Executive Summary

Introduction

In recent years, many southern Ontario urban centres have been impacted by extreme storm events (north Toronto 2005, Hamilton 2009, West Toronto 2013, Burlington 2014, and many more), leading to considerable flood and erosion damage. These events (speculated by many to be a result of climate change), along with a need to manage municipal resources in the best manner, have led the Town of Oakville to initiate the preparation of a Stormwater Management Master Plan (SWM Master Plan) to help guide the planning and design of capital works to address flood risks, establish new policy and guidelines, and develop associated strategies for the management of stormwater in the Study's focus area. The SWM Master Plan has allowed the Town to further increase its understanding of the current function of the existing stormwater system, and associated flood risks, and thereby systematically plan upgrades and enhancements to existing neighbourhood drainage systems, and provide policy direction for managing runoff from new development in these neighbourhoods. The objectives of the overall Master Plan are to provide the town with clear direction regarding:

i. The existing issues with respect to the structural condition, flow capacity and maintenance requirements of the Municipal storm system,
ii. The location and extent of these issues,
iii. Opportunities and recommendations to address and mitigate identified problems,
iv. Timeline and priorities for implementation of the recommendations
v. Estimated Costs for the implementation and long term maintenance of the system, and
vi. Preferred financial and funding mechanisms

It is noteworthy to state that this study has specifically examined and assessed the town's drainage systems comprised of storm sewers, roadside ditches and overland flow paths associated with roadways and their rights-of-way. The study has also examined remnant open channels which are unregulated artifacts of former larger watercourse systems, which have, through historical development, been removed or altered with only smaller remnant systems remaining on private lots. This study has not evaluated the performance of the town's larger regulated open watercourse systems nor the performance of the sanitary (wastewater) system, as these are more directly in the control and management of Conservation Halton and the Region of Halton respectively.

Study Process

The Town's Stormwater Management Master Plan is being completed over multiple phases, as follows:

Phase 1: Data collection and structural needs assessment
Phase 2: Detailed modelling and assessment, development of service level criteria/indicators allowing for evidence based project development and prioritization
Phase 3: Development and assessment of funding strategies to support the delivery of recommended stormwater service improvement projects

The Town of Oakville Stormwater Management Master Plan has been conducted as a Master Plan in compliance with Section A.2.7 Master Plans (ref. Municipal Engineers Association "Municipal Class Environmental Assessment," (October 2000, as amended 2007, 2011, and 2015) which addresses Phases 1 and 2 of the Class Environmental Assessment (EA) Process. Those projects considered Schedule A or A+ can proceed directly to implementation. Subsequent Schedule B projects are to be implemented in accordance with the recommendations provided in this Master Plan, and thereby may proceed directly to the *Notice of Completion* stage without further assessments, or where more complex decision-making is

required, may necessitate a stand-alone locally focused study and then move to the detailed design and implementation stages.

Master Plans are one form of Class EA document which represent long range plans which integrate infrastructure requirements for existing and future land use with environmental assessment planning principles. The following characteristics distinguish the Master Planning Process from other processes:

a. The scope of Master Plans is broad and usually includes an analysis of the whole system in order to outline a framework for future works and developments. Master Plans are not typically undertaken to address a site-specific problem.

b. Master Plans typically recommend a set of works which are distributed geographically throughout the study area and which are to be implemented over an extended period of time. Master Plans provide the context for the implementation of the specific projects which make up the plan and satisfy, as a minimum, Phases 1 and 2 of the Class EA process (ref. Figure 1). Notwithstanding that these works may be implemented as separate projects, collectively these works are part of a larger management system. Master Plan studies in essence conclude with a set of preferred alternatives and, therefore, by their nature, Master Plans will limit the scope of alternatives which can be considered at the implementation stage.

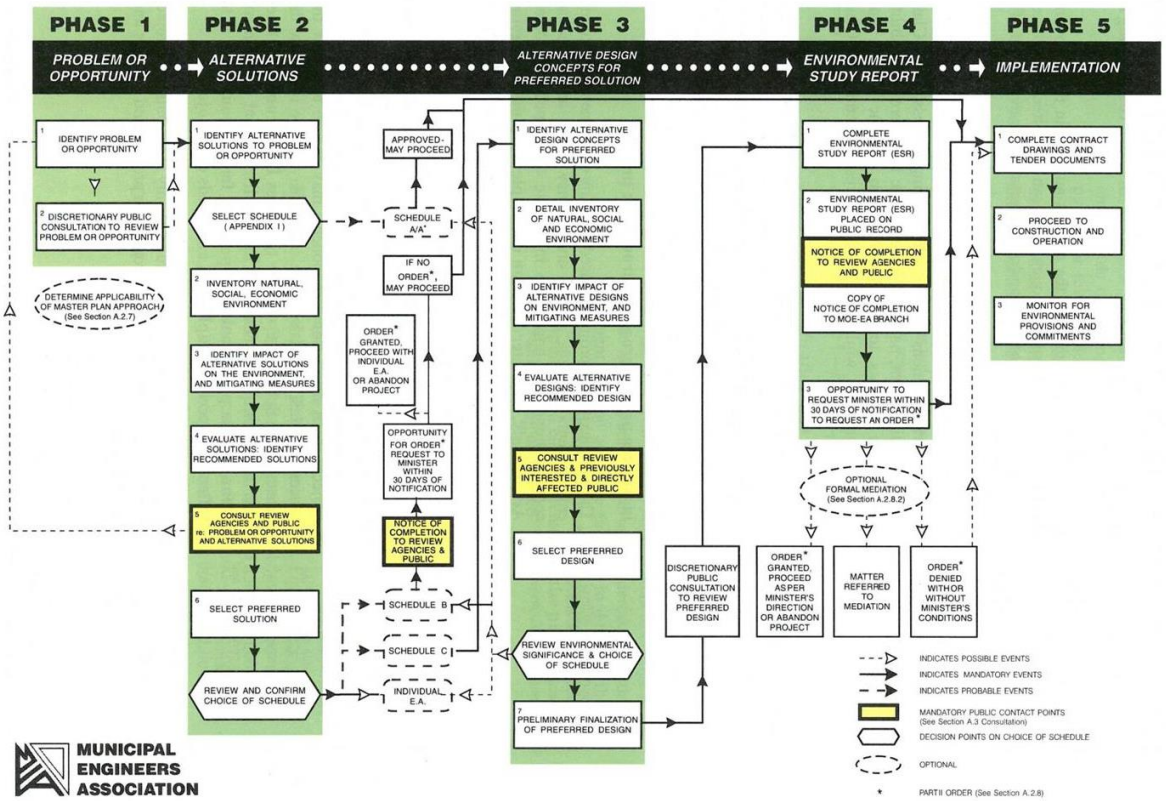

Figure 1: Municipal Class EA Process

The following are some examples of drainage projects classified according to the Municipal Class EA process, as they pertain to the recommendations from this Master Plan:

Schedule A/A+ (Pre-approved)

- Installation of inlet control devices (ICDs) within existing catch basins.
- Maintenance or repair of roadside ditches, culverts and such incidental stormwater works constructed solely for the purpose of servicing municipal road works.
- Storm sewer replacement.
- Implementation of online storage.

Schedule B (Potential for some adverse environmental effects)

- Establish new stormwater retention/detention ponds including outfalls to receiving water body where additional property is required.
- Regrading or reconstruction of municipal right-of-way.
- Grading to divert runoff within municipal drainage systems.

Focus Area

The focus area for the Stormwater Management Master Plan primarily includes the areas of the town located south of the Queen Elizabeth Way Highway, between Winston Churchill Blvd. on east, Burloak Drive on west, and Lake Ontario to the south. This focus area was selected by town staff primarily due to the age of the infrastructure in the area, and based upon the knowledge that limited stormwater management practices have historically been employed within this area. The focus area is presented in Figure 2.

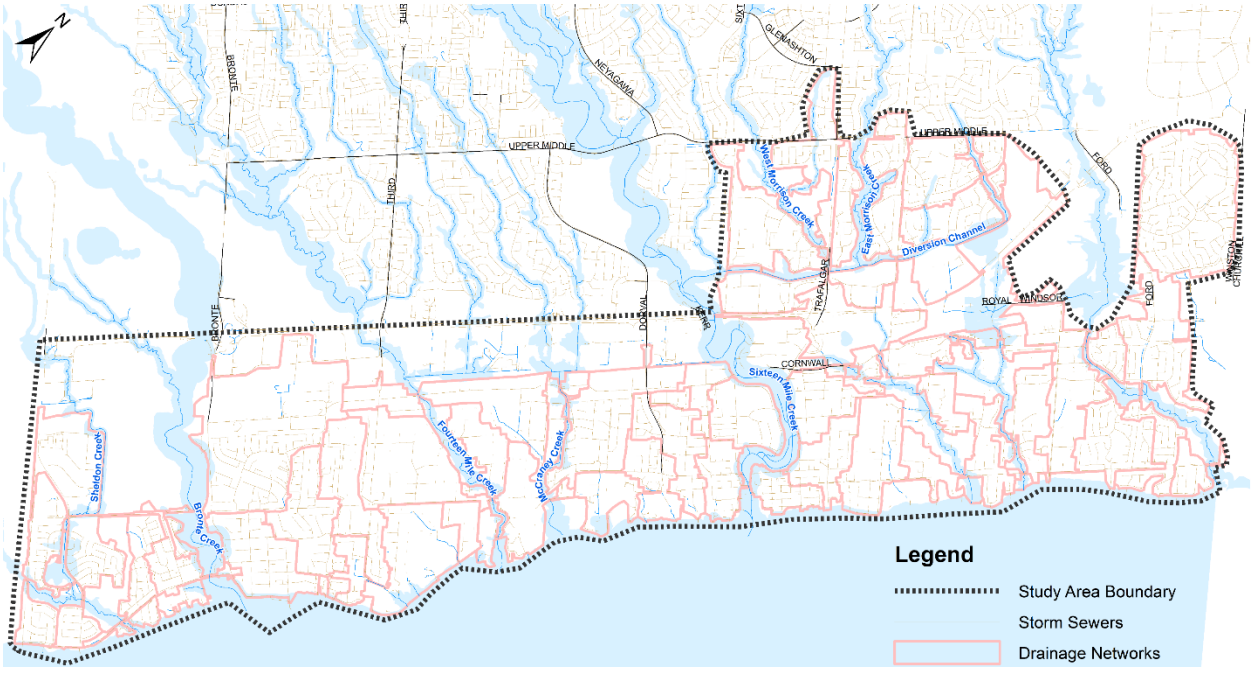

Figure 2: Focus Area Location Plan

Drainage System Performance Assessment

Detailed numerical modelling and analysis has been completed to evaluate the existing performance of the drainage system within the focus area. The drainage system is comprised of storm sewers and roadside ditches (referred to as the "minor system") and roadway right-of-ways (referred to as the "major system") which convey flow away from private properties and toward streams and Lake Ontario during storm events.

Performance metrics (denoted as red, orange, yellow and green, ref. Figures 3 and 4) have been applied through numerical modelling of the focus area to determine the associated level of service for the minor systems and major systems for each network/neighbourhood within the focus area. In each network, those system components operating to a "green" or "yellow" level-of-service have been deemed for this study to be operating to the town's desired performance level.

System performance has been assessed under general scenarios based on existing land use and existing climate, and future land use and projected future climate, as part of a climate change "stress test". The performance of the major and minor systems under each scenario have been evaluated based upon generalized Levels of Service (LOS), in order to guide the planning of new infrastructure, defined as follows:

Level of Service Criteria for Minor System (100 year storm)	
Level of Service	**Criteria**
A	Most of the storm sewer pipes within the network meet the town's performance criteria.
B	Many of the storm sewer pipes within the network meet the town's performance criteria.
C	Some of the storm sewer pipes within the network meet the town's performance criteria.
D	Few of the storm sewer pipes within the network meet the town's performance criteria.

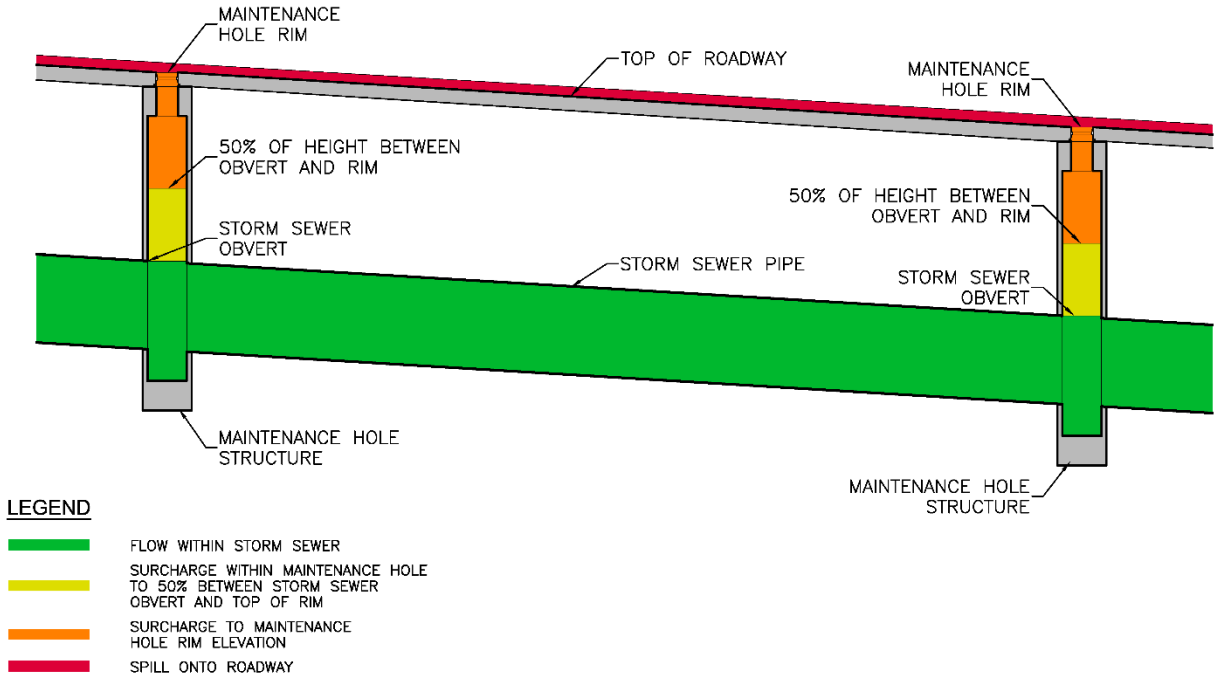

Figure 3: Minor System Performance Criteria

Level of Service Criteria for Major Systems (100 year storm)	
Level of Service	**Criteria**
A	Most of the rights-of-way within the network meet the town's performance criteria.
B	Many of the rights-of-way within the network meet the town's performance criteria.
C	Some of the rights-of-way within the network meet the town's performance criteria.
D	Few of the rights-of-way within the network meet the town's performance criteria.

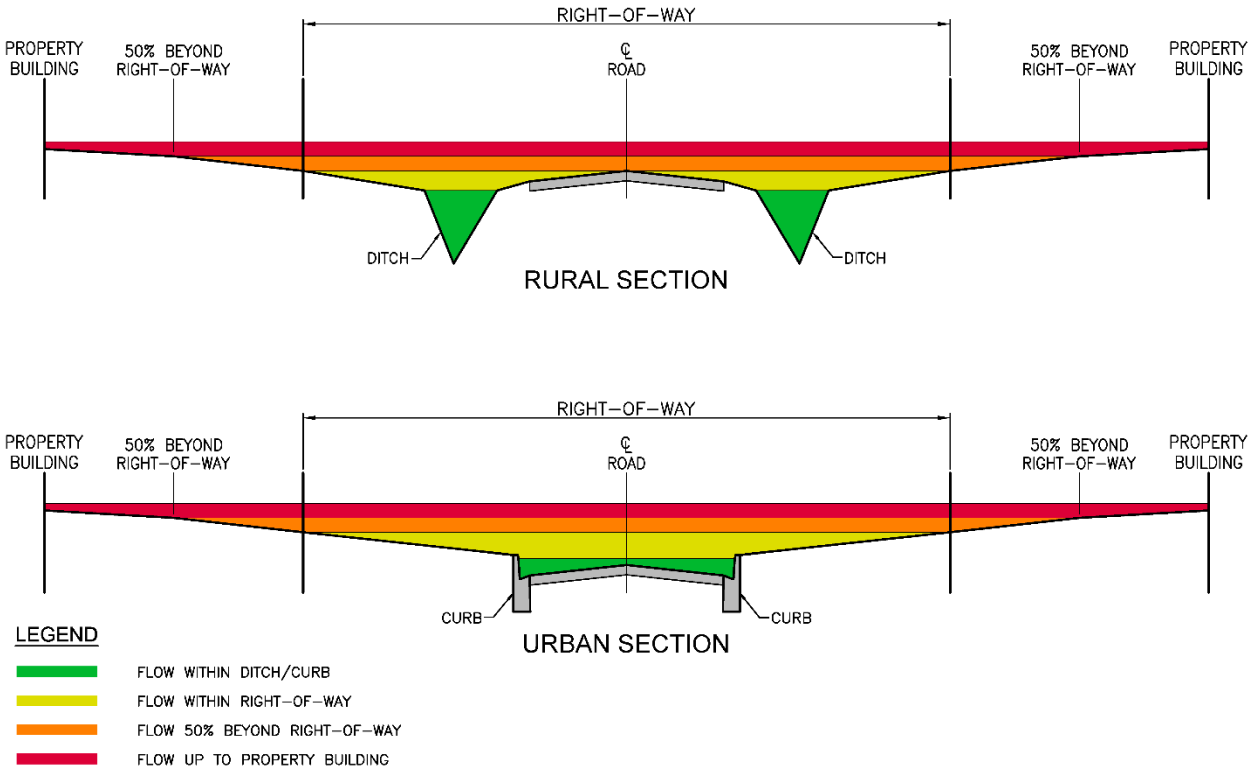

Figure 4: Major System Performance Criteria

In order to determine an overall "net" level of service category for each drainage network, considering both the major and minor system, the results have been appropriately combined; the overall results of this assessment for the existing system are presented in Figure 5.

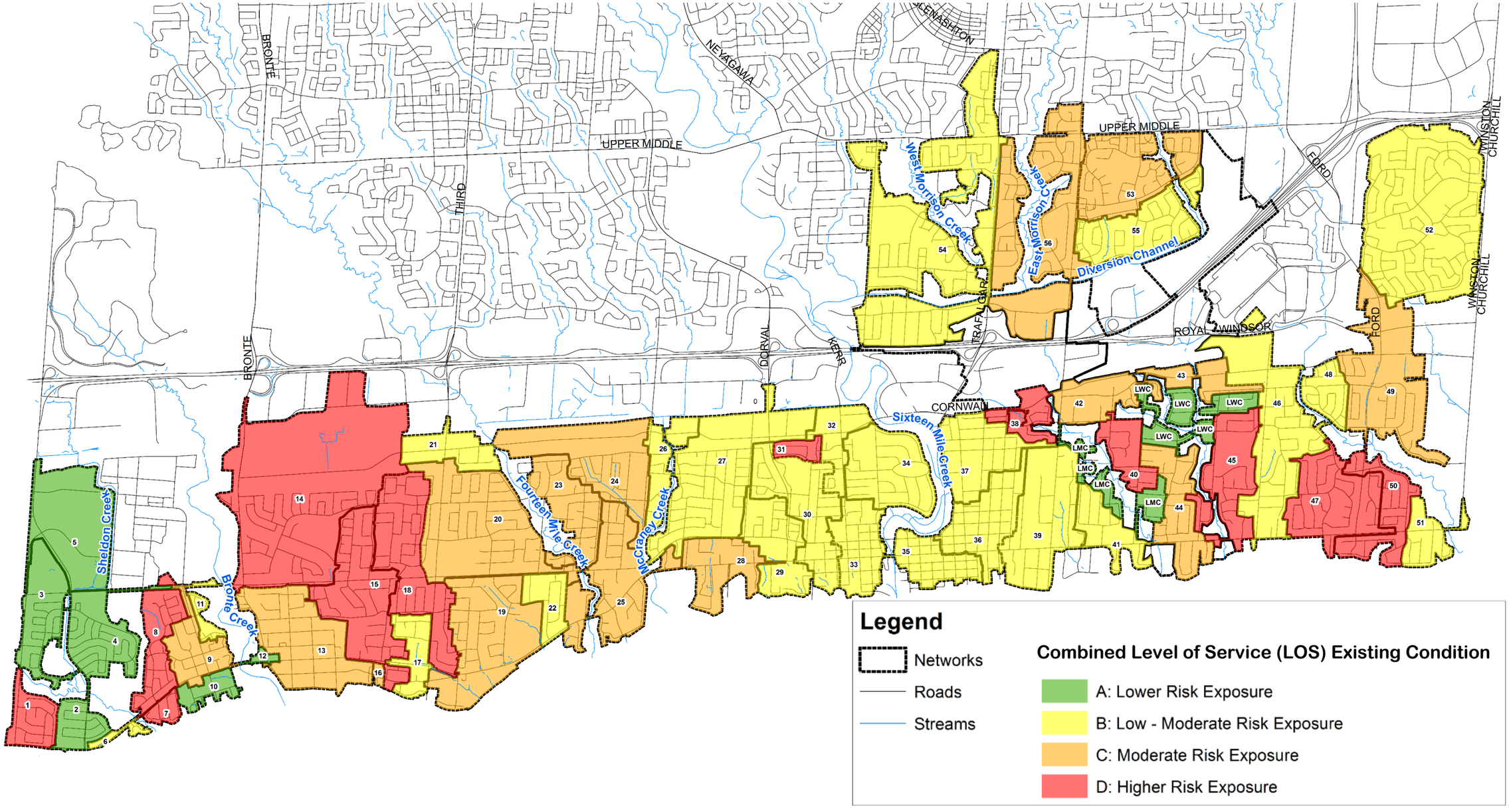

Figure 5: Combined Level of Service for Existing Drainage System

A review of the focus area performance and level of service results has demonstrated the following observations:

- Twelve (12) areas (networks) of higher risk have been identified
- The majority of the risk associated with these areas is related to basement flooding
- All the higher risk areas are located south of the QEW and in general are with areas that were developed prior to 1980
- Areas developed in the 1990's (e.g. Clearview) are of low to moderate risk exposure (i.e. Level of Service B).
- Areas post 2000 (e.g. Great Lakes Boulevard newer subdivision/test area) are of lower risk exposure (i.e. Level of Service A).

Alternative Assessment

A long list of structural alternatives has been considered in the study in order to mitigate the existing performance problems and associated risks in the respective network major and minor systems. The long list of alternatives has considered:

- Do Nothing
- Increase size of affected storm sewers, or supplement capacity
- Implement super pipes to provide on-line stormwater quantity control (storage)
- Implement on-site stormwater management for individual private properties
- Implement off-line storage areas within available public spaces
- Retrofit existing stormwater management facilities to provide additional quantity control
- Diversions (local, not inter-watershed)
- Roof leader/foundation drain disconnection (for minor systems)
- Modify grading on private property to mitigate surface flow extending onto private properties (for major systems).
- Modify grading within road right of way to mitigate surface flow extending onto private properties (for major systems).
- Low Impact Development (LID) Best Management Practices (BMPs)
- Implement inlet control devices (ICDs) within the network's roadway catchbasins to reduce inflows to the storm sewers and improve storm sewer capacity
- Combinations of above

These various alternatives have been screened for each network, to establish a set of recommended works to improve the current level of service within each network. Due to the extensive scope of required works to improve system performance and the expected period of time necessary to implement these works, the solutions have been categorized by anticipated timeframes for implementation, whereby those works considered of lower complexity and lower costs would be short term or minor, while those requiring more investment in both technical study and capital costs to implement, would be long term or major undertakings. The recommendations have been tailored to the specific conditions and requirements of each network, and generally comprise the following:

Short Term (Minor Works):

- Catchbasin Upgrades
  - Add additional catchbasins within public rights-of-way in select areas where capacity exists to increase inflows into town storm sewer system and to decrease potential for surface flooding
- Inlet Control Devices
  - Install inlet control devices in storm sewer catchbasins in select areas to reduce flows in storm sewers and minimize the potential for basement flooding
- Inlet Grates Improvements
  - Improve inlet grates at select locations to minimize the potential for clogging and surface ponding

Long Term (Major Capital):

- Storm Sewer Upgrades
  - Replace identified storm sewers to increase conveyance capacity while decreasing the potential for excessive surcharging and surface flooding
- System Storage
  - Install stormwater storage facilities to retain stormwater where the storm sewer conveyance capacity cannot be practically increased while decreasing the potential for excessive surcharging and surface flooding
- Roadway Re-profiling
  - Re-profiling roadways at the time of roadway reconstruction in areas which lack a suitable/practical alternative to address roadway surface drainage problems

Low Impact Development Best Management Practices (Public/Private Realm):

In addition to the foregoing defined capital projects, this study also examined the effectiveness of low impact development best management practices (LID BMPs) to specifically off-set the impacts associated with climate change and land use intensification. LID BMPs represent the suite of management practices aimed at treating stormwater at its source. Inherently smaller in size, these measures promote storage and infiltration/filtration of storm runoff on-lot or at-source. An iterative process was used to establish a recommended level of control to manage the predicted impacts due climate and land use change. Based on this assessment, a target control rate of about 25 mm has been advanced for application to re-developing properties (by private proponents) and re-constructed roadways (through public proponency). Through analysis, it has been demonstrated that this strategy will fully address the flood risks associated with the redevelopment and climate change for the minor system and partially off-set those impacts for the major system; other more locally specific measures will need to be advanced for fully off-setting major system impacts, at the time of detailed design.

Level-of-Service Improvements

In all cases, the implementation of the recommended works cited above, results in an improvement to the network-based level of service. The net level of service category for each drainage network within the study area, following implementation of the recommended works, is presented in Figure 6. While not all networks result in a LOS "A" or "B", by far and away the majority would achieve this desired performance, and those that do not are recommended for more detailed and more complex future study and related assessments.

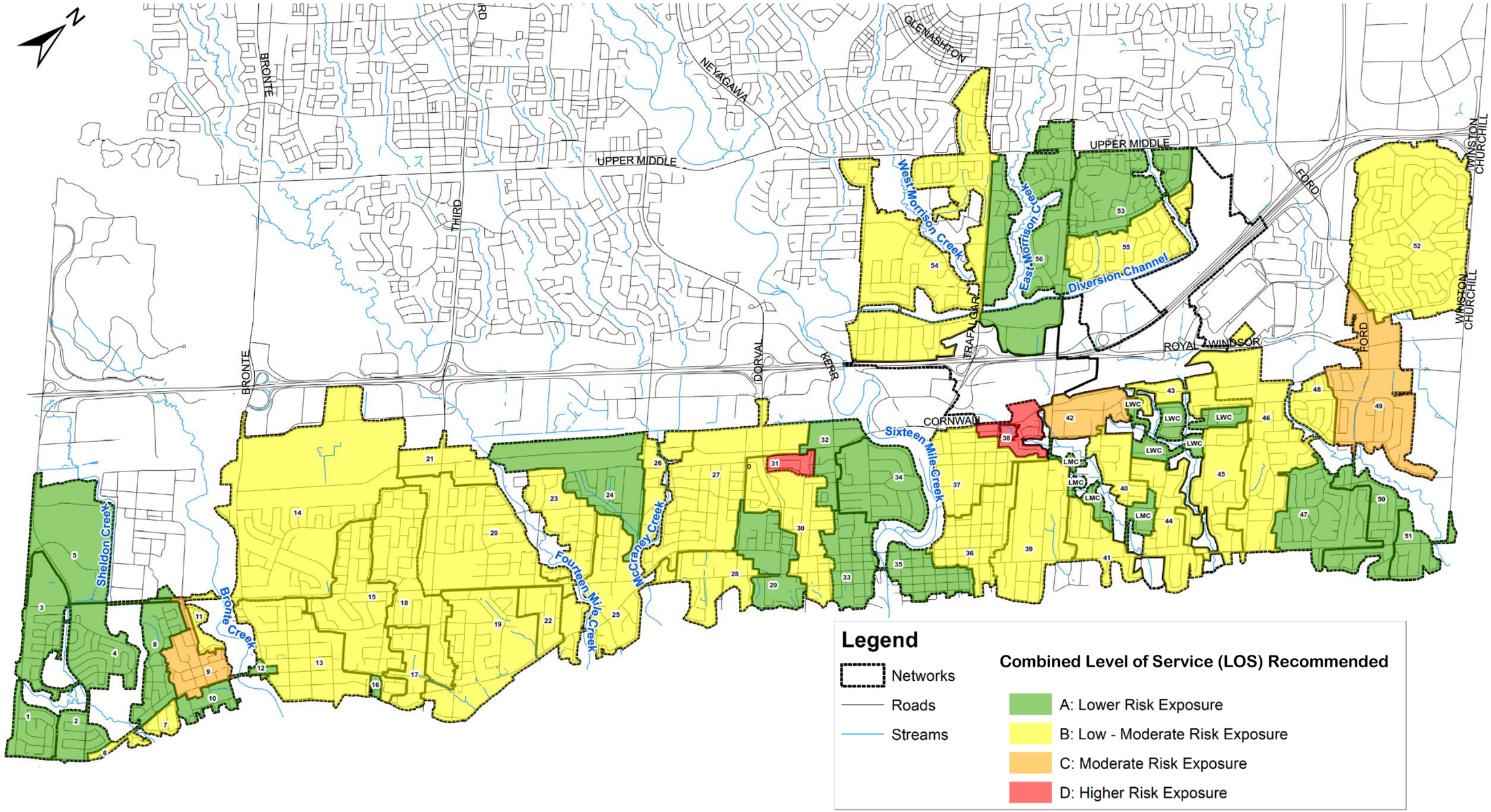

Figure 6: Combined Level of Service with Recommended Works

Remnant Channels

As noted in the *Introduction*, Remnant Channels refer to those open waterways which are not regulated by Conservation Halton. They are generally smaller systems which have largely been cut-off from main watercourses through urbanization, and are predominantly on private property. This study has assessed these features for hydraulic performance (capacity) at a high level to identify the extent of surface flow encroachment onto private properties, as part of the major system assessment described earlier. Recognizing that the remnant channels within the focus area traverse private properties, (and in some instances the specific capacity constraint to the system is privately owned), the feasibility of implementing solutions by the town can be limited. Consequently, should the Town wish to investigate further, future detailed study of each remnant channel is required to evaluate the potential alternatives, which would also provide an opportunity to consult with the locally-affected residents, to establish feasibility for implementation. Any proposed alterations by local residents to properties adjacent to these remnant channels should be specifically evaluated through the town's Development Engineering Site Process (DESP). The intent of this evaluation is to ensure flood risks are addressed through appropriate measures for sites with higher risks associated with remnant channels. In support of this process, all properties adjacent to the remnant channel systems identified through this study should be flagged within the town's property databases as requiring appropriate analyses related to drainage to demonstrate no impacts result from proposed changes to the subject properties.

Stormwater Quality Management

Current Provincial standards require stormwater quality control to be implemented for all new and redeveloped land uses. The future land uses and developments within the focus area, which would require stormwater quality control, consist primarily of future infill, intensification, and redevelopment, as well as the future reconstruction of municipal rights-of-way. The alternatives for providing stormwater quality control for future development and redevelopment of public and private lands within the focus area have include:

- Stormwater quality retrofits to existing facilities and outlets
- Stormwater quality treatment on-site for designated blocks of future development/redevelopment
- Lot-scale stormwater management retrofits at-source
- Preserve and formalize water quality treatment function of roadside ditches
- Utilize "cash-in-lieu" of on-site stormwater management in select cases
- Combinations of the above

Candidate locations for implementing stormwater quality retrofits have been reviewed across the focus area to evaluate each candidate location for retrofit potential, based upon criteria associated with the local physical, natural, social, and economic environments, providing the advantages and disadvantages specific to each location. The preferred sites for implementing stormwater quality retrofits includes retrofits within certain existing dry stormwater management facilities, as well as constructing new stormwater management facilities at select storm outfalls. The full implementation of the preferred stormwater quality retrofit strategy developed through this study would effectively treat 158.2 impervious hectares to an Enhanced standard (the highest provincial treatment class), thereby providing stormwater treatment to a component of the existing and redevelopment land base.

Furthermore, it is proposed as part of the town's water quality management plan that re-developing properties consider source controls and other best practices to remediate their current and future impacts to stormwater runoff water quality. This would also include the town's roadways at the time of re-construction. Larger redevelopment blocks (> 5ha) would generally be able to support stand-alone

stormwater management facilities, whereas smaller re-development parcels, including individual lots would typically be required to provide a suite of best practices to improve site runoff. Cash-in-lieu of on-site stormwater management could also be adopted for smaller re-development parcels less suited to source controls. The benefits of implementing a cash-in-lieu program would be to leverage funding from several small sites (where implementing stormwater quality control is difficult and/or costly and/or inefficient) to more efficiently and effectively improve stormwater quality at larger more environmentally important and currently untreated locations.

In addition, the existing roadside ditches within the town, currently provide a form of "informal" stormwater quality treatment. Consequently, where municipal roads are proposed to be reconstructed, it is recommended that consideration be given toward maintaining, enhancing and formalizing the current function offered by the existing drainage system of ditches, by either preserving their current rural geometry or considering a semi-urban section, in order to utilize the infiltration and stormwater quality treatment afforded by the roadside ditches. As such, an effort should be made to prevent the rurally serviced roads from being converted to an urbanized cross section, in order to improve water quality across the town.

Policy Review

The town's current Policies, By-Laws, and Guidelines related to stormwater and environmental protection/management have been reviewed through this study to identify potential revisions and enhancements which would support implementing the recommendations advanced in this study, as well as to comply with current Provincial policies and regulations, building upon the current practices within the industry as applicable to the Town of Oakville. The following provides an overview of the key revisions considered required to support the foregoing recommendations.

Cash-In-Lieu of on-site Stormwater Quality Control

To facilitate the possible implementation of a cash-in-lieu approach for stormwater quality control, the town would consider implementing the necessary policy/procedures to support this approach. Items to be considered include:

- establishing a cash-in-lieu rate or fee;
- establishing a drainage area (or other criteria) above which cash in lieu will not be considered (and hence on-site stormwater quality control is to be provided);
- determining preferred locations for cash-in-lieu application, as well as those locations less preferred
- regulatory issues;
- appoint Municipal Staff to manage the cash-in-lieu program; and
- be coordinated with the review of Site Plan applications by Town staff.

Planning and Stormwater Management Policies for Redevelopment

It is anticipated that much of the future development within the focus area would occur in the form of redevelopment on private residential lots, either individually or in land assemblies. This type of development has occurred in recent years, and has been largely guided by town By-Laws to determine the permissible size of the dwelling on the site. However, no guidance is currently provided regarding total coverage of redevelopment (including coverage from amenity surfaces), nor do the current standards and policies require stormwater management be implemented for these forms of redevelopment. As such, it is recommended that the town consider updating current planning and stormwater management policies to provide the appropriate guidance for determining total permissible coverage for residential redevelopments (including permissible coverage for increased amenity surfaces), as well as requirements for assessing and implementing stormwater management for these forms of redevelopment. The numerical

analyses conducted as part of this master plan have demonstrated that a minimum of about 25 mm control target is required for the full redeveloped property to address the impacts of land use and climate change over time.

Low Impact Development and Alternative Design Standards

Stormwater management practices across the Province have evolved to include a suite of practices referred to as Low Impact Development Best Management Practices (LID BMPs). These measures are specifically intended to reduce and treat a specified volume of storm runoff to receiving systems, at source. The application of LID BMPs on all new development or redevelopment within the focus area would serve to reduce the demand on the town's drainage infrastructure, and thereby maintain and enhance the level of service provided by the existing infrastructure.

Section 3.1.3.01 of the Town of Oakville Development Engineering Procedures and Guidelines makes reference to the use of LID BMPs for stormwater management, however no details are provided within the Guidelines regarding acceptable practices or design standards within the Town of Oakville. As such, it is recommended that the town consider developing guidelines and standards, specific to the application of LID BMPs on private properties and within municipal rights-of-way**.**

Climate Change

As part of this Stormwater Master Plan, a review of climate change projections and scenarios has been completed to develop estimates of future rainfall for the town, using different industry tools and methods and provide the town with recommendations for a reasonable estimate of future rainfall to be used in its planning and design process. The Town of Oakville defines its current rainfall standard in the *Development Engineering Procedures and Guidelines Manual* and uses the Environment and Climate Change Canada Toronto City (Gauge ID 6158355) station as its basis. The data record for this station spans 1940 to 2007. Based upon the results of the climate change assessment, it is recommended that the town maintain the Toronto City ECCC station as the basis for the Town's design IDF relationship as part of its stormwater management guidelines and policies.

Further, climate change scenarios have been assessed based upon projections for 2050 and 2080. Both timeframes are considered relevant to assessing potential impacts of climate change to the town's storm infrastructure. It is recommended that the town guidelines be updated to incorporate provisions for the selection of the temporal projection of rainfall, based upon the life span of the infrastructure under consideration. Furthermore, it is recommended that town procedures be updated to incorporate the following components for monitoring and assessing the impacts of climate change, as part of future projects:

- Base assessments should be completed using climate change influenced rainfall based on scenario RCP 4.5 (representing a moderate scenario with global efforts to reduce emissions).
- Stress testing designs using climate change influenced rainfall based on scenario RCP 8.5 (representing the business-as-usual high-emissions scenario). More generally, a stress testing approach be adopted when the town is considering infrastructure decisions regarding critical and long-lived infrastructure, to improve system resiliency.
- The town continue to monitor developments with regards to emissions scenarios and tracking to periodically re-evaluate the aforementioned modelling approach.

Cost Estimates and Financing

The estimated costs for implementing the recommended improvements including storm flow control and stormwater quality management under both short and long term timeframes, as per the recommendations contained in the Stormwater Master Plan are summarized as follows:

Capital Costs for Flood (Quantity) Control Works

Short-term (Minor Works)	
Inlet Control Devices	$ 1,000,000
High Capacity Inlets (23 Locations)	$ 260,000
Inlet Improvements (8 Locations)	$ 140,000
Design	$ 120,000
Staff Time	$ 80,000

Long-term (Major Works)	
Sewer Upgrades (at end of service life)	$ 138,072,000*
System Storage (Online/Offline)	$ 50,503,000
Diversions	$ 6,836,000
Remnant Channels (Diversions, Storage, Channel Works)	$ 10,072,000
Private Driveway Culverts	$ 2,611,000
"Green Infrastructure" (by town)	$ 15,275,000
Re-sectioning of Road Side Ditches	$ 2,245,000
Road Re-profiling	To be completed at the time of roadway reconstruction

Future Studies for the Recommended Works	
Study Type	**Capital Cost ($)**
Schedule A/A+	$ 15,504,000
Schedule B	$ 1,196,000
Detailed Network Analysis	$ 1,000,000

Capital Costs for Stormwater Quality Works

Short-term (Minor Works)	
Neighbourhood Retrofit Pilot	$ 145,000

Long-term (Major Works)	
Retrofit of Existing Stormwater Management Facilities	$ 1,344,000
New Stormwater Management Facilities	$ 442,000
Formalization/Improvement of Roadside Ditches	TBD

*It should be noted that the incremental costs related to storm sewer replacements (i.e. size upgrades) above which has already been contemplated for current storm sewer replacement costs, is about $45million.

As noted, the town has considered works under two time frames, short and long term, with short term reflecting simpler lower cost solutions with less planning and design, and long term relating to the others, which are generally more costly and complex to implement, both in terms of planning and design. The town has adopted risk based approach to establishing the priority for implementing the recommended works, based on the level of service in the respective networks. Specifically those locations at risk of basement flooding, due to surcharge of directly connected basements to the storm sewer system are deemed of highest priority, followed by locations where the major overland system would encroach closer than 50% to the building from the ROW. The balance of the flood risks were deemed of comparatively lower priority. While not uniform in each network (due to varying servicing types and performance levels), the percentage of each type of risk (high, medium and low) has been summed for each of the networks to allow for a consistent basis for establishing priorities across the focus area.

Next Steps

As noted above, Phase 3 of the stormwater master plan will contemplate the funding mechanisms available to support the proposed recommended works. The financing study is the next step in the overall Stormwater Master Plan and will consider all approaches including a utility fund program, similar to that which has been implemented within several other Southern Ontario municipalities over the past decade**.**