,429
Total Run-off (m3/yr)	328,397	325,009	653,406	214,589	702,429	917,019
Total Outputs (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

C.C. Tatham & Associates Ltd. Consulting Engineers Collingwood Bracebridge Orillia Barrie	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
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Climate Change Scenario 7

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Outputs						
Precipitation surplus (mm/yr)	464.4	760.1	533.9	464.4	760.1	614.6
Net surplus (mm/yr)	464.4	760.1	533.9	464.4	760.1	614.6
Evapotranspiration (mm/yr)	485.8	190.0	416.3	485.8	190.0	335.5
Inflitration (mm/yr)	232.2	0.0	177.6	228.5	0.0	112.4
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	232.2	0.0	177.6	228.5	0.0	112.4
Run-off Pervious Areas (mm/yr)	232.2	0.0	177.6	235.9	0.0	116.1
Run-off Impervious Areas (mm/yr)	0.0	760.1	178.6	0.0	760.1	386.1
Total Run-off (mm/yr)	232.2	760.1	356.2	235.9	760.1	502.1
Total Outputs (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Inputs						
Precipitation (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646
Outputs						
Precipitation surplus (m3/yr)	646,292	325,009	971,301	415,720	702,429	1,118,149
Net surplus (m3/yr)	646,292	325,009	971,301	415,720	702,429	1,118,149
Evapotranspiration (m3/yr)	676,092	81,252	757,345	434,889	175,607	610,496
Inflitration (m3/yr)	323,146	0	323,146	204,562	0	204,562
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	323,146	0	323,146	204,562	0	204,562
Run-off Pervious Areas (m3/yr)	323,146	0	323,146	211,158	0	211,158
Run-off Impervious Areas (m3/yr)	0	325,009	325,009	0	702,429	702,429
Total Run-off (m3/yr)	323,146	325,009	648,155	211,158	702,429	913,588
Total Outputs (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

C.C. Tatham & Associates Ltd. Consulting Engineers — Collingwood Bracebridge Orillia Barrie	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
	File No.:	312803	Designed:	JSN
	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 8

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Outputs						
Precipitation surplus (mm/yr)	446.5	760.1	520.2	446.5	760.1	605.8
Net surplus (mm/yr)	446.5	760.1	520.2	446.5	760.1	605.8
Evapotranspiration (mm/yr)	503.6	190.0	429.9	503.6	190.0	344.3
Inflitration (mm/yr)	223.2	0.0	170.8	219.7	0.0	108.1
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	223.2	0.0	170.8	219.7	0.0	108.1
Run-off Pervious Areas (mm/yr)	223.2	0.0	170.8	226.8	0.0	111.6
Run-off Impervious Areas (mm/yr)	0.0	760.1	178.6	0.0	760.1	386.1
Total Run-off (mm/yr)	223.2	760.1	349.4	226.8	760.1	497.7
Total Outputs (mm/yr)	950.1	950.1	950.1	950.1	950.1	950.1
Inputs						
Precipitation (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646
Outputs						
Precipitation surplus (m3/yr)	621,431	325,009	946,440	399,728	702,429	1,102,158
Net surplus (m3/yr)	621,431	325,009	946,440	399,728	702,429	1,102,158
Evapotranspiration (m3/yr)	700,954	81,252	782,206	450,881	175,607	626,488
Inflitration (m3/yr)	310,715	0	310,715	196,693	0	196,693
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	310,715	0	310,715	196,693	0	196,693
Run-off Pervious Areas (m3/yr)	310,715	0	310,715	203,035	0	203,035
Run-off Impervious Areas (m3/yr)	0	325,009	325,009	0	702,429	702,429
Total Run-off (m3/yr)	310,715	325,009	635,724	203,035	702,429	905,465
Total Outputs (m3/yr)	1,322,384	406,261	1,728,646	850,609	878,037	1,728,646

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
C.C. Tatham & Associates Ltd. Consulting Engineers Collingwood Bracebridge Orillia Barrie	File No.:	312803	Designed:	JSN
	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 9

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Outputs						
Precipitation surplus (mm/yr)	626.9	929.0	697.9	626.9	929.0	780.4
Net surplus (mm/yr)	626.9	929.0	697.9	626.9	929.0	780.4
Evapotranspiration (mm/yr)	534.3	232.3	463.3	534.3	232.3	380.9
Inflitration (mm/yr)	313.5	0.0	239.8	308.5	0.0	151.8
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	313.5	0.0	239.8	308.5	0.0	151.8
Run-off Pervious Areas (mm/yr)	313.5	0.0	239.8	318.4	0.0	156.7
Run-off Impervious Areas (mm/yr)	0.0	929.0	218.3	0.0	929.0	471.9
Total Run-off (mm/yr)	313.5	929.0	458.1	318.4	929.0	628.6
Total Outputs (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Inputs						
Precipitation (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789
Outputs						
Precipitation surplus (m3/yr)	872,587	397,233	1,269,821	561,282	858,525	1,419,807
Net surplus (m3/yr)	872,587	397,233	1,269,821	561,282	858,525	1,419,807
Evapotranspiration (m3/yr)	743,660	99,308	842,969	478,351	214,631	692,982
Inflitration (m3/yr)	436,294	0	436,294	276,188	0	276,188
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	436,294	0	436,294	276,188	0	276,188
Run-off Pervious Areas (m3/yr)	436,294	0	436,294	285,094	0	285,094
Run-off Impervious Areas (m3/yr)	0	397,233	397,233	0	858,525	858,525
Total Run-off (m3/yr)	436,294	397,233	833,527	285,094	858,525	1,143,619
Total Outputs (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

C.C. Tatham & Associates Ltd. Consulting Engineers	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
Collingwood Bracebridge Orillia Barrie	File No.:	312803	Designed:	JSN
	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 10

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Outputs						
Precipitation surplus (mm/yr)	612.0	929.0	686.5	612.0	929.0	773.0
Net surplus (mm/yr)	612.0	929.0	686.5	612.0	929.0	773.0
Evapotranspiration (mm/yr)	549.3	232.3	474.8	549.3	232.3	388.3
Inflitration (mm/yr)	306.0	0.0	234.1	301.1	0.0	148.2
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	306.0	0.0	234.1	301.1	0.0	148.2
Run-off Pervious Areas (mm/yr)	306.0	0.0	234.1	310.8	0.0	153.0
Run-off Impervious Areas (mm/yr)	0.0	929.0	218.3	0.0	929.0	471.9
Total Run-off (mm/yr)	306.0	929.0	452.4	310.8	929.0	624.8
Total Outputs (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Inputs						
Precipitation (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789
Outputs						
Precipitation surplus (m3/yr)	851,754	397,233	1,248,987	547,881	858,525	1,406,406
Net surplus (m3/yr)	851,754	397,233	1,248,987	547,881	858,525	1,406,406
Evapotranspiration (m3/yr)	764,493	99,308	863,802	491,752	214,631	706,383
Inflitration (m3/yr)	425,877	0	425,877	269,594	0	269,594
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	425,877	0	425,877	269,594	0	269,594
Run-off Pervious Areas (m3/yr)	425,877	0	425,877	278,287	0	278,287
Run-off Impervious Areas (m3/yr)	0	397,233	397,233	0	858,525	858,525
Total Run-off (m3/yr)	425,877	397,233	823,110	278,287	858,525	1,136,812
Total Outputs (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

C.C. Tatham & Associates Ltd. Consulting Engineers — Collingwood, Bracebridge, Orillia, Barrie	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
	File No.:	312803	Designed:	JSN
	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 11

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Outputs						
Precipitation surplus (mm/yr)	596.2	929.0	674.4	596.2	929.0	765.3
Net surplus (mm/yr)	596.2	929.0	674.4	596.2	929.0	765.3
Evapotranspiration (mm/yr)	565.0	232.3	486.8	565.0	232.3	396.0
Inflitration (mm/yr)	298.1	0.0	228.1	293.4	0.0	144.4
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	298.1	0.0	228.1	293.4	0.0	144.4
Run-off Pervious Areas (mm/yr)	298.1	0.0	228.1	302.9	0.0	149.0
Run-off Impervious Areas (mm/yr)	0.0	929.0	218.3	0.0	929.0	471.9
Total Run-off (mm/yr)	298.1	929.0	446.4	302.9	929.0	620.9
Total Outputs (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Inputs						
Precipitation (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789
Outputs						
Precipitation surplus (m3/yr)	829,861	397,233	1,227,094	533,799	858,525	1,392,324
Net surplus (m3/yr)	829,861	397,233	1,227,094	533,799	858,525	1,392,324
Evapotranspiration (m3/yr)	786,387	99,308	885,695	505,834	214,631	720,466
Inflitration (m3/yr)	414,930	0	414,930	262,665	0	262,665
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	414,930	0	414,930	262,665	0	262,665
Run-off Pervious Areas (m3/yr)	414,930	0	414,930	271,134	0	271,134
Run-off Impervious Areas (m3/yr)	0	397,233	397,233	0	858,525	858,525
Total Run-off (m3/yr)	414,930	397,233	812,164	271,134	858,525	1,129,659
Total Outputs (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

C.C. Tatham & Associates Ltd. Consulting Engineers Collingwood Bracebridge Orillia Barrie	Project:	Brechin and Lagoon City CSWMMP	Date:	Oct-15
	File No.:	312803	Designed:	JSN
	Subject:	Brechin Climate Change Water Budget	Checked:	JA

Climate Change Scenario 12

Catchment Designation	Pre-Development			Post-Development		
	Pervious	Impervious	Total	Pervious	Impervious	Total
Catchment Area (ha)	139.2	42.8	181.9	89.5	92.4	181.94
Inflitration Factors						
Topography Infiltration Factor	0.15	0.15	-	0.15	0.15	-
Soil Infiltration Factor	0.20	0.20	-	0.20	0.20	-
Land Cover Infiltration Factor	0.15	-	-	0.15	-	-
MOE Infiltration Factor	0.50	-	-	0.50	-	-
Infiltration Factor	0.50	-	-	0.49	-	-
Run-Off Coefficient	0.50	0.95	-	0.51	0.95	-
Runoff from Impervious Surfaces	0.00	0.80	-	0.00	0.80	-
Inputs						
Precipitation (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Run-on (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Other Inputs (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Inputs (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Outputs						
Precipitation surplus (mm/yr)	569.0	929.0	653.6	569.0	929.0	751.8
Net surplus (mm/yr)	569.0	929.0	653.6	569.0	929.0	751.8
Evapotranspiration (mm/yr)	592.3	232.3	507.7	592.3	232.3	409.4
Inflitration (mm/yr)	284.5	0.0	217.6	280.0	0.0	137.8
Infiltration of Pervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration of Impervious Runoff (mm/yr)	0.0	0.0	0.0	0.0	0.0	0.0
Total Infiltration (mm/yr)	284.5	0.0	217.6	280.0	0.0	137.8
Run-off Pervious Areas (mm/yr)	284.5	0.0	217.6	289.0	0.0	142.2
Run-off Impervious Areas (mm/yr)	0.0	929.0	218.3	0.0	929.0	471.9
Total Run-off (mm/yr)	284.5	929.0	436.0	289.0	929.0	614.1
Total Outputs (mm/yr)	1161.3	1161.3	1161.3	1161.3	1161.3	1161.3
Inputs						
Precipitation (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789
Run-on (m3/yr)	0	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0	0
Total Inputs (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789
Outputs						
Precipitation surplus (m3/yr)	791,881	397,233	1,189,115	509,369	858,525	1,367,894
Net surplus (m3/yr)	791,881	397,233	1,189,115	509,369	858,525	1,367,894
Evapotranspiration (m3/yr)	824,366	99,308	923,675	530,264	214,631	744,895
Inflitration (m3/yr)	395,941	0	395,941	250,643	0	250,643
Infiltration of Pervious Runoff (m3/yr)	0	0	0	0	0	0
Infiltration of Impervious Runoff (m3/yr)	0	0	0	0	0	0
Total Infiltration (m3/yr)	395,941	0	395,941	250,643	0	250,643
Run-off Pervious Areas (m3/yr)	395,941	0	395,941	258,725	0	258,725
Run-off Impervious Areas (m3/yr)	0	397,233	397,233	0	858,525	858,525
Total Run-off (m3/yr)	395,941	397,233	793,174	258,725	858,525	1,117,250
Total Outputs (m3/yr)	1,616,248	496,541	2,112,789	1,039,633	1,073,156	2,112,789

Notes: 1. Evaporation from impervious areas was assumed to be 20% of precipitation and is within the acceptable range as per the Conservation Authority Guidelines for Hydrogeological Assessment Submissions (June, 2013)

2. Infiltration factors derived from MOE SWM Design Manual Table 3.1

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

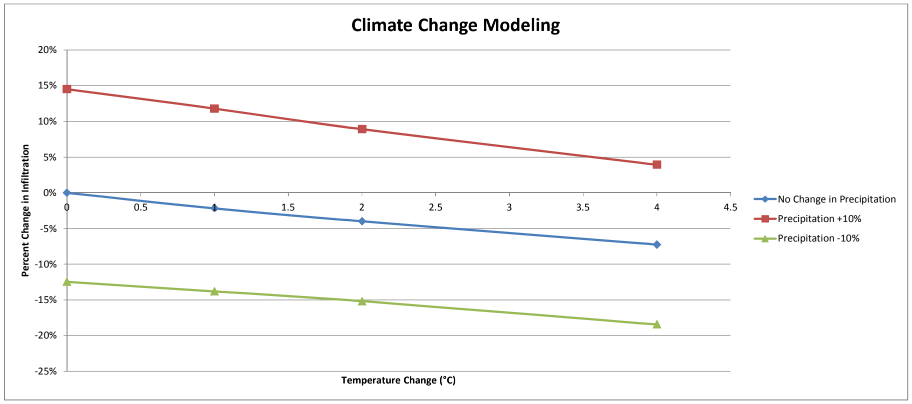
FUTURE CONDITIONS - CLIMATE CHANGE SCENARIO SUMMARY
COMBINATION OF TEMPERATURE AND PRECIPITATION CHANGE

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6	
Existing Temp, Precip.		(+1C, No change Precip)		(+2C, No change Precip)		(+4C, No change Precip)		(No Temp change , -10% Precip)		(+1C, -10% Precip)	
Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)
132.56	565.81	129.7	562.8	127.3	560.3	122.9	555.9	116.0	505.8	114.3	504.0

Scenario 7		Scenario 8		Scenario 9		Scenario 10		Scenario 11		Scenario 12	
(+2, -10 Precip)		(+4C, -10 Precip)		(No Temp change, +10% Precip)		(+1C, +10 Precip)		(+2C, +10 Precip)		(+4C, +10 Precip)	
Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)
112.4	502.1	108.1	497.7	151.8	628.6	148.2	624.8	144.4	620.9	137.8	614.1

Scenario #	Precipitation Change (%)	Temp Change (°C)	Infiltration (mm)	Percent Change
1	0	0	132.56	0%
2	0	1	129.7	-2%
3	0	2	127.3	-4%
4	0	4	122.9	-7%
5	-10	0	116.0	-12%
6	-10	1	114.3	-14%
7	-10	2	112.4	-15%
8	-10	4	108.1	-18%
9	10	0	151.8	15%
10	10	1	148.2	12%
11	10	2	144.4	9%
12	10	4	137.8	4%

Note: Percent change for infiltration assumed to be the same for all study areas



APPENDIX E:
PHOSPHORUS LOADING

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
PHOSPHOROUS BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: LAGOON CITY
CREEK REFERENCE: RAMARA CREEKS

Total Drainage Area (ha): 263.2 ha (Catchments 105/205, 118, 113/213, 119, 120, 116/216)

LAND USE CATEGORY	Existing Phosphorous Loading Rate (kg/ha/year)	Future Phosphorous Loading Rate (kg/ha/year)	Existing Area (ha)	Future Area (ha)	Existing Phosphorous Loadings (kg/year) (no controls)	Future Phosphorous Loadings (kg/year) (no controls)	Difference +/- (kg/year)	Difference (%)	Existing Phosphorous Loadings (kg/year) with Existing Controls	Existing Phosphorous Loadings (kg/year) with Retrofit Controls	Difference +/- (kg/year)	Difference (%)	Future Phosphorous Loadings (kg/year) with Only Existing Controls	Future Phosphorous Loadings (kg/year) with Retrofits	Future Phosphorous Loadings (kg/year) with Retrofits and Controls (Wet Pond (63%))	Future Phosphorous Loadings (kg/year) with Retrofits and Controls (LID (85%))	Difference (%) with Future Retrofits and Controls (85%)
Hay - Pasture	0.0700	0.0700	1.30	0.00	0.091	0.000	-0.09	-100.0%	0.091	0.091	0.000	0.0%	0.00	0.00	0.00	0.00	-100.0%
Cropland	0.1900	0.1900	5.65	12.60	1.074	2.394	1.32	122.8%	1.074	1.074	0.000	0.0%	2.39	2.39	2.39	2.39	122.8%
Turf -Sod	0.1200	0.1200	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
Quarry	0.0800	0.0800	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
High Intensity Development - R	1.3200	1.3200	166.95	250.58	220.379	330.769	110.39	50.1%	220.379	220.379	0.000	0.0%	330.77	330.77	261.22	236.94	7.5%
Unpaved Road	0.8300	0.8300	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
High Intensity Development - C/I	1.8200	1.8200	5.04	0.00	9.178	0.000	-9.18	-100.0%	9.178	9.178	0.000	0.0%	0.00	0.00	0.00	0.00	-100.0%
Transition	0.0600	0.0600	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
Polder	0.0000	0.0000	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
Forest	0.0500	0.0500	12.55	0.00	0.628	0.000	-0.63	-100.0%	0.628	0.628	0.000	0.0%	0.00	0.00	0.00	0.00	-100.0%
Wetland	0.0500	0.0500	71.68	0.00	3.584	0.000	-3.58	-100.0%	3.584	3.584	0.000	0.0%	0.00	0.00	0.00	0.00	-100.0%
Total			263.2	263.2	234.9	333.2	98.2	41.8%	234.9	234.9	0.0	0%	333.2	333.2	263.62	239.33	1.9%

Notes and Information:

1) Phosphorus Loading Rates determined from MOE's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012)

2) Future controls assume all development will be controlled by either Wet Pond (63% Removal Efficiency) or LID controls (85% Removal Efficiency)

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWNSHIP OF RAMARA
PHOSPHOROUS BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: BRECHIN
CREEK REFERENCE: RAMARA CREEKS

Total Drainage Area (ha): 181.9 ha (Catchments 105/205, 118, 113/213, 122/222. 119, 120, 116/216)

LAND USE CATEGORY	Existing Phosphorous Loading Rate (kg/ha/year)	Future Phosphorous Loading Rate (kg/ha/year)	Existing Area (ha)	Future Area (ha)	Existing Phosphorous Loadings (kg/year) (no controls)	Future Phosphorous Loadings (kg/year) (no controls)	Difference +/- (kg/year)	Difference (%)	Existing Phosphorous Loadings (kg/year) with Existing Controls	Existing Phosphorous Loadings (kg/year) with Retrofit Controls	Difference +/- (kg/year)	Difference (%)	Future Phosphorous Loadings (kg/year) with Only Existing Controls	Future Phosphorous Loadings (kg/year) with Retrofits	Future Phosphorous Loadings (kg/year) with Retrofits and Controls (Wet Pond (63%))	Future Phosphorous Loadings (kg/year) with Retrofits and Controls (LID (85%))	Difference (%) with Future Retrofits and Controls (85%)
Hay - Pasture	0.0700	0.0700	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
Cropland	0.1900	0.1900	92.65	8.20	17.604	1.558	-16.05	-91.1%	17.604	17.604	0.000	0.0%	1.56	1.56	1.56	1.56	-91.1%
Turf -Sod	0.1200	0.1200	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
Quarry	0.0800	0.0800	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
High Intensity Development - R	1.3200	1.3200	23.30	99.15	30.756	130.878	100.12	325.5%	30.756	30.756	0.000	0.0%	130.88	130.88	67.80	45.77	48.8%
Unpaved Road	0.8300	0.8300	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
High Intensity Development - C/I	1.8200	1.8200	39.74	74.54	72.327	135.663	63.34	87.6%	57.372	56.504	-0.868	-1.5%	105.92	105.05	80.81	71.17	24.0%
Transition	0.0600	0.0600	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
Polder	0.0000	0.0000	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00	0.00	0.00	0.0%
Forest	0.0500	0.0500	13.41	0.00	0.670	0.000	-0.67	-100.0%	0.670	0.670	0.000	0.0%	0.00	0.00	0.00	0.00	-100.0%
Wetland	0.0500	0.0500	12.84	0.00	0.642	0.000	-0.64	-100.0%	0.642	0.642	0.000	0.0%	0.00	0.00	0.00	0.00	-100.0%
Total			181.9	181.9	122.0	268.1	146.1	119.8%	107.0	106.2	-0.9	-1%	238.4	237.5	150.2	118.5	10.7%

Notes and Information:
1) Phosphorus Loading Rates determined from MOE's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012)
2) Future controls assume all development will be controlled by either Wet Pond (63% Removal Efficiency) or LID controls (85% Removal Efficiency)

Removal Efficiency Assumptions:
Brechin Public School has a dry pond with 0.9 ha of contributing area draining to it (assume 10% existing removal efficiency, convert to 63% removal efficiency for retrofit)
Brechin Industrial Park has a wet SWM facility with 12.9 ha of contributing area in existing and 25.8 ha in proposed (assume 63% removal efficiency)

APPENDIX F:
EROSION ASSESSMENT ANALYSIS

Erosion Threshold Analysis
Lake Simcoe Tributaries, Donnelly Drain, McNab Drain
Township of Ramara Master Stormwater Management Plan

Submitted to:

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March 12, 2014

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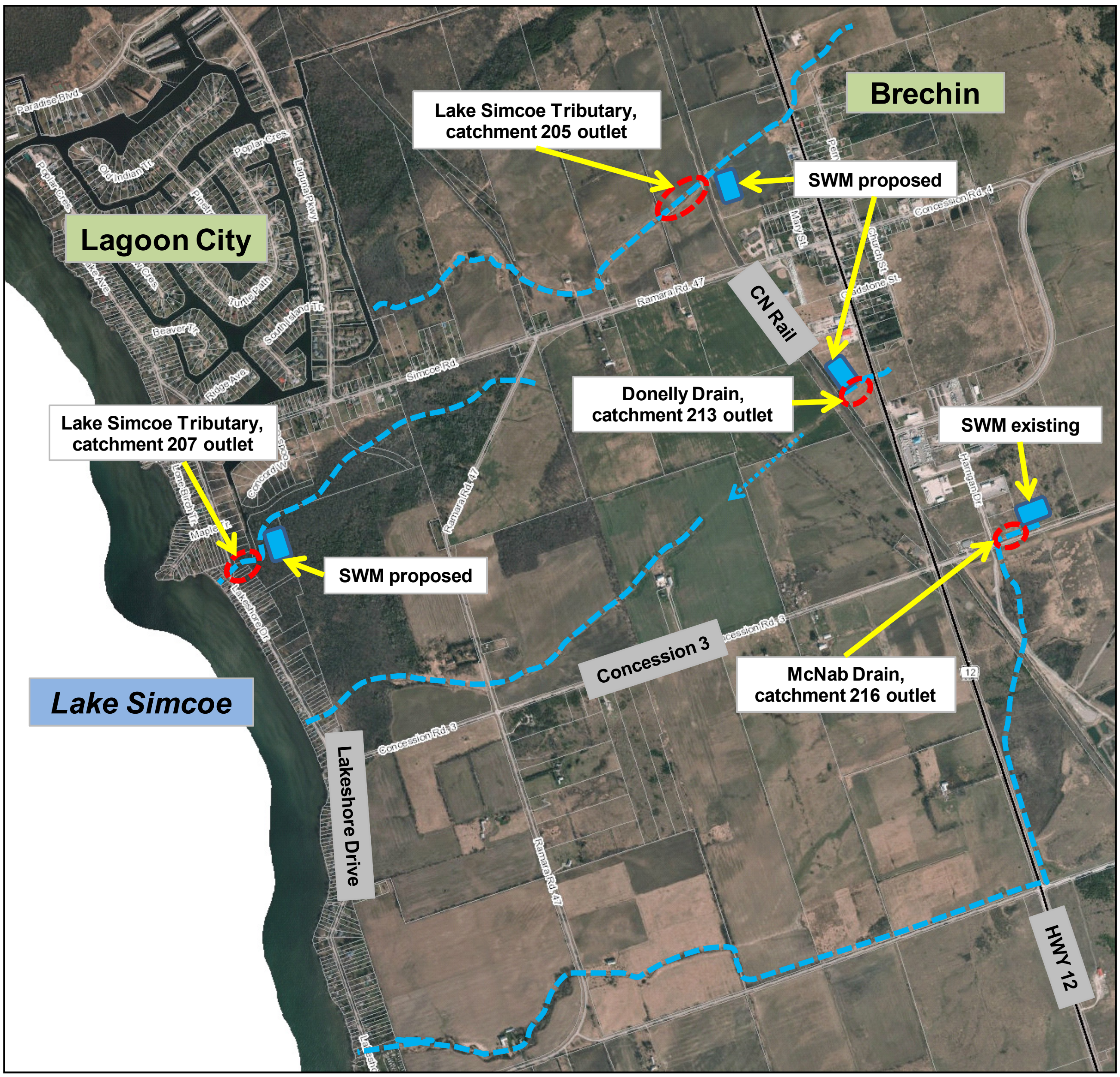
Erosion Threshold Analysis
Lake Simcoe Tributaries, Donnelly Drain, McNab Drain
Township of Ramara Master Stormwater Management Plan

Erosion threshold analysis has been undertaken for four watercourses that will receive stormwater discharge from future proposed development in the Village of Brechin and Lagoon City areas of the Township of Ramara. The study area locations are shown in Figure 1.

Figure 1: Location Map (not to scale, N▲)



Analysis has been done based on field review of channel sensitivity below proposed stormwater pond outlets, and detailed cross-section surveys of the downstream locations that will receive combined flows from the development blocks. Field measurements were used for erosion threshold modelling and the results were then used to determine the appropriate methodology for impact analysis. Exceedance-duration analysis was not identified as appropriate because all channels are deemed stable under vegetation control, therefore vegetation-hydroperiod analysis was used for detailed assessment of proposed conditions hydrology.

Watercourse Characterization

Lake Simcoe Tributary (proposed conditions catchment 205 outlet)

The Lake Simcoe Tributary on the north side of the existing Village of Brechin urban area is a 1st order watercourse with an upstream drainage area of 1.62km^2 to the CN Rail Line where future conditions stormwater will be confluent. The tributary is confluent with a manmade channel in Lagoon City approximately 1.8km further downstream which is subsequently confluent with Lake Simcoe at an assumed similar backwater elevation. The feature falls within the Simcoe Lowlands physiographic region. Topography is generalized as wide, shallow, low gradient riparian flood plain and large separation from drumlin elevations to the north and east. Upstream and downstream of the rail crossing the feature has been historically straightened for agricultural drainage through adjacent row cropping. Naturalized encroachment within the channel and in narrow buffers on each side of dense groundcover and wet to dry meadow transition is observed. Cattail stands are evident discontinuously through the channel feature.

The existing feature geometry is a legacy of past alteration and the cross-section is highly influenced by biotechnical reinforcement. Bedforms are indistinct and the feature is generally defined as a continuous run flowing through heterogeneous deposits of clay-silt, sand, and some gravel. Erosion scars are not explicitly evident and low flow definition is muted by the dense vegetative cover. Channel sinuosity is essentially non-existent and the reach average slope is just less than 0.5%. Minor low flow discharge was observed at the time of fall field work however it is assumed that the feature is ephemeral to intermittent.

Lake Simcoe Tributary (proposed conditions catchment 207 outlet)

The Lake Simcoe Tributary south of Lagoon City is a 1st order watercourse with an upstream drainage area of 1.32km^2 just above Lakeshore Drive where future conditions stormwater will be confluent. The tributary is confluent with Lake Simcoe approximately 250m downstream on the south side of Brechin Point. The feature falls within the Simcoe Lowlands physiographic region. The reach upstream and downstream of proposed future stormwater connection is a low gradient swamp forest wetland channel. High levels of organic detritus in various stages of decomposition fill and define the channel as it flows over and through medium density groundcover, shrub, and tree thicket conditions. The channel is very low gradient and low energy with the noted organic debris conditions resulting in relatively wide and shallow cross-section definition. The levels of deposition and decomposition indicate that the channel lacks the ability to transport high volumes of bedload. Flows appear permanent but sluggish, bedforms are indistinct, and excessive erosion scars are not evident. The channel likely experiences minor adjustments due to freeze-thaw processes and pore pressure changes in the mesic soil conditions.

Donnelly Drain (proposed conditions catchment 213 outlet)

The Lake Simcoe Tributary on the south side of the existing Village of Brechin urban area is a 1st order watercourse with an upstream drainage area of 0.58km^2 to the CN Rail Line where future conditions stormwater will be confluent. Below the rail line the feature is plowed through for agricultural use over a length of approximately 700m until a defined channel reappears. From this point the tributary is confluent with Lake Simcoe approximately 2.1km further downstream in Brechin Beach. The feature falls within the Simcoe Lowlands physiographic region. Topography, historic alteration, and channel characterization are very similar to the tributary on the north side of the village (catchment 205), except for smaller relative cross-sectional area and width and a lower presence of cattail vegetation. Groundcover vegetation encroachment and biotechnical reinforcement is continuous on the upstream side of the rail line, and low flow discharge is assumed to be primarily ephemeral to only occasionally intermittent as demonstrated by plowed through conditions downstream of the rail line.

McNab Drain (proposed conditions catchment 216 outlet)

The McNab Drain is a 1st order feature that originates as a roadside ditch with an upstream drainage area of 0.89km^2 that includes input from an existing stormwater management pond. The drain is confluent with Lake Simcoe approximately 4.9km downstream in Mara Beach. The feature falls within the Simcoe Lowlands physiographic region. Cross-section geometry in the reach immediately below the existing stormwater pond is typical of a manmade trapezoidal to triangular ditch that has rounded slightly through natural processes over time. Groundcover vegetation encroachment levels are very high and combined with the low gradient of approximately 0.25% the channel is dynamically stable parallel to the adjacent road. The channel bed is a continuous run and soil conditions are a heterogeneous mix of materials up to gravel with a higher fraction of sand and gravel assumed to be from winter maintenance and gravel shoulder inputs. Low flows appear to be intermittent but could have longer post event durations due to the effect of the existing stormwater pond.

Rapid Assessment Analysis

Three rapid assessment protocols were undertaken for each of the features in the reaches in proximity to proposed stormwater pond outlets. Background review and field reconnaissance suggested that the reaches closest to proposed stormwater facilities will have the greatest sensitivity to future flow changes. Areas further downstream are all generally stable and as drainage areas increase and subsequent confluent tributaries add flow, a dilution effect is achieved to the flow contribution from future ponds.

Field observations were used to score relative geomorphic and environmental attributes. Rapid Geomorphic Assessment (RGA) was used to rate channel stability and infrastructure impact. Rapid Habitat Assessment (RHA) was used to define in-stream and riparian habitat. Rapid Stream Assessment Technique (RSAT) was used to test broad indicators of channel stability, aquatic habitat, and water quality. A weighted score out of 100 was transposed from the results of each protocol and a combined average score was determined from the three tests. Four qualifying ranges of poor, fair, good, and optimal are maintained in the RHA and RSAT protocols, between the original scoring and the weighted scoring out of 100, while the three original ranges in RGA scoring are reflected as poor, fair, and good. The combined average score is qualified by poor to optimal ranges designed as a best fit of the individual protocol ranges. The detailed results are appended and included with each are photographs of typical reach conditions. Given the lack of defined bed and bank characteristics on the Donnelly Drain below the CN Rail Line, rapid assessment was done for the reach upstream of the rail line.

The results show that all reaches are deemed to be stable or ‘in regime’ per the RGA scoring. High vegetative reinforcement levels and low channel gradients are the primary factors contributing to stability. Habitat quality is generally fair to marginally good based on RHA and RSAT scoring. The lack of base flow in all but the catchment 207 tributary, the physical impacts of past alterations, and the lack of observed aquatic organisms, prevents higher scoring of habitat quality. Combined scoring for each tributary falls in the range of ‘good’ based on equal weighting averaging of each rapid assessment test.

Erosion Threshold Characterization

Erosion threshold characterization was undertaken to establish benchmark targets for discharge control provided by stormwater management treatment of the proposed development blocks. Surveys for detailed analysis were located in the sensitive reaches identified through rapid assessment. Sensitivity was measured and modeled at three surveyed bankfull or channel forming cross-sections. Given the small drainage areas, small channel sizes, and the lack of sinuosity due to alteration, three cross-sections per location were deemed adequate to represent the natural variability of channel conditions in a localized reach. Backwater influences caused by large woody debris were avoided. Channel forming debris flow lines and fallen and matted groundcover vegetation lines were used as best as possible to identify cross-section width. In addition, given the slight degree of entrenchment characterizing each of the Donnelly and McNab Drains and the catchment 205 tributary, the cross-section measurements were biased to a channel capacity level rather than a nested channel forming or active flow level. Similar to rapid assessment work the Donnelly Drain was surveyed on the upstream side of the rail line, instead of the downstream side. Channel geometry was measured laterally at each cross-section and the longitudinal profile was shot using bankfull indicators. Channel bed substrates were measured through random-step Wolman pebble counts and recorded using the Wentworth sediment distribution scale.

Open channel flow models were created for each cross-section location. Each model required input of channel bed substrate data, cross-section dimensions, gradient, and bank geometry. Modeling tests were done for each cross-section and erosion indicators and thresholds were reviewed.

Subsequent checks were done to determine the critical stability threshold discharge. This discharge represents a reach based average point at which channel instability begins to occur with rising flow stage and rising discharge, or conversely when instability stops with falling flow stage and falling discharge. This discharge then becomes the comparative flow regime target for detailed analysis of stormwater management hydrology. Iterative flow stage adjustments can be made in each cross-section model until the appropriate stability criteria are achieved over the primary shear stress and velocity threshold tests, with secondary checks made of stream power and Froude number. **Table 2** presents the threshold criteria used for this analysis based on ‘small’ watercourse channel typology which display a high degree of vegetation control.

Table 2: Critical stability threshold criteria

	low flow morphology		
	riffle	run	pool / glide
semi-alluvial firm to dense till channels	D_{84} pavement	D_{84} pavement or vegetation control*	D_{100} pavement or vegetation control*
alluvial cohesionless channels	D_{50} pavement	D_{50} pavement or vegetation control*	D_{84} pavement or vegetation control*

*vegetation control criteria varies depending on vegetation type and density
note: step-pool and cascade-step-pool channels require case by case study

The first row criteria are applied for this study case, based on soil conditions and channel type. All surveyed reaches are dominated by run typology, with vegetation control deemed to be appropriate for testing overall stability. Conservative vegetation control criteria are identified as 40N m^{-2} for shear stress and 1.2m s^{-1} for channel velocity (Fischenich 2001) based on average to above average rooting depth and density. Higher thresholds are common and viable under very high levels of vegetative encroachment and this could be argued as applicable for all reaches except the catchment 207 tributary.

Existing condition shear and velocity results reviewed for all twelve cross-sections in all four reaches are seen to fully meet the criteria for vegetation control. Secondary checks of stream power and Froude number, under existing conditions, also suggest no evidence of adverse channel adjustment. Stream power is below a stability threshold of 400 watts m^{-1} (Sear et. al. 2003) and all Froude numbers are less than one thus confirming subcritical flow.

Based on these results, no iterations were required to adjust flow stage for dynamic stability. All reaches are deemed fully stable at channel capacity flows due to biotechnical reinforcement. The results suggest that vegetation-hydroperiod analysis is appropriate as a conservative test of future stability. This analysis will check potential impacts to vegetation viability under longer flow event inundation up to channel capacity stage under post development flows.

Vegetation-Hydroperiod Analysis

Vegetation-hydroperiod testing was done to check the influence of the future flow duration change that will occur at levels below channel capacity flow. Vegetation-hydroperiod modelling investigates the affect of saturation over time on the mechanical rooting density and surface layer velocity protection thresholds of biotechnical reinforcement. A vegetation-hydroperiod model was used to determine if the extra flow duration results in adverse changes to the integrity of the soil and vegetation matrix lining the respective study reaches.

Individual cross-sections from each reach were selected based on the highest or most conservative channel capacity velocity, combined with the highest tractive force. Flow stage adjustments were made in each of these cross-section models to match frequent event peak flows that fall below channel capacity. Hydrology modelling of the 4hr Chicago distribution with 24hr extended detention of the 25mm event was supplied by C.C. Tatham. Modelling shows over control of individual peak events therefore the more conservative velocity under existing conditions was used at the respective higher peaks. This maximum stage velocity was conservatively tested against allowable duration curves for average and high density groundcover vegetation conditions. Average density is deemed to occur along the Lake Simcoe Tributary catchment 207, and high density conditions occur along the other three reaches. Modelling was reviewed for start to finish event durations using 0.001cms as a cut-off criterion.

Existing and proposed flow durations at each flow increment were tabulated within the model. Allowable event durations were generated and comparative results were produced. Detailed modelling results and the velocity duration curves used for analysis are appended.

For the Lake Simcoe Tributary catchment 205 and the Donnelly and the McNab Drains, all comparison steps of existing and proposed conditions are seen to have no duration exceedances. The Lake Simcoe Tributary catchment 207 has exceedance at the 25yr event by a factor of 0.03% over 100 years. Individual 25yr events will last approximately twice as long as the allowable duration based on this factor. The difference is deemed to be small and have negligible long term impact. It must be recognized that most of the longer duration actually occurs at rising or dropping velocities lower than the peak of the flow stage, therefore all results are conservatively over estimated.

The combined results corroborate the qualitative observations of existing conditions and suggest that long term biotechnical vegetation control is presently and will continue to be the defining state for the study reaches.

The results do suggest however that a possible shift in vegetation type might occur due to the extended duration of future condition flows. Proposed durations on the Lake Simcoe Tributary catchment 205 and the Donnelly and McNab Drains are several times higher than existing conditions. Typically this means the potential for increased density of emergent vegetation such as cattails under the shallow and drawn out flows that will occur through and after event peaks. The effect may be less distinct, or not even seen, on the Lake Simcoe Tributary catchment 207 feature because the extended duration at more frequent events occupies a low flow already void of emergent vegetation due to the forest canopy shading.

Biotechnical or vegetation control conditions leading to channel stability are concluded to be preserved and maintained based on the vegetation-hydroperiod analysis results.

Conclusions

Erosion threshold analysis has been undertaken for four watercourses that will receive stormwater discharge from future proposed development areas in the Village of Brechin and Lagoon City areas of the Township of Ramara.

Analysis has been done based on field review of channel sensitivity below proposed stormwater pond outlets and detailed cross-section surveys of the downstream locations that will receive combined flows from the development blocks. Erosion threshold modeling results were then used in vegetation-hydroperiod analysis for all reaches under study.

Allowable flow durations within the depth range of channel capacity were checked and determined to meet allowable criteria for extended level of saturation and to not be detrimental to vegetative integrity from a vegetation-hydroperiod basis.

The methods of analysis presented in this report do not preclude a catastrophic event potentially causing some erosion due to unforeseen circumstances (e.g. SWM pond failure, culvert failures, major debris jam scour, beaver dam construction/breaching, or combinations thereof, etc.). The results presented here are also contingent on long term preservation and maintenance of the existing dense vegetation conditions within the respective corridors.

Prepared by,

Bill de Geus

Bill de Geus, B.Sc., CET, CPESC, EP
AquaLogic Consulting

References

Chapman, L.J., and D.F. Putnam. 1984. The Physiography of Southern Ontario: Ontario Geological Survey, Special Volume 2.

Fischenich, C. 2001. Stability Thresholds for Stream Restoration Materials. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-29), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Sear, D.A., Newson, M.D., and C.R. Thorne. 2003. Guidebook of Applied Fluvial Geomorphology, R&D Technical Report FD1914. Defra/Environment Agency Flood and Coastal Defence R&D Programme. Defra Flood Management Division, London, ENG.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Township of Ramara Master Stormwater Management Plan
Lake Simcoe Trib (proposed conditions catchment 205 outlet)
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00
Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.00
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00

STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.04
SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	96.4

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	14	20--16	15-11	10-6	5-0
Pool Substrate Characterization	4	20--16	15-11	10-6	5-0
Pool Variability	4	20--16	15-11	10-6	5-0
Sediment Deposition	10	20--16	15-11	10-6	5-0
Channel Flow Status	2	20--16	15-11	10-6	5-0
Channel Alteration	3	20--16	15-11	10-6	5-0
Channel Sinuosity	2	20--16	15-11	10-6	5-0
Bank Stability u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Vegetative Protection	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width	3	10-8	7-6	5-3	2-0
u/s R	3	10-8	7-6	5-3	2-0
/200	81				
/100	40.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	10	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	5	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	4	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	1	8-7	6-5	4-3	2-0
/50	30				
/100	60.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

(RGA + RHA + RSAT) / 3 =	66	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Reach overview showing straightened alteration and dense vegetative encroachment

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.

2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: Township of Ramara Master Stormwater Management Plan
Lake Simcoe Trib (proposed conditions catchment 207 outlet)
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.43
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00
Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.20
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00

STABILITY INDEX (SI) = (A + D + W + P) / 4 = **0.16**

SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment

100 - (100*SI) = **84.3**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	8	20--16	15-11	10-6	5-0
Pool Substrate Characterization	3	20--16	15-11	10-6	5-0
Pool Variability	3	20--16	15-11	10-6	5-0
Sediment Deposition	5	20--16	15-11	10-6	5-0
Channel Flow Status	11	20--16	15-11	10-6	5-0
Channel Alteration	12	20--16	15-11	10-6	5-0
Channel Sinuosity	12	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	106				
/100	**53**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	7	8-7	6-5	4-3	2-0
Physical Instream Habitat	4	8-7	6-5	4-3	2-0
Water Quality	4	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	3	7-6	5-4	3-2	1-0
Biological Indicators	2	8-7	6-5	4-3	2-0
/50	28				
/100	**56.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	64	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Reach overview showing the channel through swamp forest conditions. Low gradient and a high level of organic input

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: Township of Ramara Master Stormwater Management Plan
Donnelly Drain (proposed conditions catchment 213 outlet)
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	
Lobate bar	
Coarse material in riffles embedded	
Siltation in pools	1
Medial bars	
Accretion on point bars	
Poor longitudinal sorting of bed materials	
Deposition in the overbank zone	
n/7 =	0.14

Degradation	
Exposed bridge footing(s)	
Exposed sanitary/storm sewer/pipeline etc.	
Elevated stormsewer outfall(s)	
Undermined gabion baskets/concrete aprons etc.	
Scour pools d/s of culverts/stormsewer outlets	
Cut face on bar forms	
Head cutting due to knick point migration	
Terrace cut through older bar material	
Suspended armour layer visible in bank	
Channel worn into undisturbed overburden/bedrock	
n/10 =	0.00

Widening	
Fallen/leaning trees/fence posts etc.	
Occurrence of Large Organic Debris	
Exposed tree roots	
Basal scour on inside meander bends	
Basal scour on both sides of channel through riffle	
Gabion baskets/concrete walls etc. out flanked	
Length of basal scour >50% through subject reach	
Exposed length of previously buried pipe/cable etc.	
Fracture lines along top of bank	
Exposed building foundation	
n/10 =	0.00

Planimetric Form	
Formation of chute(s)	
Single thread channel to multiple channel	
Evolution of pool-riffle form to low bed relief form	
Cut-off channel(s)	
Formation of island(s)	
Thalweg alignment out of phase meander form	
Bar forms poorly formed/reworked/removed	
n/7 =	0.00

STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.04**
SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	**96.4**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

	Score	Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

	Score	Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	14	20--16	15-11	10-6	5-0
Pool Substrate Characterization	3	20--16	15-11	10-6	5-0
Pool Variability	3	20--16	15-11	10-6	5-0
Sediment Deposition	9	20--16	15-11	10-6	5-0
Channel Flow Status	1	20--16	15-11	10-6	5-0
Channel Alteration	2	20--16	15-11	10-6	5-0
Channel Sinuosity	2	20--16	15-11	10-6	5-0
Bank Stability u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Vegetative Protection	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width	3	10-8	7-6	5-3	2-0
u/s R	3	10-8	7-6	5-3	2-0
/200	76				
/100	**38**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

	Score	Optimal	Good	Fair	Poor
Channel Stability	10	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	4	8-7	6-5	4-3	2-0
Water Quality	4	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	0	8-7	6-5	4-3	2-0
/50	26				
/100	**52.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

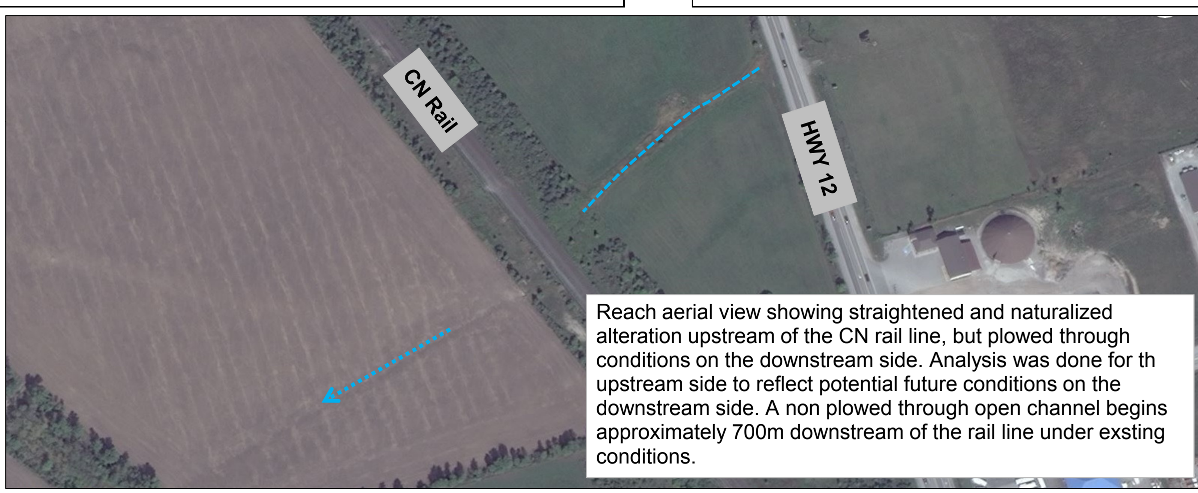
Combined Assessment

Riffle Run Channel Type

	Score	Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

	Score	Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	62	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



Reach aerial view showing straightened and naturalized alteration upstream of the CN rail line, but plowed through conditions on the downstream side. Analysis was done for th upstream side to reflect potential future conditions on the downstream side. A non plowed through open channel begins approximately 700m downstream of the rail line under exsting conditions.

References
1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: **Township of Ramara Master Stormwater Management Plan**
McNab Drain (proposed conditions catchment 216 outlet)
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation		
	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	1
	Deposition in the overbank zone	
	n/7 =	0.29

Degradation		
	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening		
	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.00

Planimetric Form		
	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00

STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.07**
SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	**92.9**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

	Score	Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

	Score	Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	14	20--16	15-11	10-6	5-0
Pool Substrate Characterization	4	20--16	15-11	10-6	5-0
Pool Variability	4	20--16	15-11	10-6	5-0
Sediment Deposition	10	20--16	15-11	10-6	5-0
Channel Flow Status	3	20--16	15-11	10-6	5-0
Channel Alteration	3	20--16	15-11	10-6	5-0
Channel Sinuosity	2	20--16	15-11	10-6	5-0
Bank Stability u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Vegetative Protection	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width	3	10-8	7-6	5-3	2-0
u/s R	3	10-8	7-6	5-3	2-0
/200	82				
/100	**41**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

	Score	Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	5	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	4	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	1	8-7	6-5	4-3	2-0
/50	29				
/100	**58.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

	Score	Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		100-80	80-56	55-30	29-0

Glide Pool Channel Type

	Score	Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	64	100-80	80-56	55-30	29-0

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.

2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis
Township of Ramara Master Stormwater Management Plan
Lake Simcoe Tributary, Catchment 205 - Section 1

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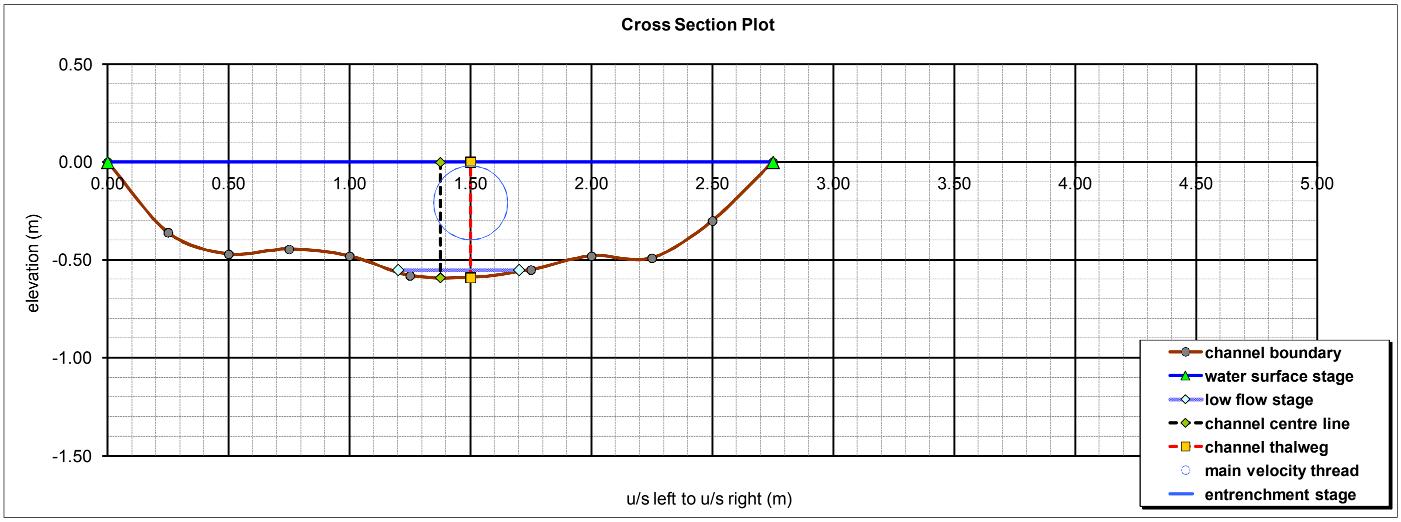
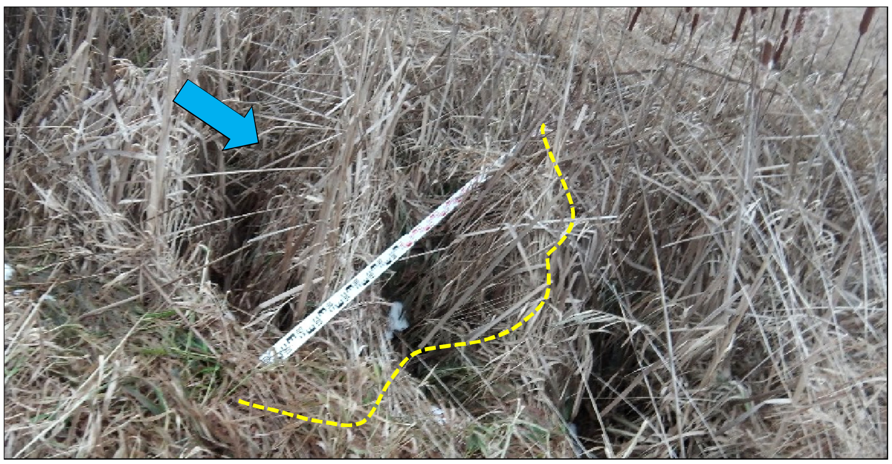
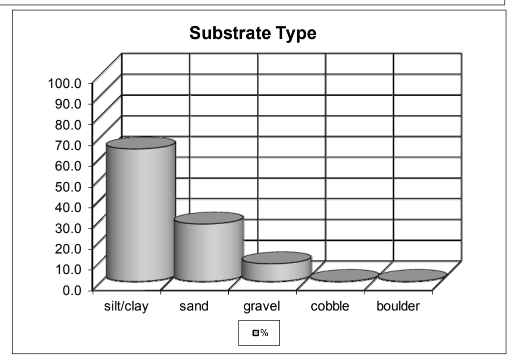






Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.19
R (m)	0.37
TW (m)	2.75
WP (m)	3.20
max d (m)	0.59
mean d (m)	0.43
$E_{s\,(Limerinos)}$ (m) [+]	
$E_{s\,(Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	1852.31
ff V mean/V*	13.14
ff D_{84}	21.83
ff mean	17.48
SMOOTH BED	

Hydraulic Ratios	
ER max d	16.36
r_c / TW	
TW / Lf_w	
TW/max d	4.7
TW/mean d	6.4

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.002	0.10	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.054	D_{50}	0.003	0.13	YES	YES	YES	YES
		D_{84}	0.023	1.05	NO	YES	YES	YES

Section Data

ER_e (m)	0.59	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.75	2.75
Lf_e (m)	-0.550	Lf stations L / R	1.20	1.70	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.59	1.50	
E_g ($m\ m^{-1}$)	0.0039				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})	T_*	D_{30}	D_{50}	D_{84}
				291.9	243.3	73.0
B3	0.0017	0.0026	saltation	YES	YES	YES
C3	0.0001	0.0026	rolling	YES	YES	YES
C4	0.0055	0.0110	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.05	0.06	0.20	50.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)	0.03	0.05	0.06	0.19	48.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.692	Q (cms)	
V ($m\ s^{-1}$)	0.58	V ($m\ s^{-1}$)	
n	0.055	n	
Fr	0.28	*Fr*	
D_c rectangular (m)	0.19	D_c rectangular (m)	
D_c trapezoidal (m)	0.27	D_c trapezoidal (m)	
D_c triangular (m)	0.40	D_c triangular (m)	
D_c parabolic (m)	0.22	D_c parabolic (m)	
D_c mean (m)	0.27	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	26.47	Ω (watts m^{-1})	
ω_a (watts m^{-2})	8.27	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	3.01	ω_a/TW (watts m^{-1})	
*Re**	0.1	*Re**	
Re	189700	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	1.44		
τ_{calc} ($N\ m^{-2}$)	14.16		
$\tau\ D_{crit}$ (gr-co) (mm)	14.60		
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.04	0.09	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.07	0.17	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

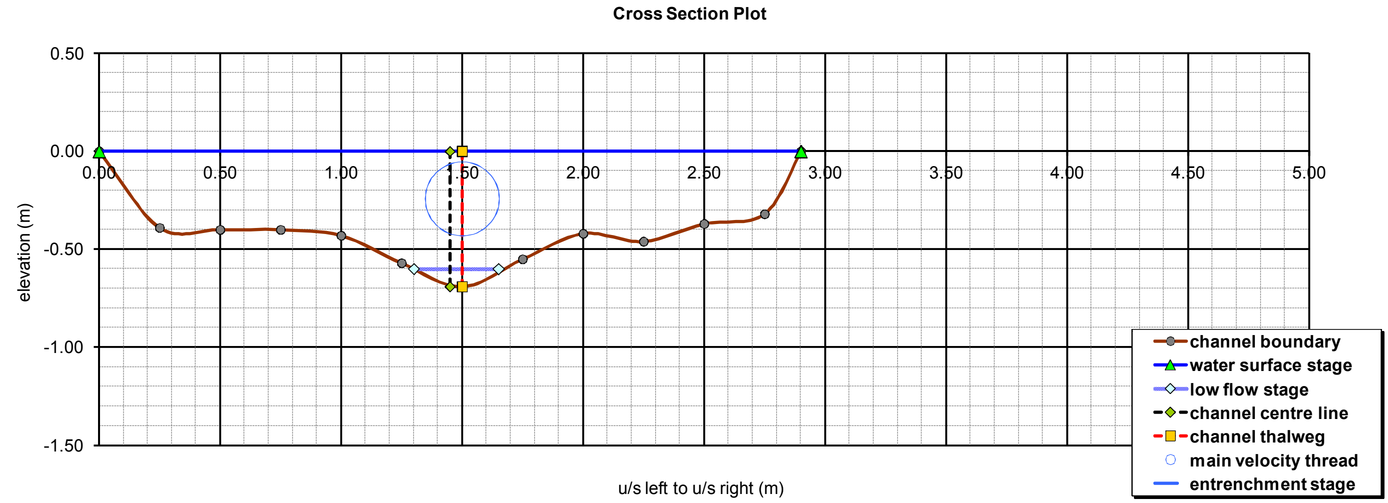
Substrate Type (%)

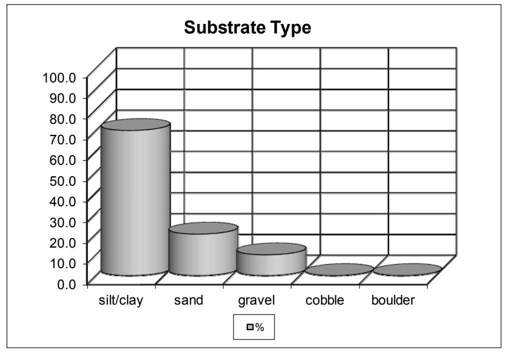
silt/clay	sand	gravel	cobble	boulder
63.8	27.7	8.5	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Township of Ramara Master Stormwater Management Plan
Lake Simcoe Tributary, Catchment 205 - Section 2





Morphology Type		Hydraulic Geometry	
cascade		A (m^2)	1.23
step		*R* (m)	0.36
riffle		TW (m)	2.90
run	●	WP (m)	3.47
glide		max d (m)	0.69
pool		mean d (m)	0.43
thalweg out of phase		$E_{s\ (Limerinos)}$ (m) [+]	
Hydraulic Roughness		$E_{s\ (Strickler)}$ (m) [+]	
rr R/D_{84}	355.14	**Hydraulic Ratios**	
ff V mean/V*	11.15	ER max d	15.52
ff D_{84}	17.81	r_c / TW	
ff mean	14.48	TW / Lf_w	
SMOOTH BED		TW/max d	4.2
		TW/mean d	6.8

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.002	0.10	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.052	D_{50}	0.003	0.14	YES	YES	YES	YES
		D_{84}	0.126	5.92	NO	NO	NO	YES

Section Data

ER_e (m)	0.69	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.90	2.90
Lf_e (m)	-0.600	Lf stations L / R	1.30	1.65	
W_{fp} (m)	45.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.69	1.50	
E_g ($m\ m^{-1}$)	0.0038				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)	T_*	D_{30}	D_{50}	D_{84}
				272.7	227.2	13.6
B3	0.0017	0.0025	saltation	YES	YES	YES
C3	0.0001	0.0018	rolling	YES	YES	YES
C4	0.0055	0.0100	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.05	0.06	1.00	25.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)	0.03	0.05	0.06	0.97	24.25
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.691	Q (cms)	
V ($m\ s^{-1}$)	0.56	V ($m\ s^{-1}$)	
n	0.055	n	
Fr	0.27	*Fr*	
D_c rectangular (m)	0.18	D_c rectangular (m)	
D_c trapezoidal (m)	0.27	D_c trapezoidal (m)	
D_c triangular (m)	0.40	D_c triangular (m)	
D_c parabolic (m)	0.22	D_c parabolic (m)	
D_c mean (m)	0.27	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	25.74	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	7.41	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	2.55	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.1	*Re**	
Re	174502	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	1.35		
τ_{calc} ($N\ m^{-2}$)	13.23		
τ D_{crit} (gr-co) (mm)	13.63		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.04	0.10	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.16	0.40	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
70.0	20.0	10.0	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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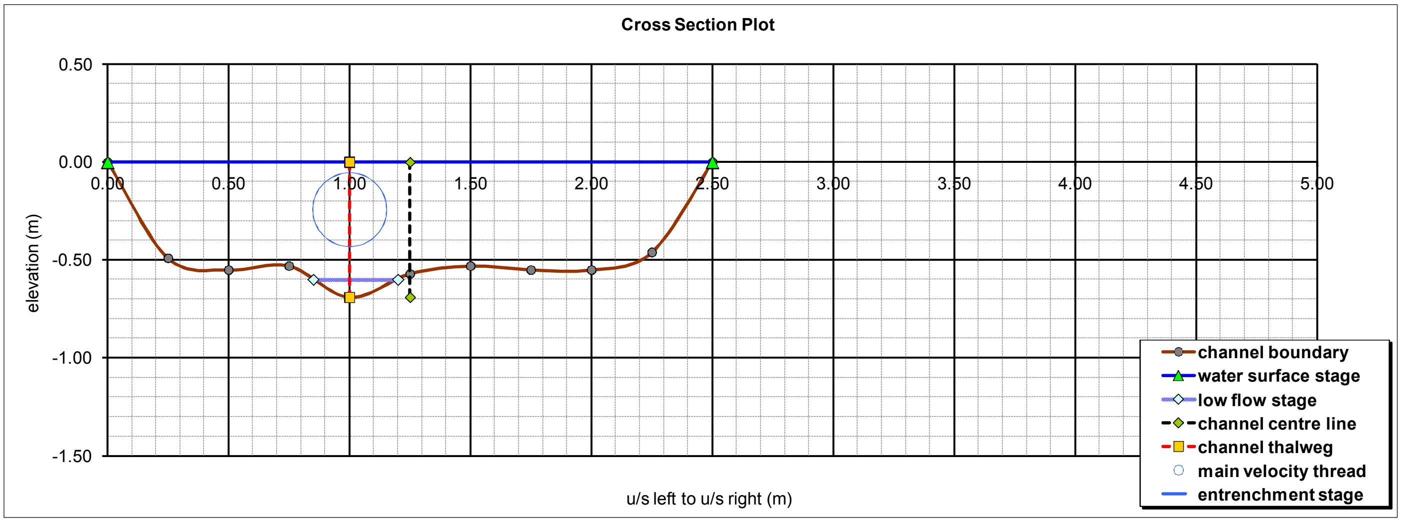
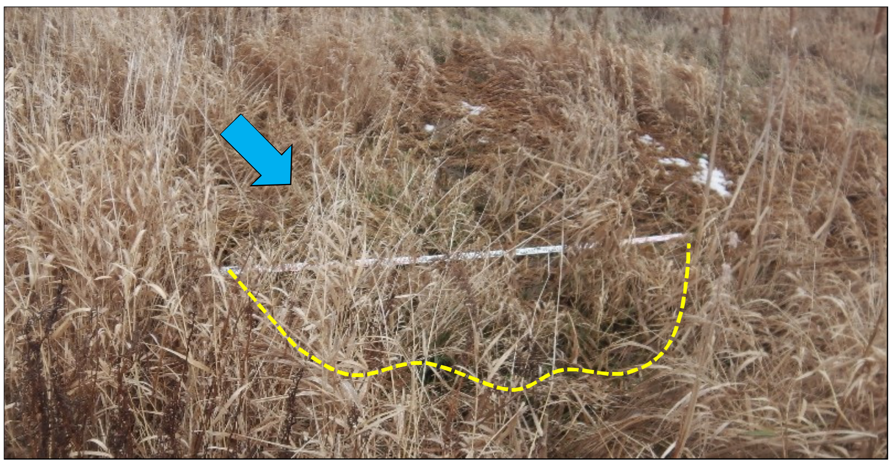
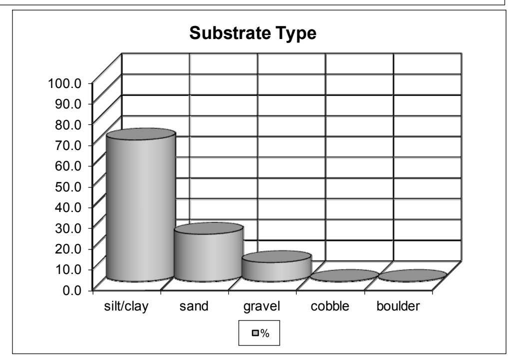
Project: **Erosion Threshold Analysis**
Township of Ramara Master Stormwater Management Plan
Lake Simcoe Tributary, Catchment 205 - Section 3







Morphology Type		Hydraulic Geometry	
cascade		A (m^2)	1.23
step		R (m)	0.39
riffle		TW (m)	2.50
run	●	WP (m)	3.18
glide		max d (m)	0.69
pool		mean d (m)	0.49
thalweg out of phase		$E_{s\ (Limerinos)}$ (m) [+]	
Hydraulic Roughness		$E_{s\ (Strickler)}$ (m) [+]	
rr R/D_{84}	387.36	**Hydraulic Ratios**	
ff V mean/V*	11.28	ER max d	18.00
ff D_{84}	18.17	r_c / TW	
ff mean	14.73	TW / Lf_w	
SMOOTH BED		TW/max d	3.6
		TW/mean d	5.1

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.002	0.10	YES	YES	YES	YES
V_* (m s^{-1})	0.051	D_{50}	0.003	0.14	YES	YES	YES	YES
		D_{84}	0.126	5.99	NO	NO	NO	YES

Section Data

ER_e (m)	0.69	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.50	2.50
Lf_e (m)	-0.600	Lf stations L / R	0.85	1.20	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.69	1.00	
E_g (m m^{-1})	0.0034				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	266.1	221.8	13.3
B3	0.0017	0.0025	saltation	YES	YES	YES
C3	0.0001	0.0017	rolling	YES	YES	YES
C4	0.0055	0.0100	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.05	0.06	1.00	15.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.03	0.05	0.06	0.97	14.55
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.691	Q (cms)	
V (m s^{-1})	0.56	V (m s^{-1})	
n	0.055	n	
Fr	0.26	*Fr*	
D_c rectangular (m)	0.20	D_c rectangular (m)	
D_c trapezoidal (m)	0.27	D_c trapezoidal (m)	
D_c triangular (m)	0.40	D_c triangular (m)	
D_c parabolic (m)	0.21	D_c parabolic (m)	
D_c mean (m)	0.27	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	23.02	Ω (watts m^{-1})	
ω_a (watts m^{-2})	7.25	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	2.90	ω_a/TW (watts m^{-1})	
*Re**	0.1	*Re**	
Re	190819	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	1.32		
τ_{calc} (N m^{-2})	12.91		
τ D_{crit} (gr-co) (mm)	13.31	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.04	0.10	
D_{84} V_c (vcs +) (m s^{-1})	0.16	0.39	

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
68.2	22.7	9.1	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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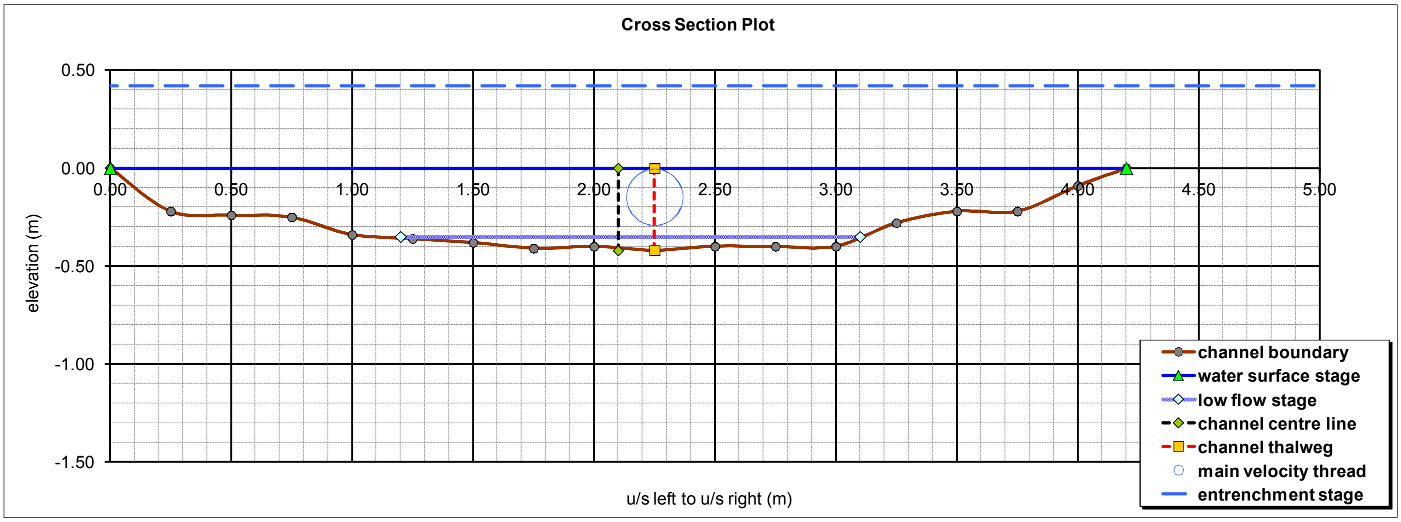
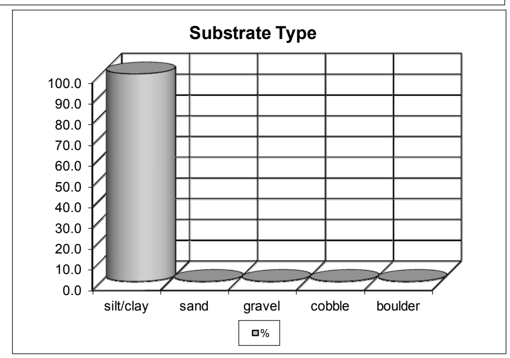
Project: Erosion Threshold Analysis
Township of Ramara Master Stormwater Management Plan
Lake Simcoe Tributary, Catchment 207 - Section 1





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.26
R (m)	0.29
TW (m)	4.20
WP (m)	4.39
max d (m)	0.42
mean d (m)	0.30
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	5718.14
ff V mean/V*	15.30
ff D_{84}	24.36
ff mean	19.83
SMOOTH BED	

Hydraulic Ratios	
ER max d	10.71
r_c / TW	
TW / Lf_w	
TW/max d	10.0
TW/mean d	14.1

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.001	0.08	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.034	D_{50}	0.001	0.10	YES	YES	YES	YES
		D_{84}	0.002	0.15	YES	YES	YES	YES

Section Data

					TW ck
ER_e (m)	0.42	ER stations L / R	-20.00	25.00	
WS_e (m)	0.000	WS stations L / R	0.00	4.20	4.20
Lf_e (m)	-0.350	Lf stations L / R	1.20	3.10	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.42	2.25	
E_g ($m\ m^{-1}$)	0.0020				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	165.1	144.4	115.5
B3	0.0016	0.0024	saltation	YES	YES	YES
C3	0.0001	0.0015	rolling	YES	YES	YES
C4	0.0051	0.0096	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.04	0.04	0.05	0.06
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)	0.03	0.03	0.04	0.05	0.06
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.607	Q (cms)	
V ($m\ s^{-1}$)	0.48	V ($m\ s^{-1}$)	
n	0.040	n	
Fr	0.28	*Fr*	
D_c rectangular (m)	0.13	D_c rectangular (m)	
D_c trapezoidal (m)	0.25	D_c trapezoidal (m)	
D_c triangular (m)	0.38	D_c triangular (m)	
D_c parabolic (m)	0.22	D_c parabolic (m)	
D_c mean (m)	0.25	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	11.89	Ω (watts m^{-1})	
ω_a (watts m^{-2})	2.71	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	0.64	ω_a/TW (watts m^{-1})	
*Re**	0.1	*Re**	
Re	121184	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.57		
τ_{calc} ($N\ m^{-2}$)	5.60		
τ D_{crit} (gr-co) (mm)	5.78		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.03	0.09	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.03	0.10	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
100.0	0.0	0.0	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: **Erosion Threshold Analysis**
Township of Ramara Master Stormwater Management Plan
Lake Simcoe Tributary, Catchment 207 - Section 2

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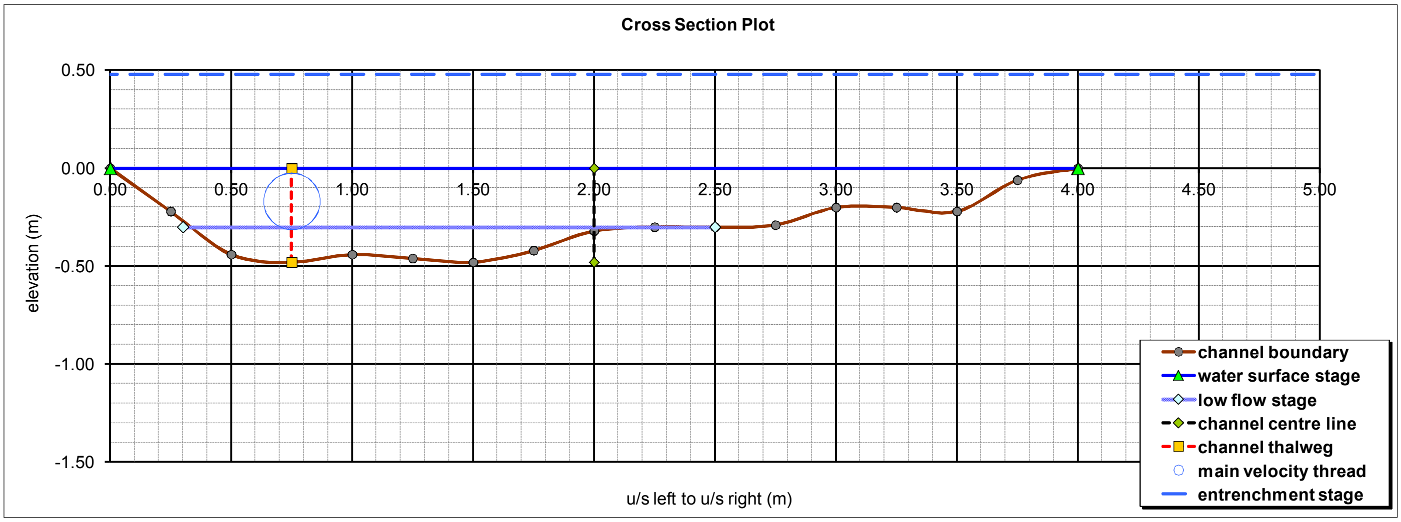
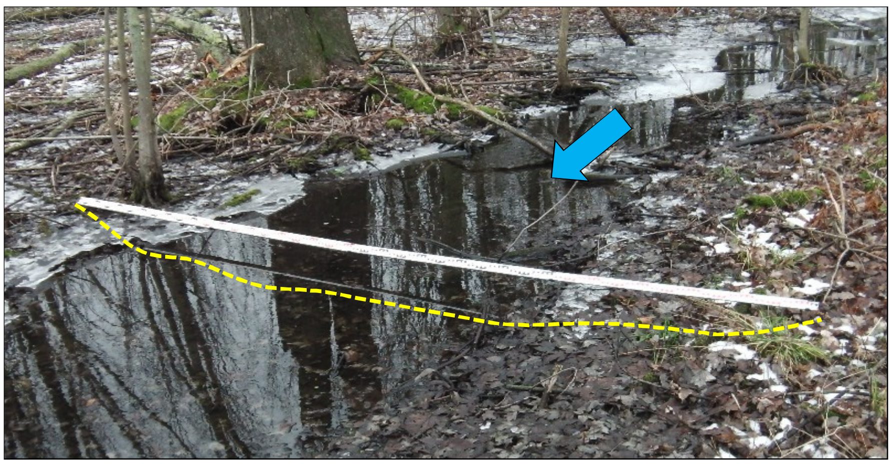
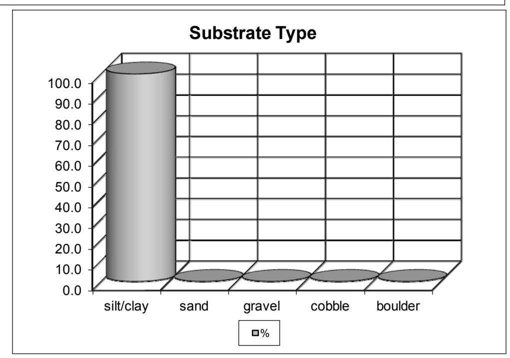






Morphology Type		Hydraulic Geometry	
cascade		A (m^2)	1.21
step		R (m)	0.28
riffle		TW (m)	4.00
run	●	WP (m)	4.27
glide		max d (m)	0.48
pool		mean d (m)	0.30
thalweg out of phase		$E_{s\ (Limerinos)}$ (m) [+]	
Hydraulic Roughness		$E_{s\ (Strickler)}$ (m) [+]	
rr R/D_{84}	5653.40	**Hydraulic Ratios**	
ff V mean/V*	15.26	ER max d	11.25
ff D_{84}	24.38	r_c / TW	
ff mean	19.82	TW / Lf_w	
SMOOTH BED		TW/max d	8.3
		TW/mean d	13.3

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.001	0.07	YES	YES	YES	YES
V_* (m s^{-1})	0.035	D_{50}	0.001	0.09	YES	YES	YES	YES
		D_{84}	0.002	0.15	YES	YES	YES	YES

Section Data

ER_e (m)	0.48	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	4.00	4.00
Lf_e (m)	-0.300	Lf stations L / R	0.30	2.50	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.48	0.75	
E_g (m m^{-1})	0.0022				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})	T_*	D_{30}	D_{50}	D_{84}
				179.5	157.1	125.7
B3	0.0016	0.0024	saltation	YES	YES	YES
C3	0.0001	0.0015	rolling	YES	YES	YES
C4	0.0051	0.0096	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.04	0.04	0.05	0.06
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.03	0.03	0.04	0.05	0.06
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.607	Q (cms)	
V (m s^{-1})	0.50	V (m s^{-1})	
n	0.040	n	
Fr	0.29	*Fr*	
D_c rectangular (m)	0.14	D_c rectangular (m)	
D_c trapezoidal (m)	0.25	D_c trapezoidal (m)	
D_c triangular (m)	0.38	D_c triangular (m)	
D_c parabolic (m)	0.22	D_c parabolic (m)	
D_c mean (m)	0.25	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	13.09	Ω (watts m^{-1})	
ω_a (watts m^{-2})	3.07	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	0.77	ω_a/TW (watts m^{-1})	
*Re**	0.1	*Re**	
Re	124705	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} (kg m^{-2})	0.62		
τ_{calc} (N m^{-2})	6.09		
τ D_{crit} (gr-co) (mm)	6.28		
D_{50} V_c (vcs +) (m s^{-1})	0.03	0.09	
D_{84} V_c (vcs +) (m s^{-1})	0.03	0.10	

Substrate Type (%)

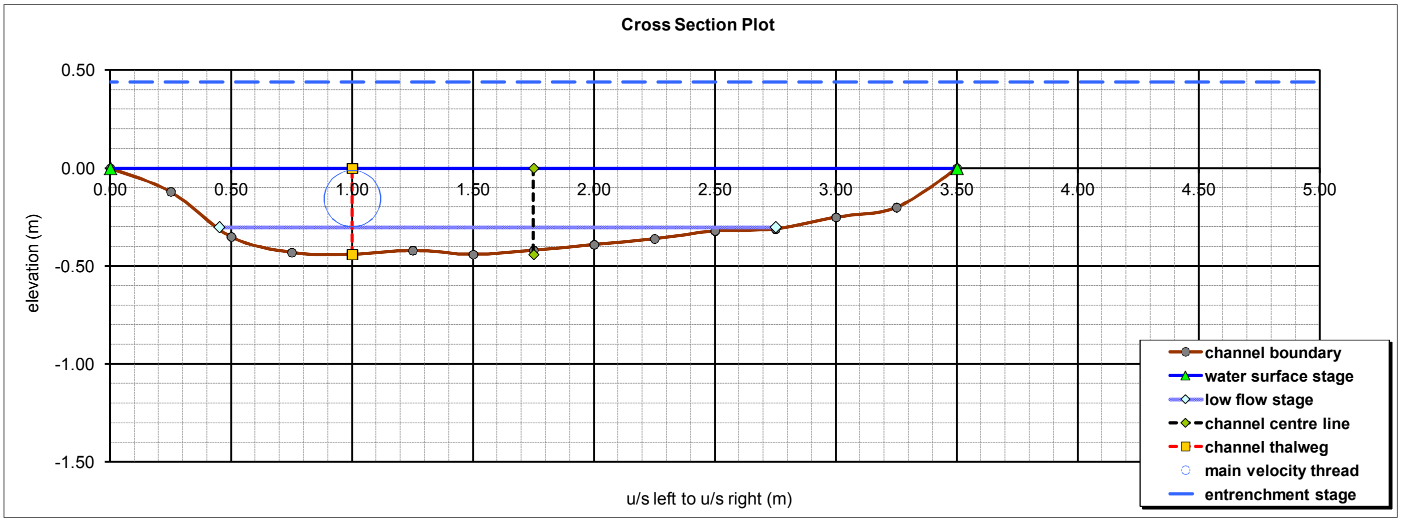
silt/clay	sand	gravel	cobble	boulder
100.0	0.0	0.0	0.0	0.0

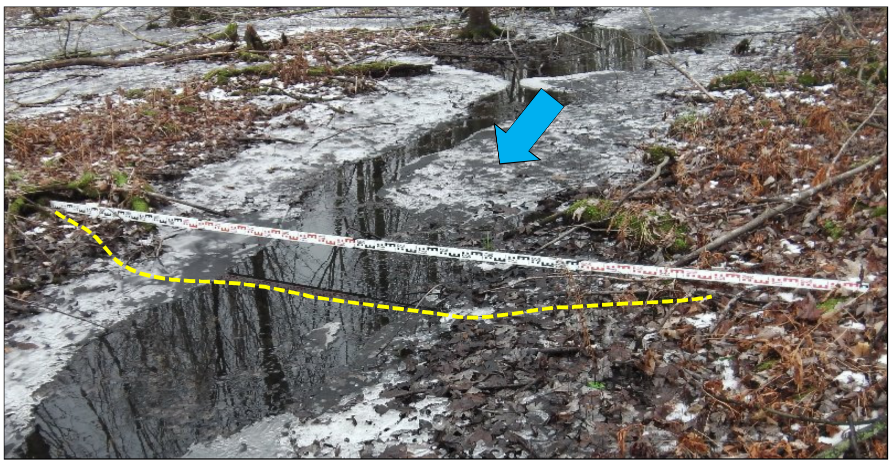
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

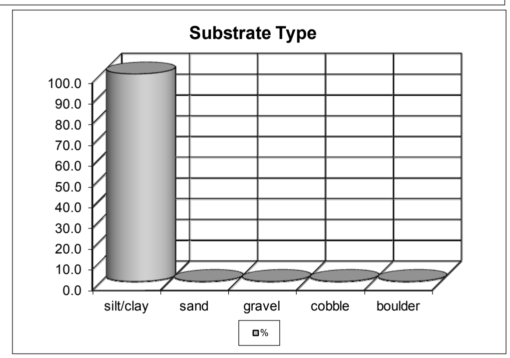
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Township of Ramara Master Stormwater Management Plan
Lake Simcoe Tributary, Catchment 207 - Section 3







Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.11
R (m)	0.30
TW (m)	3.50
WP (m)	3.72
max d (m)	0.44
mean d (m)	0.32
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	5979.14
ff V mean/V*	15.37
ff D_{84}	24.51
ff mean	19.94
SMOOTH BED	

Hydraulic Ratios	
ER max d	12.86
r_c / TW	
TW / Lf_w	
TW/max d	8.0
TW/mean d	11.0

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.001	0.07	YES	YES	YES	YES
V_* (m s^{-1})	0.038	D_{50}	0.001	0.09	YES	YES	YES	YES
		D_{84}	0.002	0.14	YES	YES	YES	YES

Section Data

ER_e (m)	0.44	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.50	3.50
Lf_e (m)	-0.300	Lf stations L / R	0.45	2.75	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.44	1.00	
E_g (m m^{-1})	0.0024				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	207.1	181.2	145.0
B3	0.0016	0.0024	saltation	YES	YES	YES
C3	0.0001	0.0015	rolling	YES	YES	YES
C4	0.0051	0.0096	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.04	0.04	0.05	0.06
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.03	0.03	0.04	0.05	0.06
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.607	Q (cms)	
V (m s^{-1})	0.55	V (m s^{-1})	
n	0.040	n	
Fr	0.31	*Fr*	
D_c rectangular (m)	0.15	D_c rectangular (m)	
D_c trapezoidal (m)	0.25	D_c trapezoidal (m)	
D_c triangular (m)	0.38	D_c triangular (m)	
D_c parabolic (m)	0.22	D_c parabolic (m)	
D_c mean (m)	0.25	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	14.27	Ω (watts m^{-1})	
ω_a (watts m^{-2})	3.83	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.10	ω_a/TW (watts m^{-1})	
*Re**	0.1	*Re**	
Re	143023	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	0.72		
τ_{calc} (N m^{-2})	7.03		
τ D_{crit} (gr-co) (mm)	7.25		
D_{50} V_c (vcs +) (m s^{-1})	0.03	0.08	
D_{84} V_c (vcs +) (m s^{-1})	0.03	0.09	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
100.0	0.0	0.0	0.0	0.0

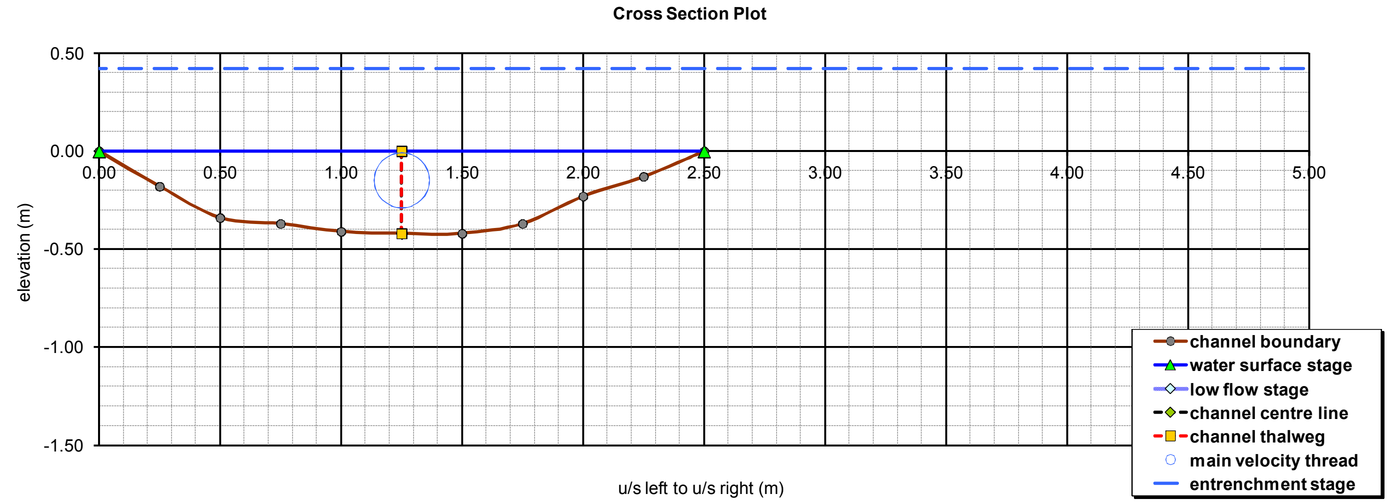
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

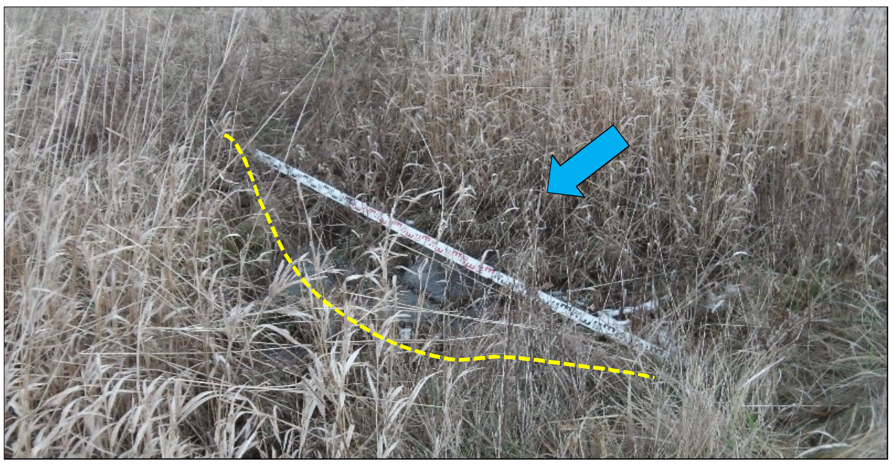
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

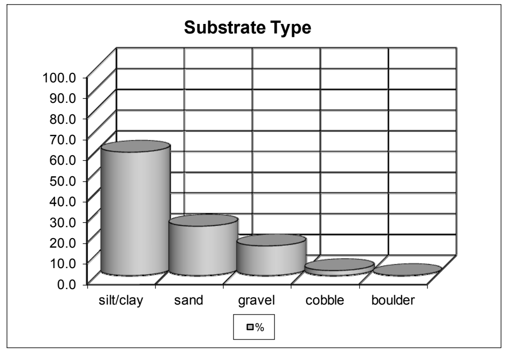
AquaLogic

B. de Geus 05.11

Project: Erosion Threshold Analysis
Township of Ramara Master Stormwater Management Plan
Donnelly Drain, Catchment 213 - Section 1







Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.72
R (m)	0.27
TW (m)	2.50
WP (m)	2.70
max d (m)	0.42
mean d (m)	0.29
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	88.50
ff V mean/V*	9.37
ff D_{84}	14.12
ff mean	11.74
SMOOTH BED	

Hydraulic Ratios	
ER max d	18.00
r_c / TW	
TW / Lf_w	
TW/max d	6.0
TW/mean d	8.7

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.002	0.11	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.046	D_{50}	0.003	0.16	YES	YES	YES	YES
		D_{84}	0.247	13.21	NO	NO	NO	NO

Section Data					
ER_e (m)	0.42	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.50	2.50
Lf_e (m)	-0.420	Lf stations L / R	1.25	1.25	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
$\underline{z}$		T_e (m) $T_{o/s}$ (m)	-0.42	1.25	
E_g ($m\ m^{-1}$)	0.0039				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	209.2	174.3	3.5
B3	0.0014	0.0019	saltation	YES	YES	YES
C3	0.0000	0.0003	rolling	YES	YES	YES
C4	0.0039	0.0066	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.05	0.06	3.00	80.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)	0.03	0.05	0.06	2.91	77.60
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	1.04		
τ_{calc} ($N\ m^{-2}$)	10.15		
τ D_{crit} (gr-co) (mm)	10.46		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.04	0.12	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.27	0.82	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
59.5	23.8	14.3	2.4	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.335	Q (cms)	
V ($m\ s^{-1}$)	0.47	V ($m\ s^{-1}$)	
n	0.055	n	
Fr	0.28	*Fr*	
D_c rectangular (m)	0.12	D_c rectangular (m)	
D_c trapezoidal (m)	0.20	D_c trapezoidal (m)	
D_c triangular (m)	0.30	D_c triangular (m)	
D_c parabolic (m)	0.17	D_c parabolic (m)	
D_c mean (m)	0.20	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	12.81	Ω (watts m^{-1})	
ω_a (watts m^{-2})	4.74	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.90	ω_a/TW (watts m^{-1})	
*Re**	0.1	*Re**	
Re	108748	*Re*	
turbulence	LOW	turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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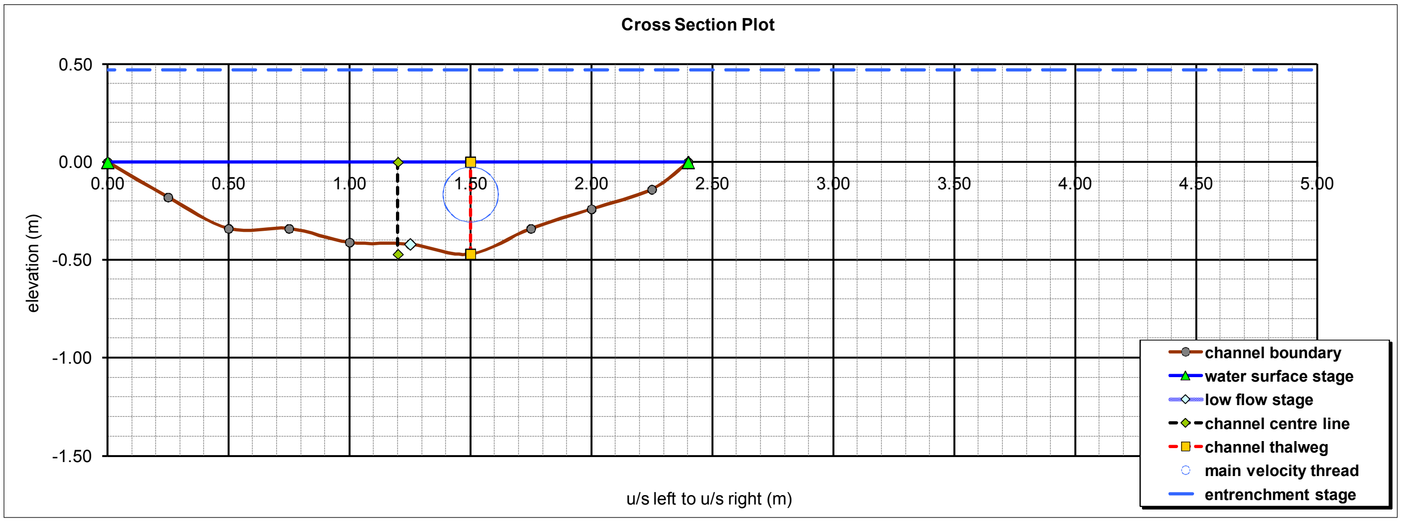
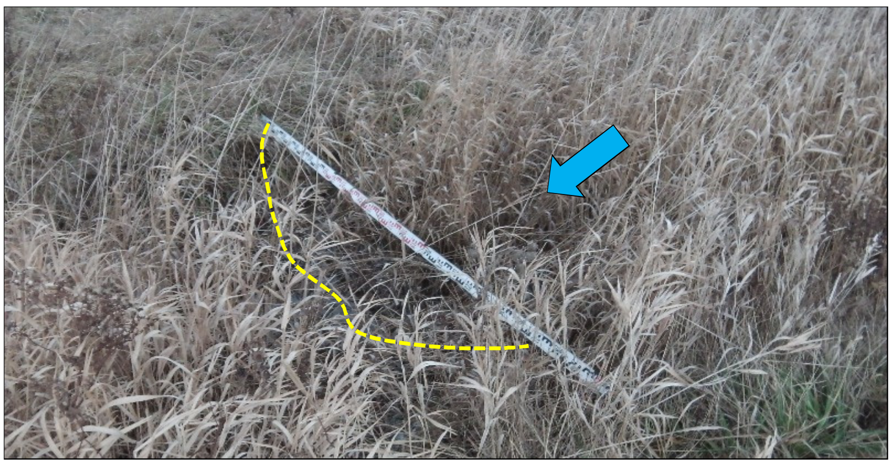
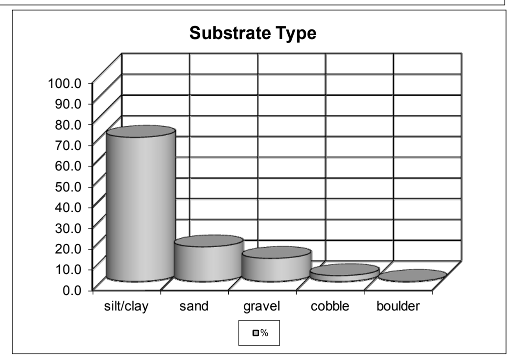
Project: Erosion Threshold Analysis
Township of Ramara Master Stormwater Management Plan
Donnelly Drain, Catchment 213 - Section 2







Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.71
R (m)	0.27
TW (m)	2.40
WP (m)	2.65
max d (m)	0.47
mean d (m)	0.30
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	134.78
ff V mean/V*	9.88
ff D_{84}	15.21
ff mean	12.54
SMOOTH BED	

Hydraulic Ratios	
ER max d	18.75
r_c / TW	
TW / Lf_w	
TW/max d	5.1
TW/mean d	8.1

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.002	0.11	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.046	D_{50}	0.003	0.16	YES	YES	YES	YES
		D_{84}	0.196	10.44	NO	NO	NO	NO

Section Data

ER_e (m)	0.47	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.40	2.40
Lf_e (m)	-0.420	Lf stations L / R	1.25	1.25	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.47	1.50	
E_g ($m\ m^{-1}$)	0.0039				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})	T_*	D_{30}	D_{50}	D_{84}
				212.4	177.0	5.3
B3	0.0014	0.0020	saltation	YES	YES	YES
C3	0.0000	0.0004	rolling	YES	YES	YES
C4	0.0039	0.0068	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.05	0.06	2.00	70.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)	0.03	0.05	0.06	1.94	67.90
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.336	Q (cms)	
V ($m\ s^{-1}$)	0.47	V ($m\ s^{-1}$)	
n	0.055	n	
Fr	0.28	*Fr*	
D_c rectangular (m)	0.13	D_c rectangular (m)	
D_c trapezoidal (m)	0.20	D_c trapezoidal (m)	
D_c triangular (m)	0.30	D_c triangular (m)	
D_c parabolic (m)	0.17	D_c parabolic (m)	
D_c mean (m)	0.20	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	12.86	Ω (watts m^{-1})	
ω_a (watts m^{-2})	4.86	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	2.02	ω_a/TW (watts m^{-1})	
*Re**	0.1	*Re**	
Re	111543	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	1.05		
τ_{calc} ($N\ m^{-2}$)	10.30		
τ D_{crit} (gr-co) (mm)	10.62		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.04	0.11	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.22	0.66	

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

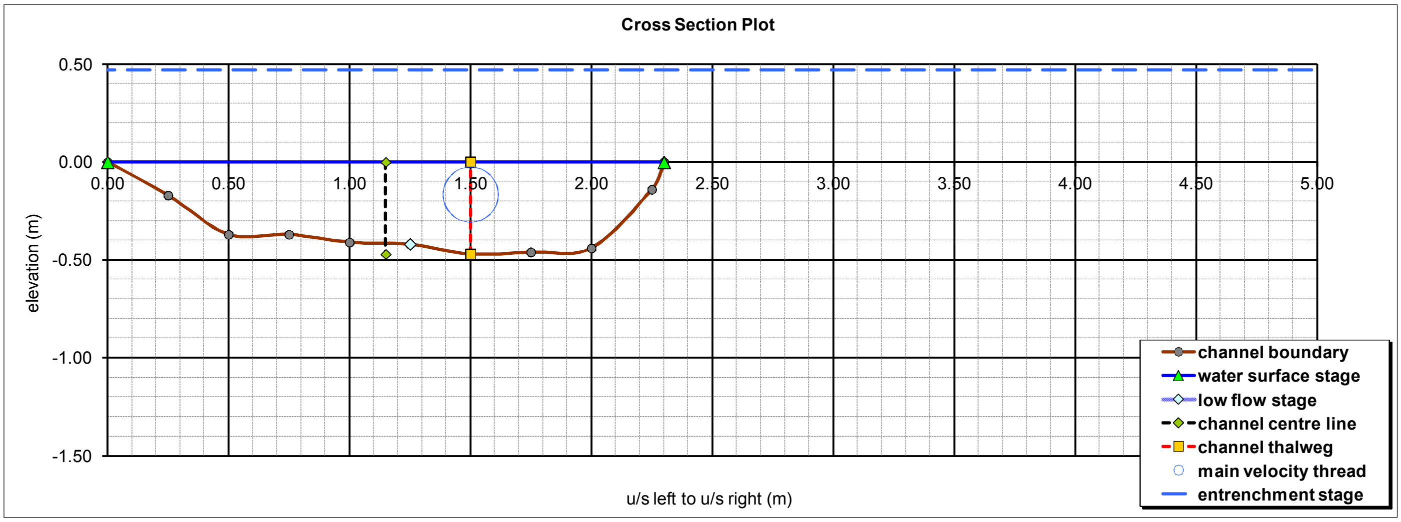
Substrate Type (%)

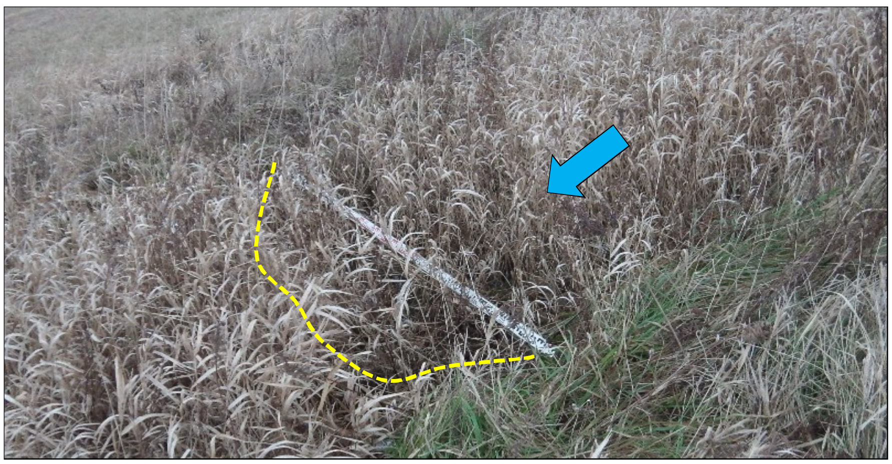
silt/clay	sand	gravel	cobble	boulder
69.4	16.7	11.1	2.8	0.0

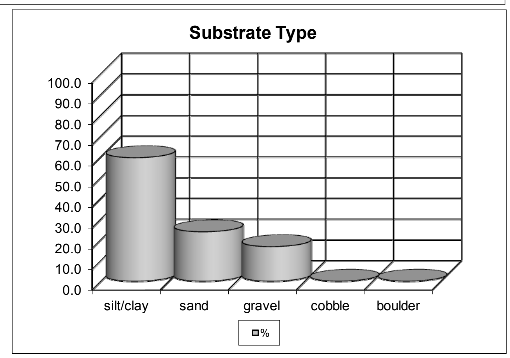
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis
Township of Ramara Master Stormwater Management Plan
Donnelly Drain, Catchment 213 - Section 3

B. de Geus 05.11







Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.80
R (m)	0.30
TW (m)	2.30
WP (m)	2.67
max d (m)	0.47
mean d (m)	0.35
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	149.48
ff V mean/V*	10.05
ff D_{84}	15.60
ff mean	12.82
SMOOTH BED	

Hydraulic Ratios	
ER max d	19.57
r_c / TW	
TW / Lf_w	
TW/max d	4.9
TW/mean d	6.6

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.002	0.13	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.041	D_{50}	0.003	0.18	YES	YES	YES	YES
		D_{84}	0.196	11.70	NO	NO	NO	NO

Section Data

ER_e (m)	0.47	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.30	2.30
Lf_e (m)	-0.420	Lf stations L / R	1.25	1.25	
W_{fp} (m)	45.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.47	1.50	
E_g ($m\ m^{-1}$)	0.0028				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	169.1	140.9	4.2
B3	0.0014	0.0020	saltation	YES	YES	YES
C3	0.0000	0.0004	rolling	YES	YES	YES
C4	0.0039	0.0068	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.05	0.06	2.00	6.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)	0.03	0.05	0.06	1.94	5.82
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.342	Q (cms)	
V ($m\ s^{-1}$)	0.43	V ($m\ s^{-1}$)	
n	0.055	n	
Fr	0.23	*Fr*	
D_c rectangular (m)	0.13	D_c rectangular (m)	
D_c trapezoidal (m)	0.20	D_c trapezoidal (m)	
D_c triangular (m)	0.31	D_c triangular (m)	
D_c parabolic (m)	0.16	D_c parabolic (m)	
D_c mean (m)	0.20	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	9.39	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	3.51	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	1.53	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.1	*Re**	
Re	112349	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.84		
τ_{calc} ($N\ m^{-2}$)	8.20		
$\tau\ D_{crit}$ (gr-co) (mm)	8.46		
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.04	0.13	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.22	0.73	

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

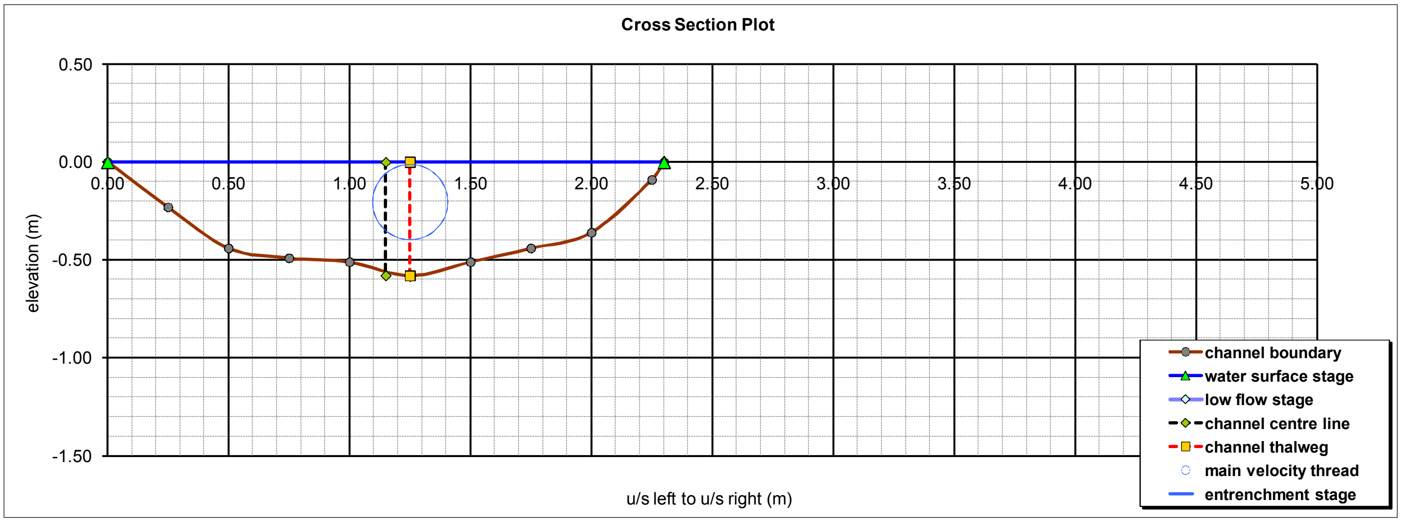
Substrate Type (%)

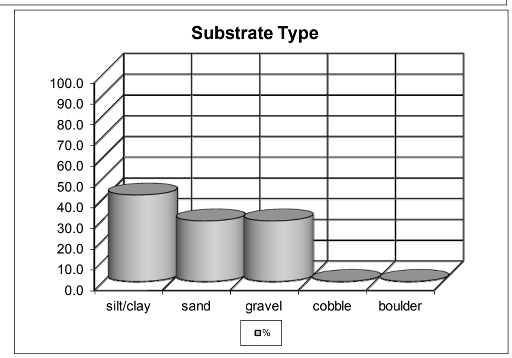
silt/clay	sand	gravel	cobble	boulder
59.5	23.8	16.7	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Township of Ramara Master Stormwater Management Plan
McNab Drain, Catchment 216 - Section 1





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.90
R (m)	0.34
TW (m)	2.30
WP (m)	2.68
max d (m)	0.58
mean d (m)	0.39
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	37.40
ff V mean/V*	8.46
ff D_{84}	12.18
ff mean	10.32
SMOOTH BED	

Hydraulic Ratios	
ER max d	19.57
r_c / TW	
TW / Lf_w	
TW/max d	4.0
TW/mean d	5.9

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.002	0.12	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.042	D_{50}	0.008	0.44	YES	YES	YES	YES
		D_{84}	0.438	25.51	NO	NO	NO	NO

Section Data

ER_e (m)	0.58	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.30	2.30
Lf_e (m)	-0.580	Lf stations L / R	1.25	1.25	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.58	1.25	
E_g ($m\ m^{-1}$)	0.0026				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})	T_*	D_{30}	D_{50}	D_{84}
				176.8	88.4	1.0
B3	0.0015	0.0019	saltation	YES	YES	NO
C3	0.0001	0.0003	rolling	YES	YES	NO
C4	0.0042	0.0065	Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.05	0.10	9.00	50.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)	0.03	0.05	0.10	8.73	48.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.404	Q (cms)	
V ($m\ s^{-1}$)	0.45	V ($m\ s^{-1}$)	
n	0.055	n	
Fr	0.23	*Fr*	
D_c rectangular (m)	0.15	D_c rectangular (m)	
D_c trapezoidal (m)	0.22	D_c trapezoidal (m)	
D_c triangular (m)	0.33	D_c triangular (m)	
D_c parabolic (m)	0.17	D_c parabolic (m)	
D_c mean (m)	0.22	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	10.29	Ω (watts m^{-1})	
ω_a (watts m^{-2})	3.83	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.67	ω_a/TW (watts m^{-1})	
*Re**	0.2	*Re**	
Re	131976	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.88		
τ_{calc} ($N\ m^{-2}$)	8.58		
$\tau\ D_{crit}$ (gr-co) (mm)	8.84		
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.05	0.16	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.47	1.49	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
41.7	29.2	29.2	0.0	0.0

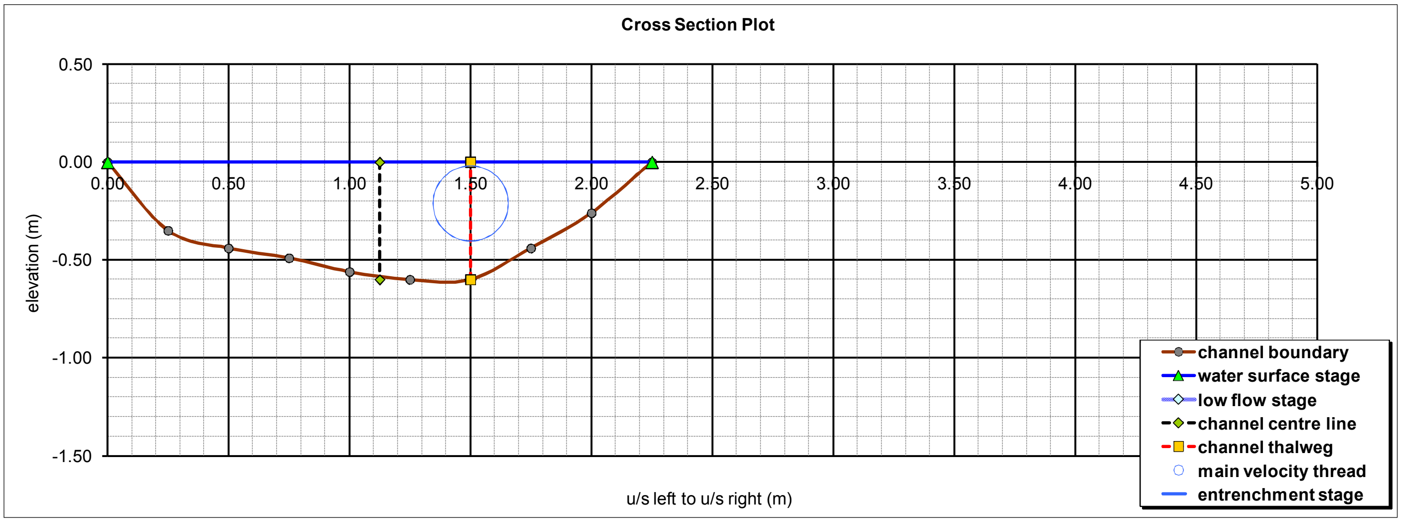
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

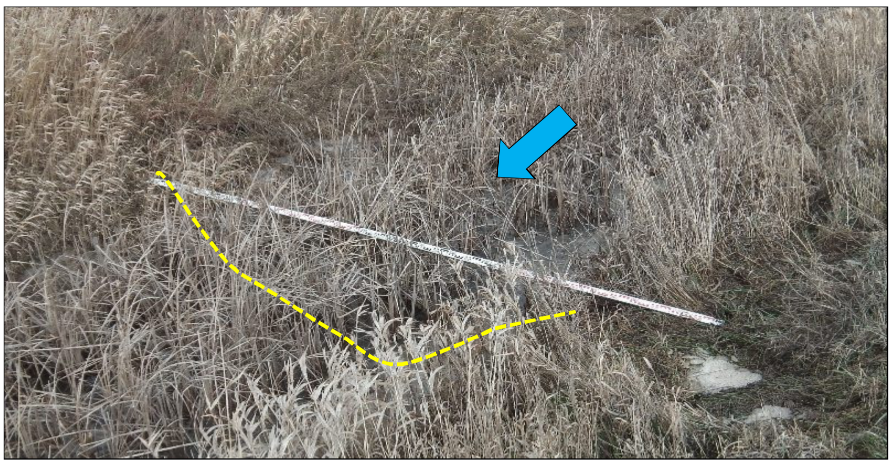
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

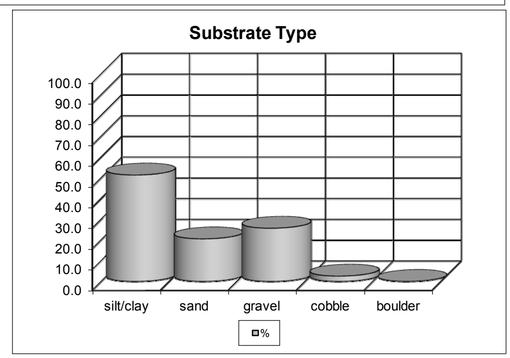
Project: **Erosion Threshold Analysis**
Township of Ramara Master Stormwater Management Plan
McNab Drain, Catchment 216 - Section 2

AquaLogic

B. de Geus 05.11







Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.94
R (m)	0.35
TW (m)	2.25
WP (m)	2.68
max d (m)	0.60
mean d (m)	0.42
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	34.90
ff V mean/V*	8.40
ff D_{84}	12.06
ff mean	10.23
SMOOTH BED	

Hydraulic Ratios	
ER max d	20.00
r_c / TW	
TW / Lf_w	
TW/max d	3.8
TW/mean d	5.4

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.002	0.13	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.040	D_{50}	0.003	0.18	YES	YES	YES	YES
		D_{84}	0.462	28.11	NO	NO	NO	NO

Section Data					
ER_e (m)	0.60	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.25	2.25
Lf_e (m)	-0.600	Lf stations L / R	1.50	1.50	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) / $T_{o/s}$ (m)	-0.60	1.50	
E_g ($m\ m^{-1}$)	0.0023				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	162.2	135.2	0.8
B3	0.0015	0.0019	saltation	YES	YES	NO
C3	0.0001	0.0003	rolling	YES	YES	NO
C4	0.0042	0.0065	Ø	NO	NO	YES

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.05	0.06	10.00	70.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)	0.03	0.05	0.06	9.70	67.90
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.403	Q (cms)	
V ($m\ s^{-1}$)	0.43	V ($m\ s^{-1}$)	
n	0.055	n	
Fr	0.21	*Fr*	
D_c rectangular (m)	0.15	D_c rectangular (m)	
D_c trapezoidal (m)	0.22	D_c trapezoidal (m)	
D_c triangular (m)	0.33	D_c triangular (m)	
D_c parabolic (m)	0.17	D_c parabolic (m)	
D_c mean (m)	0.22	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	9.08	Ω (watts m^{-1})	
ω_a (watts m^{-2})	3.39	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.51	ω_a/TW (watts m^{-1})	
*Re**	0.1	*Re**	
Re	131856	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	0.80		
τ_{calc} (N m^{-2})	7.87		
τ D_{crit} (gr-co) (mm)	8.11		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.04	0.13	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.49	1.63	

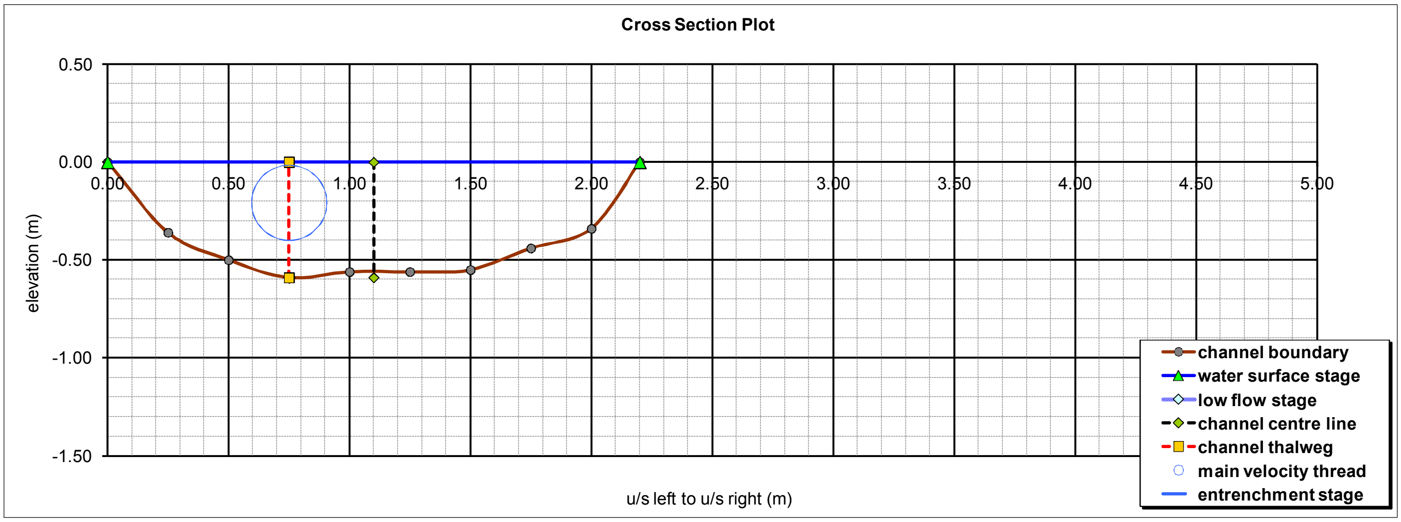
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

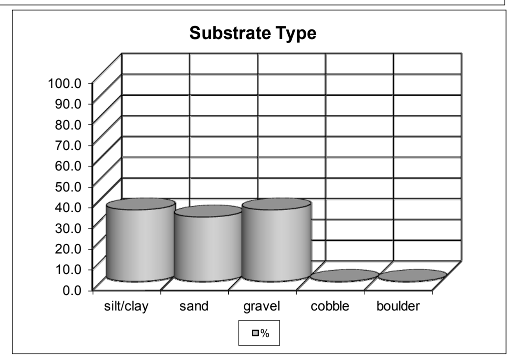
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
51.3	20.5	25.6	2.6	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis
Township of Ramara Master Stormwater Management Plan
McNab Drain, Catchment 216 - Section 3

B. de Geus 05.11





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.97
R (m)	0.36
TW (m)	2.20
WP (m)	2.68
max d (m)	0.59
mean d (m)	0.44
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	36.07
ff V mean/V*	8.46
ff D_{84}	12.19
ff mean	10.33
SMOOTH BED	

Hydraulic Ratios	
ER max d	20.45
r_c / TW	
TW / Lf_w	
TW/max d	3.7
TW/mean d	5.0

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.003	0.19	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.038	D_{50}	0.071	4.56	NO	NO	NO	YES
		D_{84}	0.462	29.65	NO	NO	NO	NO

Section Data

ER_e (m)	0.59	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.20	2.20
Lf_e (m)	-0.590	Lf stations L / R	0.75	0.75	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.59	0.75	
E_g ($m\ m^{-1}$)	0.0020				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})	T_*	D_{30}	D_{50}	D_{84}
				121.5	14.6	0.7
B3	0.0015	0.0019	saltation	YES	YES	NO
C3	0.0000	0.0003	rolling	YES	YES	NO
C4	0.0042	0.0064	Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.06	0.50	10.00	25.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)	0.03	0.06	0.49	9.70	24.25
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.397	Q (cms)	
V ($m\ s^{-1}$)	0.41	V ($m\ s^{-1}$)	
n	0.055	n	
Fr	0.20	*Fr*	
D_c rectangular (m)	0.15	D_c rectangular (m)	
D_c trapezoidal (m)	0.21	D_c trapezoidal (m)	
D_c triangular (m)	0.32	D_c triangular (m)	
D_c parabolic (m)	0.17	D_c parabolic (m)	
D_c mean (m)	0.21	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	7.78	Ω (watts m^{-1})	
ω_a (watts m^{-2})	2.90	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.32	ω_a/TW (watts m^{-1})	
*Re**	1.1	*Re**	
Re	129933	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	0.72		
τ_{calc} (N m^{-2})	7.07		
τ D_{crit} (gr-co) (mm)	7.29		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.38	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.49	1.71	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
34.5	31.0	34.5	0.0	0.0

GEO-VEG v.1.2 Vegetation-Hydroperiod Erosion Risk Model

AquaLogic

B. de Geus 08.11

Project:	**Erosion Threshold Analysis**
	Township of Ramara Master Stormwater Management Plan
	Lake Simcoe Tributary, Catchment 205
	TEST for HIGH DENSITY VEGETATION

RETURN EVENT MODELING

i) $T_a = 148.97V^{-4.091}$

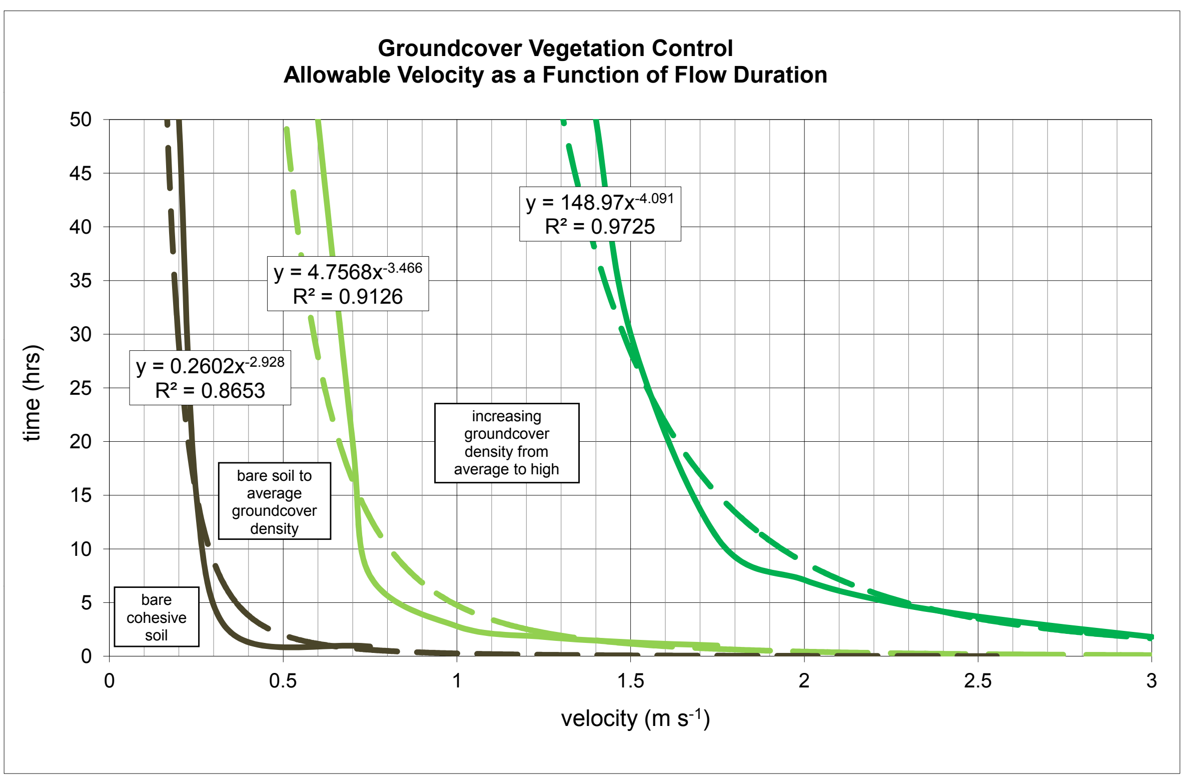
	25mm	2yr	5yr	10yr	25yr	50yr	100yr	diff %
max flow Q ($m^3\ s^{-1}$)	0.20	0.42	0.80					
*max velocity V ($m\ s^{-1}$)	0.39	0.50	0.59					
existing event duration T_e (hrs)	5.60	5.90	6.30					
proposed event duration T_p (hrs)	101.00	104.50	106.70					
i) allowable event duration T_a (hrs)	7015.4	2538.7	1289.9					
number of events N_e	300	50	25					
total time existing T_{te} (hrs)	1680.00	295.00	157.50					
total time proposed T_{tp} (hrs)	30300.00	5225.00	2667.50					
$T_e < T_a$ (yes/no)	yes	yes	yes					
$T_p < T_a$ (yes/no)	yes	yes	yes					
total time existing over threshold OT_{te}	0.00	0.00	0.00					
total time proposed over threshold OT_{tp}	0.00	0.00	0.00					
time % existing over 100yrs	0.0000	0.0000	0.0000					
time % proposed over 100yrs	0.0000	0.0000	0.0000					

CONTINUOS MODELING

i) $T_a = 148.97V^{-4.091}$

	step 1	step 2	step 3	step 4	step 5	step 6	step 7
flow range Q ($m^3\ s^{-1}$)							
*max velocity V ($m\ s^{-1}$)							
total time existing T_{te} (hrs)							
total time proposed T_{tp} (hrs)							
i) allowable event duration T_a (hrs)							
existing number events N_e							
proposed number events N_p							
existing mean event time T_{te}/N_e (hrs)							
proposed mean event time T_{tp}/N_p (hrs)							
$T_{te}/N_e < T_a$ (yes/no)							
$T_{tp}/N_p < T_a$ (yes/no)							

*note: max velocity represents the velocity at the next highest flow step to balance the rising and falling velocity range



GEO-VEG v.1.2 Vegetation-Hydroperiod Erosion Risk Model

B. de Geus 08.11

Project:	**Erosion Threshold Analysis**
	Township of Ramara Master Stormwater Management Plan
	Lake Simcoe Tributary, Catchment 207
	TEST for AVERAGE DENSITY VEGETATION

RETURN EVENT MODELING

i) $T_a = 4.7568V^{-3.4664}$

	25mm	2yr	5yr	10yr	25yr	50yr	100yr
max flow Q ($m^3\ s^{-1}$)	0.05	0.12	0.26		0.55		
max velocity V ($m\ s^{-1}$)	0.24	0.33	0.41		0.53		
existing event duration T_e (hrs)	7.10	7.80	8.50		9.20		
proposed event duration T_p (hrs)	35.60	43.20	100.50		104.30		
i) allowable event duration T_a (hrs)	669.5	222.0	104.6		43.0		
number of events N_e	300	50	25		4		
total time existing T_{te} (hrs)	2130.00	390.00	212.50		36.80		
total time proposed T_{tp} (hrs)	10680.00	2160.00	2512.50		417.20		
$T_e < T_a$ (yes/no)	yes	yes	yes		yes		
$T_p < T_a$ (yes/no)	yes	yes	yes		no		
total time existing over threshold OT_{te}	0.00	0.00	0.00		0.00		
total time proposed over threshold OT_{tp}	0.00	0.00	0.00		245.35		
time % existing over 100yrs	0.0000	0.0000	0.0000		0.0000		
time % proposed over 100yrs	0.0000	0.0000	0.0000		0.0003		

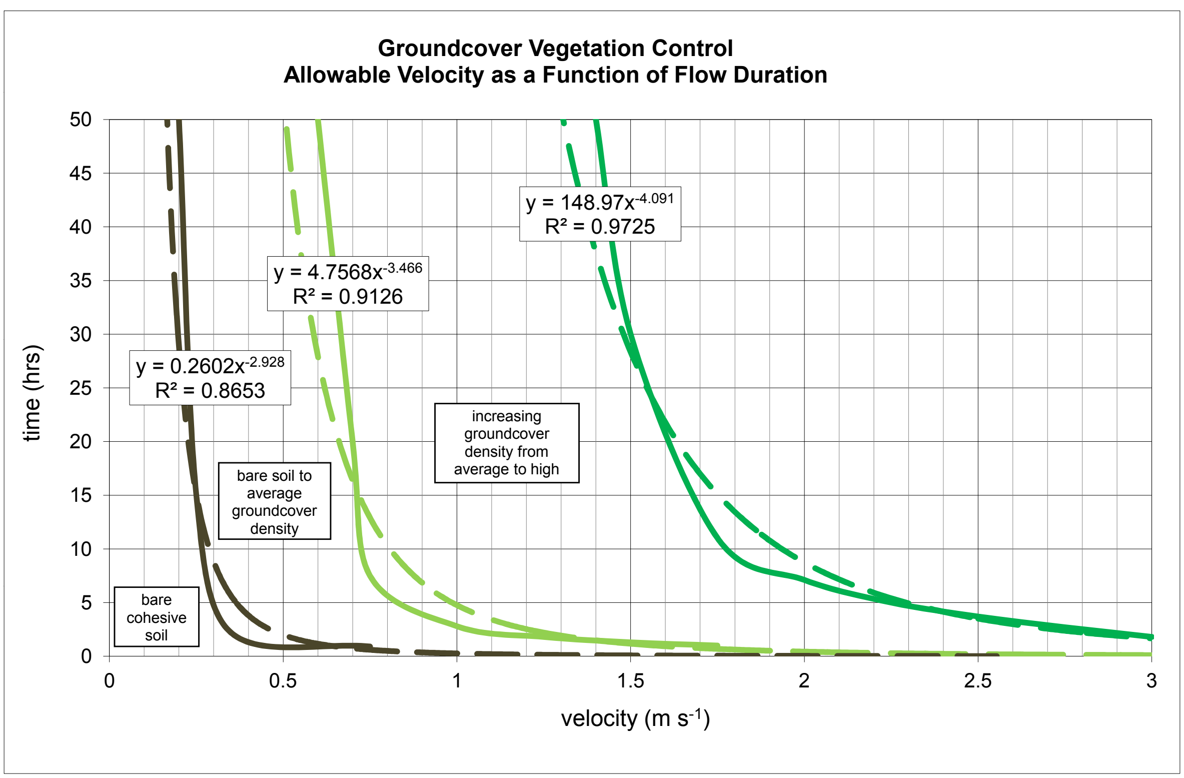
diff %

CONTINUOS MODELING

i) $T_a = 4.7568V^{-3.4664}$

	step 1	step 2	step 3	step 4	step 5	step 6	step 7
flow range Q ($m^3\ s^{-1}$)							
*max velocity V ($m\ s^{-1}$)							
total time existing T_{te} (hrs)							
total time proposed T_{tp} (hrs)							
i) allowable event duration T_a (hrs)							
existing number events N_e							
proposed number events N_p							
existing mean event time T_{te}/N_e (hrs)							
proposed mean event time T_{tp}/N_p (hrs)							
$T_{te}/N_e < T_a$ (yes/no)							
$T_{tp}/N_p < T_a$ (yes/no)							

*note: max velocity represents the velocity at the next highest flow step to balance the rising and falling velocity range



GEO-VEG v.1.2 Vegetation-Hydroperiod Erosion Risk Model

B. de Geus 08.11

Project:	**Erosion Threshold Analysis**
	Township of Ramara Master Stormwater Management Plan
	Donnelly Drain, Catchment 213
	TEST for HIGH DENSITY VEGETATION

RETURN EVENT MODELING

i) $T_a = 148.97V^{-4.091}$

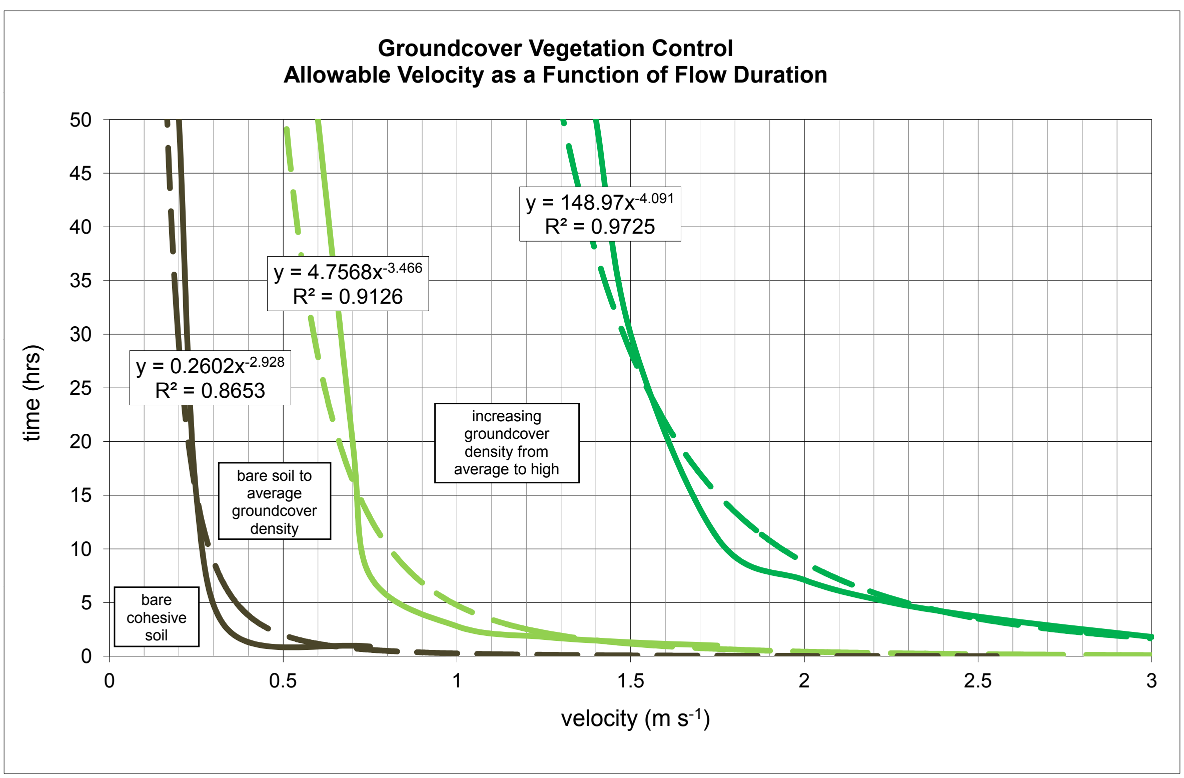
	25mm	2yr	5yr	10yr	25yr	50yr	100yr	
max flow Q ($m^3 s^{-1}$)	0.16	0.33						
*max velocity V ($m s^{-1}$)	0.38	0.47						
existing event duration T_e (hrs)	7.40	8.10						
proposed event duration T_p (hrs)	46.50	105.90						
i) allowable event duration T_a (hrs)	7802.0	3270.0						
number of events N_e	300	50						
total time existing T_{te} (hrs)	2220.00	405.00						
total time proposed T_{tp} (hrs)	13950.00	5295.00						
$T_e < T_a$ (yes/no)	yes	yes						
$T_p < T_a$ (yes/no)	yes	yes						
total time existing over threshold OT_{te}	0.00	0.00						
total time proposed over threshold OT_{tp}	0.00	0.00						
time % existing over 100yrs	0.0000	0.0000						
time % proposed over 100yrs	0.0000	0.0000						
							diff %	

CONTINUOS MODELING

i) $T_a = 148.97V^{-4.091}$

	step 1	step 2	step 3	step 4	step 5	step 6	step 7
flow range Q ($m^3 s^{-1}$)							
*max velocity V ($m s^{-1}$)							
total time existing T_{te} (hrs)							
total time proposed T_{tp} (hrs)							
i) allowable event duration T_a (hrs)							
existing number events N_e							
proposed number events N_p							
existing mean event time T_{te}/N_e (hrs)							
proposed mean event time T_{tp}/N_p (hrs)							
$T_{te}/N_e < T_a$ (yes/no)							
$T_{tp}/N_p < T_a$ (yes/no)							

*note: max velocity represents the velocity at the next highest flow step to balance the rising and falling velocity range



GEO-VEG v.1.2 Vegetation-Hydroperiod Erosion Risk Model

AquaLogic

B. de Geus 08.11

Project:	**Erosion Threshold Analysis**
	Township of Ramara Master Stormwater Management Plan
	McNab Drain, Catchment 216
	TEST for HIGH DENSITY VEGETATION

RETURN EVENT MODELING

i) $T_a = 148.97V^{-4.091}$

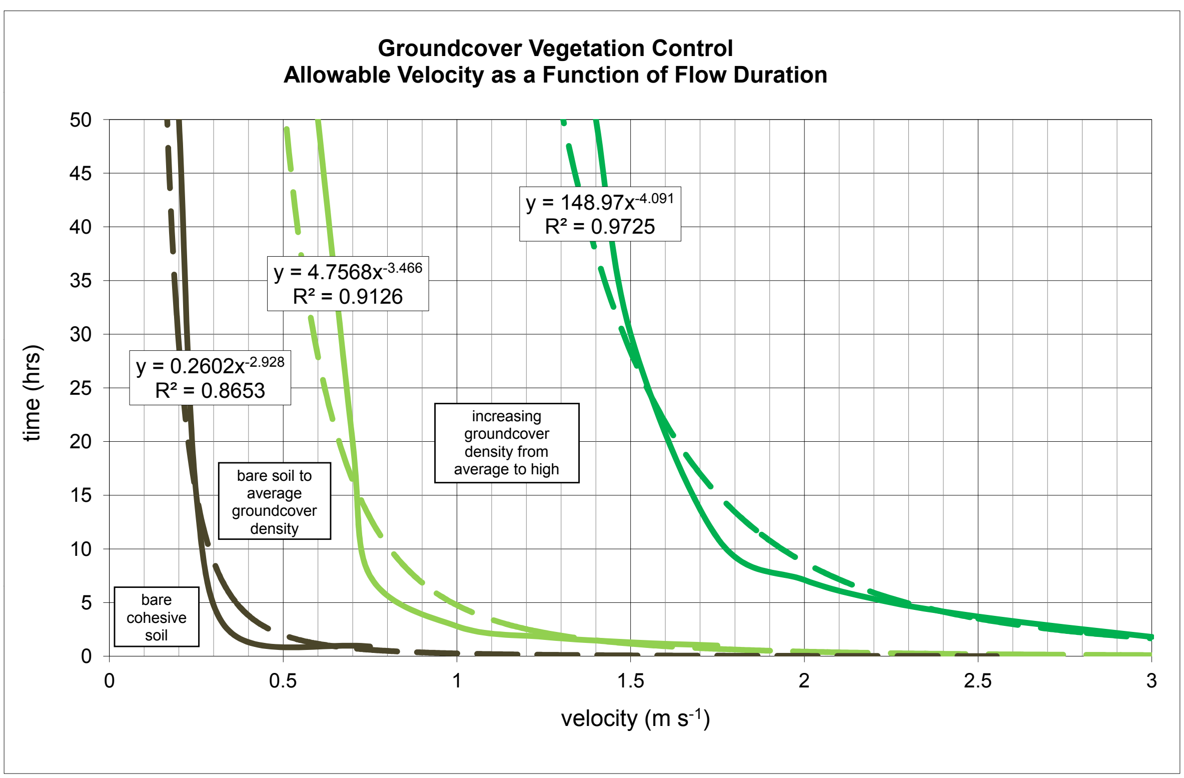
	25mm	2yr	5yr	10yr	25yr	50yr	100yr	
max flow Q ($m^3\ s^{-1}$)	0.11	0.23	0.42					
*max velocity V ($m\ s^{-1}$)	0.30	0.38	0.45					
existing event duration T_e (hrs)	4.20	4.60	4.90					
proposed event duration T_p (hrs)	78.10	79.90	80.80					
i) allowable event duration T_a (hrs)	20520.9	7802.0	3906.7					
number of events N_e	300	50	25					
total time existing T_{te} (hrs)	1260.00	230.00	122.50					
total time proposed T_{tp} (hrs)	23430.00	3995.00	2020.00					
$T_e < T_a$ (yes/no)	yes	yes	yes					
$T_p < T_a$ (yes/no)	yes	yes	yes					
total time existing over threshold OT_{te}	0.00	0.00	0.00					
total time proposed over threshold OT_{tp}	0.00	0.00	0.00					
time % existing over 100yrs	0.0000	0.0000	0.0000					
time % proposed over 100yrs	0.0000	0.0000	0.0000					
							diff %	

CONTINUOS MODELING

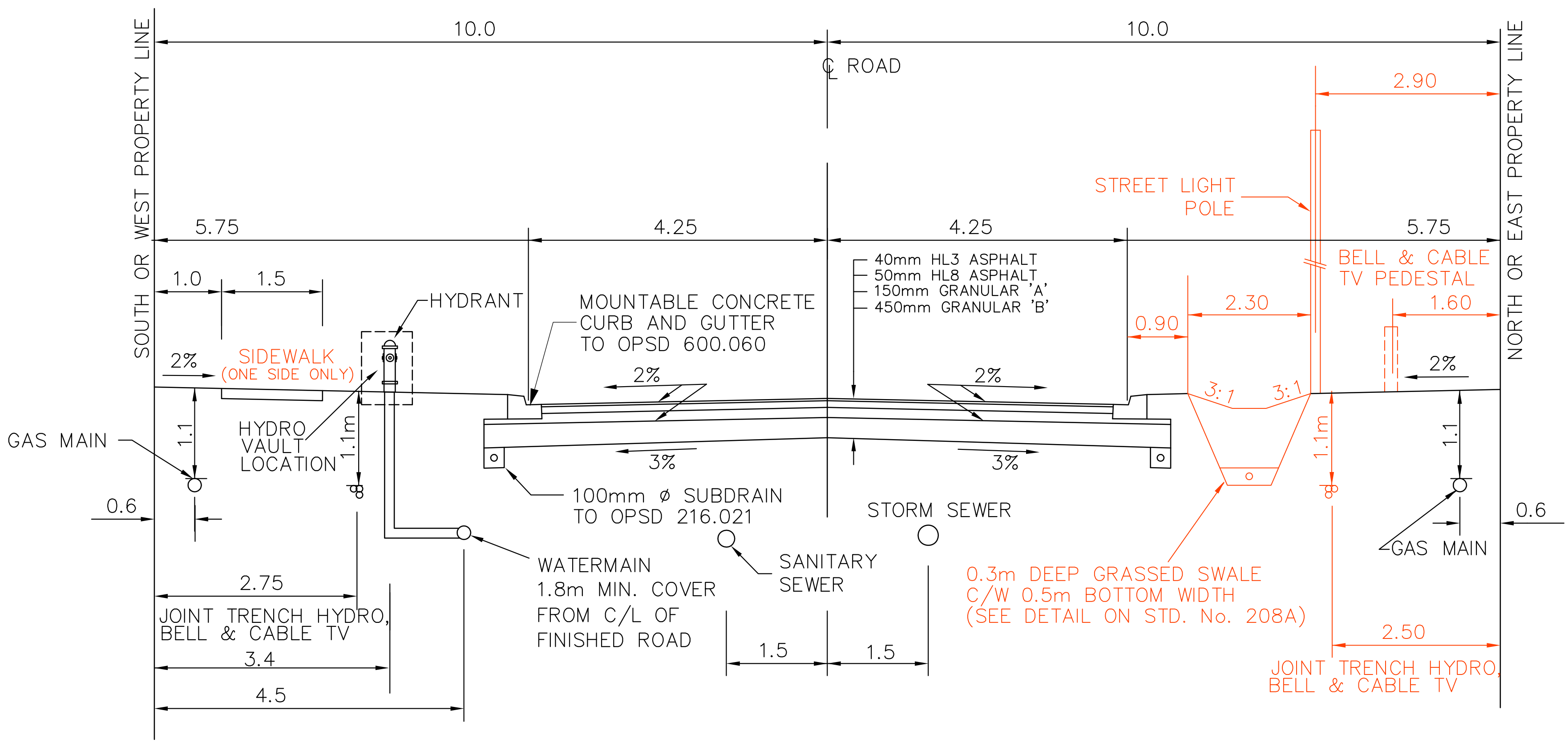
i) $T_a = 148.97V^{-4.091}$

	step 1	step 2	step 3	step 4	step 5	step 6	step 7
flow range Q ($m^3\ s^{-1}$)							
*max velocity V ($m\ s^{-1}$)							
total time existing T_{te} (hrs)							
total time proposed T_{tp} (hrs)							
i) allowable event duration T_a (hrs)							
existing number events N_e							
proposed number events N_p							
existing mean event time T_{te}/N_e (hrs)							
proposed mean event time T_{tp}/N_p (hrs)							
$T_{te}/N_e < T_a$ (yes/no)							
$T_{tp}/N_p < T_a$ (yes/no)							

*note: max velocity represents the velocity at the next highest flow step to balance the rising and falling velocity range



APPENDIX G:
LID URBAN ROAD CROSS SECTION



NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE SHOWN.
2. MINIMUM PAVEMENT AND ROAD STRUCTURE DESIGN AS PER TOWNSHIP DESIGN CRITERIA OR AS PER GEOTECHNICAL INVESTIGATION RECOMMENDATION.
3. ALL SERVICE LOCATIONS SHOWN ARE FOR GUIDELINE PURPOSES ONLY AND MAY DEVIATE AS PER THE DIRECTION OF THE TOWNSHIP WHEN STANDARD LOCATION CANNOT BE ACHIEVED.
4. WHERE ONE SIDEWALK IS CONSTRUCTED IT SHALL BE ON THE NORTH AND EAST SIDE OF THE ROAD.
5. TREES TO BE PLACED IN LOCATIONS AS PER APPROVED LANDSCAPE PLAN.

NO.	REVISION	APR'D	DATE

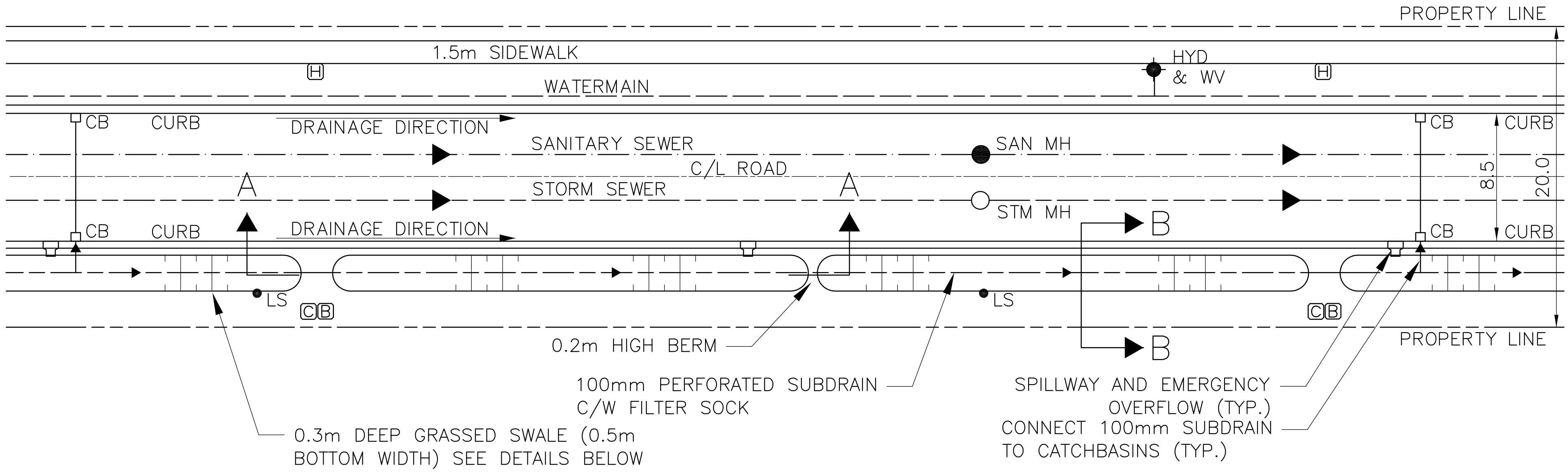
TOWNSHIP OF RAMARA

URBAN – LOW IMPACT DEVELOPMENT

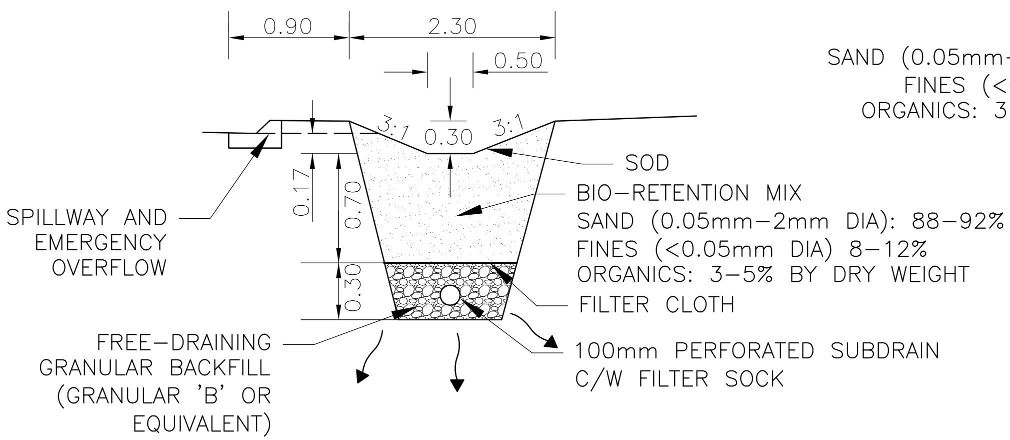
20.0m ROAD ALLOWANCE
8.5m ASPHALT SURFACE

APR'D:		DATE:	NOV/06
DRAWN:		SCALE:	NTS
STD. No.	208R		

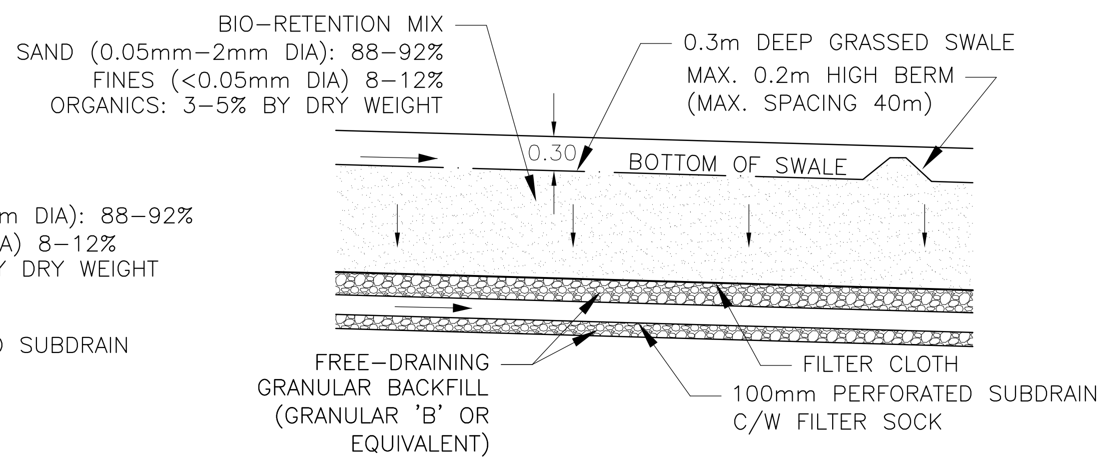
PLAN VIEW



SECTION B–B



SECTION A–A



NO.	REVISION	APR'D	DATE

TOWNSHIP OF RAMARA

URBAN – LOW IMPACT DEVELOPMENT

20.0m ROAD ALLOWANCE
8.5m ASPHALT SURFACE

APR'D:	DATE: MAR/14
DRAWN:	SCALE: NTS
STD. No. 208A	