Black Creek Stormwater Optimization Study
Municipal Class Environmental Assessment
Master Plan Report (Phases 1 & 2)

February 2012

AECOM

VAUGHAN

Environment

Black Creek Stormwater Optimization Study – Municipal Class Environmental Assessment Master Plan Report (Phases 1 & 2)

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Project No.:
60117240

Date:
February, 2012

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February 28, 2012

Mr. Saad Yousaf, P.Eng.
Project Manager
Development / Transportation Engineering Department
City of Vaughan
2141 Major MacKenzie Drive
Vaughan, ON L6A 1T1

Dear Mr. Yousaf:

Project No: 60117240

Regarding: Black Creek Stormwater Optimization Study
Municipal Class Environmental Assessment
Master Plan Report (Phases 1 & 2)

We are pleased to submit three (3) copies of our Final Report on the above-noted study. The document provides a comprehensive discussion of the following information:

- The problem/opportunity statement and other background information;
- The identification and description of alternative solutions to the problem;
- An inventory of the environmental characteristics of the Study Area;
- The evaluation process followed to select the preferred solution;
- The selection of the preferred solution;
- The elements of the Master Plan strategy;
- A summary of the public and agency consultation process; and
- Details regarding the implementation of the preferred solution.

As presented in the Report, the next steps in the Class EA process involve the completion of Phases 3 and 4, which facilitate the final design and implementation of the improvement works that comprise the Master Plan.

We look forward to our continued involvement on this important undertaking, and assisting the City with the completion of Phases 3 and 4 of the Master Plan.

Please call me if any questions arises or additional information is required.

Sincerely,
AECOM Canada Ltd.

Joe Puopolo, P.Eng., PMP
Project Manager

JW/JP:mm / Encl.
cc: Mr. Sameer Dhalla, Toronto and Region Conservation

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Executive Summary

INTRODUCTION

The area under consideration for this Master Plan Class EA Study (the Study Area) includes the portion of the Black Creek subwatershed that is located within the City of Vaughan (City) municipal boundaries, extending north from Steeles Avenue to Major MacKenzie Drive, and between Keele Street to the east and Pine Valley Drive to the west (refer to ***Figure ES-1***). The Study Area covers an area of approximately 1,500 ha, which is almost entirely urbanized and comprised of a combination of residential, commercial and industrial lands.

A number of key stormwater management (SWM) issues have been identified within the Study Area by the City and the Toronto and Region Conservation Authority (TRCA). These considerations were established based on the results of hydrologic and hydraulic modelling, as well as field investigations carried out during and following major rainfall events, including the August 19, 2005 storm. Further confirmation has been provided by AECOM, which include the following:

- A significant number of structures and municipal infrastructure is located within the regulatory floodplain, including portions of Highways 400 and 7, and Jane Street;
- Due to insufficient capacity of the Black Creek channel and associated hydraulic structures at certain locations, particularly along Jane Street between the 407ETR and Highway 7, flooding of structures, roadways and municipal infrastructure occurs during comparatively frequent storm events;
- Limited stormwater quality treatment features within a majority of the older industrial areas of the Study Area is contributing to the degraded water quality within Black Creek;
- Channel erosion is occurring within the natural portion of Black Creek between Steeles Avenue and the 407ETR;
- The proximity of existing structures and municipal infrastructure adjacent to Black Creek poses a significant constraint to the implementation of measures to increase the hydraulic capacity of the existing channel corridor;
- A number of development initiatives are currently being considered within the Study Area (i.e., Vaughan Metropolitan Centre, OPA 620, Rutherford Business Park North, Toronto-York Spadina Subway Extension Highway 407 Station, Invar, etc.) – accordingly, an opportunity exists to implement appropriate quality and quantity controls within these areas.

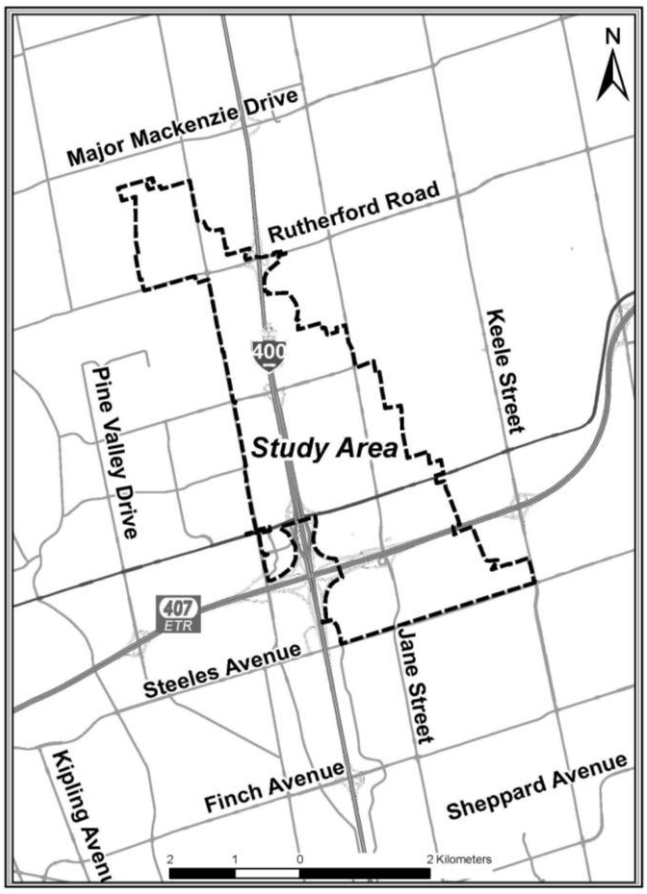

Figure ES-1. Limits of Study Area

In order to address these issues and find opportunities to improve existing conditions within the Study Area, a Master Plan approach was followed for this Class Environmental Assessment (EA). This document presents a summary of the relevant background information compiled for the Study, the definition of

the problem/opportunity, the identification of the alternative solutions, as well as the evaluation methodology and the Master Plan strategy.

STUDY PURPOSE AND OBJECTIVES

The overall goal of the Study is to address the ongoing flooding, water quality and channel erosion issues that have been identified within the Study Area. To achieve this goal, the following objectives were defined for the ***Black Creek Stormwater Optimization Study***:

i) Characterize the existing environmental conditions by establishing the location, extent, significance and sensitivities of the existing natural features within the creek and valley corridor;

ii) Identify retrofit measures that can be incorporated into existing development to address both quantity and quality control deficiencies;

iii) Evaluate a range of alternatives, including source, conveyance and end-of-pipe measures, structural works, best management practices and policies that can be applied to address recognized problems;

iv) Incorporate emerging sustainable technologies for the treatment of stormwater (i.e., green roofs, rainwater harvesting, grey water re-use, permeable pavement, etc.);

v) Ensure that all solutions achieve adequate protection for municipal infrastructure located within the Study Area; and

Flooding at Highway 7 and Jane Street Following August 19th, 2005 Storm

vi) Satisfy the requirements of the Ministry of the Environment (MOE) Class EA process, including public and regulatory agency consultation.

PROBLEM/OPPORTUNITY

Notwithstanding the existing SWM controls, development through much of the Study Area occurred prior to the adoption of current SWM practices. The limited incorporation of effective SWM controls, whether lot level, conveyance or end-of-pipe facilities, has contributed to an increase in localized flooding, degraded water quality and accelerated channel erosion.

In addition to the above, a number of proposed development initiatives are scheduled for implementation within the Study Area, which should be considered as part of this Study. Therefore, further to addressing the current flooding, erosion and water quality issues, the Study offers the opportunity to examine the implications of future development in the City of Vaughan within the Black Creek subwatershed.

Accordingly, an opportunity exists to develop a comprehensive strategy that will establish appropriate flood control and erosion protection works for the existing properties and future/planned development within the Study Area, as well as measures to improve the water quality within Black Creek, while maintaining and enhancing the aquatic and terrestrial habitats. In order to implement this strategy, a subwatershed-based approach was adopted to ensure that the full range of concerns, objectives and potential solutions are recognized and reconciled.

ALTERNATIVE SOLUTIONS

In order to address the problem defined for the project, a number of improvement alternatives were identified for each of the issues noted above (i.e., flooding, water quality and channel erosion). The improvement alternatives considered for further evaluation are listed below.

i) Flood Improvement Alternatives

- Alternative F1 – Do Nothing
- Alternative F2 – 100-Year Storm Improvements

- Alternative F3 – August 19, 2005 Storm Improvements
- Alternative F4 – Regional Storm Improvements

ii) Water Quality Improvement Alternatives

- Alternative WQ1 – Do Nothing
- Alternative WQ2 – SWM Quality Ponds
- Alternative WQ3 – Centralized Oil-Grit Separators

iii) Channel Eros4ion Improvement Alternatives

- Alternative E1 – Do Nothing
- Alternative E2 – Additional SWM Controls
- Alternative E3 – In-stream Restoration Strategies

PREFERRED SOLUTION

The alternative solutions were comparatively evaluated according to a qualitative assessment with criteria representing the broad definition of the environment, as described in the EA Act, including natural, social, cultural and financial considerations. As part of the evaluation, the alternative solutions were ranked in order of preference with respect to their net effects on the environment. The components of the preferred solution are summarized in ***Table ES-1*** below and shown on ***Figures ES-2 and ES-3***.

PUBLIC AND AGENCY CONSULTATION

Further to the Notice of Commencement, project information was presented to the public and relevant agencies through Public Information Forums (PIFs) on the following dates:

- *Thursday May 20, 2009 from 6:00 to 9:00 p.m.* – the purpose of this PIF was to identify the Study objectives, define the problem/opportunity statement and present the results of the existing conditions assessment that was carried out during the initial stages of the project.
- *Thursday March 11, 2010 from 6:00 to 9:00 p.m.* – the purpose of this PIF was to present the alternative solutions developed to address the problem/opportunity statement, the evaluation methodology and the preferred Master Plan strategy.

During and following the PIFs, members of the public and agency representatives were invited to provide comments for consideration in the project, which were documented and followed-up with a response.

RECOMMENDED STORMWATER OPTIMIZATION MASTER PLAN

The recommended Master Plan strategy for the ***Black Creek Stormwater Optimization Study*** involves the implementation of the above-noted proposed works that comprise the preferred solution, together with a wide range of proposed SWM criteria that should be satisfied as part of all future development initiatives.

Table ES-1. Capital Works of the Preferred Alternatives and Master Plan

Issue	Preferred Alternative	Description of Preferred Alternative	Estimated Capital Cost
Flooding	***Alternative F4*** Regional Storm Improvements	The objective of this alternative is to provide sufficient capacity within Black Creek to convey the runoff generated by the Regional Storm (i.e., Hurricane Hazel) without flooding adjacent buildings, and minimal flooding of roads or municipal infrastructure. The proposed works involve the construction of a new naturalized channel to replace the existing segment of Black Creek between the Edgeley Pond and the 407ETR, and new bridges at road crossings. (Highway 7, Doughton Road and Interchange Way)	$30 M
Water Quality	***Alternative WQ3*** SWM Quality Ponds	These works consist of the retrofit of five existing SWM ponds and the construction of five new SWM pond in the Study Area to provide a water quality control component. Many of these projects have been recommended through previous studies or identified as a requirement for proposed development initiatives.	$18 M
Erosion	***Alternative E3*** In-stream restoration measures	These works involve a combination of in-stream restoration measures to address localized erosion or bank instability issues. In addition, it should be noted that further erosion control will be provided through the construction of new SWM ponds and the SWM pond retrofits that have been identified in previous studies carried out by the City and TRCA, together with proposed development initiatives (i.e., VMC, OPA 620, TYSSE Highway 407 Station, etc.).	$2 M

Note: The estimated capital cost excludes land acquisition costs.

As prescribed under the Master Plan approach, the components of the preferred solution, which include a variety of Schedule A/A+, B and C undertakings, can be implemented separately over time as development proposals are advanced, funding becomes available and the necessary regulatory approvals are secured.

Further to the above, the Master Plan provides recommendations for future development within the Study Area, including applicable SWM criteria and policies as well as appropriate Best Management Practices (BMPs) and a summary of municipal operations and maintenance measures that should be considered for implementation by the City.

IMPLEMENTATION CONSIDERATIONS

Given the diversity of undertakings proposed as part of the recommended Master Plan, a number of factors must be considered to ensure that these projects are implemented in a coordinated and effective manner, and all additional regulatory requirements are satisfied. Accordingly, the timeframe for the implementation of the proposed works will vary for the preferred flooding, water quality, and erosion improvement alternatives.

Aside from the in-stream erosion strategies proposed along the natural portions of Black Creek, the recommended improvement measures that comprise the preferred alternatives for flooding and water quality must be coordinated with the Vaughan Metropolitan Centre (VMC), OPA 620 and the *Toronto-York Spadina Subway Extension* initiatives. In addition, further regulatory approvals will be required prior to the implementation of the proposed works.

NEXT STEPS

The Master Planning process for the ***Black Creek Stormwater Optimization Study*** was carried out in accordance with Approach #3, as outlined in Appendix 4 of the MEA document (October 2000, as amended in 2007). Under this approach, Phases 1 to 3 of the Class EA process must be completed, followed by the preparation of a Master Plan document (i.e., Phase 4).

To that end, all of the tasks required to be carried out for Phases 1 and 2 of the Class EA process have been completed, and the level of investigation, consultation and documentation are sufficient to fulfill the requirements prescribed for Schedule A/A+ and B projects.

However, the preferred solution that has been selected to address flooding within the Study Area involves the construction of three bridges, which are considered to be Schedule C undertakings, as the estimated cost for each of the structures exceeds $2.7 million.

In order to satisfy the requirements for the Schedule C undertakings associated with the recommended Master Plan, Phases 3 and 4 of the Class EA process must be carried out prior to the implementation of the proposed works. Accordingly, further information will be provided as part of this Master Plan Class EA to document Phases 3 and 4, prior to issuing a *Notice of Completion* for the Schedule C projects.

In addition, the preferred solution will also require approval under the *Canadian Environmental Assessment Act* (CEAA), as the proposed channel works along the segment of Black Creek between the 407ETR and Highway 7 will require authorization from the Department of Fisheries and Oceans (DFO) under the *Federal Fisheries Act*.

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2007

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UTM Zone 17N, NAD 83

Legend

- Subwatershed Boundary
- SouthernBoundary
- Proposed Black Creek Channel Corridor (Refer to Figure ES-3)
- Watercourse
- Proposed Stormwater Management Pond
- Existing Stormwater Management Quality Control Pond
- Recommended Stormwater Management Pond Retrofit
- Proposed In-Stream Erosion Restoration Location

Black Creek Stormwater
Optimization Study Master Plan
Class Environmental Assessment

Preferred Improvement Alternatives

February 2012
Project 60143860

Figure ES-2

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Map Document: (N:\projects\2009\90057\2009\Final\GISSpatial\MXDs\ReportMXDs\90057PreferredImprovementAlternatives.mxd)
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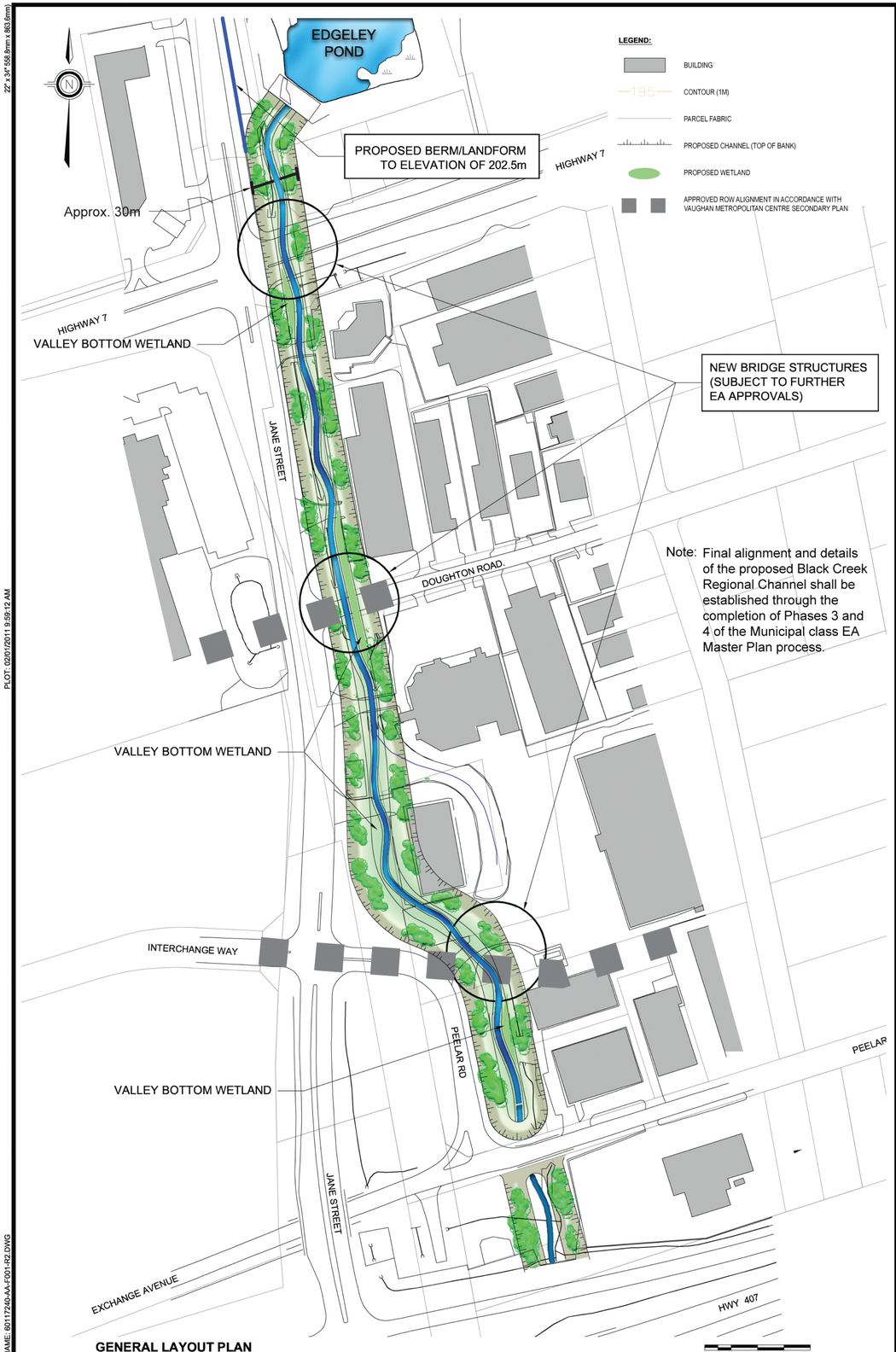
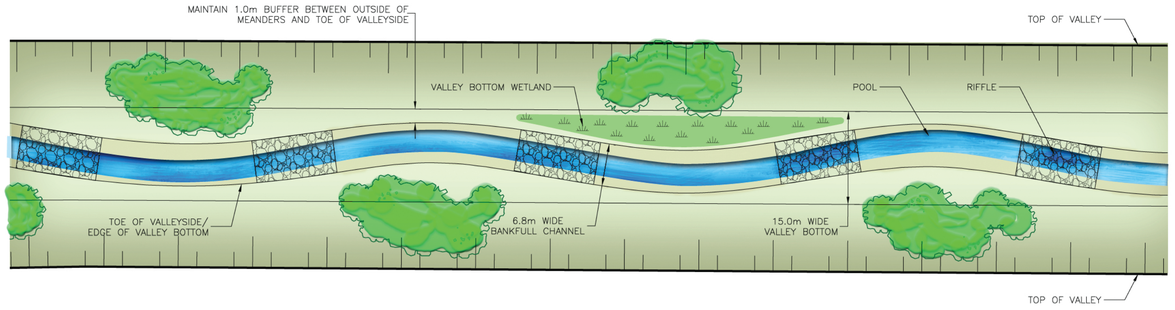
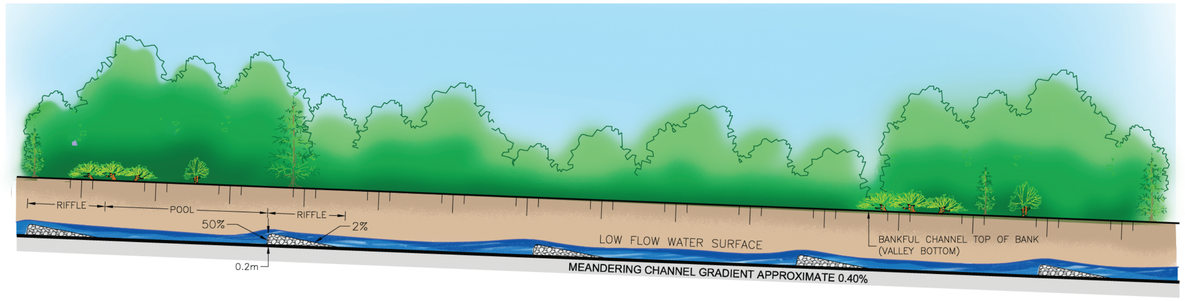


Note: Final alignment and details of the proposed Black Creek Regional Channel shall be established through the completion of Phases 3 and 4 of the Municipal class EA Master Plan process.

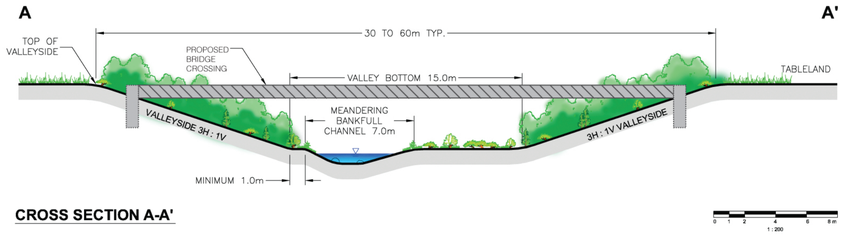
GENERAL LAYOUT PLAN



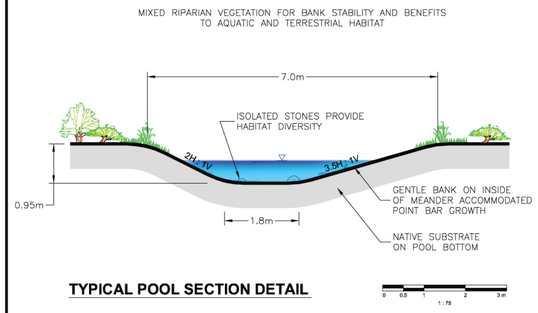
TYPICAL CHANNEL PLAN



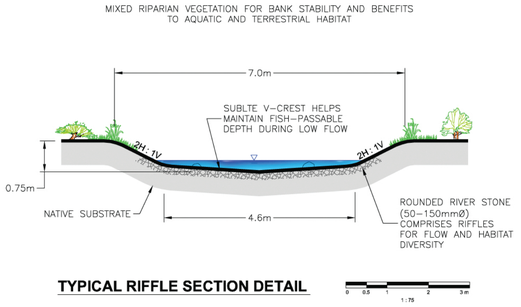
TYPICAL CHANNEL PROFILE



CROSS SECTION A-A'



TYPICAL POOL SECTION DETAIL



TYPICAL RIFFLE SECTION DETAIL

AECOM VAUGHAN

Black Creek Stormwater Optimization Study Channelization Concept for Preferred EA Flood Control Alternative (F4)

PROJECT NUMBER	DATE	FIGURE
60117240	May, 2011	ES-3

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1. Introduction

1.1 Background

Development through much of the Black Creek subwatershed within the City of Vaughan (City) occurred prior to the adoption of current stormwater management (SWM) practices. The limited incorporation of effective SWM measures, whether lot level, conveyance or end-of-pipe controls, has contributed to an increase in localized flooding, accelerated channel erosion and impaired water quality.

There are a number of key SWM issues, constraints and opportunities that have been identified within the Black Creek Subwatershed Study Area by the City and the Toronto and Region Conservation Authority (TRCA). These considerations were established based on the results of hydrologic and hydraulic modelling as well as field investigations carried out during and following major rainfall events, including the August 19, 2005 storm. Specific SWM issues, constraints and opportunities that have been observed within the Study Area are summarized below.

Flooding of Jane Street and Adjacent Properties South of Highway 7

- A significant number of structures and municipal infrastructure is located within the Regulatory (i.e., Regional Storm) Floodplain, including portions of Highway 400, Highway 7 and Jane Street;
- Considerable portions of the Black Creek channel and associated hydraulic structures provide insufficient capacity, particularly along Jane Street between the 407ETR and Highway 7, causing flooding of structures, roadways and municipal infrastructure that are located with the Regulatory Floodplain;
- The level of water quality protection currently provided varies widely across the upper Black Creek subwatershed, with little to no water quality treatment for many of the older industrial areas, resulting in impaired quality of runoff contributing to Black Creek;
- Localized erosion has been observed at multiple locations within the natural portion of Black Creek between the 407ETR and Steeles Avenue.
- The proximity of existing structures and municipal infrastructure to Black Creek poses a significant constraint to the implementation of measures to increase the hydraulic capacity of the channel;
- Significant geotechnical issues have been identified for the gabion basket retaining wall upstream of Peelar Road; and
- A number of development initiatives are currently being considered within the Study Area - i.e., Vaughan Metropolitan Centre (VMC), OPA 620, Rutherford Business Park North, Toronto-York Spadina Subway Extension (TYSSE) Highway 407 Station, etc. – accordingly, an opportunity exists to implement appropriate quality and quantity controls.

1.2 Study Purpose and Objectives

The City, together with TRCA, initiated the ***Black Creek Stormwater Optimization Study*** to address localized flooding issues, ongoing channel erosion and impaired water quality that has been identified within the Study Area.

Given the diversity of issues and potential solutions, a subwatershed-based approach was adopted to ensure that the full range of concerns and objectives are recognized and reconciled. Specifically, the objectives of the Study are to:

i) Characterize the existing environmental conditions by establishing the location, extent, significance and sensitivities of the existing natural features within the Black Creek system and associated valley corridors;

ii) Identify stormwater retrofit measures that can be incorporated into existing developments to address both quality and quantity control;

iii) Review and confirm the suitability of the SWM strategies established for proposed development initiatives within the Study Area (i.e., VMC, OPA 620, TYSSE);

iv) Evaluate a range of alternatives, including source, conveyance and end-of-pipe measures, structural works, management practices and policies that can be applied to address recognized problems;

v) Incorporate emerging sustainable technologies for the treatment of stormwater (i.e., green roofs, rainwater harvesting, grey water re-use, permeable pavement, etc.);

vi) Ensure that all solutions achieve adequate protection for municipal infrastructure located within the Study Area; and

vii) Satisfy the requirements of the Ministry of the Environment (MOE) Class EA process, including public and regulatory agency consultation, as well as those of the Canadian Environmental Assessment Act (CEAA), if required.

1.3 Overview of the Municipal Class EA Planning Process

As required under the *Ontario Environmental Assessment Act* (OEAA), the Study followed the Municipal Class EA planning process, as prescribed by the Municipal Engineers Association (MEA) (October 2000, as amended in 2007). The Municipal Class EA process allows the City to satisfy the requirements of the EA Act for municipal infrastructure without having to either undertake an Individual EA or request a specific exemption for the project. Municipal projects addressed by the Class EA may be implemented without further approval under the OEAA, provided that the approved Municipal Class EA planning process is carried out.

The stated purpose of the OEEA is to provide for *the betterment of the people of the whole or any part of Ontario by providing for the protection, conservation and wise management in Ontario of the environment*, where the broad environment includes the natural, social, cultural, built, and economic environments.

The provisions of the OEEA require municipalities to carry out an environmental assessment for public works projects, including those undertaken for municipal roads, water and wastewater systems, and transit ventures that are subject to the Municipal Class EA process. As described in the MEA Class EA document, this process is a five phased decision-making framework for the planning and design of municipal infrastructure.

The key principles of the Class EA process include:

- Consultation with affected parties upon commencement, and throughout the process, of the Study;
- Consideration of a reasonable range of alternatives, including both the functionally different "alternatives to" and the "alternative methods" of implementing the preferred solution;
- Identification and consideration of the effects of each alternative solution and/or method on all aspects of the environment (i.e., natural, cultural, social, economic, etc.);
- Systematic evaluation of all alternative solutions and/or methods in terms of the advantages and disadvantages associated with each to determine the net environmental effects; and
- Provision of clear and complete documentation of the planning process that was followed, to ensure transparency and traceability of the decision-making process.

1.3.1 Project Classifications

The Municipal Class EA document classifies projects into four separate categories depending on the potential environmental effects and significance: Schedule A/A+, B, and C undertakings. The level of review associated with each category to satisfy the Class EA requirements, and thereby achieve compliance with the EA Act, is described below.

- ***Schedule A/A+***
  This category includes projects that are limited in scale, have minimal environmental impacts and include a variety of municipal maintenance and operational activities. These undertakings are approved and may proceed directly to Phase 5 for implementation. As part of the 2007 amendments

to the EA process, the Schedule A+ classification was introduced to supplement the requirements of Schedule A undertakings, which includes projects that are pre-approved; however, the public must be notified prior to project implementation (i.e., Phase 5).

- ***Schedule B***
  These projects have the potential for some adverse environmental effects and, therefore, the municipality is required to undertake a screening process (i.e., Phases 1 and 2) involving mandatory contact with directly affected public and relevant agencies to ensure that they are aware of the project and that their concerns are addressed. In addition, it is required that a document must be prepared and submitted for review by the public and review agencies for these undertakings. If there are no outstanding concerns, the municipality may proceed to Phase 5 for implementation.
- ***Schedule C***
  Projects included under this classification have the potential for significant environmental effects and must proceed under the full planning and documentation procedures specified in the MEA Class EA document (i.e., Phases 1 to 4). An Environmental Study Report must be prepared and submitted for review by the public and relevant agencies for these undertakings. If there are no outstanding concerns, the municipality may proceed to Phase 5 for implementation.

1.3.2 Master Plan Process

The Municipal Class EA document includes a Master Plan process that allows a proponent, such as the City, to carry out the planning, design, and construction of a group of related municipal works together rather than separately on a project-by-project basis, thus providing the following benefits:

- The rationale for the individual projects is better defined;
- The infrastructure alternatives are more broadly established;
- The extent of potential effects are better understood;
- The ability to integrate land use planning; and
- The ability to assess decisions from a variety of perspectives.

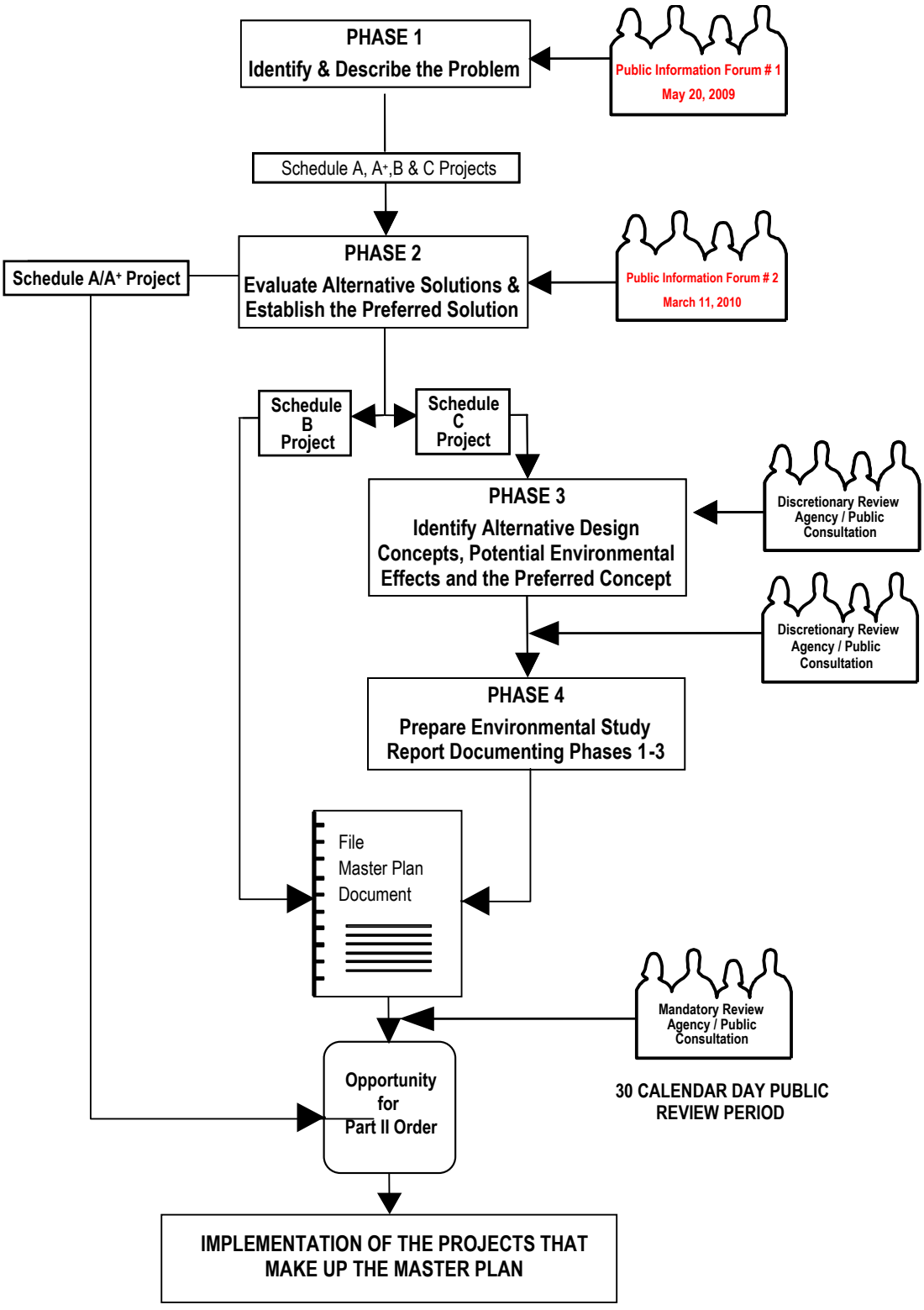
The Master Planning process differs from project specific undertakings in several aspects, and facilitates long range planning that enables the municipality to identify opportunities and proactively develop strategies for addressing any associated issues. This approach generally yields a series of individual activities, projects, and programs, together with a phased implementation plan that covers an extended time period. Accordingly, the works may be implemented separately as individual projects but, collectively, they form part of the overall management system embodied in the Master Plan. An outcome of the Master Planning process is the identification of individual projects as Schedule A/A+, B, or C undertakings, based on their level of complexity and potential effects on the environment.

The level of assessment followed for the ***Black Creek Stormwater Optimization Study*** (Phase 1 and 2) combined with Phases 3 to 4 will ensure that the Class EA process is satisfied. The resulting SWM improvement strategy considers a reasonable range of alternatives to address deficiencies in the drainage system and identify potential solutions to reduce the risk of flooding of roadways and buildings, enhance stormwater quality and protect against further erosion within the Black Creek channel and tributaries.

The Study was undertaken in accordance with Approach #3, as described in Appendix 4 of the MEA Class EA document. This approach involves the preparation of a Master Plan document at the conclusion of Phase 4 of the Municipal Class EA process, where the level of investigation, consultation and documentation are sufficient to fulfill the requirements for both the Schedule B and C projects.

An overview of the Municipal Class EA process is shown on ***Figure 1***, which provided the framework for the current Study, and the following provides a description of the phases that were completed in the preparation of this Master Plan.

Figure 1. Overview of the Municipal Class EA Process



Phase 1: Identify the Problem / Opportunity

This phase involves not only identifying the problem/opportunity, but also describing it in sufficient detail to lead to a clear problem/opportunity statement. As part of describing the problem/ opportunity, input from review agencies and the public can be solicited.

Phase 2: Identify and Evaluate Alternative Solutions to the Problem / Opportunity

This phase involves the following six steps:

i) Identify all reasonable alternative solutions to the problem / opportunity;
ii) Prepare a general inventory of the existing natural, social and economic environments in which the project is to occur;
iii) Identify the net positive and negative effects of each alternative solution including mitigating measures;
iv) Evaluate the alternative solutions;
v) Consult with review agencies and the public to solicit comment and input; and
vi) Select or confirm the recommended solution.

Phase 3: Identify & Evaluate the Design Alternatives for Implementing the Preferred Solution

This phase involves the following six steps:

i) Identify alternative design concepts for implementing the preferred solution;
ii) Prepare a detailed inventory of the existing natural, social and economic environments;
iii) Identify the net positive and negative effects of each alternative design concept including mitigating measures;
iv) Evaluate the alternative design concepts;
v) Consult with review agencies and the public to solicit comment and input; and
vi) Select/confirm the preferred design concept.

Phase 4: Prepare Master Plan Document

Following completion of Phase 3, documentation of the initial three phases must be prepared and placed on public record for a period of at least 30 calendar days to provide review agencies and the public with an opportunity to review these materials.

During this review period, concerned individuals have an opportunity to request a Part II Order under the EA Act before the project may proceed to implementation. A Part II Order requires that an Individual EA be carried out, documented, and submitted to the Minister of the Environment for review and approval. The decision on whether the project should be subject to a Part II Order rests with the Minister. In addition, the Minister may deny the Part II Order, but attach a condition to the denial requiring the proponent to undertake the Project as a Schedule C rather than a Schedule B under the Class EA process. Once the public review period has expired and there are no outstanding Part II Order requests, the municipality may proceed to the final phase of the planning and design process.

Phase 5: Complete Contract Drawings and Documents and Proceed to Construct, Operate, and Monitor the Project

This phase involves completing contract drawings and tender documents, incorporating the recommended solution and mitigating measures identified during the previous phases of the process. Once contracts are awarded, construction can take place and the project is implemented. Any monitoring programs identified during the Class EA shall be undertaken to ensure that the environmental provisions and commitments made during the process are fulfilled and effective.

1.3.3 Public and Agency Consultation

As required under the Class EA process for Schedule B and C undertakings, consultation with the public and government review agencies is necessary throughout the project. The purpose of the consultation process is to inform stakeholders of the project details and give all interested parties an opportunity to provide input or comments related to the undertaking. A description of the consultation activities carried out during Phases 1 and 2 of the ***Black Creek Stormwater Optimization Study*** is presented in Section 4 of the report.

2. Phase 1 – Identification & Description of the Problem

2.1 Description of the Master Plan Study Area

The Black Creek subwatershed is located within the cities of Vaughan and Toronto, and forms part of the Humber River watershed. Black Creek's main channel is approximately 36 km in length, with its headwaters in Vellore Village near Weston Road and Major MacKenzie Drive, and its outlet is located at the Humber River near the Lambton Golf and Country Club.

The area under consideration for this Class EA Study includes the portion of the Black Creek subwatershed that is located within the City of Vaughan municipal boundaries, generally extending north from Steeles Avenue to Major MacKenzie Drive, and between Keele Street to the east and Pine Valley Drive to the west(refer to ***Figure 2***). The Study Area covers an area of approximately 1,500 ha, which is almost entirely urbanized and comprised of a combination of residential, commercial and industrial lands.

2.2 Identification of the Problem/Opportunity

In the Province of Ontario, adequate stormwater management (SWM) controls are a requirement of development to prevent downstream flooding and erosion, maintain groundwater resources and protect water quality. These measures are implemented to ensure public safety and minimize the potential for damage to private property and municipal infrastructure, and protect the natural environment.

Notwithstanding the existing SWM controls, development through much of the Study Area occurred prior to the adoption of current SWM practices. The limited incorporation of effective SWM controls, whether lot level, conveyance or end-of-pipe facilities, has contributed to an increase in localized flooding and erosion, as well as degraded water quality. A description of the specific issues within the Study Area regarding flooding, water quality and channel erosion is provided below.

i) Flooding

Significant flooding of Jane Street and Highway 7, as well as the properties and infrastructure that are adjacent to Black Creek, occurs during minor to moderate rainfall events (i.e., above 5-year storm). In addition, the risk of flooding to roadways and private properties within other portions of the Study Area has been identified in previous studies completed by the City and TRCA.

ii) Water Quality

Many of the older commercial/industrial areas within the Study Area were developed with limited or no water quality controls and, as a result, the quality of runoff contributing to Black Creek has been impacted.

iii) Channel Erosion

Several locations of moderate to significant erosion have been identified along the natural reaches of Black Creek between Steeles Avenue and the 407ETR, including bed and bank erosion that has led to significant slope instability in some cases.

2.3 Problem/Opportunity Statement

An opportunity exists to develop a comprehensive strategy that will establish measures to improve the water quality within Black Creek, as well as appropriate flood control and erosion protection works for the existing properties and future/planned development within the subwatershed. Further, there is also an opportunity to protect and enhance the natural habitat along Black Creek. In order to prepare and implement a comprehensive strategy, a subwatershed-based approach is most appropriate to ensure that the full range of concerns, objectives and potential solutions are recognized and reconciled.

3. Phase 2 – Identification & Evaluation of Alternative Solutions to the Problem

3.1 General

Given that the Study is following the Class EA process for a Master Plan and is expected to consist of a variety of Schedule A/A+, B and C undertakings, the first step of Phase 2 was to prepare a description of the Study Area and an inventory of the existing natural, social and economic conditions. In order to characterize these conditions, a thorough review of relevant background information was carried out, together with comprehensive field investigations, and detailed hydrologic and hydraulic modelling of the Black Creek system and contributing drainage areas.

3.2 Description of the Study Area

Following the identification of the problem and opportunities established for the Study, an assessment of existing environmental conditions was undertaken. The purpose of this step in the Class EA process is to establish an inventory of the natural, social and economic environments within the upper Black Creek subwatershed, which are to be considered when determining the potential net effects that could result from the implementation of each of the alternative solutions.

The existing conditions assessment included a comprehensive review of available background information, together with the results of detailed field investigations to fill any data gaps identified. A summary of the secondary source information reviewed and the field reconnaissance carried out is provided below.

3.2.1 Summary of Available Background Information

3.2.1.1 Secondary Source Information

Background information sources provided by the City and Toronto and Region Conservation Authority (TRCA), as well as that collected from additional government agencies, is listed below.

- The VMC Plan, Secondary Plan for Vaughan Metropolitan Centre (Urban Strategies Inc. and AECOM, September 2010)
- Stormwater Management Report Final Design: Highway 407 Station Spadina Subway Extension (AECOM 2010)
- City of Vaughan, Natural Heritage in the City (AECOM, April 2010)
- Stormwater Management Report Final Design: Highway 407 Station Spadina Subway Extension (AECOM, 2010) and the associated hydrologic and hydraulic computer models;
- Existing Conditions Report – Highway 407 Subway Station: Toronto-York Spadina Subway Extension (AECOM, 2009);
- Updated VMC SWM Assessment Memo – Vaughan Metropolitan Centre Master Servicing Strategy (The Municipal Infrastructure Group, 2009) and the associated hydrologic computer model;
- City-Wide Drainage and Stormwater Management Criteria Study (Clarifica Inc., January 2009);
- City of Vaughan Stormwater Management Retrofit Study (Aquafor Beech Ltd., November 2009);
- Hydraulic Analysis – Peelar Road Culvert Replacement (Sernas Associates, October 2008)
- Technical Design Brief – Black Creek at Peelar Road (Geomorphic Solutions, December 2008)
- Draft Vaughan Corporate Centre Master Servicing Strategy (The Municipal Infrastructure Group, December 2008);
- Draft Master Stormwater Management Strategy Report – Official Plan Amendment 620 Steeles Corridor (The Sernas Group, May 2007);
- Jane Street Corridor (South of Rutherford Road) Residential Potential Land Use Review (City, June 2007);
- Black Creek Flood Plain Mapping – TRCA (June, 2006);
- City of Vaughan Official Plan Amendment No. 600 (City, January 2003);

- Official Plan Amendment 650 – Vellore Village District Centre (City, August 2003);
- Hydrologic Analysis of the Black Creek Watershed and the Resolution of Post Development Stormwater Runoff Controls and Facilities for the Vaughan/400 Industrial Park (Ander Engineering & Associates Limited, January 1986).
- TRCA Ecological Land Classification (ELC) completed in 2002;
- Ontario Ministry of Natural Resources (OMNR) Natural Resource Value and Information System (NRVIS) database (OMNR, 2008), including data pertaining to natural area delineations and conservation; and
- OMNR Natural Heritage Information Centre (NHIC) database (NHIC, 2008), including data pertaining to natural area descriptions and rare species element occurrences.

3.2.1.2 Field Investigations

Following the collection, review, and compilation of the above-noted background documentation, a wide range of field investigations were carried out to confirm the background information provided in the above-noted documents and fill any identified data gaps. The purpose of the field reconnaissance and inventory work was to facilitate the characterization of existing conditions within the Study Area, and included the following tasks:

- Inspection of the overall stability of the watercourse channel and the individual hydraulic structures along its length;
- Assessment of creek characteristics, such as typical cross-sectional profile of pools and riffles, pebble count, entrench-ment, surrounding vegetation and land use;
- Further identification and categorization of the location and severity of barriers to fish passage;
- Rapid Stream Assessment Technique (RSAT) and Rapid Geomorphic Assessment (RGA) for each identified reach to provide a qualitative estimate of channel stability, health, and function; and
- Field verification of culvert geometry and dimensions.


AECOM Staff Carrying Out Field Investigations

In addition to the above, extensive field investigations were undertaken as part of the *Toronto-York Spadina Subway Extension* (TYSSE) project. These investigations focused on the existing aquatic and terrestrial environmental conditions, as well as water quality and flow characteristics, for the portion of Black Creek between Canadian National Railway (CNR) tracks, which transect the Study Area north of Steeles Avenue and the crossing of Jane Street south of Pennsylvania Avenue. The information compiled as part of these investigations was made available for this Study.

3.2.2 Physical Characteristics

3.2.2.1 Regional Setting

As noted, the Study Area consists of the portion of the Black Creek subwatershed located in the City of Vaughan, within the Regional Municipality of York (York Region). The remaining larger area of the subwatershed is located south of Steeles Avenue in the City of Toronto. The Black Creek subwatershed comprises part of the Humber River system, which is the largest watershed within the jurisdiction of the TRCA.

The Study Area experiences a continental climate, which varies between hot, moist summers and cold, dry winters that are moderated by the Great Lakes. Average annual precipitation in the Humber River watershed typically ranges from 798 to 933 mm, while mean annual evapotranspiration varies between 469 and 517 mm depending on elevation and proximity to Lake Ontario

(TRCA, 2008). The largest storm event on record is Hurricane Hazel, which generated approximately 214 mm of rainfall on October 15, 1954.

3.2.2.2 Surficial Soils and Existing Surface Cover

The surficial soils within the Study Area are predominately comprised of sandy, silty, clayey till and fine-textured glaciolacustrine deposits. Available mapping indicates that the native soils consist of Chinquacousey Clay Loam, Halton Clay, and Peel Clay. The topography of the subject area is generally flat, and is almost entirely developed with a combination of residential subdivisions in the northern portion of the subwatershed and commercial/ industrial areas to the south, along with segments of two provincial highways (i.e., Highway 400 and the 407ETR). Additional information regarding surficial geology, soils and topography is provided in ***Section 3.2.7***.

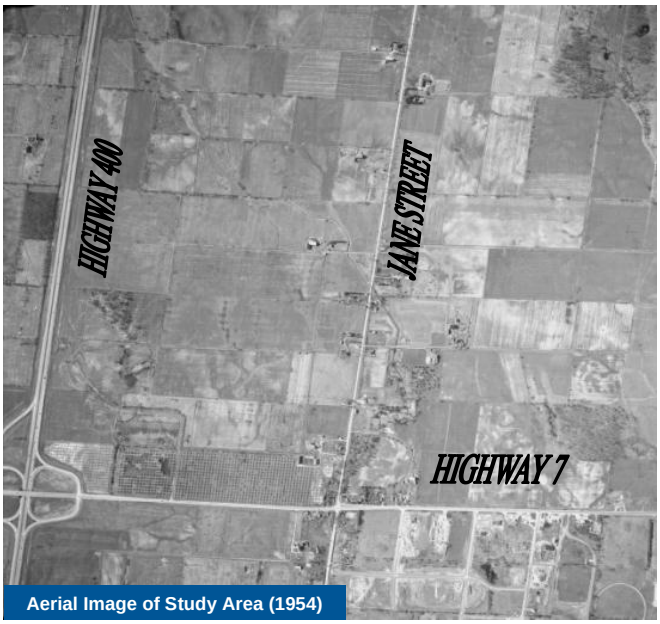
3.2.2.3 Municipal Drainage Systems

Within the City of Vaughan, the Black Creek subwatershed is fully urbanized and is serviced primarily by a network of storm sewers to convey minor system flows, while runoff generated by significant rainfall events (i.e., greater than a 5-year storm) is directed to major system outlets along road right-of-ways and unoccupied lands.

Drainage for the remaining undeveloped and open areas generally occurs by sheet flow to a series of ditches and swales, which ultimately discharge into the Black Creek system. Further details related to the current drainage characteristics and existing infrastructure within the Study Area are provided in ***Section 3.2.5*** and shown on ***Figure 3***.

3.2.3 Land Use Planning Considerations

The land use assessment carried out for the Study is based on a review of current land use planning documents that apply to the Study Area, including the Provincial Policy Statement (PPS), the York Region Official Plan (YROP), and the City of Vaughan Official Plan. Land use policies were reviewed in hierarchical order, beginning with Provincial policies, Regional Plans, followed by local Municipal Plans. These documents were reviewed to identify policies pertaining to the Study Area and its land uses, as well as policies concerning stormwater management. Information on existing land uses was gathered from mapping provided by the City and further confirmed using recent aerial orthoimagery, and field reconnaissance. Current and future land use information is presented on ***Figure 4***.



Aerial Image of Study Area (1954)

3.2.3.1 Policies and Plans

i) Provincial Policy Statement

The current Provincial Policy Statement (PPS) was introduced in March, 2005 and aims to guide appropriate development while protecting resources of provincial interest, public health and safety, and the quality of the natural environment. Policies regarding Building Strong Communities focus on the orderly development of land, including the works necessary to meet the current and projected need for infrastructure.

The PPS also encourages the planning of infrastructure to be integrated with the planning for growth to meet the current and projected needs of the area. It also promotes the improvement of existing infrastructure prior to the development of any new

infrastructure within a municipality/ region. Specifically, Section 1.6.2 of the PPS states that:

> *"the use of existing infrastructure and public service facilities should be optimized, wherever feasible, before consideration is given to developing new infrastructure and public service facilities."*

Given that the Study Area is established and well developed, the PPS is relevant for the proposed undertaking as it relates to optimizing existing infrastructure first, prior to reviewing options for new infrastructure if necessary. Policies from the PPS that specifically address employment areas in terms of their land use objectives and infrastructure needs include:

1.3.1 Planning authorities shall promote economic development and competitiveness by:

c) planning for, protecting and preserving employment areas for current and future uses; and

d) ensuring the necessary infrastructure is provided to support current and projected needs.

Furthermore, the PPS supports watershed planning and water quality and quantity management as follows:

2.2.1 Planning authorities shall protect, improve or restore the quality and quantity of water by:

a) using the watershed as the ecologically meaningful scale for planning;

b) minimizing potential negative impacts, including cross-jurisdictional and cross-watershed impacts;

g) ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces.

ii) York Region Official Plan

The York Region Official Plan (YROP) recognizes the Study Area as part of an Urban Area. As such, York Region supports the identification and development of the municipality of local centres, to be linked through efficient public transit. The YROP also recognizes the open space to the west of Jane Street where Black Creek crosses Steeles Avenue as part of the Regional Greenlands System.

The YROP contains watershed planning policies relevant to stormwater quality and quantity management in the Study Area. Specifically, the York ROP commits York Region to working with municipalities, conservation authorities and other agencies in the preparation of watershed planning initiatives to:

- establish and achieve water quality objectives for the watershed;
- address the long-term cumulative impact of development in the watershed; and
- recommend appropriate SWM techniques, including, but not limited to, best management practices, the use of natural vegetative drainage corridors and the use of permeable surfaces.

The natural environment policies of the YROP also establish that the natural quality and hydrological characteristics of watercourses and lakes including aquatic habitat, baseflow, water quality, temperature, storage levels or capacity are to be maintained, and no development will be permitted that has the potential to create an overall negative effect on specified watercourses, including Black Creek.

iii) City of Vaughan OPA 600: Official Plan

OPA 600 represents the City's current Official Plan. Schedule A of OPA 600 designates six areas overlapping the Study Area, which include:

- Vellore Urban Village, subject to Schedule B, including the Study Area north of Rutherford Road;
- the Vaughan Corporate Centre Planning Area, subject to OPA 500, along Highway 7;
- a portion of the Vaughan Centre Shopping District, on the east side of Highway 400 south of Rutherford Road;

- a Community Area (Woodbridge) including the part of the Study Area east of Weston Road and south of Rutherford Road;
- Significant Open Space & Valley Lands, along the Black Creek channel, beginning south of the Vaughan Centre Shopping District; and,
- Employment Areas within the remaining portions of the Study Area.

OPA 600 also outlines a number of relevant policies with respect to water quality management including:

- Stormwater quality and quantity control is required for all proposed developments, in accordance with the MOE's *Stormwater Management Practices Planning and Design Manual*, June 1994.
- The City of Vaughan does not generally accept stormwater management facilities as part of parkland dedication, except in discretionary cases in which the stormwater management facility is designed as a substantial addition to the park environment.
- A Master Environmental Servicing Plan (MESP) is required as an integral part of the block plan process for the Vellore Urban Village. The MESP must consider a range of stormwater management practices, and select techniques according to flooding and erosion conditions, the type of fisheries present, soil conditions, and local groundwater conditions.
- Stormwater must be treated as close to the source as possible.
- The number of SWM facilities should be minimized, and these should generally be located outside of valley and stream corridors.
- Proposed stormwater quality and quantity control methods must be developed before the completion of a Block Plan, in order to permit proper assessment of development impacts on environmental features.
- Proponents must design and undertake a monitoring program for construction sites to ensure that sediment control measures remain effective throughout the entire construction period and subsequent landscaping.
- All proposed development lands must have sediment control barriers in place to the satisfaction of the City, the MNR and the TRCA before topsoil removal and grading begin.

3.2.3.2 Current Land Use

Within the City of Vaughan, the Black Creek subwatershed is almost completely urbanized and current land use is predominantly commercial/ industrial, along with some residential areas, as well as undeveloped lands and open space. In addition, segments of three provincial highway corridors (i.e., Highways 400, 7 and 407ETR) and the CN Rail York Subdivision transect the Study Area.

Further to the above, the Study Area can be divided into the following three principle areas with respect to current land use:

- The area north of Rutherford Road is mainly residential with some parklands and several schools, along with commercial development on either side of Weston Road;
- The portion of the Study Area between the 407ETR and Rutherford Road is almost entirely comprised of industrial and commercial areas, together with a considerable segment of Highway 400; and
- The area between Steeles Avenue and the 407ETR consists predominately of undeveloped lands and open space, including the Beechwood Cemetery, Hydro One corridor, railway tracks, Black Creek Pioneer Village and agricultural fields.

3.2.3.3 Future Land Use

As noted, a number of development initiatives have been proposed within the Study Area, which were considered in the identification and evaluation of alternative solutions. A description of these development proposals is provided below (refer to ***Figure 4***).

i) Vaughan Metropolitan Centre

The Vaughan Metropolitan Centre (VMC), formerly known as the Vaughan Corporate Centre, Secondary

Plan Area is a 600 ha parcel of land north of the 407ETR and east of Highway 400. Due to its accessibility and visibility, the VMC will be a key urban gateway to the City of Vaughan and will be linked by transit to the City of Toronto by the proposed *Toronto-York Spadina Subway Extension* project.

The VMC will be developed as a mixed-use focus for employment, entertainment, cultural and residential land uses. A central node will become the focus for the area and potentially for the City, which will support transit, have compact form and integrated land uses. Of key importance are the design guidelines which will ensure that an attractive live/work community is created, with a strong and clearly identifiable public realm and pedestrian friendly streets.

ii) OPA 620 – Steeles Corridor

The OPA 620 – Steeles Corridor (Jane to Keele) Secondary Plan is approximately 43 ha and is bounded by Steeles Avenue to the south, Jane Street to the west, Keele Street to the east and the Hydro corridor to the north. The purpose of the Secondary Plan is to establish policies that will guide the City in its consideration of development applications within the Steeles Avenue Corridor. Similar to the VMC, Steeles Avenue will also have a Subway Station within the Secondary Plan area and will focus on the increased density options for the area.

iii) Toronto-York Spadina Subway Extension

This undertaking involves the extension of the Toronto Transit Commission (TTC) Spadina Subway system from the existing Downsview Station in a north-westerly direction into the City of Vaughan. The entire length of the proposed extension will be underground, and will include five new subway stations. Three of the proposed stations will be located within the City's boundaries: Steeles West (within the OPA 620 lands); 407ETR (at Jane Street); and the terminus station within the VMC area (near Jane Street and Highway 7). The preliminary alignment of the proposed subway extension and the station locations are shown on ***Figure 4***.

3.2.4 Natural Environment

3.2.4.1 Aquatic Ecology

A review of available background information indicates that the Black Creek subwatershed is classified as a small to intermediate riverine warmwater habitat, comprised of a series of first, second, and third order streams (MNR & TRCA, 2005). A total of 18 fish species have historically been identified within the subwatershed, of which 16 are native.

TRCA has two fish sampling stations along the portion of Black Creek within the Study Area, which are located at Black Creek Pioneer Village and near the intersection of Highway 7 and Jane Street (refer to ***Figure 5***). Sampling conducted at these locations by TRCA, MNR and Steedman between 1984 and 2004 found Blacknose Dace (*Rhinichthys atratulus*), Creek Chub (*Semotilus atromaculatus*) and White Sucker (*Catostomus commersonii*). Historical sampling by MNR in August, 1991 found Brook Stickleback (*Culaea inconstans*) and Common Shiner (*Luxilus cornutus*) in Black Creek near the intersection of Highway 7 and Jane Street.

The field investigations conducted by AECOM staff on November 19, 2008 indicate that excellent fish habitat exists in the natural segments of the main and west branches of Black Creek between Steeles Avenue and the 407ETR. Observations along the main branch between the CNR tracks and the Jane Street crossing south of the 407ETR reveal a moderate to high in-stream cover, good variation in flow depths and a variety of substrate material consisting of sand, silt, gravel and cobbles. However, upstream of the 407ETR crossing, the main branch has been significantly altered to facilitate development and consists predominately of a series of engineered channels.

A number of low-flow barriers were observed along the main branch of Black Creek, which are expected to obstruct the migration of fish. These include a perched outlet at the Peelar Road culvert, a collapsed culvert upstream of Peelar Road as well as the on-line weir structure located within the Edgeley Pond near the intersection of Highway 7 and Jane Street, which prevent any movement of fish to the upstream

reaches of Black Creek. Similar barriers to fish passage were also noted along the West Tributary.

Further to the above, detailed field investigations carried out during 2010 for the proposed Toronto-York Spadina Subway Extension, including electrofishing surveys, identified a number of fish species that currently inhabit the segment of Black Creek between the CNR tracks and its crossing of Jane Street south of Pennsylvania Avenue. The species collected include Blacknose Dace, Bluegill (*Lepomis macrochirus*), Brook Stickleback, Common Carp (*Cyprinus carpio*), Common Shiner, Creek Chub, Golden Shiner (*Notemigonus crysoleucas*), Horneyhead chub (*Nocomis biguttas*), Pumpkinseed (*Lepomis gibbosus*), and White Sucker.

All of the above-noted species are native, with the exception of the Common carp, and are commonly occurring in Ontario. In addition, these species are all generally found to be moderately to highly tolerant of poor water quality and other disturbances.

Terrestrial Resources To supplement the available background information, field investigations were completed on November 12 and 19, 2008 to verify and update existing vegetation mapping within the Study Area. Vegetation communities were classified according to ELC protocols for southern Ontario (Lee *et al.* 1998). Communities were mapped to Ecosite and Vegetation type where possible, based on dominant species and substrate characteristics observed in the field.

Seasonal limitations precluded the possibly of accurate documentation of vegetation species associations, particularly in communities and/or structural layers where woody and/or robust herbaceous taxa are not dominant. Similarly, the vascular plant species list was limited by the seasonality of investigations. Despite the noted limitations, investigations were sufficient to establish a suitable characterization of vegetation cover.

Terrestrial Conditions

Vegetation Communities

The field investigations enabled the documentation of ten Ecosite level classifications, as follows: Cultural Meadow, Cultural Thicket, Cultural Plantation, Cultural Woodland, Deciduous Forest, Mixed Forest, Meadow Marsh, Shallow Marsh, Deciduous Swamp and Swamp Thicket. Cultural community categories dominate the Black Creek system within the Study Area, with the largest natural areas occurring between Steeles Avenue and the 407ETR. An additional natural area exists immediately upstream of Highway 7, which is associated with a remnant valley system and on-line SWM facility (i.e., Edgeley Pond).

One provincially rare vegetation community, SWD1-2 (Bur Oak Mineral Deciduous Swamp) was recorded immediately north of Highway 7. This unit includes small (<10 m^2) isolated patches of organic accumulation. All community types recorded are considered common and widespread throughout southern Ontario.

Other notable associations include FOD1-1 (Dry Red Oak Deciduous Forest), a mature stand occurring on a remnant valley slope immediately north of Highway 7, and the wetland complex in the floodplain area, on TRCA property, immediately north of Steeles Avenue. The results of ELC mapping completed for the Study are provided on ***Figure 5***.

Flora

Based on field investigations, a total of 102 species of vascular plants were documented. One additional taxa were recorded at the genus level, *Poa sp.*, to indicate specimens observed without characters necessary to warrant identification to the species level.

Engineered Diversion Channel Upstream of Jane Street and Pennsylvania Avenue

One locally significant species was identified, Cow-parsnip (*Heracleum maximum*), designated uncommon by Varga *et al.* (2000). One plant was observed in the floodplain at the Black Creek Pioneer Village property managed by TRCA immediately north of Steeles Avenue. All other plants observed are considered common and widespread throughout southern Ontario.

A total of 102 alien species were documented, representing approximately 35% of species recorded. The high alien proportion is considered typical of urban environments throughout southern Ontario; however, seasonal limitations prevented a complete assessment of floristic composition.

Non-native species demonstrate particular dominance in the Black Creek channel throughout the Study Area, including many species planted for bank stability purposes, as well as species tolerant of fluctuating water levels and quality typical of urban disturbances. Alien species naturalized in relatively high numbers throughout the upper Black Creek subwatershed include Norway Maple (*Acer platanoides*), Manitoba Maple (*Acer negundo*), Black Locust (*Robinia pseudoacacia*), Crack Willow (*Salix fragilis*), Russian Olive (*Elaeagnus angustifolia*), Tartarian Honeysuckle (*Lonicera tatarica*), Guelder Rose (*Viburnum opulus*), Common Lilac (*Syringa vulgaris*), European Buckthorn (*Rhamnus cathartica*), Common Reed (*Phragmites australis*), Narrow-leaved Cattail (*Typha angustifolia*), Cool Season Blue Grass (*Poa sp.*), Dame's Rocket (*Hesperis matronalis*) and Bird Vetch (*Vicia cracca*).

3.2.5 Subwatershed Hydrologic and Hydraulic Characterization

3.2.5.1 Existing Land Use Conditions

i) Model Set-up

The primary computational tool for establishing the hydrologic conditions within the Study Area was the current version of the SWMHYMO hydrology computer model for the Humber River watershed developed by TRCA. The portion of the model representing the Black Creek subwatershed was abstracted and used for determining the hydrologic regime within the Study Area. The accuracy of the model to represent the physical characteristics of the area was then determined through a comprehensive review of available background information provided by TRCA and the City (i.e., recent studies, topographic mapping, storm sewer data), and further confirmed through field investigations.

The initial examination of the SWMHYMO model revealed numerous inaccuracies within the portion that characterizes the Study Area, likely attributable to a lack of detailed information with respect to existing drainage infrastructure and SWM facilities. Important elements that were not reflected in the model include the existing on-site controls for most of the commercial/ industrial developments within the Study Area, as well as many of the SWM ponds and on-line control structures along Black Creek. In addition, the model was prepared in 2002 and does not account for the recent development that has occurred within the Study Area, including many significant changes in land use.

A more recent hydrology model was also available that represents the northern portion of the Study Area. The OTTHYMO model was compiled for the Rutherford Business Park (Urban Ecosystems, 2005), which is bounded by Highway 400, Weston Road, Langstaff Road and Rutherford Road. The model represents proposed development conditions for the Rutherford Business Park as well as for upstream areas, accounting for SWM ponds, on-site controls and updated catchment areas and characteristics. This model provides a higher level of detail than the original TRCA model (2002), but only covers the Black Creek subwatershed upstream of Highway 400.

Given the above, it was determined that a new model was necessary to more accurately reflect the hydrologic conditions within the Study Area. Accordingly, an updated SWMHYMO model was compiled to represent the Study Area. Information from the above-noted OTTHYMO model was incorporated into the SWMHYMO model previously prepared by TRCA, along with several additions and modifications. The model was further refined by amalgamating smaller catchments and revising the drainage characteristics accordingly.

The additions and modifications that were included in the updated SWMHYMO model are summarized below.

i) The catchment areas between Highway 400 and Jane Street north of Highway 7 were re-delineated based on available documentation, recent topographic mapping and existing storm sewer data. The catchment areas were corrected in the hydrology model, and drainage characteristics were adjusted as required.

ii) Existing on-site controls were added for the commercial/industrial areas, which include limiting rooftop discharge rates to 42 L/s/ha and total site runoff to 180 L/s/ha for all rainfall events up to and including the 100-year event. These flow controls were determined from the information provided in the report entitled *Hydrological Analyses of the Black Creek Watershed and the Resolution of Post Development Stormwater Runoff Controls and Facilities for the Vaughan/400 Industrial Park* (Ander Engineering, 1986).

iii) The following existing SWM features were also incorporated into the Updated Model:

- The on-line pond northeast of the intersection of Jane Street and Highway 7 (i.e., Edgeley Pond), based on current topographic mapping and stage-storage data provided in the above-referenced Ander Engineering report;
- The on-line control structures located within the quantity control facilities upstream of the intersection of Jane Street and Pennsylvania Avenue and at Creditview Road; and
- The SWM pond located within Black Creek Pioneer Village near Jane Street and Steeles Avenue.
- The resultant SWMHYMO model was considered to represent the existing land use conditions with the Study Area, and is hereinafter referred to as the Updated Model.

ii) Model Verification

Following the above-noted revisions, efforts were made to verify the accuracy of the updated SWMHYMO model. Unfortunately, there is no active streamflow gauge on Black Creek within the City's boundary to assist with the verification of the model. Although streamflow records are not available, TRCA provided historical high water marks at several locations through the Study Area that had been surveyed immediately following the August 19, 2005 storm.

In addition to the high water mark information, precipitation data associated with the August 19, 2005 storm is available for a number of rainfall gauges within, or in the vicinity of, the Study Area. Details regarding location, ownership and rainfall depth recorded during the August 19, 2005 storm for each of the applicable gauges are summarized in ***Table 1*** below.

Table 1. Recorded Rainfall Depths for August 19, 2005 Storm

Rain Gauge Location	Nearest Intersection	Owner	Rainfall Depth (mm)
York University Green Roof	Steeles Avenue & Jane Street	TRCA	123
Vellore Woods Public School	Weston Road & Major MacKenzie Drive	City	111
Sue Grange Farm	Rutherford Road & Highway 27	Private	90

It was determined that the rainfall data from the York University Green Roof gauge was the most appropriate for the model assessment, given its proximity to the Study Area and the anticipated accuracy of the data, which is managed by TRCA.

An input rainfall hyetograph was created using data supplied by the TRCA for the York University Green Roof gauge, which was incorporated into the SWMHYMO model to simulate the peak flows generated during the August 19, 2005 storm event. The input file captured both the moderate storm event that occurred in the morning of that date, as well as the very intense rainfall that occurred in the afternoon. A total storm duration of 12 hours, with a 5 minute time step, was employed in the hydrologic model.

The majority of the high water marks recorded by TRCA staff were located at SWM ponds through the Study Area, and the water levels were above the design 100-year level for most of the facilities. At these levels, flow discharges from the ponds via the emergency overflow outlet. The stage-discharge

characteristics of the emergency overflow are not finely represented in the SWMHYMO model and, therefore, direct comparisons between observed and simulated water levels are difficult. The observed water levels were above the design 100-year water levels at the SWM ponds located at the northwest corner of Weston Road and Rutherford Road, northeast of the Highway 400/407ETR interchange, and near the intersection of Jane Street and Highway 7 (i.e., Edgeley Pond). It should be noted that the SWMHYMO model also predicts that flow levels exceed the 100-year water elevations at all three of these ponds.

The modelling results for the August 19, 2005 storm event were analysed and the maximum SWM pond volumes were converted into the corresponding water elevations using the previously noted stage-storage data. These elevations were compared to the high water levels observed by TRCA staff during the August 19, 2005 storm, which are presented in ***Table 2***.

Table 2. Maximum Flow and Water Level Comparison for the August 19, 2005 Storm

SWM Pond Location	Peak Flows (m^3/s)		High Water Level (mASL)	
	Estimated[1]	*SWMHYMO*	*Observed*[2]	*SWMHYMO*
Rutherford Road & Weston Road	8.3	9.3	213.10	N/A
Upstream of Creditview Road (i.e., Rutherford Business Park)	4.8	10.5	205.10	205.49
Upstream of Jane Street & Pennsylvania Avenue	N/A	52.5	203.30	203.65
Jane Street & Highway 7 (i.e., Edgeley Pond)	18.4	49.1	201.95	202.20
407ETR & Highway 400	6.4	4.7	193.90	N/A

Notes: 1. *Estimated peak flows calculated based on TRCA's rating curves for each SWM pond.*
2. *High water levels observed by TRCA staff during August 19th, 2005 storm event.*

As indicated in the table above, the computed and observed high water marks compare reasonably well, with minor differences noted for the three on-line SWM facilities along Black Creek. The discrepancies between the computed and observed water surface elevations are expected to be a result of a variety of factors, which include the following:

- Temporal variations in the rainfall depth over the Study Area – the rainfall data used to simulate the August 19th, 2009 storm was collected at the York University green roof near the intersection of Jane Street and Steeles Avenue, which resulted in minor inconsistencies in the rainfall conditions over the entire Study Area. Rainfall data collected at the gauges west and north of the Study Area were lower (refer to ***Table 1***). Accordingly, the peak flows generated within the northern portion of the Study Area for this storm event could be over estimate, which would dissipate through the multiple on-line quantity control facilities along Black Creek.
- The majority of high water marks recorded by TRCA staff following the August 19th, 2005 storm were above the 100-year storm design depth for most of the SWM facilities where these measurements were taken. At these depths, a significant portion of the flows discharging from these facilities occurs though the emergency overflow outlet, which is not generally captured by the corresponding stage-discharge relationship included in the SWMHYMO model, as noted previously. As a result, the peak flows discharging from these facilities during significant events such as the August 19th, 2005 storm may be higher than the computed values.

iii) Results of Analysis

Following the assessment process using the August 19, 2005 storm event, the 2 through 100-year storm events were simulated using the Updated SWMHYMO model. The 6 and 12-hour AES storm distributions were used, which is consistent with the TRCA's hydrology model for the Humber River watershed. The higher of the two peak flows was selected at each point of interest, including five flow nodes through the Study Area (refer to ***Figure 3***). The results from both the original TRCA and the updated SWMHYMO model are compared in ***Table 3***.

Table 3. Comparison of Existing Condition Flows (m^3/s)

TRCA Flow Node	Location	Source	Catchment Area (ha)	Storm Event Return Period (Years)					
				2	5	10	25	50	100
46.3	Jane Street & Highway 7	TRCA	823	16.5	23.9	29.8	37.2	44.2	50.6
		Updated	767	3.8	6.8	9.2	12.7	15.8	19.1
		Difference	*(56)*	*(12.7)*	*(17.1)*	*(20.6)*	*(24.5)*	*(28.4)*	*(31.5)*
46.2	Main Branch U/S of CNR York Subdivision	TRCA	1066	25.1	36.9	44.6	56.7	66.6	75.9
		Updated	999	9.0	12.9	15.6	19.1	21.8	24.8
		Difference	*(67)*	*(16.1)*	*(24.0)*	*(29.0)*	*(37.6)*	*(44.8)*	*(51.1)*
46.1	West Branch U/S of CNR York Subdivision	TRCA	356	5.3	8.6	11.6	14.7	23.1	29.2
		Updated	371	7.7	10.8	13.3	17.4	20.9	24.2
		Difference	*15*	*2.4*	*2.2*	*1.7*	*2.7*	*2.2*	*5.0*
46.0	Confluence at CNR York Subdivision	TRCA	1422	30.4	44.9	54.9	70.2	83.0	95.1
		Updated	1370	16.5	23.6	28.8	36.5	42.7	49.0
		Difference	*(52)*	*(13.9)*	*(21.3)*	*(26.1)*	*(33.7)*	*(40.3)*	*(46.1)*
47.2	Jane Street & Steeles Avenue	TRCA	2127	37.8	59.0	74.6	94.8	111.4	127.2
		Updated	2075	26.3	40.6	51.5	67.2	79.1	90.4
		Difference	*(52)*	*(11.5)*	*(18.4)*	*(23.1)*	*(27.6)*	*(32.3)*	*(36.8)*

Notes: Values in parentheses indicate a reduction in peak flows.

As indicated, the estimated peak flows simulated along the main tributary of Black Creek using the Updated Model are considerably lower relative to the original TRCA model, with significant differences at the upstream nodes. At Node 46.3, which represents the outlet of the Edgeley Pond, near the intersection of Jane Street and Highway 7, the peak flows from the Updated Model are dramatically reduced, which is expected to be due to the following:

- A reduction of 56 ha in the total catchment area at this node (based on detailed topographic mapping), which corresponds to an approximate 7% reduction in the contributing drainage area;
- The Updated Model includes the on-line control structure near Jane Street and Pennsylvania Avenue as well as Edgeley Pond, which provide a substantial amount of flood storage volume upstream of this node;
- The Updated Model accounts for the on-site controls for the existing industrial/commercial developments within the Vaughan/400 Industrial Park; and
- Detailed information obtained from the OTTHYMO model developed for the Rutherford Business Park and contributing areas upstream of Highway 400 was incorporated into the Updated Model, which includes several additional SWM facilities that provide peak flow attenuation.

It should be noted that similar reductions in flows estimates also arose at downstream locations along the main branch of Black Creek.

Following the comparison of return period flow events between the original TRCA and updated SWMHYMO models, a similar assessment was undertaken for the Regional Storm event (i.e., Hurricane Hazel). To complete this exercise, the existing SWM detention facilities were removed from the updated SWMHYMO model, in accordance with the floodplain management policies of TRCA and the Ministry of Natural Resources (MNR). In addition, the Curve Number (CN) values were converted to antecedent moisture condition (AMC) III to reflect saturated soil conditions following the initial 36 hours of rainfall.

Further to the above, an areal reduction factor was applied to the Regional Storm data to account for the variation in rainfall depths throughout the Study Area, as specified by MNR guidelines. A comparison of the estimated peak flows generated for the Regional Storm using the original TRCA and the updated SWMHYMO model with the areal reduction factor applied is presented in ***Table 4***.

Table 4. Regional Storm Flow Comparison

TRCA Flow Node	Location	Original TRCA Flow (m^3/s)	Updated Flow (m^3/s)	Areal Reduction Factor	Updated Flow with Reduction (m^3/s)
46.3	Jane Street & Highway 7	108.4	109.0	0.992	108.1
46.2	Main Branch U/S of CNR York Subdivision	139.0	136.4	0.982	133.8
46.1	West Branch U/S of CNR York Subdivision	49.9	52.7	1.000	52.7
46.0	Confluence at CNR York Subdivision	186.7	187.8	0.982	184.3
47.2	Jane Street & Steeles Avenue	244.0	251.6	0.963	241.5

As can be noted from ***Table 4***, the results indicate only a minor differences between the original TRCA and Updated Models at all locations considered.

3.2.5.2 Future Land Use Conditions

To determine whether the previously described development initiatives currently being considered in the Study Area could impact the hydrologic conditions within the upper Black Creek subwatershed, a detailed review of available documentation and further analyses were carried out. As part of this assessment, the existing conditions SWMHYMO model was modified to account for the anticipated changes in land use as well as modifications to the drainage systems that service these areas. A description of the proposed development initiatives, together with the SWM strategy that has been established to service each of these areas, is provided below.

i) Vaughan Metropolitan Centre

As noted, the VMC spans an area of 600 ha (VMC), located east of Highway 400 and north of the 407ETR (refer to ***Figure 4***). Information regarding the recommended SWM servicing strategy was obtained from a report entitled *Vaughan Metropolitan Centre Master Servicing Strategy* (TMIG, 2008) and a subsequent memorandum entitled *Updated VMC SWM Assessment* (TMIG, 2009). Direction on planning policies was taken from the document entitled The WMC Plan, Secondary Plan for the Vaughan Metropolitan Centre (Urban Strategies Inc. and AECOM, September 2010)

Based on a review of the above-noted documents, the VMC Master Servicing Strategy recommends that the overall SWM plan should consist of a combination of on-site Low Impact Development (LID) measures, together with several extended detention wet ponds. The proposed VMC development area was separated into four quadrants for the purpose of establishing the preferred SWM strategy and completing the supporting hydrological analyses. Four scenarios were evaluated based on the degree of lot level controls provided and the corresponding SWM facility requirements.

The preferred scenario includes the implementation of on-site measures to limit the 2-year post-development peak flow rates to pre-development levels as well as to capture and retain the first 15 mm of rainfall over the building footprints for all storm events. In addition, end-of-pipe facilities will be required to supplement the proposed on-site measures in order to satisfy the applicable criteria for quantity, quality and erosion control prescribed by the City and TRCA. There are existing SWM ponds located within three of the quadrants, which will require expansion in order to provide the necessary volume requirements. A new pond is proposed for the quadrant that is not currently serviced by an existing facility.

ii) OPA 620 – Steeles Corridor

The SWM strategy for the OPA 620 development area involves a combination of lot level and end-of-pipe SWM facilities to provide adequate quality, quantity and erosion controls. Information related to the proposed SWM strategy was obtained from the draft *Master Stormwater Management Strategy Report* (Sernas, 2007) and the subsequent response to TRCA comments. The design criteria include the provision of an 'enhanced' level of water quality protection, attenuation of post-development peak flows at pre-development levels using the unit flow equations developed for the Humber watershed, and

detention of the runoff from a 25 mm storm for 48 hours to protect against erosion of receiving watercourses. In addition, the SWM strategy aimed to maintain the water balance through the on-site infiltration of up to 7.5 mm of rainfall for each event.

In order to achieve the above-noted controls, the recommended SWM strategy includes the incorporation of one or more lot level LID measures to reduce peak flows and runoff volumes, improve water quality and maintain the rate of infiltration, together with two end-of-pipe SWM facilities. The proposed SWM facilities consist of a new pond adjacent to Steeles Avenue within the OPA 620 development area as well as the retrofit of the existing on-line pond located within the Black Creek valley at Black Creek Pioneer Village.

iii) Toronto-York Spadina Subway Extension

As noted, the proposed extension of the Spadina Subway system into Vaughan will include the construction of three new subway stations within the City's boundaries (i.e., Steeles West, Highway 407 and VMC). The proposed subway extension is to be constructed below ground for its entire length. Proposed SWM controls at the proposed Steeles West and VMC stations have been integrated into the recommended SWM strategy for the respective OPA 620 and VMC (i.e., OPA 500) development areas outlined above. Details regarding the SWM strategy were obtained from the *Stormwater Management Report Final Design: Highway 407 Station Spadina Subway Extension* (AECOM, 2010).

The proposed Highway 407 station is to be constructed on an agricultural field south of the 407ETR to the west of Jane Street, and will include a number of buildings as well as a large parking lot. The recommended SWM strategy involves combination of on-site LID measures (i.e., green roof, bioretention measures, oil-grit separators), together with the construction of a new SWM pond and wetland, in order to satisfy the objectives prescribed by the City and TRCA. The design criteria include the provision of an 'enhanced' level of water quality protection, attenuation of post-development peak flows at pre-development levels using the unit flow equations developed for the Humber watershed, and detention of the runoff from a 25 mm storm for 48 hours to protect against erosion of receiving watercourses.

Based on the above, the updated SWMHYMO model was modified to account for the anticipated changes in land use that will result from the proposed development initiatives, as well as the corresponding alterations to the associated drainage system and the addition of new SWM facilities. The results of the hydrologic analysis carried out for future conditions are summarized in ***Table 5***, which also compares these values with the updated existing condition peak flows.

Table 5. Estimated Peak Flows (m^3/s) Under Future Conditions

TRCA Flow Node	Location	Source	Storm Event Return Period (Years)						Regional Storm
			2	5	10	25	50	100	
46.30	Highway 7 @ Jane Street	Updated	3.8	6.8	9.2	12.7	15.8	19.1	108.1
		Future	3.7	5.7	7.9	10.8	13.4	16.3	106.1
		Difference	*(0.1)*	*(0.9)*	*(1.3)*	*(1.9)*	*(2.4)*	*(2.8)*	*(2.0)*
46.20	Main Branch U/S of CNR York Subdivision	Updated	9.0	12.9	15.6	19.1	21.8	24.8	133.8
		Future	6.8	9.7	11.8	14.5	16.7	20.0	130.5
		Difference	*(2.2)*	*(3.2)*	*(3.8)*	*(4.6)*	*(5.1)*	*(4.8)*	*(3.3)*
46.10	West Branch U/S of CNR York Subdivision	Updated	7.7	10.8	13.3	17.4	20.9	24.2	52.7
		Future	7.1	10.0	12.3	15.6	18.6	21.3	56.3
		Difference	*(0.6)*	*(0.8)*	*(1.0)*	*(1.8)*	*(2.3)*	*(2.9)*	*3.6*
46.00	Confluence at CNR York Subdivision	Updated	16.5	23.6	28.8	36.5	42.7	49.0	184.3
		Future	13.5	19.5	23.7	30.1	35.3	40.2	184.8
		Difference	*(3.0)*	*(4.1)*	*(4.1)*	*(6.4)*	*(7.4)*	*(8.8)*	*0.5*
47.20	Jane Street & Steeles Avenue	Updated	26.3	40.6	51.5	67.2	79.1	90.4	241.5
		Future	21.8	33.5	42.3	54.6	64.1	73.2	240.2
		Difference	*(4.5)*	*(7.1)*	*(9.2)*	*(12.6)*	*(15.0)*	*(17.2)*	*(1.3)*

Note: Values in parentheses indicate a reduction in peak flows.

As indicated in the table, the future condition peak flows are generally lower than those estimated under existing conditions for all flow nodes and storm events, and the reductions escalate progressively moving downstream. These reductions can be attributed to the use of the Unit Flow Equations for the Humber watershed, which was applied for flow attenuation considerations for each of the proposed development initiatives described previously.

3.2.5.3 Hydraulic Analysis

i) Model Set-Up

Subsequent to the completion of the hydrologic assessment, a hydraulic analysis was carried out to confirm the flood vulnerable areas within the Study Area and determine the extent of flooding along the Black Creek channel. For the purpose of the analysis, the original HEC-RAS model for Black Creek was obtained from TRCA, which includes the main branch of the creek extending upstream from Steeles Avenue to the on-line quantity control facility that services the Rutherford Business Park.

Following a detailed review of the HEC-RAS model, as well as recent topographic mapping for the upper Black Creek subwatershed and the results of field investigations, it was determined that the model generally provides an accurate representation of the existing hydraulic conditions throughout the Study Area.

Notwithstanding, a number of corrections were required to update the hydraulic model previously established to represent existing conditions, which are summarized below:

- The minimum weir flow elevation for a number of the culverts between the 407ETR and Highway 7 were set much higher than the actual roadway elevation for these structures. It is expected that these discrepancies occurred as a result of the conversion of the hydraulic model from the original HEC-2 to HEC-RAS. The model was corrected by clearing this elevation from the culvert editor and allowing the program to automatically determine the minimum roadway elevation for weir flow.
- The dimensions of multiple culverts along the main branch of Black Creek were determined to be inaccurate through the field verification process. Accordingly, the characteristics of these structures were revised in the updated HEC-RAS model using measurements collected in the field.
- The flow data in the HEC-RAS model was updated to reflect the output conditions from the updated SWMHYMO hydrology, as described previously. The 2 through 100-year in the model were replaced with the updated flows, and the August 19, 2005 storm peak flows were added as an additional flow profile.
- Additional flow change locations were also added to the model, based on the more detailed output available from the updated hydrology model. At each flow change location, the largest flow of the 6-hour and 12-hour storm duration was chosen for each event, to provide the most conservative values.

Existing 6.0 x 4.3 m Concrete Box Culvert Beneath the 407ETR

ii) Model Update

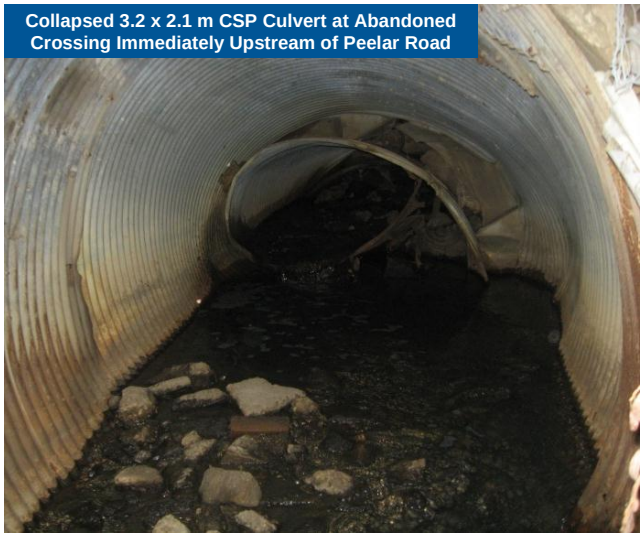
In addition to the above, the HEC-RAS model was further refined using updated topographic survey information provided by TRCA for the portion of the Black Creek channel and adjacent tableland areas between 407ETR to just north of Doughton Road. Although a detailed review of the enhanced topographic mapping, prepared by J.D. Barnes (2010) indicates that the overall topography (i.e., contour mapping) appears to be in general agreement, the following discrepancies were identified:

- While the geometric shape of each cross-section generally matches that in the original TRCA model, there were notable differences in the channel invert elevations at all of the cross-sections, with significant variations (i.e., up to 1.83 m) observed at many locations;
- Elevations within the floodplain and tableland areas are consistently higher than shown on previous mapping and within the original HEC-RAS provided by TRCA – for example, the spot elevations along Peelar Road are approximately 0.4 m higher than previously indicated; and
- The existing 3.2 x 2.1 m CSP arch culvert at the abandoned crossing immediately upstream of the Peelar Road has completely collapsed and, as a result, no longer conveys significant flood flows through the structure (refer to adjacent photograph).

To update the model, the geometric data for each of the cross-sections within this area were revised to reflect the updated topographic conditions. In addition, the collapsed culvert was removed from the HEC-RAS model and the cross-section was modified to consist of a normal channel section. As a result, the updated geometry and invert elevation at this location is not directly comparable to the original HEC-RAS model. For further information regarding the updated hydraulic analysis, refer to the letter report entitled *HEC-RAS Hydraulic Model Update and Floodplain Delineation for a Portion of Black Creek within the City of Vaughan* (AECOM, 2010) provided in **Appendix A**.

iii) Model Verification

In order to verify the updated HEC-RAS model, the maximum computed water surface elevation at a number of locations was compared to the observed high water marks recorded by TRCA staff following the August 19th, 2005 storm event. As indicated in ***Table 6***, the computed and observed water level elevations compare reasonably well.


Collapsed 3.2 x 2.1 m CSP Culvert at Abandoned Crossing Immediately Upstream of Peelar Road

As indicated in **Section 3.2.5.1**, the discrepancies between the computed and observed water surface elevations can be attributed to temporal variations in the rainfall depth over the Study Area, together with the extrapolation of the stage-discharge data above the 100-year design levels within the on-line quantity control facilities along Black Creek.

Table 6. Maximum Water Surface Elevation Comparison for the August 19, 2005 Storm

Cross-Section Location		TRCA Observed High Water Mark (mASL)	HEC-RAS Water Surface Elevation [1] (mASL)	Difference
XS 46.413	Upstream of the on-line control structure at Creditview Road	205.10	206.13	+1.03
XS 46.274	Upstream of the on-line control structure at Jane Street & Pennsylvania Avenue	203.30	204.18	+0.88
XS 46.214	On-line pond at Jane Street & Highway 7 (i.e., Edgeley Pond)	201.95	202.20	+0.25
XS 46.190	Jane Street, downstream of Highway 7 [2]	200.00	200.49	+0.49

Note: 1. Based on results of updated hydraulic modelling carried out by AECOM (2010).
2. Estimated from photographs of flooding and topographic mapping provided by TRCA – water levels determined through inspection of buildings in the commercial plaza east of Jane Street.

The results of the hydraulic analysis indicate that, although flows for the events below the 100-year storm are generally contained within the Black Creek channel/floodplain for much of its length, there are portions of the Study Area that are susceptible to flooding during moderate and significant storm events. Flood vulnerable buildings, roadways and hydraulic structures are shown on ***Figure 6***, together with the Regulatory Floodplain limits associated with the Regional Storm. As shown, a majority of the culverts and associated roadways along the length of Black Creek within the City of Vaughan, as well as many of the structures located on the table lands directly adjacent to the creek, are at risk of flooding during high flow conditions.

As demonstrated during the August 19th, 2005 storm event, the portion of the Study Area along the main branch of Black Creek between the 407ETR and Highway 7 is particularly susceptible to a considerable level of flooding, which could occur during moderate storm events. Conversely, the flood vulnerable areas upstream of Highway 7 are generally at risk of minor flooding during significant rainfall events (i.e., > 100-year storm).

A comparison of the maximum water surface elevations calculated as part of this current Study and the TRCA values for the 100-year and Regional Storm events at a series of cross-sections is provided in ***Table 7***. As indicated, the maximum water surface elevations for both the 100-year and Regional Storm events are considerably higher than previously calculated for the portion of Black Creek between the 407ETR and Highway 7.

Further to the above, the HEC-RAS model was used to evaluate the capacity of the culverts and channel reaches through the Study Area using the peak flows predicted by the updated SWMHYMO model. Details regarding existing culvert characteristics (i.e., dimensions, material, location, etc.) is provided in ***Table 8***, together with hydraulic capacity information for full flow conditions as well as the maximum flow prior to overtopping of the associated roadway.

The results of the hydraulic analysis using the HEC-RAS model to determine the capacity of the existing culverts in the Study Area indicate the following:

- The culverts located along Black Creek in the northern portion of the Study Area (i.e., upstream of Applewood Crescent) can convey the flows generated by the August 19th, 2005 storm event without causing flooding of adjacent properties or roads;
- The culverts located between Applewood Crescent and upstream of Highway 7 can accommodate flows up to a 100-year storm event without causing flooding of adjacent properties or roads;
- The culverts located between Highway 7 to upstream of Peelar Road are undersized and can only convey flows associated with minor to moderate storm events – two of the existing culverts are capable of passing only the 5-year storm flows;

Table 7. Comparison of Maximum Water Surface Elevation (m)

Cross-Section Location		100-Year Storm			Regional Storm		
		TRCA	AECOM	Difference	TRCA	AECOM	Difference
XS 46.410	Upstream of Highway 400	203.85	203.88	0.03	206.90	206.91	0.01
XS 46.280	Upstream of Jane Street	202.64	202.64	0.00	204.29	204.29	0.00
XS 46.210	Upstream of Highway 7	199.88	200.51	0.63	201.08	201.20	0.12
XS 46.120	Upstream of 407ETR	193.21	193.51	0.30	197.71	198.17	0.46
XS 46.040	Upstream of CNR Tracks	187.48	187.48	0.00	191.20	191.19	(0.01)
XS 46.000	Upstream of Steeles Avenue	183.04	183.04	0.00	184.54	184.54	0.00

Notes: 1. XS values represent cross-section locations in HEC-RAS model.
2. ( ) refers to negative value.

Table 8. Existing Culvert and Hydraulic Capacity Information

Culvert ID	Dimensions (m) (H x W x L)	No. of Cells	Material/Type	Hydraulic Capacity (Storm Event)		Location
				Full Flow[1]	Maximum[2]	
C1	3.0 x 1.5 x 41	4	Concrete box	100-Year	August 19, 2005	Creditview Road
C2	2.4 x 2.4 x 80	3	Concrete box	100-Year	August 19, 2005	Highway 400
C3	2.4 x 2.4 x 60	3	Concrete box	100-Year	August 19, 2005	Langstaff Road
C4	2.4 x 2.4 x 38	3	Concrete box	100-Year	August 19, 2005	Highway 400 N/B Off-ramp (@ Langstaff Road)
C5	4.3 x 2.4 x 30	2	Concrete box	50-Year	100-Year	Applewood Crescent
C6	4.3 x 2.4 x 35	2	Concrete box	50-Year	100-Year	Edgeley Boulevard
C7	4.3 x 2.4 x 30	2	Concrete box	50-Year	100-Year	Millway Avenue
C8	4.3 x 2.4 x 40	2	Concrete box	25-Year	100-Year	Pennsylvania Avenue
C9	2.4 x 2.1 x 59	2	Concrete box	100-Year	100-Year	Jane Street
	2.4 x 1.2 x 59	1	Concrete box			
C10	3.0 x 1.5 x 23	3	Concrete box	>2-Year	100-Year	Edgeley Pond Outlet
C11	3.7 x 1.5 x 64	1	Concrete box	>2-Year	25-Year	Highway 7
C12	3.8 x 1.5 x 17	1	CSP arch	>2-Year	10-Year	Private Driveway (7717 Jane Street)
C13	3.2 x 2.1 x 20	1	CSP arch	>2-Year	5-Year	Private Driveway (7695 Jane Street)
C14	3.2 x 2.1 x 30	1	CSP arch	2-Year	5-Year	Doughton Road
C15	3.2 x 2.1 x 20	1	CSP arch	2-Year	25-Year	Private Driveway (7601 Jane Street – Paradise Banquet & Convention Centre)
C16	3.2 x 2.1 x 52	1	CSP arch	2-Year	50-Year	Private Driveway (7551 Jane Street – Vaughan Iceplex)
C17[3]	3.2 x 2.1 x 20	1	CSP arch	n/a	n/a	Abandoned Crossing
C18	3.7 x 2.4 x 30	1	CSP arch	25-Year	100-Year	Peelar Road
C19	6.0 x 4.3 x 215	1	Concrete box	August 19, 2005	Regional Storm	407ETR
C20	6.0 x 4.3 x 65	1	Concrete box	August 19, 2005	August 19, 2005	Jane Street
C21	3.0 x 3.5 x 32	2	CSP arch	10-Year	100-Year	CNR Tracks (York Subdivision)

Notes: 1. *Indicates free flowing conditions with no head at inlet (i.e., water surface elevation at or below pipe obvert).*
2. *Indicates maximum flow prior to overtopping of associated roadway.*
3. *As noted, culvert C17 has collapsed and, accordingly, has been removed from the HEC-RAS model.*

- The Jane Street culvert south of the 407ETR safely conveys flows up to and including the August 19th, 2005 storm event;
- Although the culvert along the main branch of Black Creek beneath the 407ETR can accommodate the Regional Storm flows without overtopping the associated roadway, this structure causes significant backwater effects resulting in flooding of upstream properties and roadways (i.e., Peelar Road/Exchange Avenue); and
- The CNR culvert crossing at the York Subdivision tracks is significantly undersized, which causes considerable inundation of the Black Creek channel and adjacent lands upstream of the structure. Under the Regional Storm conditions the backwater created by this crossing would result in the flooding of the Jane Street underpass at the CNR York Subdivision east of Black Creek.

The hydraulic capacity of the reaches along the main tributary of Black Creek is presented in ***Table 9***.

The results of the hydraulic assessment of the channel reaches using the HEC-RAS model indicate the following:

- Upstream of Highway 7, the Black Creek channel can convey flows generated by significant rainfall events, including the 100-year and/or August 19th, 2005 storm event;

Table 9. Existing Black Creek Reach Capacity

Reach ID	Upstream Limit		Downstream Limit		Hydraulic Capacity[1]
	Road/SWM Facility	*Culvert ID*	*Road/SWM Facility*	*Culvert ID*	
R1	Weston Road	-	Creditview Road	C1	August 19, 2005
R2	Creditview Road	C1	Highway 400	C2	August 19, 2005
R3	Highway 400	C2	Langstaff Road	C3	August 19, 2005
R4	Langstaff Road	C3	Highway 400 N/B Off-ramp (@ Langstaff Road)	C4	August 19, 2005
R5	Highway 400 N/B Off-ramp (@ Langstaff Road)	C4	Applewood Crescent	C5	100-Year
R6	Applewood Crescent	C5	Edgeley Boulevard	C6	August 19, 2005
R7	Edgeley Boulevard	C6	Millway Avenue	C7	100-Year
R8	Millway Avenue	C7	Pennsylvania Avenue	C8	100-Year
R9	Pennsylvania Avenue	C8	Jane Street	C9	100-Year
R10	Jane Street	C9	Edgeley Pond (U/S of Highway 7)	N/A	August 19, 2005
R11	Edgeley Pond (U/S of Highway 7)	C10	Highway 7	C11	100-Year
R12	Highway 7	C11	Private Driveway (7717 Jane Street)	C12	5-Year
R13	Private Driveway (7717 Jane Street)	C12	Private Driveway (7695 Jane Street)	C13	5-Year
R14	Private Driveway (7695 Jane Street)	C13	Doughton Road	C14	10-Year
R15	Doughton Road	C14	Private Driveway (7601 Jane Street – Paradise Banquet & Convention Centre)	C15	10-Year
R16	Private Driveway (7601 Jane Street – Paradise Banquet & Convention Centre)	C15	Private Driveway (7551 Jane Street – Vaughan Iceplex)	C16	25-Year
R17	Private Driveway (7551 Jane Street – Vaughan Iceplex)	C16	Abandoned Crossing	C17	50-Year
R18	Abandoned Crossing		Peelar Road		100-Year
R19	Peelar Road	C17	407 ETR	C18	August 19, 2005
R20	407 ETR	C18	Jane Street	C19	100-Year
R21	Jane Street	C19	CNR tracks (York Subdivision)	C20	100-Year
R22	CNR tracks (York Subdivision)	C20	Steeles Avenue	-	Regional Storm

Notes: 1. Indicates hydraulic capacity at the top of the channel/valley bank at the most restrictive segment of the reach.

- The channel reaches between Highways 7 and Peelar Road can only accommodate flows associated with minor to moderate storm events, including two reaches with adequate capacity for only a 5-year storm; and
- The natural reaches of the Black Creek main branch downstream of the 407ETR, which generally consists of a low flow channel and larger valley corridor, provide sufficient capacity to convey flows generated by a 100-year storm event or greater.

3.2.5.4 Floodplain Management Considerations

The results of the hydrologic and hydraulic analyses for existing conditions indicate that through much of the Study Area, the major drainage systems have adequate capacity to convey the peak flows resulting from the 100-year and August 19th, 2005 storm events without impacting adjacent roadways or properties. However, significant ongoing flooding issues have been identified at a number of locations, which are summarized below and illustrated on ***Figure 6***.

- Minor flooding of roadways and properties adjacent to Black Creek occurs during major storm events (i.e., > 100-year storm) along a considerable portion of the main tributary between the Rutherford Business Park and the on-line control structure near Jane Street and Pennsylvania Avenue;
- Significant flooding of roadways and properties adjacent to Black Creek between the 407ETR and Highway 7 occurs during minor to significant storm events (i.e., 5-year storm); and

- A portion of Jane Street at the CNR York Subdivision underpass is within the Regulatory floodplain and, accordingly, flooding of the roadway could occur during a significant rainfall event.

It should be noted that the Updated SWMHYMO model is based on proposed development conditions in the Rutherford Business Park. The northern portion of this block was undeveloped in 2005 and, therefore, the hydrology model is expected to predict higher flow rates, and corresponding water levels, relative to actual observations. Note also that the rainfall gauge located to the north and west of the Study Area recorded lower total storm depths and water levels relative to the York University green roof gauge that was applied to the entire Study Area. This may be responsible for some of the over-estimation of peak flows and water levels in the upper reaches of the Study Area.

Flooding at the Intersection of Jane Street and Highway 7 Following the August 19th, 2005 Storm

Considering the differences between actual and modeled development conditions, the potential variability of storm intensities over the Study Area, and the accuracy of the recorded high water mark elevations, it is concluded that the hydrologic and hydraulic models updated through the subject study reasonably represent the Black Creek subwatershed within the City of Vaughan. The models are considered sufficiently accurate to identify potential flooding problems and to evaluate alternative solutions to improve flow and flooding conditions through the Study Area.

Subsequent to the update of the HEC-RAS model to address the inconsistencies identified with respect to culvert sizes, as well as topographic conditions within the Black Creek channel and tableland areas, the floodplain mapping for the area between the 407ETR and Highway 7 was revised to reflect the corresponding changes in the water surface elevations associated with the Regional Storm (refer to **Appendix A**). As shown, the limits of the updated Regulatory Floodplain in this area do not vary significantly from the original mapping, and no additional structures will be impacted. Further, the updated mapping and floodplain delineation has resulted in the elimination of a 'spill' area currently located across Jane Street, immediately north of Peelar Road.

3.2.6 Water Quality Considerations

In 2006 and 2007, water quality samples were collected from Black Creek by TRCA at Station HU1RWMP, which is located approximately 20 m downstream of the CNR tracks (refer to ***Figure 5***). The samples were analyzed for a wide range of parameters, including inorganic compounds, nutrients, and general chemistry. Measured concentrations of several parameters that are indicators of urban water quality are summarized in ***Table 10***, together with the corresponding Provincial Water Quality Objectives (PWQO), where available.

Table 10. Selected Water Quality Results for Black Creek Station HU1RWMP (2006-2007)

Parameter	Units	PWQO	Range	Average
pH	–	6.5 – 8.5	7.97 – 8.33	8.12
Chlorides	mg/L	–	159 – 15,100	1557
E. coli	CFU/100 mL	100	40 – >20,000	2,980
Total Boron	µg/L	200	10 - 620	111
Total Cadmium	µg/L	0.5	0.3 – 1	0.7
Total Cobalt	µg/L	0.5	1 – 5	2.9
Total Copper	µg/L	5	3 – 19	7
Total Iron	µg/L	300	269 – 1460	660
Total Lead	µg/L	5	1.7 – 23	11
Total Phosphorus	mg/L	0.03	0.04 – 0.34	0.1
Total Silver	µg/L	0.1	0.3 – 1.1	0.7
Total Suspended Solids	mg/L	–	2 – 86	16

Notes: 1. PWQO – Provincial Water Quality Objectives (MOEE, 1994).
2. Average concentrations that exceed the respective PWQO are highlighted in grey.

A review of the results of the analyses for 2006 and 2007, as well as a comparison of the measured concentrations with the associated PWQO value for each of the parameters considered, revealed the following:

- The majority of the average total metals concentrations exceeded their respective PWQOs during this period;
- Although *E. coli* concentrations exceeded the PWQO, the range observed during this period is typical of urban watercourses and increased concentrations (>20,000 CFU/100 mL) were generally associated with rainfall events;
- Total phosphorus levels exceeded the PWQO for every sampling event, however, the range of concentrations observed at this location is within the range typically measured in urban watercourses;
- TSS levels were significant, but within the typical range for urban watercourses; and
- The range of chloride concentrations observed is typical of southern Ontario urban watercourses, which is expected to occur as a result of salting of roadways during winter months.

Additional water quality sampling was also carried out in 2009 and 2010 as part of the *Toronto-York Spadina Subway Extension* (TYSSE) project. The results of the sampling program are consistent with the previously collected water quality data, as described above.

3.2.7 Fluvial Geomorphology

A fluvial geomorphological and erosion assessment was undertaken for the segment of Black Creek and its tributaries that are located within the Study Area. The objective was to provide insight into where and through what processes erosion is occurring, as a basis for developing strategies for reducing the rate of erosion in critical areas. The methodology that was followed and the results of the geomorphological and erosion assessment are summarized below.


Black Creek Upstream of Steeles Avenue

3.2.7.1 Methodology

Several sources of relevant background information were carefully reviewed to complete the desktop component of the geomorphic/ erosion assessment, including:

- Regional topographic and drainage mapping;
- Surficial geology mapping prepared by the Ontario Geological Survey and the Geological Survey of Canada;
- Historical aerial photographs from 1954, 1969 and 1993;
- Recent orthophotography from 2005 and 2007; and
- Flood frequency and magnitude data available from the SWMHYMO/HEC-RAS model outputs.

The topographic and surficial geology mapping was reviewed to gain a detailed understanding of the conditions that could cause erosion to occur within Black Creek. Of particular importance were the current characteristics and changes in: valley confinement, channel gradient and stream substrate.

Historical aerial photographs were also examined in stereo to determine landform characteristics; characterize surrounding land use, including riparian cover; and identify high cut-banks. Most importantly, however, the aerial photographs provided an opportunity to detect natural and anthropogenic changes in channel configuration and morphology over time. This comparison provided a basis for identifying the factors most likely responsible for the erosion observed at a particular location and the sites that are at risk of continued erosion without immediate attention.

Following the background review of available information, field investigations were completed along main branch of Black Creek from Steeles Avenue to its headwater reaches near Rutherford Road, as well as within the East and West tributaries (refer to ***Figure 7***). Particular attention was applied to the reaches that exhibit predominantly natural conditions and those that have experienced considerable erosion. Observations of channel morphology were recorded, including valley confinement, channel pattern, bankfull shape and dimensions, substrate type and riparian vegetation. Significant sites of erosion were carefully examined and photographed (refer photographic inventory in **Appendix B**). As a basis for evaluating the erosion potential at critical locations between Steeles Avenue and Jane Street, cross-sections and the slope of the bankfull energy gradient (approximated by the water surface between riffle crests) were measured, and a modified Wolman (1954) pebble count was conducted. Critical velocities and discharge were estimated based on Lane (1955), using the approach outlined by Newbury and Gaboury (1994).

In addition, the Rapid Geomorphic Assessment (RGA) (MOE, 1999) and Rapid Stream Assessment Technique (RSAT) (Galli, 1996), which were developed to provide a standardized, qualitative means of evaluating the stability and overall health of suburban streams, were completed within each of the reaches that exhibit at least some natural conditions.

3.2.7.2 Geomorphic Conditions

For descriptive purposes, and to properly evaluate channel stability according to site-specific forcing mechanisms, Black Creek has been divided into eight distinct reaches (refer to ***Figure 7***). Each of the reaches is described in ***Table 11***, including information regarding the limits of each reach along with the corresponding channel characteristics.

As noted, RGA and RSAT calculations were carried out to determine the stability and geomorphic health of the natural reaches of Black Creek within the Study Area (refer to **Appendix C**). The results of the calculations are summarized in ***Table 12***, which indicate that all of the reaches continue to be 'in adjustment' and, therefore, a dynamic equilibrium has not been attained at these locations. Further, all of the reaches were assessed to be in 'fair condition,' with the exception of Reach 4, which has been determined to be in 'poor condition.'

A channel with a 'fair condition' rating has common bank failures, low to moderate in-stream and riparian habitat diversity, and some indications of impacted water quality. A 'poor condition' channel has widespread bank failures, low in-stream and riparian habitat diversity, and water quality is impacted by urbanization.

In addition, a number of erosion sites were identified along the segment of Black Creek that extends from Steeles Avenue to Highway 7. The type of erosion and resulting severity varied considerably, from erosion along the outer bank of meanders to significant slope instability of valley-walls. A description of the field observations and apparent cause of erosion at each location is provided in ***Table 13***.

3.2.7.3 Erosion Processes

A variety of processes are responsible for the erosion observed along Black Creek and its tributaries. However, as discussed previously, the channels appear to be responding to more frequent, intense, flashier floods primarily by down-cutting and widening. In most cases, bed scour has led to undercutting of the lower banks, which is followed by slumping.

In order to gain a more thorough understanding of the susceptibility of the bed to erosion, two sites of erosion within the natural reaches of Black Creek between Steeles Avenue and Jane Street were investigated in detail. The cross-sections observed are described below. The flow and erosion conditions for these reaches are summarized in ***Table 14***.

Table 11. Geomorphic Characteristics of Black Creek Reaches

Reach	Limits	Channel Characteristics
1	Steeles Avenue to CNR York Subdivision	• the channel exhibits a partly confined, irregularly meandering channel pattern; • bankfull width and depth averages were approximately 7 m and 0.8 m, respectively; • several oxbows (partly or wholly infilled with fine sediment and organic material) were observed, indicating that the entire valley bottom area is within the meander belt; • bed material is predominantly alluvial sand and gravel, with isolated patches of till-derived cobbles, and the pool-riffle sequence is well developed; • exposed tree roots in eroding banks and large woody debris jams are causing a local deflect of the thalweg into the banks; and • the reach neither appears to be degrading nor aggrading; however, bank erosion is moderately extensive throughout this segment of the channel.
2	CNR York Subdivision to Jane Street	• the channel exhibits a compound, irregularly meandering pattern, partly confined by moderately steep valley-sides; • bankfull width is variable, ranging from approximately 2 m within irregular chutes through cohesive sediments near the upstream end to 7 m near the downstream limit, and bankfull depth ranges between about 0.7 and 0.9 m; • bed material made up of a mix of gravelly and cobbley alluvium, with discontinuous segments of exposed till; • the gradient is notably steeper in the downstream section, locally more than 1%, and the pool-riffle sequence is well developed; and • evidence of a man-made off-line wetland facility was noted adjacent to the creek.
3	Jane Street to 407ETR	• the channel exhibits irregular meanders, an active side channel and a recent oxbow; • bankfull width ranges between 2 and 4 m, while depth is approximately 0.7 m; and • the alignment of approximately 75 m of the channel is directly adjacent to the Beechwood Cemetery pond, with a narrow berm (~1.5 m wide) separating these features.
4	407ETR to Hwy 7	• the channel has undergone considerable anthropogenic modification to accommodate development (currently comprises an engineered, trapezoidal geometry for much of this reach); • bankfull width varies between approximately 9 m at the downstream end of the reach to 7 m just downstream of Hwy 7, with a depth of about 1.2 m; and • the gradient is relatively low throughout the reach, such that fine sediment has accumulated on the bed, which is partly lined with cobble rip-rap.
5	Hwy 7 to Jane Street	• the entire length of this reach has been replaced by an engineered trapezoidal channel, and has experienced significant realignment to accommodate development; • bankfull width and depth are approximately 3 m and 0.7 m, respectively; and • fine sediment from road runoff and organic muck has accumulated on the bed.
6	Jane Street to Rutherford Road	• approximately 800 m of the channel upstream of Highway 400 has been re-aligned and modified to facilitate development of the Rutherford Business Park; • the channel follows a regular, sinuous planform, to mimic more natural conditions; • bankfull width of 2 m remains as designed, but the depth has been reduced to less than 0.5 m; and • upstream of Rutherford Road, Black Creek no longer exists and drainage is accomplished through a network of municipal storm sewers.
West Trib.	CNR York Subdivision to 407ETR	• the channel is moderately well defined, with low, steep banks and a narrow deep valley, including a rip-rap lined segment that follows the railway embankment; • bankfull width and depth of approximately 2.5 m and 0.5 m, respectively; • the tributary exhibits a sinuous channel pattern, with a number of side channels that cross riparian wetlands and poorly developed pools and riffles; and Riparian vegetation, which consists primarily of low shrubs and cattails, helps stabilize the banks.
East Trib.	Confluence with main branch to 407ETR	• bed material consists of alluvial sand and gravel along the bed, except in scour pools where the underlying till is exposed; • the channel exhibits a sinuous channel pattern, and riffle morphology is dominant; • bankfull width and depth of approximately 4 m and 0.6 m, respectively; and • bed material is composed of patches of till-derived cobble and downstream-transported rip-rap overlying competent till.

Table 12. Summary of Results of RGA and RSAT

Reach	Rapid Geomorphic Assessment		Rapid Stream Assessment Technique	
	Stability Index Value	Interpretation	Total Score	Interpretation
Reach 1	0.43	In adjustment	28	Fair condition
Reach 2	0.53	In adjustment	21	Fair condition
Reach 3	0.44	In adjustment	19	Fair condition
Reach 4	0.52	In adjustment	14	Poor condition
West Tributary	1.49	In adjustment	26	Fair condition
East Tributary	0.44	In adjustment	21	Fair condition

Table 13. Summary of Observations and Causes of Erosion

Erosion Site	Reach	Erosion Observations	Cause of Erosion
ES1	1	Significant erosion is occurring along outer bank of meander near existing storm sewer outfall and cobblestone deflector.	Natural erosion along outer bank of meander, with concentrated flow at edge of soon-to-be-outflanked deflection berm.
ES2	1	Old wooden fence has collapsed into channel due to bank undercutting.	Natural erosion along outer bank of meander.
ES3	1	Gabion baskets along bank opposite from pond overflow spillway have been outflanked and undermined, collapsing into channel.	Degradation (down-cutting) and natural erosion along outer bank of meander, exacerbated by periodic pond overflow.
ES4	1	Discontinuous rip-rap and filter cloth lining banks have narrowed channel and exacerbated bank erosion.	Velocities are higher through narrower channel, and local flow obstructions have concentrated flow along banks.
ES5	1	2 m high eroding cut-bank along outside of meander.	Natural erosion along outer bank of meander.
ES6	West Tributary	Erosion of gravel road embankment delivering fill material into downstream channel.	Surface runoff has formed rills and outflow from perched culvert has incised gully into embankment.
ES7	2	Minor erosion of the toe of a railway embankment, where channel is forced to bend sharply westward.	Trajectory of flow from bed-armoured upstream channel segment directly into embankment, from which seepage is emerging at contact between the railway sub-grade material and underlying glaciolacustrine clayey silt.
ES8	2	Large boulders, debris and cobble weirs placed in channel have exacerbated local bank erosion.	Materials project into channel from banks, reducing capacity and deflecting flow into 'unarmoured' portions of banks.
ES9	2	High valleyside cut-bank is gradually being undercut along the outer bank of a meander, above which private property extends to the crest of the slope.	Degradation (down-cutting) and natural erosion along outer bank of meander, exacerbated by local bed steepness and seepage from lower valley-side.
ES10	2	High valleyside cut-bank below a Hydro One transmission tower is gradually being undercut along the outer bank of a meander, which is predisposed to natural 'cut-off'.	Natural erosion along outer bank of meander, which may increase in severity once the imminent meander 'cut-off' occurs.
ES11	2	Erosion along outer bank of meander, at the edge of a farm access driveway and residential property.	Natural erosion along outer bank of meander.
ES12	East Tributary	Significant erosion along the northern bank has caused the channel to come within 1 m of a Hydro One transmission tower.	Degradation (down-cutting), widening and local retrogressive erosion (head-cutting).
ES13	3	Localized bank instability along the berm between the channel and Beechwood Cemetery pond.	Natural widening of historically narrowed and straightened channel segment, combined with piping of fine sediments driven by pond-channel head difference
ES14	3	2 m high eroding cut-bank along meander.	Degradation (down-cutting) and natural erosion along outer bank of meander.
ES15	3	Minor erosion of the toe of the valleyside above which the east-bound on-ramp to Hwy 407 is set back approximately 30 m.	Natural erosion along the toe of a steep valley-side.
ES16	4	Severe undercutting of alternate banks, which has collapsed banks and created partial obstructions to flow.	Degradation (down-cutting), which has led to channel entrenchment, and thalweg sinuosity within a historically straightened reach.
ES17	4	Gabion retaining wall less than 10 m from a parking area has been undermined by bed scour to a point that it is overhanging and collapsing into channel.	Degradation (down-cutting) and erosion of foundation soils of retaining wall.
ES18	4	An old road crossing has been overtopped and breached by floods, resulting in partial channel blockage by rubble, debris and fallen trees and inundation of mature forest upstream.	Fluvial incision and colluvial collapses while floodwaters overtopped under capacity and/or blocked CSP culverts beneath old road crossing.

Table 14. Flow and Erosion Conditions at Representative Erosion Sites

Reach	Cross-Section	Flow Condition [1]	Discharge (m^3/s)	Average Velocity (m/s)	Energy Gradient[2] (m/m)	Depth (m)	Critical Grain Size[3] (mm)	Proportion of Bed Mobile (%)
1	1	Bankfull	5.4	1.2	0.0037	0.75	30	45
		Critical	7.5	1.3	0.0037	0.91	35	50
2	2	Bankfull	4.2	1.4	0.0080	0.77	60	80
		Critical	0.39	0.62	0.0080	0.28	25	50

Notes: 1. *Bankfull depth based on field indicators (e.g., vegetation change, slope breaks, etc.); critical flow assumed to correspond to median grain size at state of incipient motion.*
2. *Energy gradient estimated from water surface elevation at consecutive riffle crests.*
3. *Critical grain size estimates based on Lane (1955), using the approach developed by Newbury and Gaboury (1994).*

Critical flows were estimated based on field measurements of each bankfull cross-section, the bankfull energy gradient and the distribution of grain sizes for the bed materials, and on visual estimation of resistance to flow (Manning's n) from Hicks and Mason (1998) and standard values used by the TRCA.

Evidence of Bank Erosion

The estimates of the critical grain sizes corroborate observed field conditions. In Reach 1, recently deposited bars were composed of gravel and small cobbles, whereas larger cobbles derived from till exhibited discolouration and algal growth, suggesting they are not mobilized by frequent flows contained within the channel. Over time, undermining of larger stones and ice forces has led to incremental down-stream transport. As indicated in ***Table 14***, the majority of bed material within Reach 2 may be mobile during bankfull conditions and a depth of approximately 0.3 m is required to mobilize 50% of the bed. Indeed, nearly all of the bed material at erosion site E8 had been deposited recently, and fresh exposures of the competent till underlying the alluvium are widespread.

While velocities and the corresponding shear stress along the bed and banks are ultimately responsible for most of the erosion observed along Black Creek and its tributaries, there is no doubt that anthropogenic changes in channel dimensions and shape, configuration, gradient and substrates have exacerbated the problem. The following section provides a hierarchical framework for identifying opportunities to reduce erosion, beginning with mitigation at the watershed scale and ultimately providing techniques to address site-specific erosion concerns.

3.3 Identification and Description of Alternative Solutions

In response to the issues identified in the Problem/ Opportunity Statement, a wide range of improvement alternatives have been identified for further evaluation. Given that the Problem/Opportunity Statement identifies various issues related to stormwater quantity and quality, alternative solutions have been developed and evaluated separately for flooding, erosion and water quality considerations. Accordingly, the alternatives identified for the purpose of addressing each of these issues are described in the corresponding section below.

It should be noted that, although the 'Do Nothing' alternative does not address the issues described in the Problem/Opportunity Statement, the EA Act requires its consideration in all Class EAs as a means of providing a benchmark for evaluating the other alternatives.

3.3.1 Flood Improvement Alternatives

As noted in ***Section 3.2.5*** and shown on ***Figure 6***, ongoing flooding issues have been identified at a number of locations in the Study Area through previous studies and observed during significant rainfall events (e.g., August 19, 2005 storm), which have been confirmed as part of the current Study. For the purpose of developing an appropriate strategy to address these issues, the portions of the Study Area that are susceptible to flooding have been separated into the two following categories, based on the risk of flooding and the resulting severity of potential impacts.

i) Minor flooding during significant rainfall events (i.e., greater than a 100-year storm); and
ii) Significant flooding during minor to moderate rainfall events (i.e., greater than a 5-year storm).

The portion of the Study Area that has the potential to experience minor flooding during significant rainfall events is located along the segment of Black Creek that extends upstream from Jane Street and Pennsylvania Avenue to just upstream of the Highway 400 crossing of Black Creek (refer to ***Figure 6***). The channel and associated hydraulic structures for this portion of Black Creek can adequately convey the flows generated by a 100-year storm, while the flood depths estimated for the Regional Storm are minor (i.e., less than 1 m). Accordingly, it is recommended that site level investigations and improvements are carried out when re-development of these properties occurs. Therefore, these areas have not been considered for further flood improvements.

In contrast, the segment of Black Creek between the 407ETR to just upstream of Highway 7 can only accommodate flows generated by a 5-year storm. Due to the limited capacity within this reach of Black Creek, the adjacent properties, structures and portions of Jane Street, Peelar Road and Highway 7 are susceptible to considerable flooding during moderate rainfall events (refer to ***Figure 6***). In order to address flooding in this area, a variety of alternatives have been identified for further evaluation, as described below.

3.3.1.1 Alternative F1 – Do Nothing

As indicated, this alternative does not include the implementation of any improvements within the Study Area and, accordingly, the status quo would be maintained.

3.3.1.2 Alternative F2 – 100-Year Storm Improvements

The objective of this alternative is to provide sufficient capacity within this segment of Black Creek to convey the runoff generated by a 100-year storm event without significant flooding of adjacent structures, roads or municipal infrastructure. The proposed works involve culvert improvements at two private crossings located between Doughton Road and Peelar Road – including the replacement of the existing structures with 5x3 m concrete box culverts, or equivalent hydraulic opening (refer to ***Figure 8***).

3.3.1.3 Alternative F3 – August 19, 2005 Storm Improvements

The objective of this alternative is to provide sufficient capacity within Black Creek to convey the runoff generated by a rainfall event equivalent in magnitude to the August 19, 2005 storm without significant flooding of adjacent structures, roads or municipal infrastructure. The proposed works involve culvert improvements at Highway 7 and at two private crossings between Doughton Road and Peelar Road, including the replacement of the existing structures with twin 5x3 concrete box culverts, or equivalent hydraulic opening (refer to ***Figure 9***).

3.3.1.4 Alternative F4 – Regional Storm Improvements

The objective of this alternative is to provide sufficient capacity within Black Creek to convey the runoff generated by the Regional Storm (i.e., Hurricane Hazel) without significant flooding of adjacent structures, roads or municipal infrastructure. The proposed works involve the construction of a new naturalized channel to replace the existing segment of Black Creek between the Edgeley Pond and the 407ETR, with bridges at existing and future road

crossings and localized grading of Jane Street, both upstream and downstream of Highway 7 (refer to ***Figure 10***).

3.3.2 Water Quality Improvement Alternatives

The level of water quality protection currently provided varies significantly across the Study Area. Many of the older industrial areas were developed prior to the adoption of current SWM practices (SWMPs) and provide limited or no water quality controls, while other areas are serviced using a variety of Best Management Practices (e.g., wet ponds, oil-grit separators, etc.). For the purpose of implementing more consistent quality control measures, the Study Area has been divided into a number of separate catchment areas depending on drainage boundaries, existing SWM servicing, and both current and proposed land use considerations (refer to ***Figure 11***).

As indicated, water quality treatment has been implemented for portions of the Study Area at the time of development. In most cases, the SWM facilities that service these areas provide an adequate level of water quality protection. In addition, there are large portions of the Study Area where re-development initiatives are underway (i.e., VMC, OPA 620, Weston/400 North Development Area, Invar Development, TYSSE Highway 407 Station). Appropriate SWM servicing strategies have been established for these areas that follow the criteria prescribed by the City, TRCA, and MOE. Furthermore, there is a considerable amount of open space between Steeles Avenue and the 407ETR, including the Hydro One corridor, Black Creek Pioneer Village, Beechwood Cemetery and a large agricultural area.

In light of the above, there are no water quality improvements proposed for the portions of the Study Area that currently provide adequate SWM treatment, as well as areas where re-development is planned or where lands are designated as 'Open Space.' Accordingly, these areas have been screened from further consideration. Alternative water quality improvement measures identified for the remainder of the Study Area are described below.

3.3.2.1 Alternative WQ1 – Do Nothing

As indicated, this alternative does not include the implementation of any improvements within the Study Area and, accordingly, the status quo would be maintained.

3.3.2.2 Alternative WQ2 – Installation of Centralized Oil-Grit Separators (OGS)

This alternative involves the installation of centralized OGS within areas where water quality treatment is either limited or non-existent under existing conditions. Where practical, these units would be installed along the existing storm sewer system within the municipal road right-of-way, which would limit the need for the acquisition of private property and facilitate future maintenance requirements (refer to ***Figure 11***).

3.3.2.3 Alternative WQ3 – Retrofit or Construct SWM Ponds

Under this alternative, a number of existing SWM ponds within the Study Area would be retrofitted to include a water quality treatment component, together with the construction of a new SWM pond. These initiatives have been examined thoroughly and recommended as part of previous studies and include the following:

- Expansion of the Edgeley Pond that is located northeast of Jane Street and Highway 7 (City pond #37/TRCA Pond #18) and the dry detention pond between Chrislea Road and Jevlan Drive south of Carlauren Road (City pond #66/TRCA pond #41) (Aquafor Beech, 2009);
- Expansion of three existing SWM ponds within the VMC development area, including the Edgeley Pond (identified at SWM Pond P1), the Interchange Pond and SWM Pond P2 (TMIG, 2009);
- Expansion of the existing SWM pond within Black Creek Pioneer Village to service the OPA 620 development lands (Sernas, 2009); and
- Construction of a new SWM pond east of Jane Street, north of Peelar Road (TMIG, 2009).

The above-noted existing and proposed SWM ponds and the catchment areas that each facility would service are shown on ***Figure 11*** for further reference.

3.3.3 Channel Erosion Improvement Alternatives

As described in ***Section 3.2.5*** and further illustrated on ***Figure 12***, bed and bank erosion are widespread along the natural and slightly altered reaches of Black Creek between Steeles Avenue and Highway 7. Upstream of Highway 7, where much of the channel exhibits an engineered cross-section with few bends, there are no significant erosion concerns. In total, 18 distinct sites of erosion were observed, which vary from moderate to severe. To address these erosion issues, the alternatives described below have been identified for further consideration.

However, due to the severity of the erosion issues identified within the Study Area and the limited opportunity to implement practical solutions to address these issues (i.e., physical constraints), a number of screening criteria have been developed to determine whether these alternatives should be considered for further evaluation, which include:

i) Potential to address Problem/Opportunity statement;
ii) Ability to implement; and
iii) Cost-effectiveness.

3.3.3.1 Alternative E1 – Do Nothing

As indicated, this alternative does not include the implementation of any improvements within the Study Area and, accordingly, the status quo would be maintained. It is expected that this would result in continued erosion of the channel bed and banks at an unnatural and significant rate until the creek has attained a dynamically stable planform, profile and cross-section. Natural reaches with few 'hard' anthropogenic controls, such as Reaches 2 and 3, would likely achieve an 'in regime' channel the earliest, although it may still take decades or more to attain this state. In comparison, Reach 4, which is confined within an unnaturally straight and deep channel with armoured banks, would likely continue to erode along its bed and banks under this configuration.

Sites where continued erosion may pose a risk to public safety, property or aquatic and terrestrial ecosystems are of greatest concern. Infrastructure could be damaged or destabilized, which could require expensive emergency measures to address these problems in the future. Unnaturally high rates of bank erosion, particularly in such silty soils as are found throughout the Study Area, can introduce large quantities of fine sediment into the water column and compromise the health and productivity of aquatic biota. Major bank undercutting and slumping can destroy important riparian vegetation and terrestrial habitats. Overall, the 'Do Nothing' alternative is at risk of chronic channel adjustments and potentially severe acute impacts.

Given that the 'Do Nothing' alternative would not address the ongoing erosion issues within the Study Area, along with the substantial impacts that are expected to occur if this approach is followed, it is not deemed an appropriate course of action. Accordingly, this alternative does not satisfy the above-noted screening criteria and was not considered further.

3.3.3.2 Alternative E2 – Additional SWM Controls

This alternative involves the implementation of additional SWM measures to provide erosion protection through further lot level, conveyance and end-of-pipe controls. These measures would be applied to portions of the Study Area where limited or no erosion control currently exist, apart from areas where re-development is to occur or areas designated as 'Open Space'. Accordingly, the additional SWM controls to be implemented as part of this alternative would include the incorporation of Low Impact Development (LID) measures at a site level (e.g., green roofs, rainwater harvesting, infiltration systems, etc.) or the retrofit of existing SWM facilities. Erosion control requirements for current and future development initiatives are summarized in ***Section 5.1***.

As noted previously, the areas that do not currently provide adequate erosion protection include many of the older commercial/industrial developments and the segment of Highway 400 that transects the Study Area. Given the physical constraints associated with implementing on-site erosion control measures within

these areas, this approach is considered to be impractical. Further, the City recently completed a study that evaluated existing SWM ponds to determine the potential benefits and priority of retrofitting these facilities (Aquafor Beech, 2009), which identified three ponds within the Study Area. However, one of these ponds (TRCA Pond #22) has already been retrofitted and the others have very limited potential to incorporate additional storage for erosion control purposes.

Due to the physical constraints associated with this alternative and the extremely limited benefits that are expected to result following implementation, it does not satisfy the above-noted screening criteria. Therefore, it has been removed from further consideration.

3.3.3.3 Alternative E3 – In-stream Restoration Strategies

The objective of this alternative is to address erosion concerns on a case-by-case basis, in light of the anticipated impacts associated with the 'Do Nothing' alternative and the limited opportunity to reduce the extent and rate of erosion through additional SWM controls. As noted, the unnaturally frequent and high peak flows exacerbate the effects of erosion throughout Black Creek and its tributaries, but a different combination of fluvial, colluvial and hydrogeological processes is responsible for the type and rate of erosion identified at each site. Therefore, the resolution of each erosion concern relies on an understanding of the site-specific processes and channel characteristics. A summary of the relevant observations and causes of erosion, together with the recommended restoration strategy for each location, is presented on the table provided on ***Figure 12***.

Given that Alternatives E1 and E2 have been screened from further consideration, it has been determined that this alternative is the most effective and appropriate approach to address the ongoing erosion issues occurring within the Study Area. Accordingly, the in-stream restoration strategies described in the above-referenced table comprises a component of the preferred solution and will be included as components of the recommended Master Plan.

3.4 Evaluation of Alternative Solutions

3.4.1 Description of the Evaluation Methodology

Taking the existing environment into consideration, the alternative solutions were comparatively evaluated according to a descriptive or qualitative assessment based on the appropriate criteria developed within the following categories of consideration representing the broad definition of the environment described in the Ontario Environmental Assessment Act (OEAA):

- **Technical –** having regard for the technical suitability/longevity, and other engineering aspects of the alternative solution.
- **Natural Environment –** having regard for protecting the natural and physical components of the environment (i.e., air, land, water and biota) including natural and/or environmentally sensitive areas.
- **Social –** having regard for residents, neighbour-hoods, businesses, community character, social cohesion and community features.
- **Cultural –** having regard for historical/ archaeological remains, and heritage features.
- **Financial –** having regard for the capital costs of the alternative solution, excluding land acquisition costs.

Within each category, project-specific evaluation criteria were developed based on a review of the Municipal Class EA, the existing conditions of the Study Area, the alternative solutions being considered, and the Problem/ Opportunity statement.

3.4.2 Application of the Evaluation Methodology

Once developed, the criteria established for each of the above-noted assessment categories were used to comparatively evaluate the alternative solutions and identify a recommended solution for each through a "net effects analysis" consisting of the following steps:

i) Apply the appropriate evaluation criteria to each of the alternative solutions to identify the potential effects on the environment.

ii) Identify reasonable mitigative measures available to avoid or minimize any potential negative environmental effects on the environment.

iii) Apply the mitigative measures to identify the net positive or negative effects on the environment.

iv) Identify the relative advantages and disadvantages for each alternative solution based on the net environmental effects.

A summary of the results of applying the preceding evaluation methodology to each of the alternative solutions that have been identified to address flooding and water quality issues in the Study Area is presented in ***Tables 15*** and ***16***, respectively.

3.4.3 Ranking of the Alternative Solutions

3.4.3.1 Flood Improvement Alternatives

The flood improvement alternatives were ranked in order of preference according to their net effects on the environment as identified in the comparative evaluation process and summarized in ***Table 17***.

3.4.3.2 Water Quality Improvement Alternatives

The overall ranking of the water quality improvement alternatives and the corresponding rationale is provided in ***Table 18***.

3.5 Selection of the Preferred Solution

The preferred solution consists of a combination of the recommended improvement alternatives selected to address the flooding, water quality and erosion issues identified within the Study Area. The components of the preferred solution, together with a description of the proposed works associated with each, are summarized in ***Table 19***.

Also shown in ***Table 19*** are the associated capital costs for each component of the preferred solution. The costs estimates were developed in consultation with the City following the submission of the draft report. As can be noted, the total cost for the preferred solution is estimated at $50 M, exclusive of land acquisition costs.

The design information for the preferred alternative has been developed to a conceptual/functional level of detail. The final alignments and details, particularly of the Black Creek Regional Channel, will be established through the completion of Phases 3 and 4 of the Municipal Class EA Master Plan process.

Table 15. Comparative Evaluation Summary of Flood Improvement Alternatives

Areas of Consideration/Criteria	Alternative #1 *Do Nothing*	Alternative #2 *100-year Storm Event Improvements*	Alternative #3 *August 19, 2005 Storm Improvements*	Alternative #4 *Regional Storm Improvements*
Description of Alternative	No flood improvements proposed within the Study Area.	Culvert improvements at two private crossings located between Doughton Road and Peelar Road, including the replacement of existing structures with 5x3 m concrete box culverts.	Culvert improvements at 3 crossings, including the replacement of existing structures with twin 5x3 m culverts; one located at Highway 7 and two at private crossings between Doughton Road and Peelar Road.	Construction of a new approximately 950 m long trapezoidal, naturalized channel from the outlet of the Edgeley Pond to Highway 407, with bridges at all required road crossings.
1. Technical Assessment Group				
1.1 Potential for improved public safety.	No potential for improving public safety.	Moderate potential for improving public safety. Proposed works will provide flood protection for all rainfall events up to and including the 100-year storm; however, flooding of roads and buildings will occur during rainfall events with greater intensity, including the August 19, 2005 storm.	Moderate potential for improving public safety. Proposed works will provide flood protection for all rainfall events up to and including the August 19, 2005 storm; however, flooding of roads and buildings will occur during rainfall events with greater intensity, including the Regional Storm (i.e., Hurricane Hazel).	High potential for improving public safety. Proposed works will provide flood protection for all rainfall events up to and including the Regional storm (i.e., Hurricane Hazel).
1.2 Constructability of proposed infrastructure.	No infrastructure is required for the 'Do Nothing' alternative.	High potential for implementation as only minor infrastructure is required.	Moderate potential for implementation; as the location, duration and sizing of infrastructure is greater than that proposed for Alternative #2.	Low potential for implementation, as the infrastructure requirements are significant (i.e., bridge crossings at multiple locations, extensive natural channel construction, etc.) as well as considerable property acquisition.
1.3 Potential for future maintenance requirements.	High potential for future maintenance requirements due to on-going channel and bank erosion and debris/blockages at crossings.	Moderate potential for future maintenance requirements as there will be improvements at each of the crossings.	Moderate potential for future maintenance requirements as there will be improvements at each of the crossings.	Low potential for future maintenance requirements as the existing channel and crossings would be replaced by a design that would minimize the need for future maintenance.
1.4 Potential for conflicts with existing municipal and utility services.	No potential for conflicts with existing utilities.	Low potential for conflicts with existing utilities. Minimal relocation of utilities would be required.	High potential for conflicts with existing utilities along Highway 7. Major relocation/realignment of utilities would be required.	High potential for conflicts with existing utilities at Highway 7, Doughton Road and Peelar Road. Major relocation/realignment of utilities would be required.
2 Natural Environment Assessment Group				
2.1 Potential for effects on the terrestrial environment.	Moderate potential for continued loss of vegetation due to the ongoing erosion as a result of flooding.	Moderate potential for continued loss of vegetation due to the ongoing erosion as a result of flooding.	Moderate potential for continued loss of vegetation due to the ongoing erosion as a result of flooding.	Although this alternative involves the alteration of approximately 950 m of Black Creek, there would be an overall net benefit to the terrestrial environment following the construction of a naturalized channel.
2.2 Potential for effects on the aquatic environment.	Moderate potential for adverse effects on the aquatic environment due to the continued transport of sediment by storm runoff, which occurs due to the ongoing erosion.	Low potential for adverse effects on the aquatic environment due to the continued transport of sediment by storm runoff, which occurs due to the ongoing erosion.	Moderate potential for adverse effects on the aquatic environment due to the continued transport of sediment by storm runoff, which occurs due to the ongoing erosion.	Low potential for effects on the aquatic environment, as there will be a net benefit associated with the addition of a naturalized channel between Highways 7 and 407.
2.3 Potential for effects on environmentally significant landform/features.	No potential for effects on environmentally significant landforms/features.	Low potential for effects on environmentally significant landforms/features.	Low potential for effects on environmentally significant landforms/features.	Low potential for effects on environmentally significant landforms/features.
2.4 Potential for effects on known habitat for Species of Concern.	No known Species of Concern are located with the Study Area.	No known Species of Concern are located with the Study Area.	No known Species of Concern are located with the Study Area.	No known Species of Concern are located with the Study Area.
2.5 Potential for effects on baseflow and/or groundwater resources.	No potential effects on baseflow and/or groundwater resources.	No potential effects on baseflow and/or groundwater resources.	No potential effects on baseflow and/or groundwater resources.	No potential effects on baseflow and/or groundwater resources.
2.6 Potential for short-term construction related effects on aquatic and terrestrial ecosystems and groundwater resources.	No potential short-term construction related effects on aquatic and terrestrial ecosystems and groundwater resources.	Low potential for short-term construction related effects on aquatic and terrestrial ecosystems and groundwater resources, which can be mitigated through the use of appropriate erosion and sediment control measures and other Best Management Practices.	Moderate potential for short-term construction related effects on aquatic and terrestrial ecosystems and groundwater resources, which can be mitigated through the use of appropriate erosion and sediment control measures and other Best Management Practices.	High potential for short-term construction related effects on aquatic and terrestrial ecosystems and groundwater resources. However, these potential impacts can be mitigated through the use of appropriate erosion and sediment control measures and other Best Management Practices.
3 Social Environment Assessment Group				
3.1 Potential for disturbing nearby land owners, businesses, and community and recreation facilities through temporary and/or permanent effects (i.e., construction noise, dust, traffic and property access issues).	No potential effects on existing land owners, businesses, and community and recreation facilities through temporary effects.	Minor potential for disturbance to existing land owners, businesses, and community and recreation facilities through temporary effects (i.e., construction effects, traffic and property access disruptions).	Moderate potential for disturbance to existing land owners, businesses, and community and recreation facilities through temporary effects (i.e., construction effects, traffic and property access disruptions).	High potential for disturbance to existing land owners, businesses, and community and recreation facilities through temporary effects (i.e., construction effects, traffic and property access disruptions).

Table 15. Comparative Evaluation Summary of Flood Improvement Alternatives

Areas of Consideration/Criteria	Alternative #1 *Do Nothing*	Alternative #2 *100-year Storm Event Improvements*	Alternative #3 *August 19, 2005 Storm Improvements*	Alternative #4 *Regional Storm Improvements*
3.2 Potential for damage to private property due to flooding.	High potential for damage to private property due to flooding.	Moderate potential for damage to private property due to flooding (i.e., > 100-year storm) following implementation of the proposed works.	Moderate potential for damage to private property due to flooding (i.e., > August 19, 2005 storm) following implementation of the proposed works.	Low potential for damage to private property due to flooding following implementation of the proposed works.
3.3 Potential for requiring the acquisition of private property.	No private property required.	No private property required.	No private property required.	High potential for acquisition of property to implement this alternative.
3.4 Opportunity to integrate with planned/future land uses in the surrounding area (i.e. balance development/open space, etc.).	No opportunity to integrate with future land uses.	Low potential to integrate proposed works with planned/future land uses in the surrounding area.	Low potential to integrate proposed works with planned/future land uses in the surrounding area.	High potential to integrate the proposed naturalized channel into the VMC development initiative.
4 Cultural Environment Assessment Group				
4.1 Potential for effects on archaeological resources.	No effects on archaeological resources.	No likely effects on archaeological resources.	No likely effects on archaeological resources.	No likely effects on archaeological resources.
4.2 Potential for effects on cultural/ heritage resources.	No effects on cultural/heritage resources.	No effects on cultural/heritage resources.	No effects on cultural/heritage resources.	No effects on cultural/heritage resources.
5 Financial Assessment Group				
5.1 Costs associated with property acquisition and/or temporary working easements.	No costs associated with property acquisition and/or temporary working easements.	No costs associated with property acquisition; however, temporary working easements will be necessary at proposed culvert replacement locations.	No costs associated with property acquisition; however, temporary working easements will be necessary at proposed culvert replacement locations.	High costs associated with property acquisition to implement this alternative.
5.2 Costs for implementation (i.e., capital costs, utility relocation, etc.).	No capital costs associated with the 'Do Nothing' alternative.	Low capital costs required for implementation.	Moderate capital costs required for implementation.	High capital costs required for implementation.
5.3 Annual operations and maintenance (O&M) Costs.	Higher annual maintenance costs, due to ongoing flooding and continued erosion problems.	Moderate annual maintenance costs	Moderate annual maintenance costs	Moderate annual maintenance costs

Table 16. Comparative Evaluation Summary of Water Quality Improvement Alternatives

Areas of Consideration/Criteria	Alternative #1 *Do Nothing*	Alternative #2 *Centralized Oil-Grit Separators*	Alternative #3 *SWM Quality Ponds*
Description of Alternative	No water quality improvements proposed within the Study Area.	This alternative involves the installation of centralized oil-grit separators within areas where water quality controls are limited or do not exist under existing conditions.	Under this alternative, a number of existing SWM ponds within the Study Area would be retrofitted to include a water quality control component, together with the construction of a new SWM pond.
1. Technical Assessment Group			
1.1 Potential for improved public safety.	No potential for improving water quality.	Moderate potential for improving water quality.	Moderate potential for improving water quality.
1.2 Constructability of proposed infrastructure.	There are no proposed works associated with the 'Do Nothing' alternative.	Moderate potential for implementation, as significant infrastructure is required and conflicts with existing utilities are likely.	High potential for implementation, as conventional construction methods will be employed. Further, these initiatives are recommended in previous studies undertaken by the City of Vaughan.
1.3 Potential for future maintenance requirements.	Periodic maintenance will continue to be required for existing SWM ponds.	High potential for future maintenance requirements (i.e., sediment removal).	High potential for future maintenance requirements (i.e., sediment removal).
1.4 Potential for conflicts with existing municipal and utility services.	No potential for conflicts with existing utilities.	Moderate potential for conflicts with existing utilities.	Low potential for conflicts with existing utilities.
2. Natural Environment Assessment Group			
2.1 Potential for effects on the terrestrial environment.	No potential for effects on the terrestrial environment.	Low potential for effects on the terrestrial environment.	Moderate potential for effects on the terrestrial environment, including removal of existing vegetation at the Edgeley Pond and the pond at Black Creek Pioneer Village. Compensation for the loss of terrestrial resources can be provided within other portions of the Black Creek valley system.
2.2 Potential for effects on the aquatic environment.	High potential for effects on the aquatic environment due to degraded water quality.	Moderate potential for effects on the aquatic environment.	Low potential for effects on the aquatic environment.
2.3 Potential for effects on environmentally significant landform/features.	No potential for effects on environmentally sensitive landforms/features.	Low potential for effects on environmentally sensitive landforms/features.	Moderate potential for effects on environmentally sensitive landforms/ features, including the removal of the woodlot within the Edgeley Pond, which can be mitigated through compensation within other portions of the Black Creek valley system.
3. Social Environment Assessment Group			
3.1 Potential for disturbing nearby land owners, businesses, and community and recreation facilities through temporary and/or permanent effects (i.e., construction noise, dust, traffic and property access issues).	No potential effects on nearby land owners, businesses, and community and recreation facilities through temporary and/or permanent effects.	High potential effects on nearby land owners, businesses, and community and recreation facilities through construction effects (i.e., noise, dust, traffic issues, etc.).	Moderate potential effects on nearby land owners, businesses, and community and recreation facilities through construction effects (i.e., noise, dust, traffic issues, etc.).
3.2 Potential for requiring the acquisition of private property.	No private property required.	Moderate potential for requiring property acquisition at some locations.	High potential for requiring property acquisition for new SWM pond to service southeast quadrant of proposed VMC development.
4. Cultural Environment Assessment Group			
4.1 Potential for effects on archaeological resources.	No likely effects on archaeological resources.	No likely effects on archaeological resources.	No likely effects on archaeological resources.
4.2 Potential for effects on cultural/ heritage resources.	No effects on cultural/heritage resources.	No effects on cultural/heritage resources.	Potential for effects on cultural/ heritage resources associated with retrofit/expansion of the existing SWM pond at Black Creek Pioneer Village (i.e., possible relocation/removal of existing buildings).
5. Financial Assessment Group			
5.1 Costs associated with property acquisition and/or temporary working easements.	No costs associated with property acquisition and/or temporary working easements.	Low costs associated with property acquisition and/or temporary working easements, as most locations are within the municipal road right-of-way.	Moderate costs associated with property acquisition and/or temporary working easements for the new SWM pond to service the proposed VMC development.
5.2 Costs for implementation (i.e., capital costs, utility relocation, etc.).	No capital costs associated with the 'Do Nothing' alternative.	Higher capital costs required for implementation.	Moderate capital costs required for implementation.
5.3 Annual operations and maintenance (O&M) Costs.	No O&M costs associated with the 'Do Nothing' alternative.	High annual O&M costs required for periodic removal of accumulated sediment.	Moderate annual O&M costs required for periodic removal of accumulated sediment.

Table 17. Ranking of Alternative Flood Improvement Alternatives

Rank	Alternative Flood Improvement Solutions	Rationale
1	***Alternative F4*** – Regional Storm Improvements	Although this alternative involves the highest capital and, property acquisition costs as well as significant regulatory approvals requirements, it is the only alternative that fully addresses the problem and opportunities defined for the Project.
2	***Alternative F3*** – August 19, 2005 Storm Improvements	Although this alternative involves moderate capital costs and a moderate potential for effects on the Natural and/or Social Environments, it does not require acquisition of property and addresses the flooding problem and opportunities defined for the Project to the extent practical. However, it should be noted that flooding of roadways and buildings would continue to occur during events of greater magnitude than the August 19, 2005 storm (e.g., Regional Storm).
3	***Alternative F2*** – 100-Year Storm Improvements	Although this alternative involves lower capital costs, does not require the acquisition of private property, and has a lower potential for effects on the Natural and/or Social Environments, it only partially addresses the flooding problem and opportunities defined for the Project. Accordingly, flooding of roadways and buildings would continue to occur during significant rainfall events (i.e., >100-year storm).
4	***Alternative F1*** – Do Nothing	Although there would be no potential capital costs associated with the 'Do Nothing' alternative, the flooding issues would continue to occur and the problem and opportunities defined for the Project would not be addressed, which could result in a high potential for effects on the Social Environment, moderate effects on the Natural Environment, and frequent maintenance efforts would be required on a continual basis.

Table 18. Ranking of Alternative Water Quality Improvement Alternatives

Rank	Alternative Water Quality Improvement Solutions	Rationale
1	***Alternative WQ3*** – SWM Quality Ponds	Although this alternative involves high capital and annual O&M costs, a high potential for the need to acquire property, and a moderate potential for effects on the Natural Environment, it is the most effective alternative for addressing the problem and opportunities defined for the Project.
2	***Alternative WQ2*** – Centralized Oil-Grit Separators	Although this alternative involves a low potential for effects on the Natural Environment, and does not require acquisition of property, it requires a high capital cost and moderate O&M costs, and only partially addresses the problem and opportunities defined for the Project.
3	***Alternative WQ1*** – Do Nothing	Although there would be no potential capital costs associated with the 'Do Nothing' alternative, the water quality issues would continue to occur and the problem and opportunities defined for the Project would not be addressed, which could result in a high potential for effects on the Natural Environment.

Table 19. Components of the Preferred Alternative

Issue	Preferred Alternative	Description of Preferred Alternative	Estimated Capital Cost
Flooding	***Alternative F4*** – Regional Storm Improvements	Although this alternative involves the highest capital, property acquisition and O&M costs as well as significant regulatory approvals requirements, it is the only alternative that fully addresses the problem and opportunities defined for the Project.	$30 M
Water Quality	***Alternative WQ3***– SWM Quality Ponds	Involves the construction of five SWM ponds and the retrofit of five existing SWM ponds in the Study Area to provide a water quality control component. Many of these projects have been recommended through previous studies or identified as a requirement for proposed development initiatives.	$18 M
Erosion	***Alternative E3*** – In-stream restoration measures	Consists of a combination of in-stream restoration measures to address localized erosion or bank instability issues. In addition, it should be noted that further erosion control will be provided through the construction of new SWM ponds and the SWM pond retrofits that have been identified in previous studies carried out by the City and TRCA, together with proposed development initiatives (i.e., VMC, OPA 620, TYSSE Highway 407 Station, etc.).	$2 M
		Total:	$50 M

Note: ***The estimated capital cost excludes land acquisition costs.***

4. Public Consultation

4.1 Public and Agency Consultation during Phase 1

4.1.1 Notification of Project Commencement and Invitation for Comments

Although the Municipal Class EA process does not require a mandatory point of contact during Phase 1, a Notice of Commencement was issued as both a letter and a newspaper advertisement. As a result, all relevant review agencies, area property owners, and the public were notified of the project being initiated, the problem and opportunity being addressed, and given the opportunity to provide comments. Notification was provided through the following means:

i) By letter mailed directly to review agencies and property owners on March 16th, 2009; and

ii) By newspaper advertisement in *The Vaughan Citizen,* and *the Liberal* on March 5, 2009 and April 2, 2009.

Refer to **Appendix D** for copies of the preceding notification materials and a contact list of relevant review agencies and stakeholders. This information is provided in accordance with the standards prescribed by the MEA Class EA document (2003), which outlines the guidelines for establishing contact with appropriate review agencies in relation to the nature of the project.

4.1.2 Comments Received and Their Consideration in the Project

The majority of comments received once the Notice of Commencement was issued were from review agencies. Their comments were geared towards their interest in the project and expressed an interest in being updated as the study progressed. The agencies that responded include MOE, TRCA, GO Transit, TTC, ORC and 407 ETR. A number of local businesses and residents also provided comments, the majority requesting to be kept apprised as the project moves forward. A summary of the comments received is provided below in ***Table 20*** and a full listing of the comments is provided in the *Contact Database and Stakeholder Comment Matrix* in **Appendix E**.

4.1.3 Notification of Public Information Forum #1

Notification of the Public Information Forum (PIF) #1 was provided through the following means:

i) By letter mailed directly to review agencies and property owners on April 13th, 2009; and

ii) By newspaper advertisement in *The Vaughan Citizen* and *the Liberal* on May 7, 2009 and May 14, 2009.

Refer to **Appendix F** for copies of the preceding notification materials and contact lists.

4.1.4 Public Information Forum #1

The first PIF was held on May 20, 2009, between 6:00 p.m. and 9:00 p.m. at Black Creek Pioneer Village. The PIF followed an informal "drop-in" format with display boards presenting the project information (refer to ***Appendix F***). The PIF provided an opportunity for attendees to review the information, present their comments and discuss them directly with the City and their consultants. A summary of the PIF material presented is as follows:

- Study Background;
- Study Area Overview (complete with Study Area map);
- Overview of the Master Plan Class EA process being followed;
- Description of the Study Area Existing Conditions (i.e., land use, drainage and natural environment);
- Identification of the problems and opportunities; and,
- Description of the next steps in the EA process.

Attendance was sparse at the PIF with only 10 participants. Those in attendance included local residents, landowners and individuals from review agencies. Participants were encouraged to provide written comments on comment sheets provided as they entered. All individuals and/or agency/landowner representatives who signed in with their contact information were added to the contact database.

Table 20. Summary of Comments Received in Response to the Notice of Commencement

Review Agency/ Public Member	Summary of Comments Received	Consideration of Comments Received
MOE	• Provided general comments on Class EA process. • Provided input on elements/issues that should be included in the Class EA. • Requested that they be kept informed throughout the Study.	• Comments noted, will notify for continued involvement.
TRCA	• TRCA indicated its areas of interest in the this project, including Regulated Areas (Regulated limit/wetlands, Conservation land, etc.), Program and Policy Areas (Aquatic Species and Habitat, Aquifers, etc.) and Provincial and Federal Program Areas (ANSI's) • Provided suggestions on the criteria to be used when completing the alternatives evaluation, which were centred around the consideration of TRCA's Valley and Stream Corridor Management Program • Requested that they be kept informed throughout the Study.	• Comments noted, will notify to ensure continued involvement.
GO Transit	• Requested that they be notified for continued involvement in the process	• Comments noted, will notify for continued involvement.
TTC	• Relationship to improvements associated with the Toronto-York Spadina Subway Extension • Provided optimization study timing recommendations • Relationship to other TTC projects within the optimization study area (e.g. Transit City) • Requested that they be kept informed throughout the Study.	• Comments noted, will notify for continued involvement.
ORC	• ORC manages property owned by the Ministry of Energy and Infrastructure (MEI). • ORC believe the proposed study may directly affect ORC-managed property within the study area • Map was provided to show ORC-managed properties • ORC identified potential impacts as a result of the study for consideration including general impacts and impacts to land holdings • If there are impacts to cultural heritage features on ORC managed lands, the ORC Heritage Management Process should be used • ORC mentioned that depending on the solutions implemented, they may trigger the MEI Class EA process for Realty Activities Not Related to Electricity Projects.	• Comments noted, will notify for continued involvement.
407 ETR	• Requested that they would like to be notified for continued involvement in the process.	• Comments noted, will notify for continued involvement.
Local Business #1	• Requested that they would like to be notified for continued involvement in the process.	• Comments noted, will notify for continued involvement.
Local Business #2	• Biggest concern is with the implementation phase of any new SWM systems – should avoid interruptions to the business and its operations. • Requested that they be notified to ensure continued involvement in the process.	• Comments noted, will notify for continued involvement.
Public Member #1	• Simple solution or part of the solution should be use of rain barrels. • Strongly believe in community involvement in the management of stormwater and control of the flow. • Requested that they be notified to ensure continued involvement in the process.	• Comment noted, will notify for continued involvement.
Various Public Members	• Concerned about potential property-taking depending on the alternatives implemented. • Requested that they be notified to ensure continued involvement in the process.	• Comments noted, will notify for continued involvement.

4.1.5 Comments Received During Phase 1 and their Consideration in the Project

Due to the limited number of participants at the PIF, the comments received by the Study Team were minimal. One major concern raised by a member of a review agency was in respect to the area of Black Creek that runs under a bridge and through Black Creek Pioneer Village. The individual feels this is a high risk area in major storms and hopes that the study will be co-ordinated with the City of Toronto to ensure the area under the bridge is improved upon to handle major storm conditions. In addition, comments were furnished by TTC staff, which are summarized in ***Table 21***. A copy of the correspondence received and the associated responses are provided in **Appendix F**.

Table 21. Summary of Comments Received During Phase 1 of the Class EA

Review Agency/ Public Member	Summary of Comments Received	Consideration of Comments Received
TRCA	• Indicated that Black Creek Pioneer Village is a high risk area during major storm events. • TRCA is hopeful that this Study will be co-ordinated with the City of Toronto to ensure the area under the bridge is dealt with and improved to handle major storm conditions.	• Comments noted.
TTC	• Would like supporting flow information as well as culvert dimensions and capacities and any water quality baseline data complied which feed into the Toronto-York Spadina Subway Extension. • Made a number of recommendations with respect to the EA evaluation including: - Recommend including cross-sectional analysis and locations to be completed within various portions of the Study Area; - Event based analysis does not lend to a particularly useful approach to area drainage plan development and erosion analysis; - Request that the Study realistically recognize the existing flooding conditions particularly at the CN crossing of Jane Street, the Jane Street culvert and Jane street north of Highway 7 and elsewhere in the Study Area - The Study should make recommendations for new, enhanced or expanded storm flow facilities upstream and downstream that will accommodate anticipated flows resulting from both OPA 500 and 620.	• The results of hydrologic and hydraulic modelling carried out for the Study have been provided to the City. However, no water quality data was collected in the field, but rather was obtained from background sources (i.e., TRCA, City, MNR). • Recommendations noted and incorporated into EA evaluation where appropriate. - The evaluation of flood improvement alternatives considered a range of alternatives to improve the level of service, and the preferred alternative includes a combination of remedial measures to address the flooding, water quality and erosion issues identified in the Study Area. - Given the level of development within the Study Area, it was determined that continuous hydrologic simulation would not provide a useful basis with respect to addressing streambank erosion, as the increased frequency and magnitude of peak flow cannot be addressed through source or lot level controls, which was confirmed through discussions with the City and TRCA. - The identification and evaluation of improvement alternatives was carried out to address the noted flooding issues within the Study Area, and the preferred alternative aims to reduce the risk of flooding by increasing the capacity of Black Creek to convey the Regional Storm flows between Highways 407 and 7. Further, a recommendation has been included in the Master Plan to replace the existing culverts at the CNR crossing, which would alleviate flooding of the areas immediately upstream, including the portion of Jane Street in the vicinity of the CNR tracks. - The SWM strategies developed for the OPA 500 and 620 areas include both new and expanded SWM facilities. Recommendations regarding design criteria and SWM requirements for these developments are provided in the Master Plan.

4.2 Public and Agency Consultation during Phase 2

4.2.1 Notification of Public Information Forum #2

Notification of the PIF #2 was provided through the following means:

i) By letter mailed directly to a number of review agencies on February 26, 2010. This list also included any individuals who had expressed interest in receiving further information after the Notice of Study Commencement was issued.

ii) By newspaper advertisement in local paper – *The Vaughan Citizen* and the Liberal on February 25, 2010 and March 14, 2010.

Refer to ***Appendix G*** for the above-noted notices and contact information.

4.2.2 Public Information Forum #2

The second PIF was held on March 11, 2010, between 6:00 p.m. and 9:00 p.m. at Black Creek Pioneer Village. The PIF followed an informal "drop-in" format with display boards presenting the project information (refer to ***Appendix G***). The PIF provided an opportunity for attendees to review the information, present their comments and discuss them directly with the City and their consultants. A summary of the PIF material presented is as follows:

- Study Background;
- Study Area Overview (complete with Study Area map);
- Overview of the Master Plan Class EA process being followed;
- Description of the problems and opportunities;
- Identification of the alternative solutions to address the problems and take advantage of opportunities;
- Details regarding the evaluation methodology;
- Selection of the preferred alternative; and,
- Description of the next steps in the EA process.

4.2.3 Comments Received During Phase 2 and their Consideration in the Project

The comments received during Phase 2 of the Study are summarized below, together with the consideration of each in the project. A copy of the correspondence received and the associated responses are provided in **Appendix G**.

Table 22. Summary of Comments Received During Phase 2 of the Class EA

Review Agency/ Public Member	Summary of Comments Received	Consideration of Comments Received
TTC	• Excellent set of alternatives. • Requested electronic copy of PIF #2 display materials.	• A copy of the PIF #2 display materials was provided.
Public Member #11	• Requested information on project.	• A copy of the display materials for PIF #1 and PIF #2 was provided.
Public Member #12	• Expressed concerns related to the ongoing flooding issues that have been identified along Jane Street between Highways 407 and 7, including: - The hydraulic capacity of the existing culverts at Peelar Road and the Vaughan Iceplex entrance, which has been reduced through the accumulation of silt, trash and debris in the Black Creek channel. - A portion of Jane Street in the vicinity of Doughton Road is at a low elevation in relation to the adjacent Black Creek channel and should be raised as part of the flood improvements in the area. • The topographic data used to determine the limits of the Regional storm floodplain along Peelar Road is not an accurate representation of the existing elevations along the roadway; • The bridge structures proposed under the Regional Storm flood improvements alternative at Highway 7, Doughton Road and the Iceplex entrance are excessive – suggested that twin 5 x 5 m concrete box culverts at these locations, as well as Peelar Road, would suffice; and • Requested information with respect to proposed interim channel and culvert improvements to address flooding in the short-term.	• Comments noted and responses provided to clarify the results of the hydraulic analysis and alternatives evaluation. • Recommendations added to Master Plan report.

5. Recommended Stormwater Optimization Master Plan

The recommended Stormwater Optimization Master Plan for the Study Area consists of a combination of improvement measures to address flooding, water quality and erosion issues, along with the proposed SWM requirements and criteria for future development. This section outlines the elements of the Master Plan, provides a list of potential funding mechanisms, summarizes the requirements for future development, and identifies a variety of best management practices for municipal operations & maintenance (O&M).

5.1 Elements of the Master Plan

The elements of the Master Plan include the improvement measures selected as the preferred solution to the problems identified for the Study as well as a list of possible SWM controls for future development. These elements are summarized in ***Table 23***, together with the corresponding EA schedule, if applicable.

Table 23. Elements of the Master Plan and Corresponding EA Schedule

Proposed MP Element	Schedule A/A+	Schedule B	Schedule C
Flood Improvements			
• Replacement of culverts		✓	
• Construction of SWM facilities[1]		✓	
• Channel expansion and construction of bridges at all crossings [2]			✓
Water Quality Improvements			
• SWM pond retrofits (i.e., expansion, inlet/outlet modifications)		✓	
• Construction of SWM facilities[1]		✓	
• SWM pond maintenance (i.e., sediment removal)	✓		
Channel Erosion Improvements			
• Localized channel restoration measures	✓		
• Construction of new SWM facilities[1]		✓	

Note: 1. It should be noted that the construction of SWM facilities by private developers would not require further EA approvals.
2. In accordance with the Class EA requirements, only the bridges are considered Schedule C undertakings.

5.2 Considerations for Future Development in the Study Area

Further to the proposed improvement measures that comprise the preferred solution, an effective framework must be established to ensure that adequate SWM controls are incorporated into future development initiatives. To that end, the SWM criteria prescribed by relevant agencies (i.e., TRCA, MOE) and neighbouring communities are summarized below, together with a variety of SWM practices (SWMPs) to satisfy these criteria.

5.2.1 Stormwater Management Policies

The SWM criteria recommended for small/infill and large new developments are presented in ***Table 24***. These criteria are based on guidance provided in the MOE *Stormwater Management Planning and Design Manual* (March, 2003), the City of Toronto's *Wet Weather Flow Management Guidelines* (November, 2006) and TRCA's requirements for the Humber River watershed and the City's current site level control targets.

Table 24. SWM Policies for Future Development

Criteria Target	Small New/Infill Development (i.e., area < 5 ha)	Large new Development (i.e., area > 5 ha)
Quality Control	Enhanced level of protection (i.e., 80% TSS removal), as per the MOE *Stormwater Planning and Design Manual* (2003).	
Quantity Control	Control post-development flows to pre-development levels for all storms up to and including the 100-year event, as per the Unit Flow Equations prescribed for the Humber River Watershed (Aquafor Beech, 1997).	
Erosion Control	At a minimum, runoff from a 25 mm storm must be detained for at least 24 hours.	Proponents are required to complete an Erosion Analysis in consultation with TRCA to determine site specific erosion criteria. At a minimum, runoff from a 25 mm storm must be detained for at least 48 to 72 hours.
Water Balance	A ***minimum*** of 5 mm of rainfall must be retained on-site through best management practices described in ***Section 5.2.2***.	Retain stormwater on-site to the extent practical to maintain pre-development annual runoff volume. A ***minimum*** of 5 mm of rainfall must be retained on-site through best management practices described in ***Section 5.2.2***. Further, a water balance must be prepared in consultation with TRCA.

5.2.2 Stormwater Management Practices

In accordance with the MOE Stormwater *Management Planning and Design Manual* (2003) and the draft *Low Impact Development Stormwater Management Manual* (Credit Valley Conservation & TRCA, 2009), effective stormwater management strategies follow a treatment train approach that incorporates a combination of lot level, conveyance and end-of-pipe controls. The purpose of this approach is to ensure that:

i) Water quality is protected;

ii) There will not be an increase in flood potential;

iii) The watercourse will not undergo undesirable geomorphic change;

iv) Groundwater and baseflow characteristics are preserved; and

v) An appropriate diversity of aquatic life and opportunities for human uses will be maintained.

In this context, it is recommended that a combination of SWM practices (SWMPs) should be integrated into all future development initiatives, including infill and redevelopment projects. A wide range of lot level, conveyance and end-of-pipe BMPs are identified in ***Table 25***, together with the physical criteria associated with each and an indication of effectiveness for the criteria targets listed above.

Table 25. Stormwater Management Practices for Urban Development

Type of Control	Physical Criteria	Effectiveness			
		Water Quality Control	Water Quantity Control	Erosion Control	Water Balance
Rooftop/parking lot storage	• None	✓	✓		
Rainwater harvesting	• None	✓	✓	✓	✓
Reduced lot grading	• Topography < 5% • Min. infiltration rate ≥ 15 mm/hr	✓	✓	✓	✓
Green roofs	• Roof slope ≤ 10% • Additional structural requirements	✓	✓	✓	✓
Permeable pavement	• Topography < 5% • Min. infiltration rate ≥ 15 mm/hr • Groundwater > 1 m below bottom	✓		✓	✓
Bioretention areas	• Area ≤ 0.8 ha • Topography < 5% • Groundwater > 1 m below bottom	✓		✓	✓
Soakaway pits	• Area < 0.5 ha • Min. infiltration rate ≥ 15 mm/hr • Bedrock > 1 m below bottom • Groundwater > 1 m below bottom	✓	✓	✓	✓
Infiltration basins, chamber & trenches	• Min. infiltration rate ≥ 60 mm/hr • Bedrock > 1 m below bottom • Groundwater > 1 m below bottom	✓	✓	✓	✓
Oil-grit separators	• None	✓			
Pervious pipe & catchbasin systems	• Min. infiltration rate ≥ 15 mm/hr • Bedrock > 1 m below bottom • Groundwater > 1 m below bottom	✓	✓	✓	✓
Grassed swales	• Area < 2 ha • Topography < 5%	✓		✓	✓
Dry pond	• Area > 5 ha		✓	✓	
Wet pond/Wetland	• Area > 5 ha	✓	✓	✓	

Note: Information obtained from the Stormwater Management Planning and Design Manual (MOEE, 1994) and the Low Impact Development Manual (CVC & TRCA, 2010)

5.3 Municipal Operations and Maintenance Best Management Practices

In addition to the proposed works included in the preferred water quality improvements alternative (i.e., SWM quality ponds), there are a variety of municipal operations & maintenance (O&M) BMPs that can be implemented or enhanced to further improve the water quality of Black Creek.

i) Street and Parking Lot Cleaning

Increased cleaning of streets and municipal parking lots will reduce the amount of sediment, road salt, and heavy metals contained within the runoff contributing to Black Creek and its tributaries. High traffic routes and areas of increased pollutant loading should be targeted, and additional cleaning efforts should be carried out following the winter season to remove accumulated sand and salt from the roadways.

ii) Winter De-Icing Operations

Continued efforts should be undertaken to improve winter de-icing operations on streets and municipal parking lots and service yards. As indicated in the City's *Salt Management Plan* (2007), this includes regular training of Public Works Road Division staff, careful calibration of salt spreader equipment, the use of alternative de-icing materials (e.g., ClearLane and other modified salt products and additives), and the review and implementation of new technologies to improve road safety while protecting the environment.

iii) Storm Sewer System Inspection & Cleaning

Regular inspection and cleaning of catchbasins and manholes, as well as flushing of sewers, is an effective practice for removing accumulated materials (e.g., sediment, debris). In addition to reducing the sediment and other contaminants transported to receiving watercourses, these cleaning measures also maintain flow capacity within the storm sewer system. Cleaning activities should focus on areas with the greatest pollutant loading and near watercourses.

iv) SWM Pond Inspection & Maintenance

The MOE *Stormwater Management Design & Planning Manual* (2003) recommends that SWM ponds should be inspected after every significant storm event for the first two years of operation (average of four inspections per year), followed by annual inspections. This practice should be applied to all new SWM ponds constructed and retrofitted facilities located within City and TRCA lands. In addition, all new SWM ponds should be added to the City's SWM pond database, which was developed by Clarifica Inc. as part of the *Storm Water Management Facility Inventory and Maintenance Study* (2004). The purpose of the database is to document and track the condition of municipal SWM ponds and identify necessary maintenance requirements.

v) Culvert and Watercourse Inspection & Maintenance

Inspection and maintenance of culverts and watercourses within the Study Area should be carried out by City and/or TRCA staff on an annual basis. The condition of hydraulic structures and channel form and function should be documented, followed by the remediation of deficiencies (e.g., clogged/damaged inlets, structural concerns, etc.) and/or issues related to erosion, sediment build-up and illegal dumping.

vi) Illegal Dumping Control

As noted, a significant volume of sediment, and illegally dumped trash, and construction materials have accumulated in segments of Black Creek. It is recommended that enforcement efforts and penalties for existing by-laws are increased to deter illegal dumping in the future. If monitoring activities reveal refuse in Black Creek and its tributaries, actions should be taken to remove these materials in a timely fashion to maintain the hydraulic capacity of these watercourses.

6. Implementation Considerations

As noted in ***Section 1.3.2***, the purpose of the Master Plan process is to identify a group of related undertakings that can be considered collectively to facilitate long-range planning of a series of municipal projects. To that end, the ***Black Creek Stormwater Optimization Study*** has established a comprehensive strategy to address the flooding, water quality and erosion issues identified within the Study Area. However, given the diversity of undertakings proposed as part of the recommended Master Plan, a number of factors must be considered to ensure that these projects are implemented in a coordinated and effective manner, and all additional regulatory requirements are satisfied.

Further details regarding the timeframe for the implementation of the proposed works, coordination with current development initiatives within the Study Area, and regulatory approval requirements are summarized below. In addition, a description of potential funding mechanisms to offset the capital and operational and maintenance costs associated with proposed works that comprise the preferred alternative is provided.

6.1 Timeframe for Implementation

Given the wide range of capital projects that comprise the preferred solution, the implementation of the various elements of the Master Plan will require significant financial resources, additional regulatory approvals and coordination with a number of current development initiatives. Information regarding the anticipated timeframe for the implementation of the proposed flooding, water quality, and erosion improvements is provided below.

i) Proposed Flood Improvements

The preferred alternative to address ongoing flooding issues along Jane Street between the 407ETR and Highway 7 involves the construction of an expanded, naturalized channel with bridge structures at future creek crossing locations (refer to ***Figure 13***). As indicated in **Section 3.4.2**, the proposed works associated with this alternative will require the use of private lands, significant capital expenditures and additional regulatory approvals. Further, given the location of the proposed channel corridor within the planned Vaughan Metropolitan Centre (i.e., OPA 500) area, coordination with the planning and design of the proposed SWM infrastructure that will service this area will be required.

ii) Proposed Water Quality Improvements

The preferred alternative to provide additional water quality enhancement within portions of the Study Area involves the construction of four new SWM ponds and the retrofit of five existing facilities. However, all of the proposed new SWM ponds are to be constructed to facilitate various development initiatives within the Study Area, including the Vaughan Metropolitan Centre, OPA 620, the Highway 407 Subway station, and the Rutherford Business Park. Further, many of the existing SWM ponds that have been identified for retrofit are also related to these proposed developments. Accordingly, the timing associated with the construction and retrofit of these facilities will depend on the completion of the development within these areas.

However, the existing dry SWM pond located west of Highway 400 between Chrislea Road and Jevlan Drive is situated within an existing development and, therefore, retrofitting this facility to provide a permanent water quality volume through expansion and modifications to the outlet structure can be carried out immediately.

iii) Proposed Erosion Improvements

As noted on ***Figure 12***, the proposed erosion improvements consist of a combination of in-stream restoration works within the segment of Black Creek from Steeles Avenue to upstream of Peelar Road, as well as the East and West Tributaries. The recommended restoration works have been prioritized with respect to urgency (i.e., high, medium, low), and

the lead organization responsible for the coordination of the proposed improvements.

In terms of the timeframe to implement the proposed restoration works, it is recommended that those identified as 'High' priority should be carried out at the earliest convenience for the City to prevent further worsening of the observed erosion conditions. Of particular urgency is the existing gabion retaining wall located along the east bank of Black Creek upstream of Peelar Road. As noted in ***Section 3.2.7.2*** and further described in the memorandum included in **Appendix I**, the base of the retaining wall has been undermined through bed scour at its foundation, which has resulted in severe deformation of the structure (refer to photograph below).

It should be noted that many of the proposed restoration works will require coordination with affected land owners and TRCA, and should be carried out in consultation with members of the *Black Creek Conservation Project*.

Existing Gabion Retaining Wall Upstream of Peelar Road

Further to the above, it is expected that the erosion issues observed at locations ES10, ES11 and ES12 will be addressed through the modifications to the Black Creek channel alignment and geometry that are proposed to facilitate the construction of the Highway 407 station for the *Toronto-York Spadina Subway Extension* project.

6.2 Co-ordination with Current Projects in Study Area

As noted in ***Section 3.2.3.3***, there are a number of significant development initiatives planned within the Study Area, which will have broad and considerable implications with respect to stormwater management, including the VMC, OPA 620, and the *Toronto-York Spadina Subway Extension* project. It is recommended that efforts are made to ensure that the SWM strategies developed to service the proposed development areas are carefully integrated with the various elements of the Master Plan.

6.3 Regulatory Approvals

At a minimum, the following regulatory approvals will be required prior to the implementation of many of the proposed works that comprise the preferred alternative:

i) Additional Municipal Class EA requirements, including the completion of Phases 3 and 4 for the proposed bridge structures and Black Creek Channel involved with the preferred flood improvements alternative;

ii) A *Canadian Environmental Assessment Act* (CEAA) Screening for the proposed channel works associated with the preferred flood improvements alternative, which is expected to be triggered under the *Federal Fisheries Act*; and

iii) A permit from TRCA under O.Reg. 166/06 for the *Development, Interference with Wetlands and Alterations to Shorelines and Watercourses* for:

- the proposed channel works and new bridge crossings between 407ETR and Highway 7 that form the preferred flood improvement alternative;
- retrofitting the Edgeley Pond to provide a permanent water quality volume, as it is an on-line facility located within the Regulatory Floodplain; and
- many of the recommended in-stream restoration measures proposed to address erosion along the natural portion of Black Creek between Steeles Avenue and the 407ETR.

6.4 Potential Funding Mechanisms

In order to implement the elements of the recommended Stormwater Optimization Master Plan, significant funding will be required for capital expenditures as well as ongoing operations and maintenance costs. Based on discussions with City staff, such funds will not be available within the City's existing or forecasted budget. Accordingly, the City must identify other sources of funding, which could include the following:

i) Development Charges

This type of funding is intended to recover a portion of the growth-related costs associated with the capital infrastructure needed to service new developments, and is the most likely method of securing funding for most of these works. It is expected that this type of funding would only apply to new development and re-development initiatives and cannot be collected to fund retrofit projects. It is envisioned that the City could introduce an additional Special Area Development Charge, as is currently applied in other parts of the City (e.g., Rainbow Creek Drainage Works).

ii) Stormwater Management Levy or Utility

A specific levy or utility could be established to fund proposed SWM infrastructure within the Study Area. These funds could be collected in the form of a levy added to municipal property taxes, based on the contributing imperviousness and land use of individual properties, or could consist of a separate utility applied to property taxes.

In addition to contributing to the capital costs associated with the implementation of the proposed works that comprise the preferred solution, this type of funding could also benefit long O&M costs. It is recommended that this strategy should be implemented though a City-wide initiative, but could be introduced as a pilot project within the Study Area.

iii) Provincial or Federal Infrastructure Funding

The provincial and federal governments currently provide infrastructure funding that could be applicable to the elements of the Master Plan. The Canadian Strategic Infrastructure Program provides funding for projects for urban development initiatives, and the Ontario Strategic Infrastructure Financing Authority provides loans to municipalities to fund infrastructure projects.

iv) In Lieu Payments

Given that the majority of the Study Area has been developed and there is a limited opportunity to collect sufficient funds through development charges, additional funds could be obtained from the owners of developed lands that do not currently provide adequate on-site SWM controls. These funds would offset the costs associated with the proposed improvements necessary to address the ongoing flooding, water quality and erosion issues in the Study Area. However, it is anticipated that this type of funding would difficult to secure.

7. Summary of Conclusions and Recommendations

Following the completion of Phases 1 and 2 of the Municipal Class EA process, a summary of the key conclusions and recommendations is provided below.

i) The portion of the Black Creek subwatershed within the City of Vaughan is almost completely urbanized with a high level of imperviousness, resulting in extremely 'flashy' hydrologic conditions.

ii) A significant number of buildings and municipal infrastructure is located within the regulatory floodplain, including portions of Jane Street, and Highways 400 and 7.

iii) Development through much of the Black Creek subwatershed within the City of Vaughan occurred prior to the adoption of current SWM practices, and the limited incorporation of effective SWM measures (i.e., lot level, conveyance, and end-of-pipe controls) has contributed to:

- Significant flooding of the tableland areas adjacent to Black Creek between the 407ETR and Highway 7, which was particularly evident during the August 19th, 2005 storm event, as well as minor flooding within other portions of the Study Area;
- Degraded water quality has been observed at multiple locations along Black Creek, which exhibits high levels of suspended solids, *E. coli*, metals, chlorides, and phosphorus; and
- Substantial erosion of the bed and banks of the natural segments of the Black Creek channel and its tributaries.

iv) Following the identification and evaluation of a range of alternatives, including the completion of a "net effects analysis", the preferred alternative to address the above-noted issues was established, which are summarized below.

- **Flooding – Regional Storm Improvements:** The objective of this alternative is to provide sufficient capacity within Black Creek – a Regional Channel to convey the runoff generated by the Regional Storm (i.e., Hurricane Hazel) without flooding adjacent buildings, and minimal flooding of roads or municipal infrastructure. The proposed works involve the construction of a new naturalized channel to replace the existing segment of Black Creek between the Edgeley Pond and the 407 ETR, and new bridges at all road crossings.
- **Water Quality – SWM Quality Ponds:** In order to improve the quality of runoff contributing to Black Creek, it is proposed that many of the existing SWM ponds should be retrofitted to provide water quality enhancement and at least two new SWM ponds should be constructed. Many of these projects have been recommended through previous studies or identified as a requirement for proposed development initiatives.
- **Erosion – In-Stream Restoration Strategies:** These works involve a combination of in-stream restoration measures to address localized erosion or bank instability issues. In addition, it should be noted that further erosion control will be provided through the construction of new SWM ponds and the SWM pond retrofits that have been identified in previous studies carried out by the City and TRCA, together with proposed development initiatives (i.e., VMC, OPA 620, TYSSE Highway 407 Station, etc.).

v) As part of the Phase 3 component of the Master Plan a benefit-cost assessment should be conducted regarding the installation of a larger replacement structure for the 3.2 x 2.1 m CSP arch culverts at the entrances to the Paradise Banquet and Convention Centre and the Vaughan Iceplex as an interim measure to address ongoing flooding issues. The replacement of these structures will improve hydraulic conditions by conveying higher flows, and reducing the risk of flooding of buildings and municipal infrastructure considerably.

vi) Coordination with current development initiatives within the Study Area (i.e., VCC, OPA 620, *Toronto-York Spadina Subway Extension* project, etc.) is imperative to ensure that the recommendations of the ***Black Creek Stormwater Optimization Study*** are incorporated into the planning and design of proposed SWM strategies and facilities.

vii) The City should take **immediate** actions to address the structural deficiencies identified at the gabion retaining wall along the east bank of Black Creek upstream of Peelar Road – including the replacement of the deformed portion with a new gabion wall or similar retaining structure, removal of debris and trash along the top of the wall and within the creek, and filling of the holes between the top of the wall and the adjacent embankment (refer to **Appendix H** for further details).

viii) The silt, debris, trash and construction materials that have accumulated or has been illegally dumped within Black Creek between Peelar Road and the Vaughan Iceplex entrance should be removed to improve the hydraulic conditions at this location as well as the water quality in Black Creek (refer to photograph below).

ix) The collapsed culvert located at the abandoned crossing upstream of Peelar Road should be removed, followed by minor channel works to provide a uniform cross-sectional geometry with the upstream and downstream segments of Black Creek.

x) Consideration should be given to raising Jane Street near the intersection of Doughton Road to remove the existing sag, which will result in a reduced risk of flooding of the roadway during storm events.

xi) The existing culverts at the CNR (York Subdivision) should be replaced with larger structures to improve the hydraulic conditions and reduce flooding of the area immediately upstream, including the segment of Jane Street in the vicinity of the CNR tracks.

Evidence of Accumulated Debris and Illegally Dumped Trash Upstream of Peelar Road

8. Next Steps

As indicated in ***Section 1.3.2***, the Master Planning process for the ***Black Creek Stormwater Optimization Study*** was carried out in accordance with Approach #3, as outlined in Appendix 4 of the MEA document (October 2000, as amended in 2007). Under this approach, Phases 1 to 3 of the Class EA process must be completed, followed by the preparation of a Master Plan document (i.e., Phase 4). At a minimum, this approach must include the identification of the problem/opportunity as well as the identification and evaluation of a reasonable range of alternative solutions to the problem/opportunity, and the selection of the preferred solution, followed by the identification and evaluation of alternative design concepts (where appropriate) and the selection of preferred design concepts.

This report documents all of the tasks associated with Phases 1 and 2 of the Class EA process, which provides the level of investigation, consultation and documentation sufficient to fulfill the requirements prescribed for Schedule A and B projects. However, the preferred solution that has been selected to address flooding within the Study Area involves the construction of three bridges, which are considered to be Schedule C undertakings, as the estimated cost for each of the structures exceeds $2.7 million.

In order to satisfy the requirements for the Schedule C undertakings associated with the recommended Master Plan, Phases 3 and 4 of the Class EA process must be carried out prior to the implementation of the proposed works. Further, the preferred solution will also require approval under the *Canadian Environmental Assessment Act* (CEAA), as the proposed channel works along the segment of Black Creek between Highways 407 and 7 will require authorization from the Department of Fisheries and Oceans (DFO) under the *Federal Fisheries Act*. The outstanding requirements of the Class EA process and CEAA screening are summarized below.

8.1 Additional Class EA Process Requirements

A description of the remaining tasks to be carried out to complete Phases 3 and 4 of the Class EA process for the Schedule C undertakings is provided below. It should be noted that the proposed bridge at Highway 7 is a Regional Road and, accordingly, the proponent for this undertaking would be the Region of York and would be carried out as a separate EA.

i) Phase 3 – Identify & Evaluate the Design Alternatives for Implementing the Preferred Solution

In order to establish the Preferred Design Concept for each of the bridge structures, a reasonable range of alternative design concepts will be generated, which will be developed through balancing the potential environmental effects and cost implications with potential impacts to the natural environment and engineering feasibility.

The "net effects analysis" approach used to evaluate the alternative solutions in Phase 2 of the Class EA will be employed for the alternative design concepts. The evaluation criteria will be reviewed and modified appropriately to reflect the advantages and disadvantages associated with each of the alternative design concepts. Following the completion of the comparative evaluation process, a Recommended Design Concept will be identified by the Study Team, which will be presented to the City, TRCA and other key stakeholders.

A Public Information Forum (PIF) will be held to solicit comments on the evaluation of the alternative design concepts, the Recommended Design Concept, the potential effects, and the recommended mitigation measures. It is expected that a similar open house and presentation format to that employed in Phases 1 and 2 will be followed. Notification of the PIF will be provided to all key stakeholders and interested parties through direct mailings, as well as through a newspaper advertisement in *The Vaughan Citizen* and *The Liberal*. All attendees at the PIF will be recorded and added to the contact database, and all comments received will be documented and responded to.

ii) Phase 4 – Prepare Master Plan Report

Subsequent to the completion of Phase 3, the Study Team will prepare and submit a draft copy of the final Master Plan Environmental Study Report (ESR) for review and comment. In order to re-visit all of the proposed elements of the Master Plan, it is proposed that an additional PIF should be held to present the final Plan. The Master Plan ESR will fully document the Class EA process undertaken (Phases 1-3) in a concise, traceable manner that is easily understood by key stakeholders and members of the public, and clearly shows how the decision-making process was undertaken, including the incorporation of comments from stakeholders and agencies.

Following the incorporation of comments received during Phase 4, the Master Plan ESR will be finalized and placed on public review at appropriate community locations for a minimum of 30 days. A Notice of Completion will be prepared and circulated to stakeholders, agencies and members of the public included on the contact database, and a newspaper advertisement will be published in *The Vaughan Citizen* and *The Liberal*.

8.2 CEAA Screening

The tasks associated with the CEAA Screening are outlined below.

i) Confirm the Scope of the Environmental Assessment

After completion of the Project Description, we will confirm the scope of the project with the Responsible Agency (RA), which is expected to be DFO. The scope of the EA under the CEAA process will include all the factors identified in Section 16(1) of the CEA Act, including:

i) the environmental effects of the project, including the environmental effects of malfunctions or accidents that may occur in connection with the project and any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out;

ii) the significance of the effects referred to in paragraph (a);

iii) comments from the public that are received in accordance with this Act and the regulations;

iv) measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project; and

v) any other matter relevant to the screening, comprehensive study, mediation or assessment by a review panel, such as the need for the project and alternatives to the project, that the responsible authority or, except in the case of a screening, the Minister after consulting with the responsible authority, may require to be considered.

ii) CEAA Screening

Following confirmation of the scope of the federal EA, a CEAA screening will be carried out that will address all the factors identified above. Special attention will be paid to the assessment of the significance of each residual environmental effect (including cumulative effects). For clarity and simplicity, it is recommended that each environmental effect should be classified as: a negligible effect; a mitigable adverse effect, a significant adverse effect, or a beneficial effect. The Screening study involves:

- Identifying potential environmental effects;
- Applying mitigation measures;
- Evaluating residual effects;
- Undertaking a cumulative effects assessment; and,
- Identifying monitoring and follow up measures.

iii) Prepare CEAA Screening Report

Subsequent to the completion of the CEAA process, a draft Screening Report will be prepared for City and TRCA review and comment. Upon receipt of comments, the document will be finalized and circulated to the RA and any expert Federal Authorities (FAs). Provided that the RA and/or expert FAs are satisfied with the Screening document, the RA would post a Notice of Completion on the CEAA registry for public notification/review.

9. References

Further to the secondary source background information listed in ***Section 3.2.1***, the following documents were utilized in the preparation of the ***Black Creek Stormwater Optimization Study Master Plan*** report.

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Existing Conditions Report – Highway 407 Subway Station Toronto-York Spadina Subway Extension, September, 2009.

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