Central Lake Ontario Conservation

Technical Guidelines for Stormwater Management Submissions

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APPENDICES

1.0 INTRODUCTION

Standards established by individual municipalities, or within watershed/subwatershed studies have priority over CLOCA Submission Guidelines contained in this document.

Technical reports are to be prepared in such a manner that the entire work can be recreated by any qualified person without the need to refer to any other material. Further, any qualified person must be able to recognize and understand all of the methods, approaches, basic data, and rationale used in the calculations.

With the exception of copy written or proprietary models, equations should be given for all provided calculations. Model input and output files are to be provided in paper and digital form. All formulas and values used by the program must be clearly identified on the hard copy. Calculations are to be provided in hard copy.

CLOCA must be circulated a complete set of drawings outlining all of the proposed works. Final engineering plans and drawings must be signed and sealed by a Professional Engineer registered with the Professional Engineers of Ontario. A complete stormwater management Report will include, at a minimum, all items listed in the SWM checklist. The SWM Checklist is included in Appendix A. Should the submission not contain all the required items CLOCA reserves the right to return the submission until all items are present.

2.0 STORMWATER MANAGEMENT

CLOCA's expectations for all stormwater management submissions are outlined in the following sections, which include a description of CLOCA policies, guidance on approved methods and techniques, a summary of key hydrologic parameters, and a summary of submission requirements.

CLOCA encourages innovative green technologies in stormwater management and is willing to work with proponents wishing to explore green options. Interested proponents are encouraged to visit the Sustainable Technologies Evaluation Program (STEP) website, http://www.sustainabletechnologies.ca/.

2.1 Stormwater Management Requirements

All submissions shall identify and meet the requirements of the appropriate Watershed Management Plans and Watershed Studies. The Watershed Criteria including a listing of the Management Plans and Studies is shown in Appendix B. In addition, all submissions shall meet the requirements of the March 2003, Ministry of the Environment's Stormwater Management Planning and Design Manual.

2.1.1 Stormwater Quantity Control

Every effort should be made to maintain existing watershed boundaries and drainage patterns. Pre-consultation will be mandatory for any proposed shift in drainage boundaries.

Unless specified otherwise by the municipality, subwatershed study, or fluvial geomorphic analysis, post development peak flow rates must not exceed corresponding pre-development rates for the 1:2 year through 1:100 year design storm events. If noted in a subwatershed study, the Regional Storm must be controlled to predevelopment levels.

If there is a known deficiency in the down stream conveyance, quantity control must be provided (ie private property, undersized pipes).

Quantity control facilities are to be designed in accordance with recommendations set out in the MOE's "Stormwater Management Planning and Design Manual," (2003) and the Watershed Criteria in Appendix B.

Upon completion of construction, as built surveys including all control elevations, manhole inverts, orifice inverts, catchbasin inverts, catchbasin rim elevations, outfall, overland flow route, overflow weir, sediment bay/forebay berm elevations, pipe sizes, pipe lengths and pipe grades, will be required by CLOCA. In addition CLOCA requires the receipt of Design Engineer signoff verifying that all orifice plates and/or restricting devices have been installed as specified.

Parking Lot Storage and Rooftop Storage

CLOCA does not encourage the use of rooftop and parking lot storage for stormwater management because of the potential for flood damages and because the continual functioning of such devices cannot be guaranteed. Through normal operating conditions, parking lot and rooftop storage expose the site owner, Municipality, and Conservation Authority to potential liability for property damage. Additional liability may be incurred should the site owner remove control structures, which could cause flooding and erosion problems downstream. Refer to Section 2.2 Stormwater Management Facilities and Natural Hazards Requirements for requirements of working within the floodplain.

Typically, design ponding values do not accurately represent anticipated ponding depths or flooding frequencies, as the design does not consider impacts of partially blocked grates and outlets, or localized rainfall patterns such as short duration, intense rainfall bursts typical of summer thunderstorms. Since vehicles may be flooded, with water entering the passenger compartment at depths of less than 0.30m, the use of parking lot storage represents a significant liability risk. Similarly, the retention of stormwater on rooftops increases the potential for property damage.

The developer must be aware of the potential liabilities associated with parking lot and rooftop controls, and that CLOCA or Municipality will not be liable for any damages related to the installation, operation, modification or removal of proposed parking lot or rooftop controls.

Specific Design Requirements for Parking Lot Storage

- The maximum allowable ponding depth within the parking lot is to be limited to 0.3m or in accordance with Municipal standards.
- The maximum ponding extent, elevation and storage volume must be provided at each ponding location and must be shown on the design drawings.
- An emergency overflow system must be provided to allow all runoff exceeding the 100 year storage to be safely routed from the site to a suitable outlet.
- Orifice / pipe restrictions, inverts and design flows must be shown on the design drawings.

Specific Design Requirements for Rooftop Storage

Where rooftop controls are used, design submissions must indicate:

- the type of control to be installed (i.e., product name and manufacturer);
- the number and placement of proposed drains and weirs;
- product specifications showing design release rates for each structure;
- the maximum ponding depth, drawdown time and detained volume at each structure; and
- the total release rate and detained volume for the roof.
- Wherever possible, tamper-proof structures are to be selected.
- An emergency weir overflow or scuppers should be provided at the maximum design water elevation. Splash pads or erosion protection must also be indicated.

2.1.2 Stormwater Quality Control

Best management practices must be applied to all development in order to provide water quality treatment as per the MOE's "Stormwater Management Planning and Design Manual" (March 2003). The level of treatment required for each watershed within CLOCA is stated in Appendix B. Quality control must be provided for every site that is greater than 0.25 hectares.

Thermal quality control is vitally important for cool and cold water receiving systems. Stormwater management measures must be provided to prevent discharge of warm urban drainage.

Oil and Grit separators (OGS) will not provide effective removal of nutrients, but may be used as a pre treatment system, or as a water quality control system for small projects or infill development. OGS's may be used to achieve enhanced quality control provided they are sized in accordance with the recommendations set out by both the MOE Manual and Manufacturer. Such systems should be used with the incorporation of other quality control measures, such as naturalized buffers, grassed swales, etc. All OGSs specified must have been tested using CLOCA soils distribution outlined in the OGS study by CLOCA, 2006. Refer to Appendix E for CLOCA Oil Grit Separator Study.

A separate maintenance manual must be provided and approved, to highlight standard operating conditions and maintenance schedule and guide the site owner through recommended maintenance requirements for all aspects of the stormwater management system.

2.1.3 Stream Erosion Control

Watershed studies should be referenced for specific stormwater management requirements to protect against stream erosion. In the absence of watershed studies, the erosion requirements from the MOE Stormwater Management Practices Planning and Design Manual 2003, will be applied, requiring the 25 mm 4 hr Chicago storm be stored and released over a 24 to 48 hour period.

2.1.4 Overland Flow Routing

The developer must demonstrate that all major overland flow routes are sized for the regulatory storm event (the greater of the 1:100 year design storm or Hurricane Hazel) from the site to the creek.

Other than flow routing within site plan development, all major overland flow routes are to be secured by the (through ownership or easement) governing municipality.

2.2 Stormwater Management Facilities and Natural Hazards Requirements

The Stormwater Management Facilities must be located outside of the Regional or 1:100 year flood plain where quantity control features are proposed and outside of the 25 year floodplain where facilities are proposed for water quality only. The facility outlet for a quality control facility must be located above the 2 year floodplain elevation. If the facility location is proposed within the floodplain, the proponent should pre-consult with CLOCA staff to determine the acceptability of the location, and any other required design constraints. Facilities will not be accepted beyond valley top of bank if there are geotechnical concerns or where natural heritage features would be impacted.

All stormwater management facilities must include a maintenance access, erosion protection, a geotechnical report supporting the facilities design and detailed drawings. The drawings must show the maintenance access, erosion protection, outlet details and at least one cross section through the facility.

While development is generally not permitted within the floodplain, please note that all lots should be dry flood-proofed to the regulatory storm elevation. Should dry-flood-proofing of the entire lot not be viable, pre-consultation with CLOCA is required. CLOCA's Regulation 42/06 mapping is included in Appendix F.

Natural Hazard guidelines are in place to prevent/ minimize negative impacts to private, public and natural systems. There are several components (Limits) that comprise the Natural Hazards. Should the proposed development contain any of the components below, they must be identified.

- Riverine Hazard Limit
  - Flooding
    - All development should be located outside the regulatory floodlimit, with structure openings located 0.3 metres above the flood level.
    - In some instances, CLOCA will consider balanced cut and fill in the floodplain. In these instances, it must be shown that:
      - no flood storage will be lost (cut/fill balance calculations at every 0.3m stage)
      - no increase in flood levels (hydraulic assessment)
      - no loss of significant natural heritage features
  - Erosion
    - Confined Riverine Systems
    - Unconfined Riverine Systems
- Shoreline Hazard Limit
  - Flooding
  - Erosion
  - Bluffs
  - Beaches

The MNR has three documents that should be consulted for further information:

- River and Stream Systems Flooding Hazard Limit Technical Guide,
- River and Stream Systems Erosion Hazard Limit Technical Guide, and
- Hazardous Sites Technical Guide.

These documents are available on a CD entitled Adaptive Management of Stream Corridors in Ontario, published by the Watershed Science Centre, Trent University.

2.3 Riparian Rights

It is the developer's responsibility to demonstrate safe conveyance of the Regulatory Storm (the greater of the 1:100 year design storm or Hurricane Hazel) through the development site to a sufficient outlet, such that no adverse impacts will be incurred on up and downstream landowners. A sufficient outlet typically constitutes a permanently flowing watercourse or lake. A public right of way may also provide sufficient outlet. In the case of privately owned land, the proponent must obtain a legal right of discharge registered on title. Legal documentation, such as right of discharge, and/or written permission to discharge into a public right of way must be provided with the design submission.

2.4 Water Balance / Groundwater

In some areas significant amounts of precipitation are naturally intercepted and absorbed by the ground. These areas indicate high infiltration and the potential for high groundwater infiltration (GWI). In areas of high groundwater infiltration special measures need to be taken to ensure the balance between surface water and groundwater is maintained. A draft study titled Water Budget Study of the Watersheds in the CLOCA Area was prepared for CLOCA, by EarthFx Inc, in 2007. This study examined the relationship between surface water and groundwater through the preparation and execution of a surface water and groundwater numerical model. As a result of this study, areas were predicted that may have a higher than average infiltration potential (>148mm/year), based on the CLOCA average. A draft map showing the identified areas is included in Appendix H. Should a proposed development site contain any area identified as having higher than average infiltration potential, as per the attached map, a water budget will be required as a component of the stormwater management submission.

A water balance assessment should be completed as per the MOE's "Stormwater Management Planning and Design Manual" (March 2003). Every attempt should be made to match post development infiltration volumes to pre development levels on an annual basis. Infiltration targets may be achieved through the incorporation of a variety of best management practices including: reduced lot grading, roof leaders discharging to ponding areas or soak away pits, infiltration trenches, grassed swales/enhanced grassed swales, and pervious pipe and catch basin systems.

2.5 Erosion and Sediment Control

An erosion and sediment control section plan must be included with the submission. Erosion and sediment control for the site should be in accordance with The Erosion and Sediment Control Guidelines for Urban Construction, 2006 (All products specified in this document may be an approved equivalent). The Erosion and Sediment Control Guidelines for Urban Construction, 2006 was developed by the Sustainable Technologies Evaluation Program (STEP) and can be downloaded from their web site (http://www.sustainabletechnologies.ca/). All erosion and sedimentation controls must be shown on a separate design drawing. The erosion and sedimentation control plan must include the details for topsoil stripping including the location of topsoil stock piles and measures to prevent the movement of sediments off site.

3.0 TECHNICAL METHODS AND APPROACHES

3.1 Subcatchment Delineation – Internal & External Drainage Areas

Provide internal and external drainage boundaries for pre and post development conditions based on field reconnaissance supplemented through the use of topographic maps and aerial photo interpretation.

Sources must be provided for all topographic information used in the analysis. Reference information should include the: map title, author, publisher, scale, publishing date and flown date, or surveyor name and survey date.

Watershed points of interest must be included in the discretization scheme (ie ponds, road crossings, railways).

CLOCA's watershed boundaries and subwatershed boundaries, as developed in CLOCA hydrologic models, shall be provided in PDF format upon request.

3.2 Modeling

3.2.1 Hydrology Modeling

Stormwater runoff calculations for the site must be provided. The preferred runoff model is Visual Otthymo 2. Other models will be considered upon consultation. For small sites, less than five (5) hectares, manual calculations will be accepted such as the Modified Rational Method. All input parameters shall be provided on paper and their sources cited. All models shall be submitted in both digital and hard copy format, including input and output files.

Modeling should be completed using the most current version of the computer software. Proponents wishing to use outdated programs should contact CLOCA and relevant municipalities to obtain approval.

3.2.2. Hydraulic Modeling

If the site is within the regulation limits and may impact the floodline, hydraulic modeling must be provided. The preferred hydraulic model is the U.S. Army Corps of Engineers Hec-RAS. New models will only be accepted in the most recent Hec-RAS software.

3.2.3 Precipitation

Hydrologic modeling should follow Watershed Plan recommendations when selecting storm distributions. The distributions selected in the watershed Plan model should be used for modeling site developments. Additionally, the 1 hour AES and the 24 hour SCS Type II design storm distributions should be modeled to demonstrate peak flow control and calculate required storage volumes. Rainfall amounts should be based on the IDF curves for the precipitation station outlined in the municipality's SWM standards. In the absence of a municipal standard, CLOCA will accept IDF curves based on the Toronto Bloor Street Station 1990 data or later. IDF Curves for this station can be purchased from Atmospheric Canada. The time vs. intensity data for the 1 hour AES and the 24 hour SCS storms are provided in Appendix C, this information shall be used as a read storm in Visual Otthymo 2.

3.2.4 Hydrograph Computation

Sources for all values/approaches must be provided for the selection / calculation of Curve Numbers, Runoff Coefficients, Initial Abstraction, Time of Concentration, Overland Flow Lengths, Manning Roughness Coefficients, Infiltration Rates, Orifice Coefficients, and Weir Coefficients. Typical values/sources are provided in Appendix D.

Hydrograph time of concentration should be calculated based on the Airport Method for catchments with a runoff coefficient less than 0.40, or the Bransby-Williams Equation for catchments with a runoff coefficient greater than 0.40 (based on the weighted catchment C). Other time of concentration formulas may be accepted with the supporting information.

Time to Peak should be calculated as $tp = 0.67\ tc$, where tc is Time of Concentration.
The number of linear reservoirs for the NASHYD command shall equal 3 unless calibration results indicate otherwise.

Where runoff coefficients have been calculated for a development area, these values should be used to calculate the total imperviousness for the catchment. Impervious areas shall be determined by sampling a representative area in each sub-catchment.

All hydrologic parameters must be compared to the Master Drainage Plans to ensure compliance.

A table must provided that compares the pre development peak flows to the post development uncontrolled and controlled peak flows at key nodes.

3.2.5 Channel Routing

Sufficient channel routing should be incorporated into the hydrologic model.

Rating curves and travel times used in channel routing shall be determined by preliminary hydraulic calculations of the backwater profile or by procedures available in the approved hydrologic model, and shall be included on paper with the submission.

Hydrographs should be combined before being routed through watercourse reaches.

Cross-sections required for the hydrologic model routing procedure must be obtained from 1:2,000 topographic mapping, or from field surveys. Cross-sections shall be extended sufficiently to ensure that the flows do not exceed the range of the travel timetable.

The routing computation time step must be relative to the smallest channel section, and at a maximum equal to the hydrograph time step.

Selected Manning's roughness parameters must be in accordance with the values/approaches set out in Appendix D.

3.2.6 Reservoir Routing

When calculating orifice discharge, the available head in the orifice equation shall be the greater of the centroid of the orifice or downstream ponding elevation including depth of flow in the discharge pipe or channel.

Where routing is applied, the technical report should discuss the method of routing used and assumptions made in determining routed flows.

A stage – storage – discharge table must be included and contain the elevations of the outlet and emergency spillway. A schematic diagram showing the location of the outlet and other facility features is recommended.

Ponds that are designed to provide both quality and quantity control must have stacking storage. The quantity control storage begins above the quality requirements for extended detention.

APPENDIX A
STORMWATER MANAGEMENT CHECKLIST

GENERAL

Site Description

Location – nearest roads, watershed & subwatershed
Existing Conditions – land use on site & surrounding areas
Proposed Conditions
Drainage Area – for the site, tributary & watershed
Watercourses, Wetlands - present on site, and type (permanent or intermittent)
Drainage patterns and ultimate drainage location/outfall

Background Information

Previous Reports and Relevant SWM Requirements
Existing Models
Geotechnical Report

Figures

- ☐ Location Plan
- ☐ Pre Development Drainage Area Plan
- ☐ Post Development Drainage Area Plan
- ☐ Proposed SWMF locations
- ☐ Proposed Site Plan – grading and servicing
- ☐ Erosion and Sediment Control Plan

QUALITY CONTROL

- ☐ Level of Protection
- ☐ Drainage Area to Facility (ha)
- ☐ Percentage Impervious – total and directly connected
- ☐ SWM Facility Monitoring and Maintenance Requirements
- ☐ Facility Type:

A) OGS

- ☐ Approved Manufacturer
- ☐ Model Number
- ☐ Sizing Calculations Included
- ☐ TSS Removal (%)
- ☐ Annual Runoff Treated (%)

B) Extended Detention Wet Ponds

- ☐ Permanent Pool Storage Requirements (m^3/ha)
- ☐ Permanent Pool Storage Requirements (m^3)
- ☐ Permanent Pool Volume Provided (m^3)
- ☐ Extended Detention Storage Requirements (m^3/ha)
- ☐ Extended Detention Storage Requirements (m^3)
- ☐ Extended Detention Volume Provided (m^3)
- ☐ 0.3m of free board
- ☐ Outlet Design
- ☐ Permanent Pool Depth (m)
- ☐ Extended Detention Depth (m)
- ☐ Planting Plan
- ☐ Side Slopes above Permanent Pool
- ☐ Side Slopes below Permanent Pool
- ☐ Drawdown time (hrs)
- ☐ Length to Width Ratio
- ☐ Forebay Depth
- ☐ Forebay % of Total Facility Area
- ☐ Emergency Overflow Weir Design
- ☐ Capacity of Overflow Weir
- ☐ Design of Overflow Weir

C) Wetland

- ☐ Permanent Pool Storage Requirements (m^3/ha)
- ☐ Permanent Pool Storage Requirements (m^3)
- ☐ Permanent Pool Volume Provided (m^3)
- ☐ Extended Detention Storage Requirements (m^3/ha)
- ☐ Extended Detention Storage Requirements (m^3)
- ☐ Extended Detention Volume Provided (m^3)
- ☐ 0.3m of free board
- ☐ Outlet Design
- ☐ Drawdown time (hrs)
- ☐ Permanent Pool Depth (m)
- ☐ Extended Detention Depth (m)
- ☐ Planting Plan
- ☐ Side Slopes above Permanent Pool
- ☐ Side Slopes below Permanent Pool
- ☐ Length to Width Ratio

D) Hybrid Wet Pond / Wetland

- ☐ Permanent Pool Storage Requirements (m^3/ha)
- ☐ Permanent Pool Storage Requirements (m^3)
- ☐ Permanent Pool Volume Provided (m^3)
- ☐ Extended Detention Storage Requirements (m^3/ha)
- ☐ Extended Detention Storage Requirements (m^3)
- ☐ Extended Detention Volume Provided (m^3)
- ☐ 0.3m of free board
- ☐ Outlet Design
- ☐ Drawdown time (hrs)
- ☐ Permanent Pool Depth (m)
- ☐ Extended Detention Depth (m)
- ☐ Planting Plan
- ☐ Side Slopes above Permanent Pool
- ☐ Side Slopes below Permanent Pool
- ☐ Length to Width Ratio

QUANTITY CONTROL

- ☐ Required if *no continue to next section*
- ☐ Requirements:
- ☐ Runoff Coefficient:
- ☐ Pre Development Peak Flow (m^3/s)
- ☐ Post Development Uncontrolled Peak Flow (m^3/s)
- ☐ Post Development Controlled Peak Flow (m^3/s)
- ☐ SWMF Type
- ☐ Stage – Storage – Discharge
- ☐ Outlet design
- ☐ Total Storage Required (m^3)
- ☐ Total Storage Provided (m^3)

HAZARD LAND MANAGEMENT

- ☐ Flood lines shown on plans
- ☐ Valley top of bank, stream erosion, and steep slope allowances assessed (confined stream systems only
- ☐ Meander belt defined (in confined stream systems only)

HYDROGEOLOGY

- ☐ Soils / Hydrogeology Report
- ☐ Groundwater Elevations
- ☐ Pre & Post Development Water Budget
- ☐ Special Construction Considerations and Recharge Measures

CONSTRUCTION SEDIMENT CONTROL

- ☐ Sediment Control Plan
- ☐ Sizing of Sediment Basins and details
- ☐ Rock check dam locations and details
- ☐ Silt fence location and details
- ☐ Outlet location
- ☐ Sequencing and Maintenance/Inspection schedule

HYDROLOGIC ANALYSIS

- ☐ Digital Hydrology Model and associated rainfall input
- ☐ Schematic representation of pre and post development hydrologic models
- ☐ Hydrology Summary Output for pre and post development conditions
- ☐ Hydrology Detailed Output for one scenario

HYDRAULIC ANALYSIS

- ☐ Digital Hydraulics Model
- ☐ Text describing all of the geometry and flow option included with the model
- ☐ Text describing any changes that have been made to a CLOCA supplied model
- ☐ Drawing showing the location of all sections in relation to the subject property
- ☐ Hydraulics Summary Output Table – Section Number, Flow, Water Surface Elevation

OTHER

- ☐ All engineering drawings must be included
- ☐ Rainfall Data
- ☐ Storm sewer design sheets
- ☐ Storm sewer design drainage plan, showing areas and runoff coefficients
- ☐ All reports and plans signed and sealed

APPENDIX B
WATERSHED CRITERIA

Stormwater Criteria for CLOCA's Watersheds

Watershed	Master Plans	Hydrology	Floodplain Mapping	Water Quantity	Water Balance	Stream Erosion
Lynde Creek	Lynde Creek Water Resource Management Strategy (Gartner Lee 1994) Brooklin Master Drainage Plan Cosburn Patterson Wardman (1992) Town of Whitby Stormwater Quality and Erosion Control Enhancement Study (MMM 2001) Lynde Creek Sub Tributary MDP, Sernas, 2001 Town of Whitby Official Plan/Taunton North Community Secondary Plan, The Town of Whitby	Lynde Creek Hydrologic Model (VO2), CLOCA, 2008 12 Hour Chicago Distribution (2-100 Yr)	Lynde Creek Floodplain Mapping (HEC-RAS), Earth Tech, 2008	See Brooklin MDP for Brooklin area According to the Lynde Creek Water Resources Management Strategy, Figure 14, Quantity Control is only required on the Kinsale Branch, between Rossland Rd and the confluence with the Main branch (Except in Brooklin, refer to Brooklin MDP)	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans
Oshawa Creek (Including Goodman Creek)	Oshawa Creek Watershed Management Plan (CLOCA 2002) Oshawa Creek Watershed Study (TSH 1995) Stormwater Management Plan Champlain East Sector, Sernas 1997 Goodman Creek Stormwater Management Study, Dillon, 1983 Northwood Industrial Park Stormwater Management & Servicing Study Aquafor Beech, 2004	VO2 models for existing and future conditions 2 -100 year storms (4 hr Chicago Storm and Regional) (CLOCA 2002)	Oshawa Creek Floodplain Original (TSH 1993) digitized mapping and digital Hec2 files Oshawa Creek Floodplain Mapping in Whitby (CLOCA 2007) digital mapping and Hec-RAS Two Zone Floodplain Study for Goodman Creek (King Street, East of Stephenson Rd) Rand 1997 Two Zone Flood Plan Study for Goodman and Oshawa Creeks Immediately Upstream of the St. Lawrence and Hudson Railway Oshawa Creek Floodplain Original (Greck 2006)	Quantity Control (2-100 and Regional Storm) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans

Stormwater Criteria for CLOCA's Watersheds

Watershed	Master Plans	Hydrology	Floodplain Mapping	Water Quantity	Water Balance	Stream Erosion
Bowmanville Creek	North West Bowmanville Master Drainage Study (Sernas, 1989) North Bowmanville Stormwater Management Project (Sernas 1991) North West Bowmanville Master Drainage Study, Update for Jackman Creek Tributary (Sernas, 1996) Brookhill Subwatershed Study (Aquafor Beech, 1995)	Bowmanville & Soper Creeks Hydrologic Model (VO2), CLOCA, 2008 12 Hour Chicago Distribution (2-100 Yr)	Bowmanville & Soper Creeks Floodplain Mapping (HEC-RAS), Aquafor Beech, 2009	Quantity Control (2-100 and Regional Storm) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans For Brookhill Distributed Runoff Control Required
Soper Creek	North Glen Community Master Drainage Plan North East Bowmanvill Stormwater Management Report (Sernas 1991) Master Drainage Plan for West Branch of Soper Creek, Marshall Macklin & Monaghan 1991	Bowmanville & Soper Creeks Hydrologic Model (VO2), CLOCA, 2008 12 Hour Chicago Distribution (2-100 Yr)	Bowmanville & Soper Creeks Floodplain Mapping (HEC-RAS), Aquafor Beech, 2009	Quantity Control (2-100 and Regional Storm) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans

Stormwater Criteria for CLOCA's Watersheds

Watershed	Master Plans	Hydrology	Floodplain Mapping	Water Quantity	Water Balance	Stream Erosion
Black, Harmony, Farewell Creeks	Black Creek Master Drainage Study, Sernas, 1991 Courtice Stormwater Management Study, TSH, 1991 East Macourtice Tributary of Black Creek Master Drainage Plan Sernas, 1991 Macourtice Stormwater managment Plan, Sernas, 2003 Municipal Servicing Report Courtice North, Sernas 1996 Courtice Community Centre Stormwater Drainage & Erosion Harmony Creek Subwatershed Study, Aquafor Beech, 2000 Taunton Community Stormwater Master Plan, Sernas, 1997 Harmony Creek Watershed Study, TSH, 1990 Harmony Creek Branch 1 Stormwater Detention Study, TSH, 1983 Erosion Control & Bank Stabilization Simcoe Engineering, 1978 Harmony Creek Watershed Stormwater Management Study, TSH, 1990 Environmental Impact Statement Courtice North, Ecoplans, 1996	Black, Harmony and Farewell Creeks Hydrologic Model (VO2), CLOCA, 2009 12 Hour Chicago Distribution (2-100 Yr)	Black, Harmony and Farewell Creeks Floodplain Mapping (HEC-RAS), Aquafor Beech, 2010	Quantity Control (2-100 and Regional Storm) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites
Westside Creek	Master Drainage Plan, Westside Creek Sernas, 1992 Addendums 1-3?		Darlington - Westside Spill South of 401, CLOCA, 1997 Whitby - Bowmanville Floodplain Mapping, Dillon Consulting, 1974 Westside Creek Floodplain Mapping, GM Sernas, 1992	Quantity Control (2-100 and Regional Storm) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans

Stormwater Criteria for CLOCA's Watersheds

Watershed	Master Plans	Hydrology	Floodplain Mapping	Water Quantity	Water Balance	Stream Erosion
Pringle Creek	Pringle Creek Master Drainage Plan Update, Dillon, 1999 Discussion of Permanent Stormwater Quality Control for Taunton, Sernas, 1995 Whitby Stormwater Management Study Dillon Consulting, 1982 Town of Whitby Official Plan/Taunton North Community Secondary Plan, The Town of Whitby	Pringle Creek Master Drainage Plan Update, Dillon, 1999 12 Hour Chicago Distribution (2-100 Yr)	Pringle Creek Master Drainage Plan Update Study, Dillon Consulting, 1999 Ash Creek Diversion to Pringle Creek, Sernas, 1972	Quantity Control (2-100) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans
Tooley Creek		Tooley Creek Hydrologic Model (VO2), CLOCA, 2007 12 Hour Chicago Distribution (2-100 Yr)	Tooley Creek Floodplain Mapping (HEC-RAS), CLOCA, 2007	Quantity Control (2-100 and Regional Storm) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans
Darlington Creek		Darlington Creek Hydrologic Model (VO2), CLOCA, 2008 12 Hour Chicago Distribution (2-100 Yr)	Darlington Creek Floodplain Mapping (HEC-RAS), CLOCA, 2008	Quantity Control (2-100) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans
Corbett Creek	Whitby Stormwater Management Study Dillon Consulting, 1982 East Corbett Creek Study	4 Hour Chicago Distribution (2-100 Yr)	Corbett Creek Floodplain Mapping Greck & Associates, 2006	Quantity Control (2-100 and Regional Storm) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans
Robinson Creek	Robinson Creek Master Drainage Plan, Sernas, 1993	Robinson Creek Hydrologic Model (VO2), CLOCA, 2009 12 Hour Chicago Distribution (2-100 Yr)	Robinson Creek Floodplain Mapping (HEC-RAS), CLOCA, 2010	Quantity Control (2-100 and Regional Storm) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans
Bennett Creek			Bennet Creek Floodplain Mapping, Baseline to 401, DG Biddle, 2000 South Bowmanville Industrial Park, Dillon Consulting, 1986	Quantity Control (2-100 and Regional Storm) required unless otherwise noted in Master Plans.	Water balance required for all sites with remedial measures to match pre and post- development recharge	extended detention of 25mm storm for 24-48hrs (MOE SWMPP Manual) see also erosion sites in Master Plans

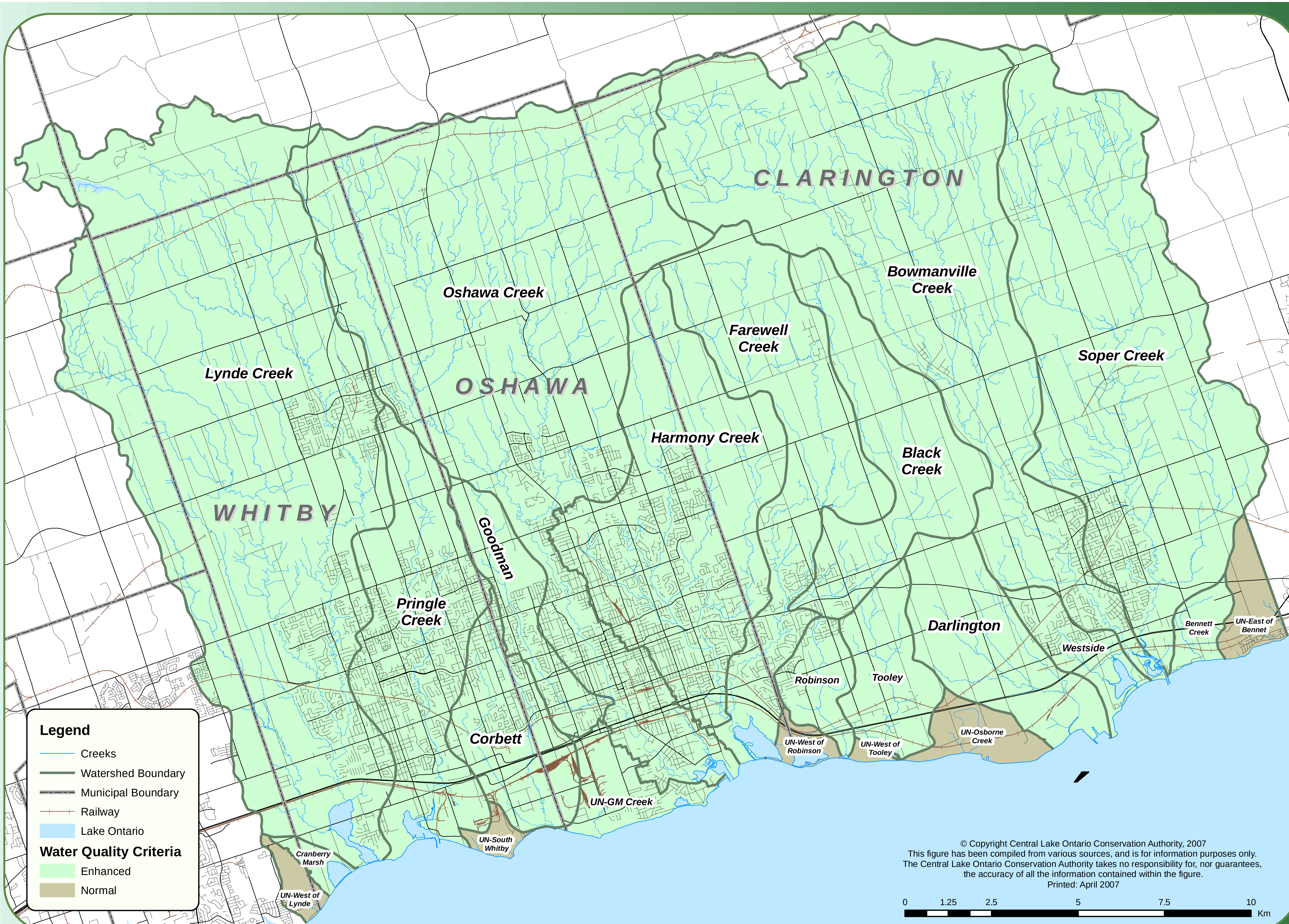
Water Quality Criteria

Watershed Name	Level of Protection	Reason
Soper Creek	Enhanced	Cold Water Fish Habitat Drains to PSW
Bowmanville Creek	Enhanced	Cold Water Fish Habitat Drains to PSW
Westside	Enhanced	Drains to PSW
Darlington	Enhanced	Diverse Fish Species
Tooley	Enhanced	Diverse Fish Species
Farewell Creek	Enhanced	Drains to PSW Cold Water Fish Habitat
Black Creek	Enhanced	Drains to PSW Cold Water Fish Habitat
Robinson	Enhanced	Diverse Fish Species
Corbett	Enhanced	Drains to PSW
Harmony Creek	Enhanced	Drains to PSW Cold Water Fish Habitat
Oshawa Creek	Enhanced	Drains to PSW Cold Water Fish Habitat
Goodman	Enhanced	Drains to PSW Cold Water Fish Habitat
Pringle Creek	Enhanced	Drains to PSW
Mclaughlin Bay Marsh	Enhanced	Drains to PSW
Lynde Creek	Enhanced	Drains to PSW Cold Water Fish Habitat
UN-West of Lynde	Normal	More Data Required
UN-GM Creek	Enhanced	Drains to PSW
UN-Osborne Creek	Normal	Drains directly to Lake Ontario More Data Required
Bennett Creek	Enhanced	Cold Water Fish Habitat
UN-East of Bennett	Normal	No Connection to Lake Ontario
Cranberry Marsh	Enhanced	Drains to PSW
UN-South Whitby	Normal	More Data Required
UN-West of Tooley	Normal	More Data Required

* UN - Unnamed

Central Lake Ontario Conservation

Water Quality Criteria



APPENDIX C
PRECIPITATION

1 Hour AES

Time (hrs)	Average Intensity (mm/hr)					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.083	10.700	14.785	17.538	21.001	23.532	26.107
0.167	32.101	44.356	52.614	63.004	70.596	78.322
0.250	53.502	73.926	87.690	105.006	117.660	130.536
0.333	74.903	103.496	122.766	147.008	164.724	182.750
0.417	68.830	95.105	112.812	135.089	151.368	167.933
0.500	29.209	40.360	47.874	57.328	64.236	71.266
0.583	11.857	16.384	19.434	23.272	26.076	28.930
0.667	4.916	6.793	8.058	9.649	10.812	11.995
0.750	2.024	2.797	3.318	3.973	4.452	4.939
0.833	0.868	1.199	1.422	1.703	1.908	2.117
0.917	0.289	0.400	0.474	0.568	0.636	0.706
1.000	0.000	0.000	0.000	0.000	0.000	0.000

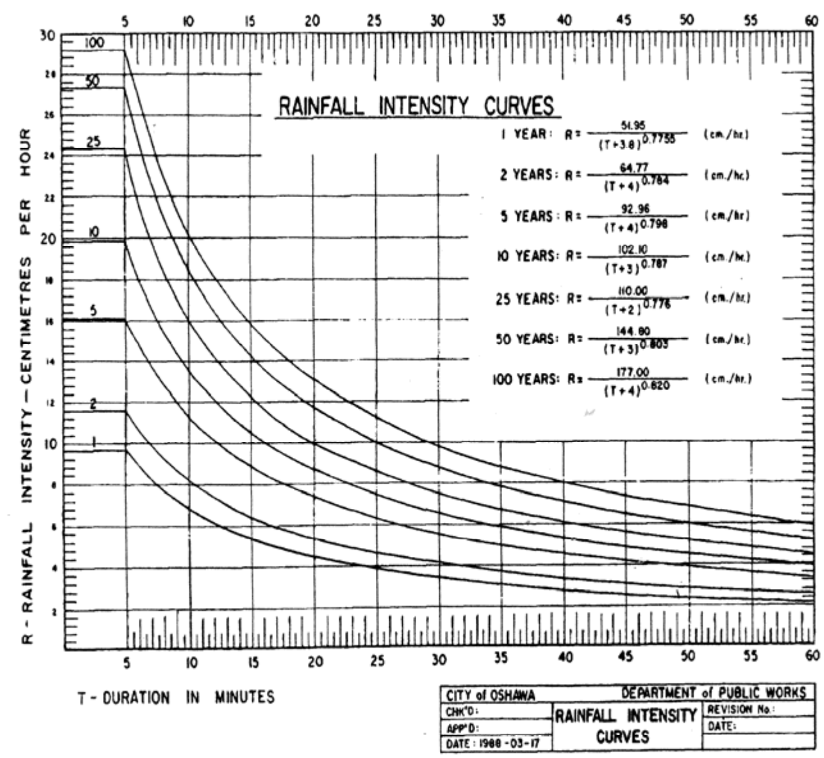
Based on the Toronto Bloor Station

24 Hour SCS

Time	Intensity (mm/hr)					
(hrs)	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
0	0.000	0.000	0.000	0.000	0.000	0.000
1	0.474	0.605	0.692	0.802	0.884	0.965
2	0.474	0.605	0.692	0.802	0.884	0.965
3	0.711	0.908	1.038	1.203	1.326	1.448
4	0.711	0.908	1.038	1.203	1.326	1.448
5	0.711	0.908	1.038	1.203	1.326	1.448
6	0.711	0.908	1.038	1.203	1.326	1.448
7	0.948	1.210	1.384	1.604	1.768	1.930
8	0.948	1.210	1.384	1.604	1.768	1.930
9	1.422	1.815	2.076	2.406	2.652	2.895
10	1.422	1.815	2.076	2.406	2.652	2.895
11	11.376	14.520	16.608	19.248	21.216	23.160
12	11.376	14.520	16.608	19.248	21.216	23.160
13	3.792	4.840	5.536	6.416	7.072	7.720
14	3.792	4.840	5.536	6.416	7.072	7.720
15	1.422	1.815	2.076	2.406	2.652	2.895
16	1.422	1.815	2.076	2.406	2.652	2.895
17	0.948	1.210	1.384	1.604	1.768	1.930
18	0.948	1.210	1.384	1.604	1.768	1.930
19	0.711	0.908	1.038	1.203	1.326	1.448
20	0.711	0.907	1.038	1.203	1.326	1.447
21	0.711	0.907	1.038	1.203	1.326	1.448
22	0.711	0.907	1.038	1.203	1.326	1.447
23	0.474	0.605	0.692	0.802	0.884	0.965
24	0.474	0.605	0.692	0.802	0.884	0.965

Based on the Toronto Bloor Station

The City of Oshawa
Accepted IDF Data



The Municipality of Clarington
Accepted IDF Data

Design Storm	Yarnell Rainfall Intensity Formulas
1:2 Year	I = 1778 / Tc + 13
1:5 Year	I = 2464 / Tc + 16
1:10 Year	I = 2819 / Tc +16
1:25 Year	I = 4318 / Tc + 27
1:50 Year	I = 4750 / Tc + 24
1:100 Year	I = 5588 / Tc + 28

Note: For 1:100 year storm event, the Chicago Storm formula should be used to be more conservative ie I = 1770 / (Tc + 4) ^ 0.82.

The Town of Whitby
Accepted IDF Data

Return Period	A	B	C
2	677.333	4.5	0.7920
5	1050.524	4.5	0.8190
10	1295.149	4.5	0.8290
25	1661.160	4.7	0.8450
50	1899.920	4.7	0.8490
100	2113.280	4.6	0.8510

The 5 year storm is the design storm and the 25 year storm is used for HGL calculations.

APPENDIX D
TYPICAL HYDROLOGIC VALUES & SOURCES

Initial Abstractions / Depression Storage

Soil Type	Initial Abstractions	MTO Typical Values	
Crop & Improved	7		Assume similar, but slightly less than Pasture
Pasture & Unimproved	8	8	
Urban Residential	1.5	2	Although the typical value is 2, the VO2 minimum is applied as the worst case scenario
Rural Residential	1.5	2	Although the typical value is 2, the VO2 minimum is applied as the worst case scenario
Industrial & Commercial	1.5	2	Although the typical value is 2, the VO2 minimum is applied as the worst case scenario
Lakes and Wetlands	0		No Literature values found, assume since surface is water, no initial abstractions.
Woodlot & Forrest	10	10	
Manicured Greenspace	5	5	
Landfill and Aggregate	10		No literature values found, assume significantly high value due to altered topography (pits)
Transportation & Utility	1.5	2	Although the typical value is 2, the VO2 minimum is applied as the worst case scenario

Values Adapted from MTO Drainage Manual Technical Guidelines, 1989
Table A.4. Original Source UNESCO, Manual on Drainage in Urbanized Areas, 1987.

Manning's n Values

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. Main Channels			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. Flood Plains			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200
3. Mountain Streams, no vegetation in channel, banks usually steep, with trees and brush on banks submerged			
a. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070

B. *Lined or Built-Up Channels*			
1. Concrete			
a. Trowel finish	0.011	0.013	0.015
b. Float Finish	0.013	0.015	0.016
c. Finished, with gravel bottom	0.015	0.017	0.020
d. Unfinished	0.014	0.017	0.020
e. Gunite, good section	0.016	0.019	0.023
f. Gunite, wavy section	0.018	0.022	0.025
g. On good excavated rock	0.017	0.020	
h. On irregular excavated rock	0.022	0.027	
2. Concrete bottom float finished with sides of:			
a. Dressed stone in mortar	0.015	0.017	0.020
b. Random stone in mortar	0.017	0.020	0.024
c. Cement rubble masonry, plastered	0.016	0.020	0.024
d. Cement rubble masonry	0.020	0.025	0.030
e. Dry rubble on riprap	0.020	0.030	0.035
3. Gravel bottom with sides of:			
a. Formed concrete	0.017	0.020	0.025
b. Random stone in mortar	0.020	0.023	0.026
c. Dry rubble or riprap	0.023	0.033	0.036
4. Brick			
a. Glazed	0.011	0.013	0.015
b. In cement mortar	0.012	0.015	0.018
5. Metal			
a. Smooth steel surfaces	0.011	0.012	0.014
b. Corrugated metal	0.021	0.025	0.030
6. Asphalt			
a. Smooth	0.013	0.013	
b. Rough	0.016	0.016	
7. Vegetal lining	0.030		0.500

C. ***Excavated or Dredged Channels***			
1. Earth, straight and uniform			
a. Clean, recently completed	0.016	0.018	0.020
b. Clean, after weathering	0.018	0.022	0.025
c. Gravel, uniform section, clean	0.022	0.025	0.030
d. With short grass, few weeds	0.022	0.027	0.033
2. Earth, winding and sluggish			
a. No vegetation	0.023	0.025	0.030
b. Grass, some weeds	0.025	0.030	0.033
c. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
d. Earth bottom and rubble side	0.028	0.030	0.035
e. Stony bottom and weedy banks	0.025	0.035	0.040
f. Cobble bottom and clean sides	0.030	0.040	0.050
3. Dragline-excavated or dredged			
a. No vegetation	0.025	0.028	0.033
b. Light brush on banks	0.035	0.050	0.060
4. Rock cuts			
a. Smooth and uniform	0.025	0.035	0.040
b. Jagged and irregular	0.035	0.040	0.050
5. Channels not maintained, weeds and brush			
a. Clean bottom, brush on sides	0.040	0.050	0.080
b. Same as above, highest stage of flow	0.045	0.070	0.110
c. Dense weeds, high as flow depth	0.050	0.080	0.120
d. Dense brush, high stage	0.080	0.100	0.140

Ref. Hec-RAS Users Manual

Curve Number (CN)

TABLE 4. RUNOFF CURVE NUMBERS

Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and $I_a = 0.2S$)

LAND USE DESCRIPTION	HYDROLOGIC SOIL GROUP			
	A	B	C	D
Cultivated land[1/]: without conservation treatment	72	81	88	91
: with conservation treatment	62	71	78	81
Pasture or range land: poor condition	68	79	86	89
good condition	39	61	74	80
Meadow: good condition	30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch	45	66	77	83
good cover[2/]	25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.				
good condition: grass cover on 75% or more of the area	39	61	74	80
fair condition: grass cover on 50% to 75% of the area	49	69	79	84
Commercial and business areas (85% impervious)	89	92	94	95
Industrial districts (72% impervious).	81	88	91	93
Residential:[3/]				
Average lot size — Average % Impervious[4/]				
1/8 acre or less — 65	77	85	90	92
1/4 acre — 38	61	75	83	87
1/3 acre — 30	57	72	81	86
1/2 acre — 25	54	70	80	85
1 acre — 20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5/]	98	98	98	98
Streets and roads:				
paved with curbs and storm sewers[5/]	98	98	98	98
gravel	76	85	89	91
dirt	72	82	87	89

1/ For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

2/ Good cover is protected from grazing and litter and brush cover soil.

3/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

4/ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

5/ In some warmer climates of the country a curve number of 95 may be used.

Source: U.S. Soil Conservation Services

Design Chart 1.09: Soil/Land Use Curve Numbers

Land Use	Treatment or Practice	Hydrologic Condition[4]	Hydrologic Soil Group			
			A	B	C	D
Fallow	Straight row	—	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	" and terraced	Poor	66	74	8	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	" and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes[2] or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	" and terraced	Poor	63	73	80	83
	" and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		—	59	74	82	86
		—	72	82	87	89
		—	74	84	90	92

For average anticedent soil moisture condition (AMC II)
[2] Close-drilled or broadcast.

[4] The hydrologic condition of cropland is good if a good crop rotation practice is used; it is poor if one crop is grown continuously.

Source: U.S. Department of Agriculture (1972)

Design Chart 1.09: Soil Conservation Service Curve Numbers (Continued)

Land Use or Surface	Hydrologic Soil Group						
	A	AB	B	BC	C	CD	D
Fallow (special cases only)	77	82	86	89	91	93	94
Crop and other improved land	66** (62)	70** (68)	74	78	82	84	86 AMC I
Pasture & other unimproved land	58* (38)	62* (51)	65	71	76	79	81
Woodlots and forest	50* (30)	54* (44)	58	65	71	74	77
Impervious areas (paved)							98
Bare bedrock draining directly to stream by surface flow							98
Bare bedrock draining indirectly to stream as groundwater (usual case)							70
Lakes and wetlands							50

Notes

(i) All values are based on AMC II except those marked by * (AMC III) or ** (mean of AMC II and AMC III).

(ii) Values in brackets are AMC II and are to be used only for special cases.

(iii) Table is not applicable to frozen soils or to periods in which snowmelt contributes to runoff.

CHART H2-8
CHART H2-9

CHART H2-8 - SOIL/LAND USE CURVE NUMBERS

Land Use or Surface	Hydrologic Soil Group						
	A	AB	B	BC	C	CD	D
Fallow (special cases only)	77	82	86	89	91	93	94
Crop and other improved land	66** (62)	70** (68)	74	78	82	84	86
Pasture & other unimproved land	58* (38)	62* (51)	65	71	76	79	81
Woodlots and forest	50* (30)	54* (44)	58	65	71	74	77
Impervious areas (paved)							98
Bare bedrock draining directly to stream by surface flow							98
Bare bedrock draining indirectly to stream as groundwater (usual case)							70
Lakes and wetlands							50

Notes

1. All values are based on AMC II except those marked * (AMC III) or ** (mean of AMC II and AMC III).
2. Values in brackets are AMC II and are to be used only for special cases.
3. Table is not applicable to frozen soils or to periods in which snowmelt contributes to runoff.
4. For detailed values in urban areas see Table 2.2 of ref. 14.
5. Source: reference 9, Chapter 9, with modifications.
6. For calculation of CN values see Form H5-1. (MTC Form PH-D-537).

CHART H2-9 - PERCENT IMPERVIOUSNESS OF URBAN AREAS

Land Use		% Imperviousness
Business	- Commercial	40 - 90
Industrial	- Light	45 - 65
	- Heavy	50 - 70
Residential	- Low density	20 - 30
	- Medium density	25 - 35
	- High density	30 - 40

Source: reference 9, Chapter 15.

MTO

Table 2.2.7 —Soil/land use curve numbers (7) for average antecedent moisture condition (AMC II)

Land use	Treatment or practice	Hydrologic condition[3]	Hydrologic soil group			
			A	B	C	D
Fallow	Straight row	—	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	" and terraced	Poor	66	74	8	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	" and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes[1] or rotation-meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	" and terraced	Poor	63	73	80	83
	" and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		—	59	74	82	86
Roads (dirt)[2]		—	72	82	87	89
(hard surface)[2]		—	74	84	90	92

[1] Close-drilled or broadcast.
[2] Including right-of-way.
[3] The hydrologic condition of cropland is good if a good crop rotation practice is used; it is poor if one crop is grown continuously. See Tables 2.2.8 and 2.2.9 for the hydrologic condition of pasture, or range and woods.

Note: For curve numbers in urban areas see (10).

Table 2.2.8 — Classification of native pasture or range

Vegetative condition	Hydrologic condition
Heavily grazed. Has no mulch or has plant cover on less than ½ of the area.	Poor
Not heavily grazed. Has plant cover on ½ to ¾ of the area.	Fair
Lightly grazed. Has plant cover on more than ¾ of the area.	Good

Table 2.2.9 — Classification of woods

Vegetative condition	Hydrologic condition
Heavily grazed or regularly burned. Litter, small trees, and brush are destroyed.	Poor
Grazed but not burned. There may be some litter but these woods are not protected.	Fair
Protected from grazing. Litter and shrubs cover the soil.	Good

Table 6. Runoff Curve Numbers for Hydrologic Soil-Cover Complexes (Antecedent Moisture Condition II) (Ref. 7).

Land use or cover	Treatment or practice	Hydrologic condition	Hydrologic soil group A	B	C	D
Fallow	Straight row	-	77	86	91	94
Row crops	Straight row	Poor	72	81	88	91
		Good	67	78	85	89
	Contoured	Poor	70	79	84	88
		Good	65	75	82	86
	Contoured and terraced	Poor	66	74	80	82
		Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	Contoured and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes* or rotation meadow	Straight row	Poor	66	77	85	89
		Good	58	72	81	85
	Contoured	Poor	64	75	83	85
		Good	55	69	78	83
	Contoured and terraced	Poor	63	73	80	83
		Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
		Fair	25	59	75	83
		Good	6	35	70	79
Meadow (permanent)		Good	30	58	71	78
Woods and forests		Very poor	56	75	86	91
		Fair	36	60	73	79
		Very Good	15	44	54	61
Farmsteads			59	74	82	86
Roads** (dirt)			72	82	87	89
(hard)			74	84	90	92

* Close-drilled or broadcast
** Including right-of-way

Source: Design and Construction Guidelines, 2nd Edition, June 1986

Runoff Coefficients

TABLE 4 - 5a

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Urban Land Uses

STORM FREQUENCIES OF LESS THAN 25 YEARS													
Land Use	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
		A			B			C			D		
		0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Paved Areas and Impervious Surfaces		0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Open Space, Lawns, etc.	Good	0.08	0.12	0.15	0.11	0.16	0.21	0.14	0.19	0.24	0.20	0.24	0.28
Industrial		0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
Commercial		0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Residential Lot Size 1/8 Acre		0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
Lot Size 1/4 Acre		0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.30	0.34	0.40
Lot Size 1/3 Acre		0.19	0.23	0.26	0.22	0.26	0.30	0.25	0.29	0.34	0.28	0.32	0.39
Lot Size ½ Acre		0.16	0.20	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.30	0.37
Lot Size 1.0 Acre		0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.29	0.35

Source: Maryland State Highway Administration

TABLE 4 - 5b

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Uses

STORM FREQUENCIES OF LESS THAN 25 YEARS														
Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

TABLE 4 - 5c

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Agricultural Land Uses

STORM FREQUENCIES OF LESS THAN 25 YEARS														
Land Use	Treatment/ Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Fallow	Straight Row		0.41	0.48	0.53	0.60	0.66	0.71	0.72	0.78	0.82	0.84	0.88	0.91
Row Crops	Straight Row	Good	0.24	0.30	0.35	0.43	0.48	0.52	0.61	0.65	0.68	0.73	0.76	0.78
	Contoured	Good	0.21	0.26	0.30	0.41	0.45	0.49	0.55	0.59	0.63	0.63	0.66	0.68
	Contoured and Terraced	Good	0.20	0.24	0.27	0.31	0.35	0.39	0.45	0.48	0.51	0.55	0.58	0.60
Small Grain	Straight Row	Good	0.23	0.26	0.29	0.42	0.45	0.48	0.57	0.60	0.62	0.71	0.73	0.75

Source: Maryland State Highway Administration

TABLE 4 - 5d

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D) Agricultural Land Uses

STORM FREQUENCIES OF LESS THAN 25 YEARS														
Land Use	Treatment/ Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Small Grain	Contoured	Good	0.17	0.22	0.27	0.33	0.38	0.42	0.54	0.58	0.61	0.62	0.65	0.67
	Contoured and Terraced	Good	0.16	0.20	0.24	0.31	0.35	0.38	0.45	0.48	0.50	0.55	0.58	0.60
Closed-seeded Legumes or Rotation Meadow	Straight Row	Good	0.15	0.19	0.23	0.31	0.35	0.38	0.55	0.58	0.60	0.63	0.65	0.66
	Contoured	Good	0.14	0.18	0.21	0.30	0.34	0.37	0.45	0.48	0.51	0.58	0.60	0.61
	Contoured and Terraced	Good	0.07	0.10	0.13	0.28	0.32	0.35	0.44	0.47	0.49	0.52	0.54	0.56

Source: Maryland State Highway Administration

Design Chart 1.07: Runoff Coefficients

- Urban for 5 to 10-Year Storms

Land Use		Runoff Coefficient Min.	Runoff Coefficient Max.
Pavement	- asphalt or concrete	0.80	0.95
	- brick	0.70	0.85
Gravel roads and shoulders		0.40	0.60
Roofs		0.70	0.95
Business	- downtown	0.70	0.95
	- neighbourhood	0.50	0.70
	- light	0.50	0.80
	- heavy	0.60	0.90
Residential	- single family urban	0.30	0.50
	- multiple, detached	0.40	0.60
	- multiple, attached	0.60	0.75
	- suburban	0.25	0.40
Industrial	- light	0.50	0.80
	- heavy	0.60	0.90
Apartments		0.50	0.70
Parks, cemeteries		0.10	0.25
Playgrounds (unpaved)		0.20	0.35
Railroad yards		0.20	0.35
Unimproved areas		0.10	0.30
Lawns	- Sandy soil		
	- flat, to 2%	0.05	0.10
	- average, 2 to 7%	0.10	0.15
	- steep, over 7%	0.15	0.20
	- Clayey soil		
	- flat, to 2%	0.13	0.17
	- average, 2 to 7%	0.18	0.22
	- steep, over 7%	0.25	0.35

For flat or permeable surfaces, use the lower values. For steeper or more impervious surfaces, use the higher values. For return period of more than 10 years, increase above values as 25-year - add 10%, 50-year - add 20%, 100-year - add 25%.

The coefficients listed above are for unfrozen ground.

Design Chart 1.07: Runoff Coefficients (Continued)

- Rural

Land Use & Topography[3]	Soil Texture		
	Open Sand Loam	Loam or Silt Loam	Clay Loam or Clay
CULTIVATED Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	0.22 0.30 0.40	0.35 0.45 0.65	0.55 0.60 0.70
PASTURE Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	0.10 0.15 0.22	0.28 0.35 0.40	0.40 0.45 0.55
WOODLAND OR CUTOVER Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	0.08 0.12 0.18	0.25 0.30 0.35	0.35 0.42 0.52
BARE ROCK	COVERAGE[3]		
	30%	50%	70%
Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	0.40 0.50 0.55	0.55 0.65 0.70	0.75 0.80 0.85
LAKES AND WETLANDS	0.05		

[2] Terrain Slopes

[3] Interpolate for other values of % imperviousness

Sources: American Society of Civil Engineers - ASCE (1960)
U.S. Department of Agriculture (1972)

APPENDIX E
CLOCA OIL GRIT SEPARATOR STUDY

Central Lake Ontario Conservation Authority
Oil/Grit Separators (OGS) Guideline (Interim)

(February 26, 2008)

The following principles will be used in the review and approval of all OGS and is based on the City of Toronto's OGS guidelines from the Wet Weather Flow Management Guidelines:

1. Oil/grit separators (OGS) may be used as spill controls, pre-treatment devices or as a source/end-of-pipe controls (as part of a treatment train approach) for water quality control. OGS are not typically designed to provide water quantity control and have no infiltration capability (i.e., no benefit to water balance).

2. The CLOCA's water quality target is the long term average removal of 80% (Enhanced treatment areas) or 70% (Normal treatment areas) of total suspended solids (TSS) on an annual loading basis from all runoff leaving the proposed development site based on the post development level of imperviousness (Refer to Appendix B). For stormwater quality control, oil/grit separators (OGS) may be applied as one element of a multi-component approach unless it is determined that it can achieve the desired water quality as a stand alone device on a site specific basis. If the OGS alone does not meet the TSS removal requirement, then the device could still be used for pre-treatment or supplemental to other stormwater control measures. If indeed the OGS is used upstream and as part of a treatment train, the following component(s) of the treatment train must be capable of removing the very fine particulates that pass the OGS in order to achieve the total removal required.

3. Typically oil/grit separators (OGS) are proprietary designs with a wide variety of sizes, shapes and configurations, many of them claiming to be able to achieve the required removal of total suspended solids (TSS). Literature review of independent performance testing suggests that these removal efficiencies are only attainable under very specific circumstances, which are highly dependent on study design, specific site conditions, particle size distribution and the varying flow conditions under which the tests were conducted. In the interim, CLOCA is prepared to accept the performance claim. It should be noted that the City of Toronto and The New Jersey Department of Environmental Protection are only accepting that OGS devices, operating alone, are capable of achieving a TSS removal efficiency of 50%.

4. Higher (> 50%) removal efficiency claims maybe considered if they are supported by new or additional field performance data verified under the same TARP Tier II Testing Protocols used in the NJDEP assessments and certification program. The NJDEP TARP Tier I Interim Approval does not preclude CLOCA's requirement to review or approve projects proposing to use OGS. In the future, the CLOCA may develop its own review program and monitoring/test protocols for the evaluation of new stormwater treatment technologies including the OGS devices.

5. The specifications of any OGS models proposed for a development must be signed and sealed by a Professional Engineer (i.e., Registered Engineer of Ontario). The required submission of information for review and approval by CLOCA must include design computations documenting the estimated performance, supported with well-documented sizing (computer modeling) program, CADD details and maintenance requirements. The OGS make and model specified on the approved Stormwater Management Report cannot be substituted with an "equivalent" model later.

6. Performance Standards – must satisfy both conditions (a) and (b)

(a) When used as a stand-alone on-site stormwater management/control device, it must achieve a minimum 80% removal of TSS from the total volume of annual runoff (on a long-term average basis) leaving the proposed development site based on the post-development level of imperviousness.

The particle size distribution and the associated settling velocities have a significant effect on TSS removal efficiencies, and settling velocities are not linearly related to particle sizes. In actual practice, the particle size distribution varies from site to site, and even during individual events. Actual sediment samples have been collected within CLOCA's jurisdiction and have been analyzed for particle size distribution. In order for an OGS to be used with CLOCA it must be tested with a particle size distribution that is finer that that of the samples found within CLOCA. In addition no particles may exceed the 1000μm range and at least 20% of the sample must be finer than 80μm. The accepted distribution is:

Particle Size	% Finer Than
50	20
192	40
373	60
743	80
1000	100

(b) When used as a stand-alone stormwater management/control device, it must also be sized to capture and treat a minimum 90% volume of the annual runoff on a long-term average basis without bypass (this is not required for pretreatment or spill control functions). When the design flow rate is exceeded during the bigger storms, the design must include a bypass feature to prevent scouring of collected solids and flushing out of oils trapped in the device.

Suspended solids removal efficiency is to be calculated based on 100% of the total runoff volume resulted from all storm events that occur in an average year. The overall solids removal efficiency of the separator must take into account the portion of stormwater runoff bypassing the OGS, as it does not receive any treatment. For OGS designed with a by-pass, the calculation of long-term suspended solid must be based on both suspended solids removal in the facility and suspended solids that by-pass the facility. (For example, when a device is sized to capture and treat only 90% volume of the annual runoff, an average TSS removal efficiency of about 90% will be required.)

For the purposes of computer modeling analysis, the following approach shall be used:

- Continuous rainfall event analysis, for an average year: The 1991 Toronto continuous rainfall data (15-minute time step) provided by Toronto Water has been identified as the most representative of long-term average precipitation patterns in the Toronto Wet Weather Flow Master Plan (2003); or
- Where an OGS is preceded by an equalization or storage facility, a lower water quality design flow rate may be identified provided that at least 90% of the estimated runoff volume in the time series simulated from an approved continuous runoff model (e.g., SWMHYMO, SWMM, STORM, etc.) is treated to the applicable performance goal (e.g., 80% overall TSS removal efficiency on an annual average basis).

OIL GRIT SEPARATOR RESEARCH

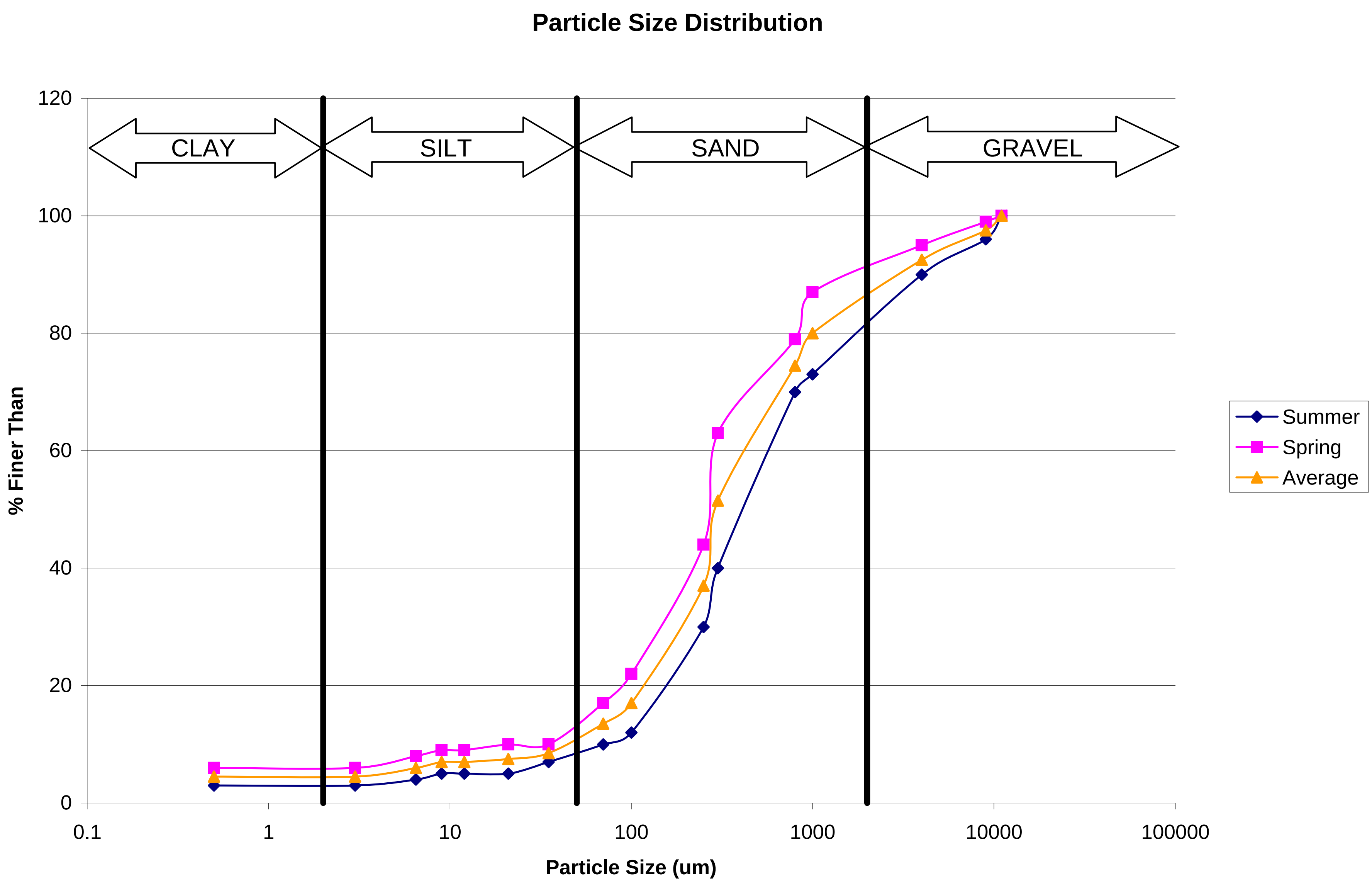
Product Summary

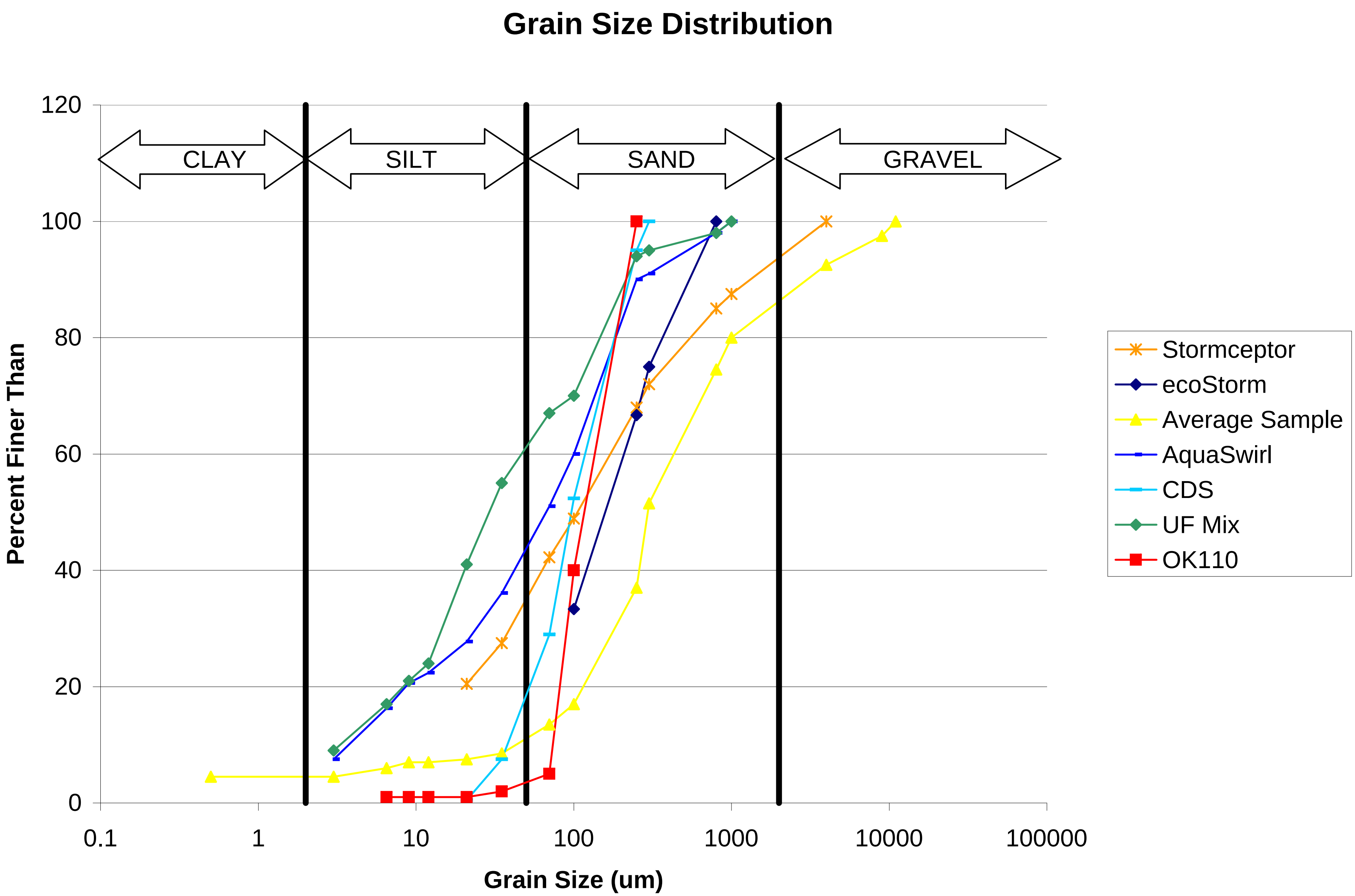
Manufacturer	Product	CLOCA Particle Size	NJDEP Interim				
			Certification	Operating Rate	SS Conc (mg/L)	Particle Size	Removal
Imbrium	Stormceptor	Y	50%	1120 gpm			50%
Aquashield	Aqua Swirl	Y	50%		320	d50 = 110	60%
Contech	Vortech	Y	50%	40 gpm/ft2	187	38-75	64%
	Vortsentry	Y	50%	9.8 gpm/ft3	209	d50 = 120	69%
	CDS High Efficiency Unit	Y	50%	500 gpm	184	d50 = 63	73%
EcoTechnic	Eco Storm	N	0%				0%
Hydro International	Downstream Defender	N	50%	20 gpm/ft3	240	d50 = 120	70%
Terra Hill Concrete	Terra Kleene Storwater Device	N	50%	288 gpm	228	d50 = 86	78%

CLOCA currently approves Stormceptor, Aqua Swirl, Vortech, Vortsentry and CDS High Efficiency Unit.

Comparison

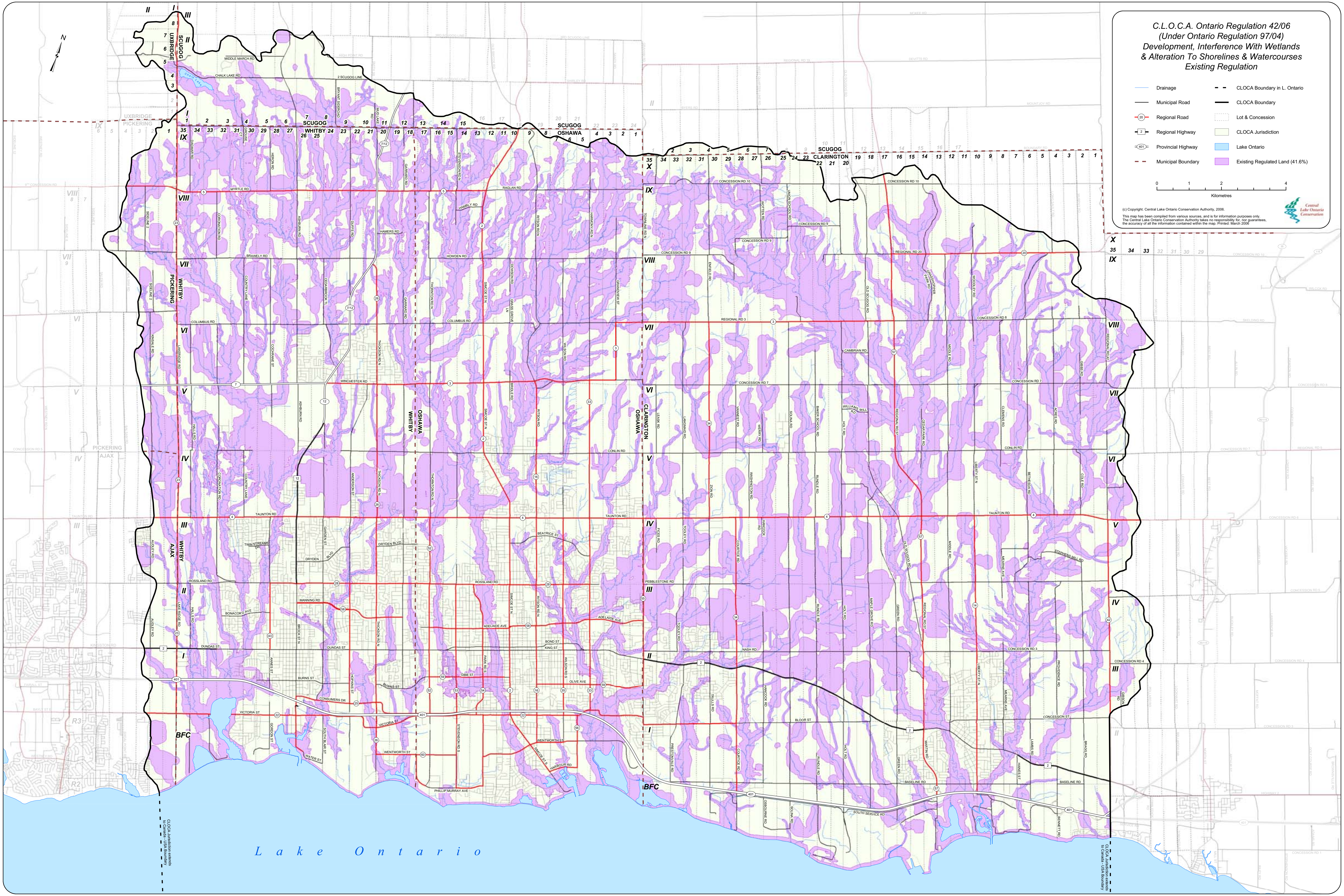
Particle Size	% Finer Than										
	Spring Sample	Summer Sample	Average Sampled	Stormceptor	ecoStorm	Vortechs	Aquaswirl	CDS	UF	OK 110
11000	100	100	100	100	100	100	100	100	100	100
9000	99	96	97.5	100	100	97	100	100	100	100
4000	95	90	92.5	100	100	83	100	100	100	100
1000	87	73	80	88	100	75	100	100	100	100
800	79	70	74.5	85	100	75	98	100	98	100
300	63	40	51.5	72	75	73	91	100	95	100
250	44	30	37	68	67	73	90	95	94	100
100	22	12	17	49	33	55	60	52	70	40
70	17	10	13.5	42	0	44	51	29	67	5
35	10	7	8.5	28	0	0	36	8	55	2
21	10	5	7.5	21	0	0	28	1	41	1
12	9	5	7	0	0	0	22	0	24	1
9	9	5	7	0	0	0	21	0	21	1
6.5	8	4	6	0	0	0	16	0	17	1
3	6	3	4.5	0	0	0	8	0	9	0
0.5	6	3	4.5	0	0	0	0	0	0	0


Particle Size Distribution
% Finer Than
Particle Size (um)
0
20
40
60
80
100
120
0.1
1
10
100
1000
10000
100000
CLAY
SILT
SAND
GRAVEL
Summer
Spring
Average



Grain Size Distribution
Percent Finer Than
Grain Size (um)
CLAY
SILT
SAND
GRAVEL
0
20
40
60
80
100
120
0.1
1
10
100
1000
10000
100000
Stormceptor
ecoStorm
Average Sample
AquaSwirl
CDS
UF Mix
OK110

APPENDIX F
CLOCA REGULATION 42/06 MAPPING


C.L.O.C.A. Ontario Regulation 42/06
(Under Ontario Regulation 97/04)
Development, Interference With Wetlands
& Alteration To Shorelines & Watercourses
Existing Regulation
Drainage
Municipal Road
Regional Road
Regional Highway
Provincial Highway
Municipal Boundary
CLOCA Boundary in L. Ontario
CLOCA Boundary
Lot & Concession
CLOCA Jurisdiction
Lake Ontario
Existing Regulated Land (41.6%)
0 1 2 4
Kilometres
(c) Copyright. Central Lake Ontario Conservation Authority, 2006.
This map has been compiled from various sources, and is for information purposes only.
The Central Lake Ontario Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map. Printed: March 2006
Central Lake Ontario Conservation
SCUGOG
UXBRIDGE
WHITBY
PICKERING
OSHAWA
CLARINGTON
AJAX
L a k e   O n t a r i o
CLOCA Jurisdiction extends to Canada - USA Boundary

APPENDIX G
RECORD OF BOARD ENDORSEMENT

CENTRAL LAKE ONTARIO CONSERVATION AUTHORITY

DATE: June 12, 2007
FILE: PSSG251
S.R.: 4669-07 **APPROVED BY C.A.O.** ________

MEMO TO: Chair and Members, CLOCA Board of Directors

FROM: R. Perry Sisson, Director, Engineering and Field Operations

SUBJECT: **<u>Technical Guidelines for Stormwater Management Submissions</u>**

Urban development applications are commonly supported by stormwater management submissions consisting of drainage system details for:

- minor (storm sewer) flow,
- major overland drainage conveyance,
- control of peak discharge to protect against surcharging infrastructure, or causing flooding,
- stormwater quality treatment,
- control against stream erosion,
- protection/maintenance of groundwater conditions,
- stream erosion restoration or alteration,
- floodplain/natural hazard assessment and management,
- sediment control during construction.

Submissions received at CLOCA vary in terms of content and quality of information. Submissions that are incomplete, or lacking in supporting information are difficult to review and consume significantly more staff time than complete submissions. These submissions delay the development review process.

In an attempt to address this issue, CLOCA staff developed the attached Stormwater Management Submission Guidelines. CLOCA's expectations for all stormwater management submissions are outlined in the Guideline, which includes a description of CLOCA policies, guidance on approved methods and techniques, a summary of key hydrologic parameters, and a summary of submission requirements. The Guideline also provides a checklist that proponents may use to ensure all the material required for an expeditious review is enclosed in the submission. CLOCA staff may also use the checklist to quickly identify missing information, and may request the missing information from the proponent prior to completing our review of the application. The document also provides stormwater management criteria for specific watersheds.

The Stormwater Management Submission Guidelines are not intended to provide design criteria and standards. For the most part, this document refers to provincial standards and requirements commonly used in the industry.
The Guidelines do address problems experienced with stormwater oil/grit removal systems, where criteria for sizing systems and proving performance of systems has not been standardized. A variety of companies manufacture oil/grit removal systems, each with their own claims for performance and method of sizing. CLOCA has provided criteria for all manufacturers to meet, and hope to "even the playing field" for Oil/Grit removal systems.

The Guidelines have been circulated for comment to local development consultants, local municipalities, and neighbouring Conservation Authorities. Comments received have been addressed as noted in the accompanying summary. It is anticipated that these Guidelines will improve the efficiency of the review process, and result in shorter review periods and faster approvals. Please note that the full Guideline including the appendices is available upon request.

RECOMMENDATION:

THAT Staff Report 4669-07 be received for information; and,

THAT the Technical Guidelines for Stormwater Management Submissions (CLOCA 2007) be endorsed and accepted for implementation of development review.

RPS/klt
Attach.

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APPENDIX H
WATER BUDGET

Central Lake Ontario Conservation

Water Budget

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