City of Ottawa

Greater Cardinal Creek Subwatershed Management Plan

Prepared by:

AECOM
105 Commerce Valley Drive West, Floor 7
Markham, ON, Canada L3T 7W3
www.aecom.com

905 886 7022 tel
905 886 9494 fax

Project Number:

60189560

Date:

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Signatures

Report Prepared By:

Joseph Puopolo, P.Eng., PMP
Senior Environmental Engineer
AECOM

Report Prepared By:

Nick Stow
Senior Planner, Natural Systems
City of Ottawa

Report Updated and Review By:

Christopher Moon, P.Eng
Project Manager, Water
AECOM

Executive Summary

The Greater Cardinal Creek Subwatershed Study was initiated to address three land use planning and environmental issues including the following:

- Environmental impacts of urban and rural development pressures within the study area;
- Documented water quality problems within Cardinal Creek; and
- Documented erosion and slope stability concerns along Cardinal Creek.

The study was planned and conducted in accordance with Official Plan Policy 2.4.3 – Watershed and Subwatershed Plans which identifies and protects the natural heritage system, recommends areas for development and preservation, provides guidelines for development and includes monitoring of all aspects of the plan.

The Subwatershed Study was also conducted as a Master Plan Municipal Class Environmental Assessment (Class B), with respect to the erosion and slope stability concerns along Cardinal Creek and documents the extent and nature of the concerns, evaluates the alternatives for addressing the problems, and identifies the preferred solution. Upon approval of the Subwatershed Study by Council, the City will post the Subwatershed Study for a mandatory 30 day review period under the *Environmental Assessment Act*, and then issue a Notice of Completion.

The Greater Cardinal Creek Subwatershed Study occurred in three phases including preparation of the terrestrial inventory and geomorphic assessment (2006-2007), preparation of the existing conditions report (2008-2009) and the preparation of the subwatershed management plan, which is the focus of this study and report herein.

A portion of the study area came under consideration for urban expansion (Urban Expansion Study Area 11) during the 2009 Comprehensive Official Plan Review (OPA 76) and subsequent appeals. After confirmation of Area 11 as an urban expansion area, the scope of the subwatershed study increased to include the development of stormwater management and other environmental guidelines for development of Area 11 (the Cardinal Creek Village development area).

This Subwatershed Management Plan includes identification, policies for protection and potential habitat restoration opportunities for the natural heritage system. This plan places an emphasis on Low Impact Development (LID) techniques in stormwater management and verification of flow targets for future development within the watershed. The protection of surface water and ground water features are reviewed and an inventory of agricultural land uses and Best Management Practices is included.

The Greater Cardinal Creek Subwatershed Study satisfies the technical requirements of the Master Plan Municipal Class Environmental Assessment (EA) with respect to the erosion and slope stability concerns along Cardinal Creek. The project was completed as a Class B Environmental Assessment, which addresses Phase 1 and Phase 2 of the process: i.e. identification of the problem, identification and evaluation of alternatives, and identification of a preferred alternative.

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1. Introduction

This report presents the subwatershed management plan (the Plan) that was prepared for the Greater Cardinal Creek Subwatershed (the Subwatershed),which includes both the Cardinal Creek basin proper, and an unnamed Tributary that drains through the former Village of Cumberland and outlets directly into the Ottawa River.

The formulation of the Plan was undertaken in two phases: the first phase entailed the preparation of the *Greater Cardinal Creek Study - Existing Conditions Report (AECOM, 2009)* which entails a comprehensive documentation of the interrelationships among the biotic and physical environment system, including the identification of groundwater resources, woodlands, streams, and other valued ecosystem features and functions. *The Existing Conditions Report* was completed and submitted to the City in 2009. This report represents the second phase of the process and presents the management strategies and programs that are recommended for implementation to ensure the long term sustainability of the Subwatershed.

The Cardinal Creek Subwatershed (RV34) forms part of the Ottawa River watershed, encompasses over 3,100 hectares (ha) of land, and includes several municipal drains as well as small, unnamed tributaries. Land use within the Subwatershed is predominately agricultural with areas of existing and approved urban development in Orléans and rural estate development in the Village of Cumberland.

This catchment area associated with the Unnamed Tributary (RV35) is approximately 550 ha in size and is also illustrated on ***Figure 1.1.*** Land use within this area is associated with village development in Cumberland, including residential, agricultural and commercial recreational uses.

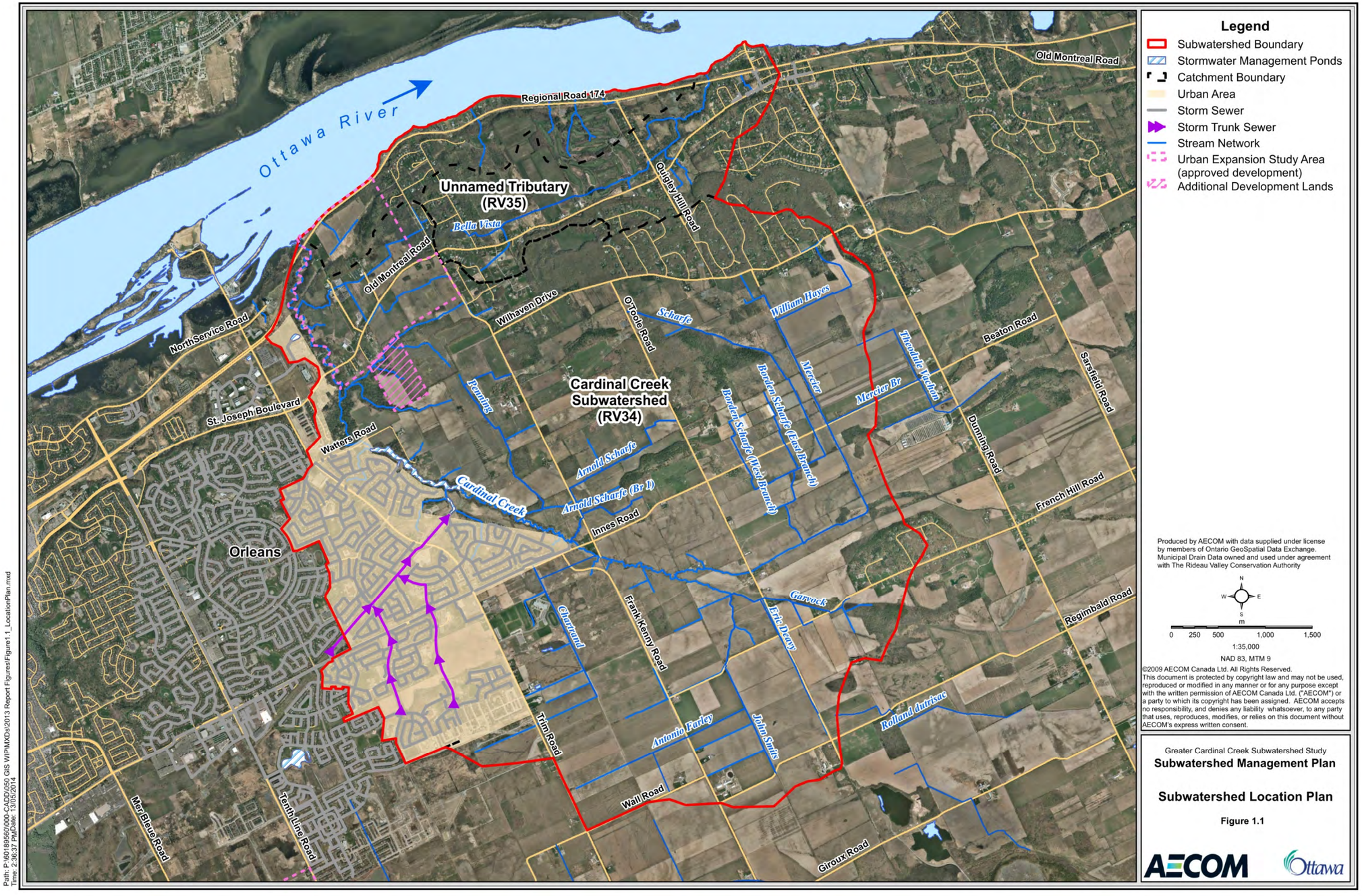
As noted in the Existing Conditions Report, at the inception of the study, Cardinal Creek formed the eastern limit of the urban boundary with the City of Ottawa. The focus of the Plan was to examine existing land use conditions and develop a framework for ameliorating and improving degraded areas, conserving and enhancing natural systems and promoting stewardship initiatives.

During the final stages of the preparation of the Existing Conditions Report, as part of the 2009 Official Plan review, City council considered a number of areas for inclusion within an expanded urban boundary, but ultimately did not include any lands within the study area. However, that decision was successfully appealed to the Ontario Municipal Board. The final OMB order was issued on June 12, 2012, and indicated that the urban boundary expansion should include and area on the east side of Cardinal Creek, roughly west of Frank Kenny Road and north of Wilhaven Drive (Urban Expansion Study Area 11).

During the appeal of the 2009 Official Plan urban boundary, work on the Greater Cardinal Creek Subwatershed Study was largely suspended, because of the potential conflicts with the appeal process and possible outcomes.

Following approval of the urban boundary expansion, the scope of the subwatershed study was expanded to incorporate the proposed land use change into the subwatershed management plan, including additional analyses to establish targets for the water quality and quantity control, downstream flood and erosion protection, maintenance of baseflow, and identification of additional site level studies and analyses that would be required to support development. Approval of the Cardinal Village development has preceded completion of the subwatershed study; however, close coordination and consultation with the Development Review Branch has ensured that the development is consistent with the recommendations of the subwatershed management plan.

This document is organized onto three main sections (in addition to this introduction), which move from an update to the existing conditions to the specific plans that have been developed to address specific components of the Subwatershed


Ottawa River
Unnamed Tributary (RV35)
Cardinal Creek Subwatershed (RV34)
Orleans
Regional Road 174
Old Montreal Road
Quigley Hill Road
Bella Vista
Willhaven Drive
North Service Road
St. Joseph Boulevard
Watters Road
O'Toole Road
Scharfe
William Hayes
Beaton Road
Sarsfield Road
Theodule Vachon
Mercier
Mercier Br
Borden Scharfe (West Branch)
Borden Scharfe (East Branch)
Dunning Road
French Hill Road
Fleming
Arnold Scharfe
Arnold Scharfe (Br 1)
Cardinal Creek
Innes Road
Garvock
Eric Deavy
Regimbald Road
Chartrand
Frank Kenny Road
Trim Road
Antonio Farley
John Smits
Rolland durisac
Wall Road
Giroux Road
Mer Bleue Road
Tenth Line Road
Legend
Subwatershed Boundary
Stormwater Management Ponds
Catchment Boundary
Urban Area
Storm Sewer
Storm Trunk Sewer
Stream Network
Urban Expansion Study Area (approved development)
Additional Development Lands
Produced by AECOM with data supplied under license by members of Ontario GeoSpatial Data Exchange. Municipal Drain Data owned and used under agreement with The Rideau Valley Conservation Authority
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Greater Cardinal Creek Subwatershed Study
Subwatershed Management Plan
Subwatershed Location Plan
Figure 1.1
AECOM
Ottawa
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2. Subwatershed Existing Conditions Report – Refinements and Updates

2.1 General

Based on the findings and conclusions from the Existing Conditions Report (August 2009), a number of key issues must be considered further for the development of the Subwatershed Plan, which involves the determination of several individual, but interrelated management strategies, each comprised of a series of management measures/actions. Section 2 of this report addresses these issues including:

- Hazard Land Management with respect to updated hydrologic analysis, regulatory mapping and slope stability assessment;
- The natural heritage system features and boundaries;
- Groundwater sensitive features and areas requiring protection,
- Classification of watercourses for the purpose of establishing setbacks under the policies of the Official Plan, and;
- Agricultural and rural areas for targeted promotion and facilitation of best management practices and stewardship activities.

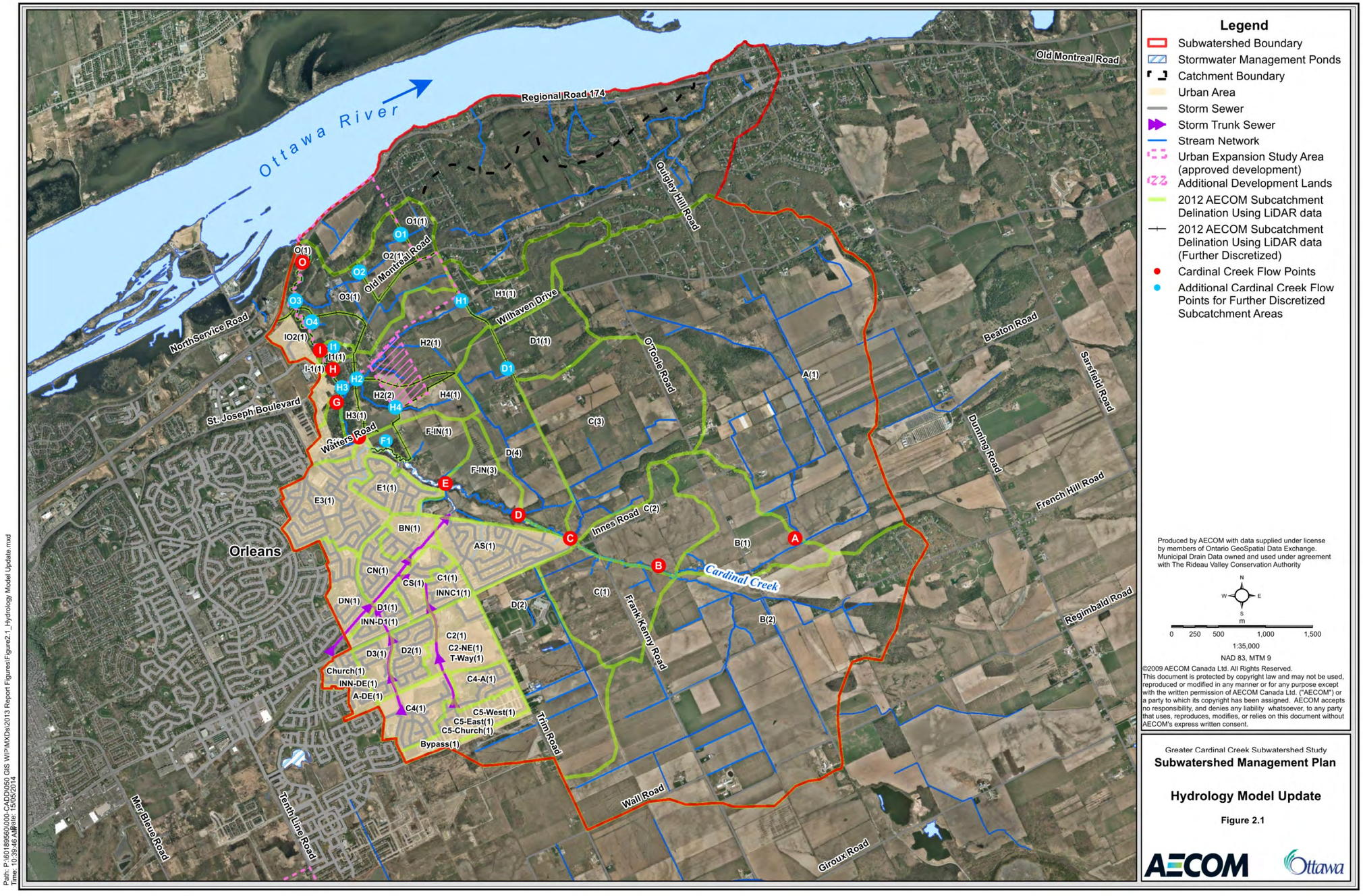
2.2 Hazard Land Management

2.2.1 Hydrologic Analysis

An XPSWMM model was previously prepared for the *City of Ottawa Greater Cardinal Creek Subwatershed Study XPSWMM Model Calibration and Verification Report* (AECOM, 2009) and used the XPSWMM model taken from the Master Drainage Plan Update Report, prepared by Cumming Cockburn Limited (CCL) in August of 2000. This XPSWMM model was calibrated by AECOM in 2009 by adjusting hydrologic parameters to more accurately represent the study area. The calibrated model was then verified using available precipitation and flow data for gauges within Cardinal Creek. The XPSWMM model has been further updated by AECOM in November 2012, refer to **Appendix A.** The following tasks were undertaken in the AECOM 2012 update:

- Revisions to subcatchment areas resulting from updated topographic information (LiDAR City of Ottawa 2011);
- Time of concentration calculations were reviewed and updated;
- Assessment of longer duration design storms was included;
- Field reconnaissance completed to verify on-site controls within urban areas;
- Review of drainage plans completed within urban areas to confirm drainage boundaries;
- Modifications to the Cardinal Creek online stormwater facility's(CCOM's) stage-discharge relationship for the overflow structure based on additional survey data;
- Further discretization of Catchment Area 11 to represent Cardinal Village; and
- Inclusion of a proposed conditions scenario for the development of Catchment Area 11 (Cardinal Village).

Under existing conditions the updated hydrology resulted in some minor increases in peak flows under the same duration design storm events. Further increases in peak flows are noted when comparing the previously applied 3-hour design storms with the updated design storms (24-hour Chicago distribution (Kiefer and Chu) and the 24-hour SCS Type II distribution). Resulting peak flows from the 24-hour Chicago distribution were similar to those calculated using the 24-hour SCS Type II distribution. Significant increase in peak flow estimates using the 24-hour storm distributions resulted in flows that exceed the previously determined 100-year snow and rainfall event.



Legend

- Subwatershed Boundary
- Stormwater Management Ponds
- Catchment Boundary
- Urban Area
- Storm Sewer
- Storm Trunk Sewer
- Stream Network
- Urban Expansion Study Area (approved development)
- Additional Development Lands
- 2012 AECOM Subcatchment Delination Using LiDAR data
- 2012 AECOM Subcatchment Delination Using LiDAR data (Further Discretized)
- Cardinal Creek Flow Points
- Additional Cardinal Creek Flow Points for Further Discretized Subcatchment Areas

Produced by AECOM with data supplied under license by members of Ontario GeoSpatial Data Exchange. Municipal Drain Data owned and used under agreement with The Rideau Valley Conservation Authority

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Greater Cardinal Creek Subwatershed Study

Subwatershed Management Plan

Hydrology Model Update

Figure 2.1

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Peak flow results for flow points along Cardinal Creek as show in **Figure 2.1**, were compared for the updated model including the hydrological and hydraulic refinements described above and are illustrated in **Tables 2.1, 2.2** and **2.3**.

Table 2.1. Comparison of Peak Flow Results for Cardinal Creek Flow Points for 3-Hour Chicago Distribution of 2, 5 and 100-year Design Storm Events for Existing and Updated XPSWMM Models

Flow Point at Cardinal Creek	Chicago Distribution, 3-Hour					
	2-Year Design Storm Event (m^3/s)		5-Year Design Storm Event (m^3/s)		100-Year Design Storm Event (m^3/s)	
	Existing XPSWMM Model	*Updated XPSWMM Model*	*Existing XPSWMM Model*	*Updated XPSWMM Model*	*Existing XPSWMM Model*	*Updated XPSWMM Model*
"A"	0.2	0.3	0.4	0.7	0.7	1.1
"B"	0.7	0.9	1.3	1.7	2.1	2.9
"C"	1.3	1.9	2.5	3.7	4.5	6.6
"D"	2.5	3.6	4.8	6.6	8.0	10.5
"F" *(D/S of Watters Rd.)*	4.6	6.3	8.4	10.3	12.1	14.7
"G"	4.7	6.4	8.6	10.4	12.3	14.8
"H"	5.3	7.4	9.8	12.2	14.3	17.8
"O"	7.6	7.9	10.3	13.0	15.0	20.0

Table 2.2. Comparison of Peak Flow Results for Cardinal Creek Flow Points for July 1, 1979 Observed Storm Event and Snow 100-Year Event Distribution for Existing and Updated XPSWMM Models

Flow Points at Cardinal Creek	July 1, 1979 Observed Storm Event (m^3/s)		Snow 100-Year Event Distribution (m^3/s)	
	Existing XPSWMM Model	Updated XPSWMM Model	Existing XPSWMM Model	Updated XPSWMM Model
"A"	1.3	2.2	2.4	4.0
"B"	3.9	5.3	5.5	7.6
"C"	8.4	12.1	10.8	14.2
"D"	13.3	17.7	13.1	17.2
"F" *(D/S of Watters Rd.)*	17.0	21.8	14.4	19.1
"G"	17.8	22.0	14.4	19.1
"H"	21.5	27.9	18.7	22.1
"O"	22.9	31.7	20.5	24.6

Table 2.3. Comparison of Peak Flow Results for Cardinal Creek Flow Points for 24-Hour Chicago and SCS Type II Distributions of 2, 5 and 100-year Design Storm Events for Existing and Updated XPSWMM Models

Flow Point at Cardinal Creek		2-Year Design Storm Event (m^3/s)		5-Year Design Storm Event (m^3/s)		100-Year Design Storm Event (m^3/s)	
		Existing XPSWMM Model	*Updated XPSWMM Model*	*Existing XPSWMM Model*	*Updated XPSWMM Model*	*Existing XPSWMM Model*	*Updated XPSWMM Model*
Chicago Distribution, 24-Hour	**"A"**	0.4	0.6	0.6	1.0	1.6	2.6
	"B"	1.0	1.4	2.1	2.4	4.5	6.1
	"C"	1.9	2.3	3.4	4.2	8.7	11.1
	"D"	3.0	3.9	5.3	6.9	12.3	16.6
	"F" *(D/S of Watters Rd.)*	6.4	7.5	10.2	11.6	17.2	21.4
	"G"	6.5	7.6	10.4	11.7	17.6	21.5
	"H"	7.2	8.8	11.7	13.7	21.1	26.5

Flow Point at Cardinal Creek		2-Year Design Storm Event (m^3/s)		5-Year Design Storm Event (m^3/s)		100-Year Design Storm Event (m^3/s)	
		Existing XPSWMM Model	*Updated XPSWMM Model*	*Existing XPSWMM Model*	*Updated XPSWMM Model*	*Existing XPSWMM Model*	*Updated XPSWMM Model*
	"O"	8.6	9.4	12.2	15.1	22.7	30.1
SCS Type II Distribution, 24-Hour	**"A"**	0.4	0.6	0.6	1.1	1.7	2.8
	"B"	1.1	1.5	2.3	2.6	4.7	6.5
	"C"	2.0	2.5	3.6	4.5	9.0	11.7
	"D"	3.7	4.0	5.6	7.1	12.5	16.5
	"F" *(D/S of Watters Rd.)*	6.8	7.5	10.3	11.4	17.0	21.4
	"G"	6.9	7.5	10.6	11.5	17.6	21.4
	"H"	7.7	8.7	12.0	13.6	21.1	26.0
	"O"	8.1	9.4	12.5	15.0	22.8	29.9

Flow locations within the Cardinal Village (Area 11) are shown in **Figure 2.1** and a comparison of peak flows existing and future uncontrolled conditions have been included in **Tables 2.4, 2.5** and **2.6**. Note that the future uncontrolled flows reported in **Table 2.4** are used to illustrate the impact of proposed development on peak flow rates.

Table 2.4. Comparison of Peak Flow Results for Area 11 Flow Points for 3-Hour Chicago Distribution of 2, 5 and 100-year Design Storm Events for Existing and Future Uncontrolled Conditions

Flow Point Within Area 11	Chicago Distribution, 3-Hour					
	2-Year Design Storm Event (m^3/s)		5-Year Design Storm Event (m^3/s)		100-Year Design Storm Event (m^3/s)	
	Existing Conditions	*Future Uncontrolled Conditions*	*Existing Conditions*	*Future Uncontrolled Condtions*	*Existing Conditions*	*Future Uncontrolled Conditions*
"F1"	0.2	0.3	0.4	0.5	0.9	1.2
"H2"	1.1	4.1	2.0	6.7	5.3	16.2
"H3"	1.2	4.3	2.1	7.1	5.6	17.6
"I1"	0.1	0.3	0.2	0.4	0.4	0.9
"O2"	0.5	1.6	0.8	2.4	2.2	5.1
"O3"	0.5	1.7	1.3	3.1	3.4	8.0
"O4"	0.4	1.4	0.7	2.0	1.7	4.2

Table 2.5. Comparison of Peak Flow Results for Area 11 Flow Points for July 1, 1979 Observed Storm Event and Snow 100-Year Event Distribution for Existing and Future Uncontrolled Conditions

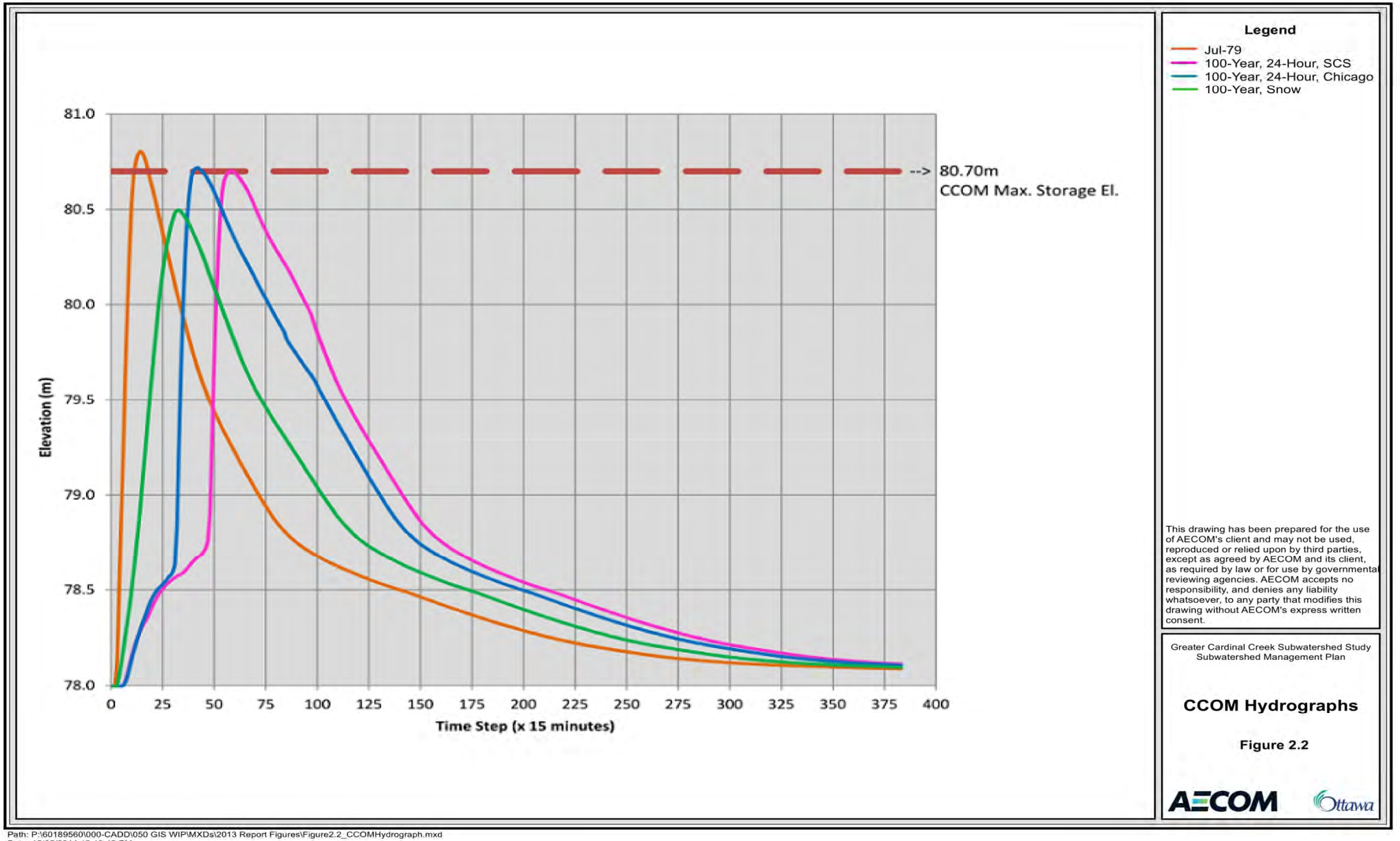
Flow Point Within Area 11	July 1, 1979 Observed Storm Event (m^3/s)		Snow 100-Year Event Distribution (m^3/s)	
	Existing Conditions	Future Uncontrolled Conditions	Existing Conditions	Future Uncontrolled Conditions
"F1"	1.0	1.1	0.2	0.1
"H2"	6.1	16.2	4.5	3.1
"H3"	6.5	17.9	4.7	3.1
"I1"	0.4	0.7	0.0	0.1
"O2"	2.7	4.9	1.1	0.8
"O3"	3.7	9.8	2.8	2.1
"O4"	1.9	3.1	0.5	0.2

Table 2.6. Comparison of Peak Flow Results for Area 11 Flow Points for 24-Hour Chicago and SCS Type II Distributions of 2, 5 and 100-year Design Storm Events for Existing and Future Uncontrolled Conditions

Flow Point Within Area 11		2-Year Design Storm Event (m^3/s)		5-Year Design Storm Event (m^3/s)		100-Year Design Storm Event (m^3/s)	
		Existing Conditions	*Future Uncontrolled Conditions*	*Existing Conditions*	*Future Uncontrolled Conditions*	*Existing Conditions*	*Future Uncontrolled Conditions*
Chicago Distribution, 24-Hour	"F1"	0.2	0.3	0.4	0.5	0.9	1.2
	"H2"	1.1	4.1	2.0	6.7	5.3	16.2
	"H3"	1.2	4.3	2.1	7.1	5.6	17.6
	"I1"	0.1	0.3	0.2	0.4	0.4	0.9
	"O2"	0.5	1.6	0.8	2.4	2.2	5.1
	"O3"	0.5	1.7	1.3	3.1	3.4	8.0
	"O4"	0.4	1.4	0.7	2.0	1.7	4.2
SCS Type II Distribution, 24-Hour	"F1"	0.2	0.3	0.4	0.5	0.9	1.0
	"H2"	1.2	3.8	2.2	6.3	5.4	14.5
	"H3"	1.3	4.0	2.3	6.7	5.8	15.6
	"I1"	0.1	0.2	0.1	0.3	0.3	0.7
	"O2"	0.5	1.5	0.9	2.2	2.2	4.6
	"O3"	0.6	1.6	1.4	2.8	3.5	7.1
	"O4"	0.4	1.0	0.7	1.5	1.7	3.0

It is evident that development within the Subwatershed will increase peak flow rates, and could result in deteriorating water quality in the area streams and watercourses. It will be necessary to place stormwater management requirements on new development to mitigate the impacts of land use change and in some cases to improve upon the degraded conditions which have resulted from historic land use practices.

Hydrological modeling shows that the Cardinal Creek Online Stormwater Management (CCOM) facility is at capacity (***Figure 2.2***).



Greater Cardinal Creek Subwatershed Study
Subwatershed Management Plan

CCOM Hydrographs

Figure 2.2

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2.2.2 RVCA Regulation Mapping

The Rideau Vally Conservation (RVCA) works to maintain and update its collection of flood hazard and regulatory limits mapping, in order to achieve effective and consistent administration and enforcement of its local regulations: Ontario Regulation (O.Reg) 174/06. As part of the Greater Cardinal Creek Subwatershed Study, the City provided the RVCA in 2012 with funding to map and to publish regulatory limits within the Cardinal Creek watershed, which is a part of the RVCA's area of jurisdiction. The RVCA used the hydrologic, hydraulic and geomorphological studies completed for this study to determine the regulation limits from existing hazards, such as floodplain, slope stability, and meander belt width.

As a result of the updating of the hydrologic model for this final report, the RVCA is reviewing and reconfirming the 2012 regulations mapping. The information presented in this report is subject to further refinements by RVCA, and will be presented in the future at a separate open house.

2.2.3 Slope Stability Assessment at Priority 1 and 2 Sites and Municipal Class Environmental Assessment Process

Through the completion of the Greater Cardinal Creek Subwatershed management plan the City of Ottawa has addressed the provisions of the *Municipal Engineers Association (MEA) Municipal Class EA document (October 2000, as amended in 2007 and 2011)*, as approved under the Environmental Assessment Act (EAA) and its requirements to prepare a Schedule B Class Environmental Assessment (Class EA) for the Priority 1 and Priority 2 slope stability projects identified in Phase 1, the Greater Cardinal Creek Subwatershed Study Existing Conditions Report (AECOM 2009)..

Based on the Ontario Municipal Engineers Association (MEA) Class EA document, typical municipal infrastructure projects are classified as either Schedule "A", "A+", "B" or "C" projects. The Priority 1 and Priority 2 slope stability projects are considered as a Schedule "B" undertaking based on the following project activity description[1] and as described below:

Schedule "B" Projects have the potential for some adverse environmental effects. The proponent is required to undertake a screening process involving mandatory contact with directly affected public and relevant review agencies to ensure that they are aware of the project and that their concerns are addressed where possible.

Schedule "B" projects require that Phases 1 and 2 of the Class EA planning process be followed and a Project File/report be prepared and submitted for review by the public. If there are no outstanding concerns raised by the public and/or review agencies, then the proponent may proceed to project implementation (Phase 5). If however, the screening process raises a concern that cannot be resolved, then the Part II Order[2] procedure (formerly referred to as a "bump-up") may be invoked. Alternatively, the proponent may voluntarily elect to plan the project as a Schedule "C" undertaking.

[1] *Works undertaken in a watercourse for the purposes of flood control or erosion control, which may include:*
- *bank or slope regrading*
- *deepening the watercourse*
- *relocation, realignment or channelization of watercourse*
- *revetment including soil bio-engineering techniques*
- *reconstruction of a weir or dam*

The subwatershed management plan is following the MEA Class EA Master Plan Approach #2 where each identified Schedule B project requires a sufficient level of investigations, consultation and documentation to be prepared in order to meet all of the Phases 1 and 2 Municipal Class EA requirements and ultimately obtain project EA clearance-approval through the Plan Notice of Completion.

The Priority 1 and Priority 2 slope stability sites address Phases 1 and 2 of the Class EA process as summarized below:

Phase 1 Identify the problem (deficiency) or opportunity.

Phase 2 Identify alternative solutions to the problem or opportunity by taking into consideration the existing environment and establish the preferred solution accounting for public and agency review and input. Document the planning process in a Municipal Class EA project file and make such documentation available for scrutiny by review agencies and the public.

Identify the Problem

Greater Cardinal Creek Subwatershed Study Existing Conditions Report, AECOM, 2009 identified: Priority 1 slope stability sites that require immediate slope stabilization; and Priority 2 slope stability sites where toe erosion protection is recommended. The slope stabilization and toe protection is required to address risk to private property, roadways, and public safety.

Alternative Solutions

A memorandum providing estimated conceptual construction costs for the preferred alternatives has been completed by Houle Chevrier Engineering, August 28, 2013, refer to **Appendix B**. The cost estimates are to a Class C Planning level of detail in accordance with the City of Ottawa cost estimate classification system. Contingencies have been applied as per the City of Ottawa contingency guidance and outlined **Table 2.7**.

Table 2.7. Preferred Alternative Costs Estimates

	Estimate Class C	Site					
		Area 8	Area 13	Old Montreal Road	Area 18	Area 19	Watters Road
Construction Cost	H-C Calculated	$90,000	$131,500	$300,000	$242,000	$28,000	$50,000
Engineering	0.2	$18,000	$26,300	$60,000	$48,400	$5,600	$10,000
Property	-						
Utilities	0.125	$11,250	$16,438	$37,500	$30,250	$3,500	$6,250
City Internal	0.085	$7,650	$11,178	$25,500	$20,570	$2,380	$4,250
Misc Soft Costs	0.05	$4,500	$6,575	$15,000	$12,100	$1,400	$2,500
Uncertainty Contingency	0.25	$22,500	$32,875	$75,000	$60,500	$7,000	$12,500
HST (13%)	0.13	$11,700	$17,095	$39,000	$31,460	$3,640	$6,500
TOTAL		**$165,600**	**$241,960**	**$552,000**	**$445,280**	**$51,520**	**$92,000**

The slope stabilization alternatives for each of the above sites where evaluated including variations of the following:

1) **Do Nothing**
2) **Slope regrading while not moving the toe of the slope**
3) **Slope regrading while moving the roe of the slope**
4) **External toe buttress**
5) **Slope reinforcement**

The evaluation of alternative solutions is based on a qualitative assessment to consider the suitability of solutions and to identify significant advantages and disadvantages with respect to the evaluation criteria developed. This forms the rationale for the identification of the preferred solution. A qualitative evaluation based on the environmental components, representing a broad definition of the environment as described in the Environmental Assessment Act outlined in **Table 2.7** has been used.

Table 2.8. Environmental Components

Environmental Component	Description
Technical	Component that considers technical suitability and other engineering aspects of the solutions.
Natural Environment	Component having regard for protecting significant natural and physical elements of the environment (i.e. air, land, water and biota) including natural heritage and environmentally sensitive policy areas.
Social/Cultural	Component that evaluates potential effects on residents, neighbourhoods, businesses, community character, social cohesion, community features, and historical/archaeological and heritage components.
Economic/ Financial	Component that addresses the potential effect on costs.

To provide an impartial, traceable and consistent evaluation, as required by the Class EA process, an evaluation matrix (refer to **Appendix B)** has been used to illustrate the highest and lowest impact each alternative carried forward has on the environment (social/cultural, natural environment, economic, technical).

Preferred Slope Stabilization Alternatives

Based on the evaluation the preferred slope stabilization alternatives have been selected as follows:

- Area 8 - Benching (Alternative 4).
- Area 13 - Benching (Alternative 4).
- Old Montreal Road – Slope reinforcement (Alternative 6).
- Area 18 – Benching (Alternative 4).
- Area 19 – Benching (Alternative 4).
- Watters Road – Slope regrading with toe reinforcement (Alternative 5).

A conceptual channel naturalization design for the Old Montreal Road site has been completed by Geomorphic Solutions (Sernas Group), May 2013, refer to **Appendix C**.

A memorandum providing estimated conceptual construction costs for the preferred alternatives has been completed by Houle Chevrier Engineering, August 28, 2013, refer to **Appendix B**.

The above projects were presented to the public and stakeholders on May 8, 2014 for review and comments. **Appendix D** includes the study contact list, public notices, public open house displays and review agency/stakeholder correspondence. To date no comments have been received that cannot be adequately addressed.

2.2.4 Karstic Features

The Ontario Geological Survey has identified much of the northern portion of the subwatershed as *karst* – areas of exposed or near-surface limestone bedrock, where dissolution of minerals along cracks and crevices creates preferential pathways for groundwater movement (Brunton and Dodge 2008). *Macro-karst* exists where water flows suffice to create caves and related features, such as sinkholes, typically along watercourses. Where Cardinal Creek descends a steep escarpment at Watters Road, it has formed a cave and sinkhole system which is identified and protected as a provincially significant Area of Natural and Scientific Interest (ANSI). *Micro-karst* exists where groundwater infiltration is sufficient to enlarge bedrock cracks of several millimetres or centimetres, but not sufficient to create cave features. Small areas of micro-karst are known within the Subwatershed study area, and there is potential for micro-karst throughout.

Detailed karst investigations have been undertaken on the Cardinal Village site and the cave system at Watters Road (Golder 1991; Worthington 2013). Site specific investigations for karst may be necessary to support future development proposals.

2.3 Natural Heritage System

2.3.1 General

Several natural heritage studies have been conducted, in part, to provide background existing environmental conditions for the Subwatershed Plan. These studies include an inventory of the terrestrial environment (Marshall Macklin Monahan (MMM, May 2007), a geomorphic assessment (Geomorphic Solutions 2007), and the *Existing Conditions Report* (AECOM 2009). This latter report integrates a comprehensive review of background data, along with field investigations to present an understanding of the environmental sensitivities and constraints within the Subwatershed.

Section 2.4.2 Policy 1 of the City of Ottawa Official Plan (OP) identifies criteria for the delineation of the Natural Heritage System (NHS), and depicts a natural heritage system for the Subwatershed on Schedule L1 of the document. However, the information shown on Schedule L1 requires updating and additions to achieve a complete natural heritage system.

Accordingly additional investigations and analysis were undertaken since the completion of the *Existing Conditions Report* to define and describe an appropriate NHS for the Subwatershed and the associated considerations. The tasks that were undertaken in this regard include:

- Preliminary classification for all area streams and municipal drains and identification of recommended development setbacks.
- A review of the recent direction and polices regarding the NHS that are included in the City's Official Plan as part of the 2009 Comprehensive Update (OPA 76) which was completed subsequent to the Existing conditions Report.
- Additional field investigations to further examine and/or confirm feature details.
- Identification of stressors to the natural environment within the Subwatershed and identification of conceptual mitigation strategies to minimize the associated effects (discussed in Section 4.3.2)

- Development of strategies and measures to ensure the long-term protection of the NHS in the Subwatershed (discussed in Section 4.3.3).

2.3.2 Watercourse Classification

Watershed science has demonstrated that the protection of water quality, aquatic habitats and fish habitat depends upon the conservation and protection of headwater areas and watercourses. Watersheds function very much like human lungs. In human lungs, the most important areas for gas exchange are not the main passages, but the numerous alveoli: the small sacs, deep in the lungs, where the ratio of surface area to volume is highest. Impairment of these alveoli through smoking, exposure to toxic fumes, or infection quickly leads to the collapse of the respiratory system. Similarly, most of the water in a watershed originates in headwater areas, entering the numerous small watercourses – sometimes ephemeral, sometimes permanent – where the ratio of shoreline and streambed to water volume is highest. These are the areas where the exchange of materials and energy between the terrestrial and aquatic systems is greatest. Consequently, they are the areas in which the protection of watercourse features is most important to the overall health of the watershed.

Ottawa's Official Plan requires development setbacks to protect watercourses and watersheds. The need for watercourse setbacks may vary by watercourse. Consequently, they will often be identified by subwatershed studies (SWS) and environmental management plans (EMP). They are implemented by zoning at the time of development review and building permit processes. Where watercourse setbacks are not established through a SWS or EMP, or those management plans do not address minimum watercourse setbacks, then Section 4.7.3 (2) of the Official Plan states that the *greater* of the following setbacks will apply:

- The regulatory flood line, where such exists;
- The geotechnical limit of the hazard lands, as established using the City of Ottawa Slope Stability Guidelines;
- 30 m from the normal high water mark of rivers, lakes and streams;
- 15 m from the existing top of bank, where there is a defined bank.

If the watercourse in question has been identified as a municipal drain through a Drainage Act process, then a larger setback may also be established through the applicable Drain Engineer's report. A larger setback requirement may also be identified through an Environmental Impact Statement where a watercourse is identified as part of a natural corridor or part of any other feature of the City's natural heritage system described in Section 2.4.2 (1) of the Official Plan (*e.g.* a watercourse associated with a significant woodland)

With some exceptions for activities subject to specific approval processes (as specified in Policy 4.7.3 (4)), the Official Plan does not permit site alteration or development within the applicable watercourse setback. Exceptions to the standard, minimum setbacks may be requested in three circumstances (Policy 4.7.3 (6)):

- On existing lots, where the standard minimum setback is not achievable (see Policy 4.7.3 (6) for details);
- "Adjacent to a minor tributary that serves primarily a surface water function and that may have only an intermittent flow."
- "Adjacent to an existing top of bank where the regulatory floodline and the geotechnical limit of the hazard lands are within 15 metres from the existing top of bank."

A request for an exception to the standard, minimum setbacks or to the prohibition on development and site alteration will only be considered if it is supported by a study that identifies and addresses the following:

- The floodplain (regulated or not) and the geotechnical limits;
- Impacts on the natural vegetation and ecological functions of the setback area, including protective functions with respect to the watercourse, intrinsic values, and intrinsic functions;

- The nature of the watercourse, including: thermal regime; sensitivity to sediments, pollutants, anthropogenic nutrient inputs; light regime; the relative importance of groundwater inputs, interflow, and surface water inputs; in-stream and near-stream structure; natural nutrient inputs and balance.

Request for exceptions to the standard, minimum setbacks are often made for headwater watercourses, based on claims that these are "minor tributaries" as *per* Policy 4.7.3 (6b). Interpretation of this policy has been complicated in the past by the lack of explicit criteria for the assessment of whether a watercourse qualifies as a minor tributary. Ottawa is currently developing standard guidelines for application of the minor tributary policy, based upon two recent documents: Evaluation, Classification and Management of Headwater Drainage Features Guidelines (CVC and TRCA 2013); Ecological Buffer Guideline Review (Beacon Environmental Ltd. 2012). A minor tributary will normally fall within one of the following recommended management categories (CVC and TRCA 2013):

- Mitigation
- Recharge Protection
- Maintain Terrestrial Linkage
- No Management Required.

The Greater Cardinal Creek Subwatershed Study takes a risk-based approach to establishing watercourse setbacks, based on recommendations in the Ecological Buffer Guideline Review (Beacon Environmental Ltd. 2012). In some cases, these setbacks supersede the minimum setbacks in the Official Plan, in order to protect "critical function zones" (Beacon Environmental Ltd. 2012). ***Table 2.8*** cross-references the recommended management categories in the Headwater Drainage Feature Guidelines (CVC and TRCA 2013) to development setbacks based on Table 7 in the Ecological Buffer Guidelines (Beacon Environmental Ltd. 2012). The development setback distances are intended to reduce the risk of not achieving the intended buffer functions to moderate or low (Beacon Environmental Ltd. 2012).

Table 2.9 Recommended Minimum Watercourse Setbacks

Management Recommendations (CVC and TRCA 2013)	Minimum Setback
Permanent Watercourse (Headwater Drainage Feature Guidelines do not apply)	The greater of: • Regulatory flood line • Geotechnical limit of hazard lands • 30 m from normal high water mark • 25 m from top of bank • Setback as determined through an Environmental Impact Statement • Setback as determined through a Drain Engineer's Report
Protection	The greater of: • Regulatory flood line • Geotechnical limit of hazard lands • 30 m from normal high water mark • 25 m from top of bank • Setback as determined through an Environmental Impact Statement • Setback as determined through a Drain Engineer's Report
Conservation	The greater of: • Regulatory flood line • Geotechnical limit of hazard lands • 30 m from normal high water mark • 25 m from top of bank • Setback as determined through an Environmental Impact Statement • Setback as determined through a Drain Engineer's Report
Mitigation (with direct fish habitat)	The greater of: • Regulatory flood line • Geotechnical limit of hazard lands • 25 m from top of bank, where there is a defined top of bank. • 25 from the watercourse centre line, where there is no defined top of bank. • Setback as determined through an Environmental Impact Statement • Setback as determined through a Drain Engineer's Report

Management Recommendations (CVC and TRCA 2013)	Minimum Setback
Mitigation (with indirect fish habitat)	The greater of: • Regulatory flood line • Geotechnical limit of hazard lands • 15 m from top of bank, where there is a top of bank. • 15 m from the watercourse centre line where there is no defined top of bank. • Setback as determined through an Environmental Impact Statement • Setback as determined through a Drain Engineer's Report
Recharge Protection	The greater of: • Regulatory flood line • Geotechnical limit of hazard lands • Setback as determined through a source water protection plan, subwatershed study, environmental management, an Environmental Impact Statement or other planning study.
Terrestrial Linkage	The greater of: • Regulatory flood line • Geotechnical limit of hazard lands • Setback as determined through an Environmental Impact Statement
None	The greater of: • Regulatory flood line • Geotechnical limit of hazard lands

Watercourses in the Greater Cardinal Creek Subwatershed have been provisionally classified through a desktop analysis, using criteria and classes from the "Evaluation, Classification and Management of Headwater Drainage Features Guidelines" (CVC/TRCA 2013). The desktop analysis used aerial photography, topographic mapping, soils, and municipal drain classifications, as well as aquatic habitat information and fisheries information from the Existing Conditions Report. Where insufficient information exists for a preliminary assessment, the watercourse has been classified as "unknown."

These classifications are intended primarily for screening and high-level planning purposes. Any specific development or site alteration proposal adjacent to one of the illustrated headwater watercourses must be accompanied by a site investigation using the methodology of the Headwater Drainage Feature Guidelines (CVC/TRCA 2013) and the Ecological Buffer Guidelines (Beacon 2012)

Appendix E and ***Figure 2.3*** presents the results of the watercourse classification.

2.3.3 Current Policies for Natural Heritage System Protection

The Subwatershed Plan provides the local context for the City of Ottawa Official Plan (2012), which guides future development as well as environmental protection. In particular Section 2.4 of the Official Plan has a mandate to Maintain Environmental Integrity, while Section 2.4.2 specifically addresses Natural Features and Functions. Policy 2.4.2.2a establishes watershed and subwatershed plans as the basis for land use planning in Ottawa.

Policy 2.4.2.1 specifies that the Natural Heritage System (NHS) encompasses the features and functions to be protected, and includes the following categories:

a) Provincially Significant Wetlands
b) Significant Habitat of Endangered and Threatened Species
c) Significant Woodlands
d) Wetlands found in association with Significant Woodlands
e) Significant Valleylands
f) Significant Wildlife Habitat
g) Life Science Areas of Natural and Scientific Interest (ANSI)

h) Earth Science Areas of Natural and Scientific Interest (ANSI)
i) Urban Natural Features
j) Forest Remnants and Corridors identified through planning or environmental studies
k) Groundwater features identified through surface or subsurface hydrogeologic investigations
l) Surface water features including headwaters, rivers, streams, lakes, seepage areas and associated riparian areas, including fish habitat

2.3.4 Subwatershed Natural Heritage System

Figure 2.4 depicts the Natural Heritage System components that were identified within the Subwatershed. The NHS components can only be identified and protected if they qualify as one of the natural features in Section 2.4.2.1 of the City of Ottawa OP. Overall the subwatershed currently contains a natural vegetation cover of 19.5%, but this ranges from approximately 40% in the north portion, to 6.1% in rural south portion to about 1% in the urban areas (AECOM 2009). Without protective measures these amounts are likely to decline. For example, approximately 50 ha were removed from one of the largest remaining woodlots since the AECOM (2009) report was completed.

i) Significant Woodlands

In accordance with the City's current Official Plan Policies (April 2014), a significant woodlands must contain all three of the following components: i) mature forest stands at least 80 years old, ii) interior forest located more than 100 m from a forest edge, and iii) surface water features such as a river, stream, drain, pond or seepage area. Woodlots therefore must be of a sufficient size to contain interior forest habitat. As noted in Figure 2.28 of the *Existing Conditions Report* only five woodlots contain interior habitat.

ii) Wetland Associated with Significant Woodlands

There is no provincially significant wetland, as evaluated, recognized and mapped by the Ministry of Natural Resources (MNR), within the subwatershed. The Petrie Island Wetland, which is recognized as a provincially significant wetland, is located just beyond the north-west corner of the subwatershed, along the Ottawa River. Under the City's Official Plan policies, a non-provincially significant wetland can qualify for inclusion in the NHS if situated within or immediately adjacent to a woodlot that is representative of a significant woodland. One locally significant wetland occurs south of Wilhaven Drive and west of Wishbourne Road which meets the NHS criterion. Another small locally significant wetland occurs in an isolated woodlot west of Trim Road and south of Innes Road.

iii) Significant Habitat of Endangered and Threatened Species

Significant habitat of endangered and threatened species is normally identified through site investigation, based on criteria established by the Ontario Ministry of Natural Resources, although it may be captured by other natural heritage features, such as provincially significant wetlands. Only the endangered butternut (which does not receive habitat protection under the Ontario Endangered Species Act) is known to occurs widely in the subwatershed (MMM 2007), especially within the escarpment forests in the north area. Although significant habitat of endangered and threatened species is not specifically identified in the subwatershed management plan, it still receives protection under the Provincial Policy Statement 2014 and the Official Plan.

iv) Significant Valleylands

Significant valleylands are defined in the Official Plan as having slopes greater than 15% and a length of more than 50 m with water present for some period of the year. Cardinal Creek from Innes Road all the way to the mouth (approximately 5 km) forms a well-defined valley and therefore qualifies as a NHS component. Another significant valleyland occurs along a defined stream valley north of Old Montréal Road and east of Quigley Hill Road at the northeast corner of the subwatershed.

v) Significant Wildlife Habitat

As defined in the City's Official Plan, significant wildlife habitat includes escarpments with a 75% or greater slope that is a minimum of 3 m in height. Such escarpments often provide specialized habitat for reptiles, bats as well as uncommon or rare vegetation communities. The OP also states that significant wildlife habitat may also include other areas as identified through a subwatershed study. Steep escarpment slopes are present in the northern portion of the study area near the Ottawa River, and just south of Old Montreal Road (***Figure 2.4***). Another disjunct escarpment is associated with woodland at the extreme southeast corner of the subwatershed, just north of French Hill Road. MMM (2007) identified several provincially rare vegetation types along these escarpments.

The Significant Wildlife Habitat Technical Guide (MNR 2000) has described various types of significant wildlife habitat, and the Natural Heritage Reference Manual (MNR 2010) has set out guidelines for their identification. Specific criteria are recommended in (MNR 2010) for Ecoregion 6E which includes the subwatershed. There are many possible types of wildlife habitat which fall under the main categories of a) seasonal wildlife concentrations, b) rare vegetation communities, c) specialized wildlife habitat, d) species of conservation concern and e) animal movement corridors. These criteria have not been applied to the subwatershed to date, but some of the larger woodlots would likely qualify under at least one of these criteria. More detailed assessment of significant wildlife habitat should be conducted where there are development applications proposals within 120 m of woodlots. Identifying these habitats requires specifically targeted field investigations.

Several parcels in the east portion of the subwatershed, along the Wishbourne Road Allowance, were identified as significant grassland habitat. These large blocks of open habitat are associated with significant woodland and locally significant wetland, and they were found to support a greater than average number of grassland bird species.

vi) Area of Natural and Scientific Interest (ANSI)

One potential life science ANSI was initially identified by Brunton (1992), but was not recommended by the Ontario Ministry of Natural Resources as a candidate ANSI: French Hill Maple Woods which includes a talus escarpment (MMM 2007). However, it is captured in the subwatershed management plan as significant woodland and significant wildlife habitat (escarpment habitat).

The Cardinal Creek Karst feature, which is located within the watercourse valley south of Watters Road, is a provincially significant Earth Science ANSI. The designated portion of the feature occupies a relatively small area, consisting of that City-owned property adjacent to the south side of Watters Road, which includes the entrance to the cave system (fenced and off-limits) and a collapsed sinkhole. The remainder of the feature lies on private property, but is entirely captured within the limits of the significant valleyland and significant woodland designations. The Existing Conditions report contains a more complete description of the feature.

vii) Urban Natural Features

These are identified as remnant woodlands, wetlands and ravines within the urban area in the City of Ottawa OP. Three areas within the subwatershed were originally identified as Urban Natural Areas (UNA) in a study by Muncaster Environmental and Brunton Consulting (2006). These are the Cardinal Creek Valley UNA adjacent to the urban area of Queenston Heights, the lower most section of Cardinal Creek (part of the Petrie Island and Mainland UNA, and the Nantes Street Woods UNA. The two Cardinal Creek areas also fall into significant valleyland. The Nantes Street Woods meets the definition of an urban natural feature, although it was assessed as low significance by MMM (2007) because of disturbed vegetation and low potential to support significant environmental functions. Although isolated, it provides a natural area in and intensive urban area and consequently it was identified as part of the NHS. The woodlot east of Trim Road and south of Innes Road is also isolated from any other natural features. It contains a wetland feature which increases its overall biodiversity and habitat value but lacks any forest interior and therefore cannot qualify as significant woodland although it meets the other two criteria. It qualifies as an Urban Natural Feature since it is at the edge of the urban area.

viii) **Forest Remnants and Corridors**

These are corridors identified through planning or environmental studies that may form remnant or discontinuous vegetation that is not significant on its own right but has potential to form habitat connection or wildlife movement corridor. These are features shown as Natural Linkage on ***Figure 2.4***. The two woodlots between Frank Kenny Road and O'Toole Road south of Wilhaven Drive do not meet all the criteria as significant woodland but form a vital connecting link between three core areas. Similarly the rather linear woodlots just north of Innes Road and extending on both sides of O'Toole Road provide a link from the large woodlot to the northeast with the Cardinal Creek Valley.

ix) Natural Linkages

The main Cardinal Creek channel is associated with sparse patches of thicket and tree groves between Innes Road and O'Toole Road but is associated with a continuous stream channel with a narrow and disturbed, but continuous band of vegetation and therefore provides the best potential corridor link through the subwatershed to the southeast corner. The OP identifies floodplains as satisfying the criteria for a corridor. The current linkage of the upper Cardinal Creek is narrow but the surrounding landscape is agricultural with few human residences and few road crossings, therefore it has potential to function as a wildlife corridor between larger blocks of significant woodland in the lower Cardinal Creek valley, and at the extreme southeast corner of subwatershed.

Another natural linkage was identified following the Wilbourne Road allowance. The road is closed but the allowance forms a narrow but continuous hedgerow strip of vegetation for at least 2.5 km providing a link between blocks of significant woodland, in an otherwise intensively cultivated landscape lacking any natural vegetation.

x) **Linkages through Country Estates**

Three large wooded areas within the subwatershed contain countryside estate housing developments. Although these forests contain houses, lawns and roads, and generally lack any interior habitat, they retain about 70% forest cover. For the most part, houses have been constructed in small building envelopes such that a forest vegetation structure remains. As a result these woodlots still provide many of the environmental functions such as groundwater infiltration and habitat for many breeding birds. In particular these areas continue to provide wildlife corridors and therefore have been identified as part of the NHS even though they are partially developed.

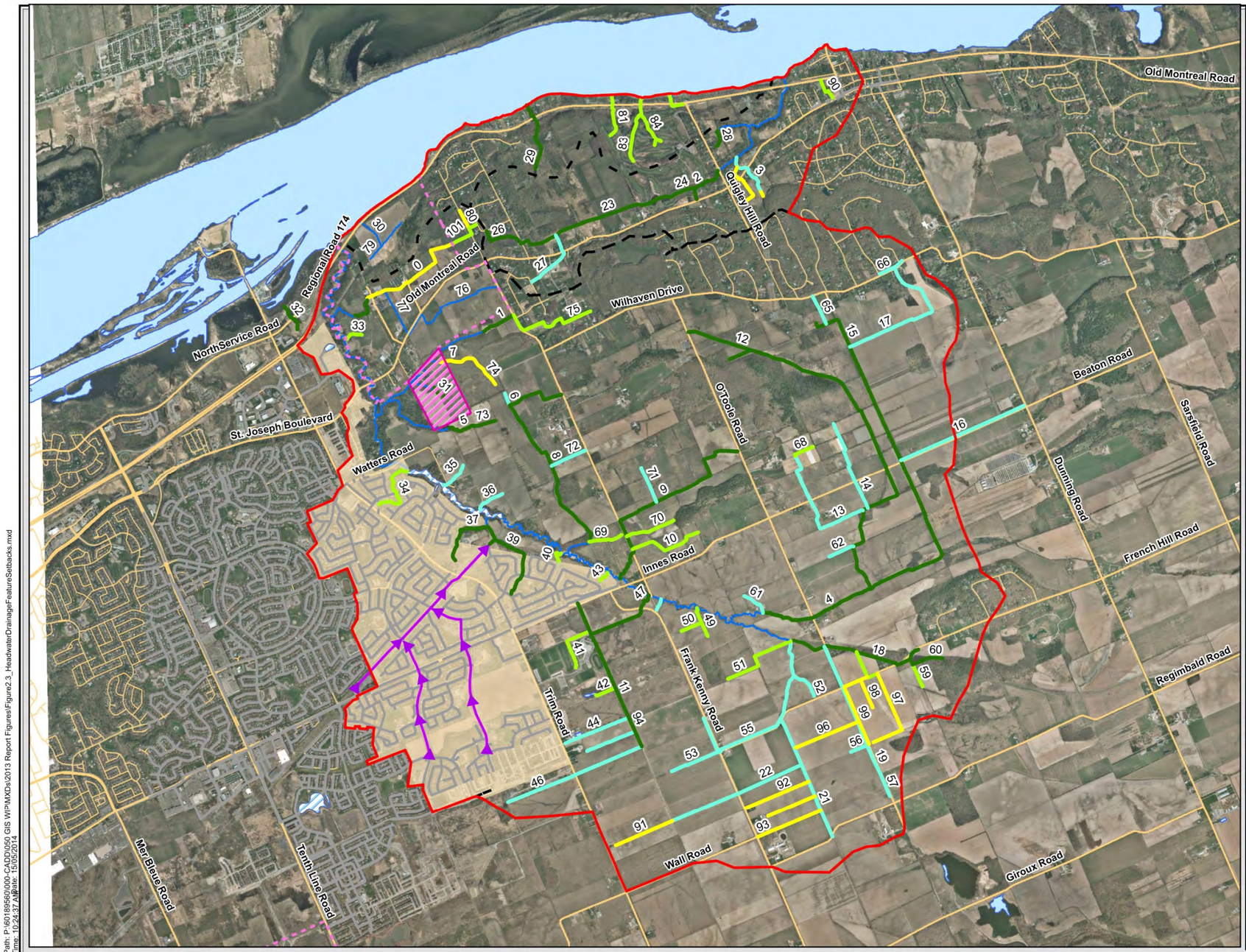
Both MMM (2007) and the Existing Conditions Report (2009) identified a number of smaller isolated woodlots as supporting elements and even core elements. These are not well linked however and lack the compliment of features or functions that would include them in the NHS.

xi) Corridor Linkages Beyond the Subwatershed

Extending habitat corridors to beyond the subwatershed would increase the overall function, where this is possible. The City (2013) completed a Natural Landscape Linkage Analysis to identify these broader linkages. The Ottawa River is a natural aquatic and riparian corridor. Petrie Island forms a core area and is closely linked from the mouth of Cardinal Creek. Another core block of forest habitat occurs about 4 km to the east. Larger regional natural core areas include Mer Bleue (7 km to the west) and forest block near Clarence Creek (9 km to the east). Ideally functional corridors should be maintained, or if possible established between subwatershed and these regional cores.

xii) Surface Water Features

Fish habitat falls under this category and any permanent flowing and many intermittent streams provide fish habitat. The entire length of Cardinal Creek constitutes fish habitat and therefore qualifies as NHS under this category. Surface water features such as streams or drains form continuous linear features that are often associated with a linear band of successional terrestrial vegetation. Even if very narrow, such a link can provide some wildlife corridor functions.



Legend

- Subwatershed Boundary
- Urban Expansion Study Area (approved development)
- Additional Development Lands
- Stormwater Management Ponds
- Catchment Boundary
- Urban Area
- Storm Sewer
- Storm Trunk Sewer
- Stream Network

Reduced Watercourse Setbacks

- Protection
- Conservation
- Mitigation
- Unknown
- 17 Watercourse Classification ID

The recommanded setback is the greater of:
a) Regulatory Floodline;
b) Geotechnical limit of hazard lands;
c) As established through an Environmental Impact Statement;
d) As established in the Drain Engineer's Report;
e) The following setbacks:
i. Protection: 30 m from the normal high water mark, or 25 m from the top of bank;
ii. Conservation: 30 m from the normal high water mark, or 25 m from the top of bank;
iii. Mitigation (with direct fish habitat) 25 m from the top of bank,or 25 m from watercourse centreline;
iv. Mitigation (with indirect fish habitat) 15 m from top of bank, or 15 m from the watercourse centreline;
v. Unknown, either recharge protection, maintain terrestrial linkage or none.

Produced by AECOM with data supplied under license by members of Ontario GeoSpatial Data Exchange. Municipal Drain Data owned and used under agreement with The Rideau Valley Conservation Authority

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1:35,257

NAD 83, MTM 9

Greater Cardinal Creek Subwatershed Study

Subwatershed Management Plan

Headwater Drainage Feature Setbacks

Figure 2.3

AECOM Ottawa

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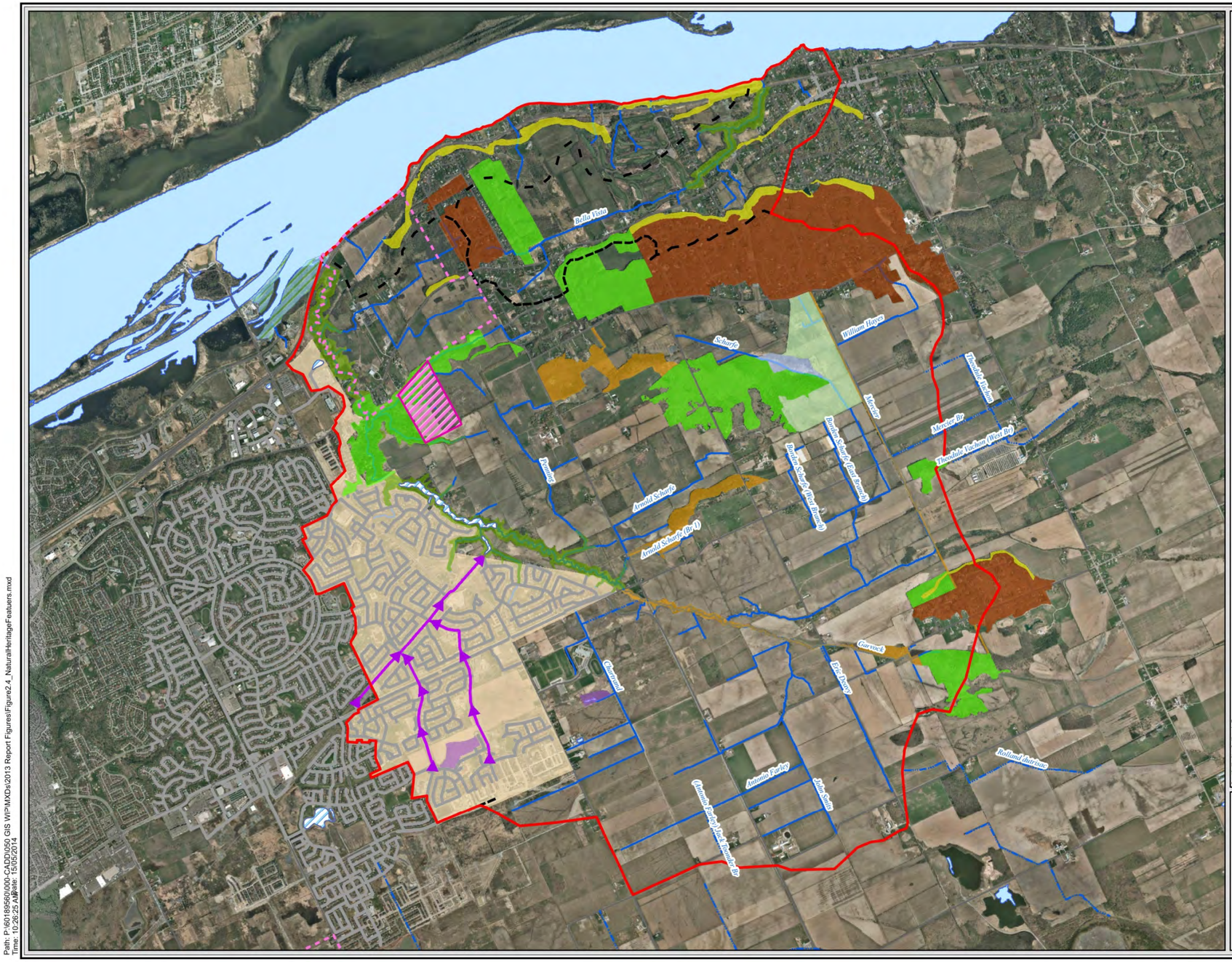

Legend

- Subwatershed Boundary
- Urban Expansion Study Area (approved development)
- Additional Development Lands
- Stormwater Management Ponds
- Storm Sewer
- Catchment Boundary
- Urban Area
- Storm Trunk Sewer
- Stream Networks

GCCSWS Natural Heritage System

- Escarpment
- Linkage through Country Estates
- Locally Significant Wetland
- Natural Linkage
- PSW
- Significant Grassland
- Significant Valleyland
- Significant Woodland
- Urban Natural Feature

Produced by AECOM with data supplied under license by members of Ontario GeoSpatial Data Exchange. Municipal Drain Data owned and used under agreement with The Rideau Valley Conservation Authority

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NAD 83, MTM 9

Greater Cardinal Creek Subwatershed Study

Subwatershed Management Plan

Natural Heritage Features

Figure 2.4

AECOM Ottawa

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2.4 Subwatershed Water Budget

2.4.1 Source Water Protection

In 2011, the Mississippi – Rideau Source Protection Region (MRSPR) completed the *Assessment Report: Rideau Valley Source Protection Area (*MRSPR 2011*)*, based on the guidance of the *Clean Water Act (2006)*. The Greater Cardinal Creek Subwatershed forms part of the Ottawa River East watershed area, which is located within the far eastern portion of the Rideau Valley Source Protection Area. The purpose of source water protection planning is to protect drinking water at watershed scale.

The *Assessment Report* is an active document, subject to periodic revision. At the time of this report, the Greater Cardinal Creek Subwatershed did not contain any municipal Wellhead Protection Zones or Intake Protection Zones. Portions of the Subwatershed have been identified as Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRA).

More detailed and current information on the *Assessment Report: Rideau Valley Source Protection Area* (MRSPR 2011) and other source water protection documents can be found on the Mississippi – Rideau Source Water Protection website: http://www.mrsourcewater.ca/.

2.4.2 Significance of Aquifers

The Subwatershed does not contain any aquifers that are used for municipal drinking water supply. Based on information in the MOE water well records, it has been interpreted that the majority of water users in the Subwatershed obtain potable water from private water wells completed within the Ordivician bedrock of the Bobcaygeon Formation, the Lindsay Formation and the Gull River Formation (AECOM 2009). Both the Bobcaygeon and the Gull River formations are known to contain karst, which are solution enhanced secondary porosity features (Brunton and Dodge 2008). The remaining water users obtain potable water from confined sand and gravel aquifer located below the till and marine clay in the northeastern portion of the subwatershed.

Sensitive Recharge Areas (SRAs) have generally been defined for the Subwatershed in ***Figure 2.6*** These SRAs were established using the same criteria as the source water protection SGRAs; however the average groundwater recharge rate for the Subwatershed was used and areas of solution enhanced bedrock and coarse-grained sand and gravel deposits at surface were included. Maintaining groundwater recharge rates in these areas is critical for maintaining groundwater quantity within the subwatershed.

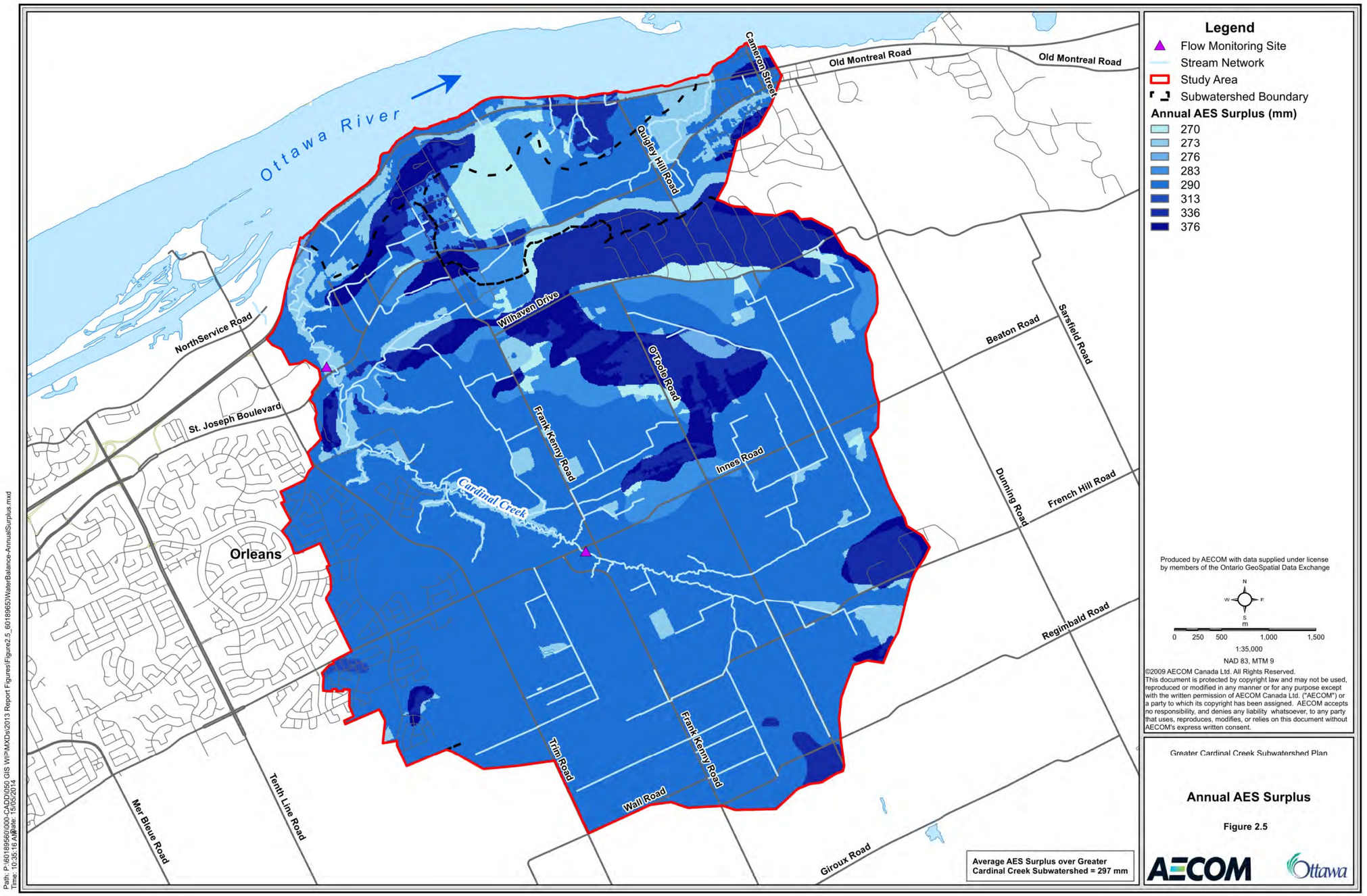
2.4.3 Groundwater Recharge and Discharge

Within the Subwatershed, groundwater is utilized for potable water by local residents and for occasional irrigation by farmers (Glen Edwards, *pers. comm.*). Groundwater discharge into streams and watercourses is an important source of baseflow during prolonged periods with limited rainfall, as evidenced by the coolwater status of Cardinal Creek and the presence of several, permanent coolwater municipal drains (AECOM 2009). Baseflow supports fish habitat and aquatic functions within the Subwatershed (AECOM 2009).

There are limited areas in the Subwatershed where groundwater recharge areas occur. Areas of solution enhanced bedrock, thin soils and coarse-grained sand and gravel deposits are the most important. They also correspond to the most important natural areas in the Subwatershed. The form and function of these areas should be protected.

The majority of groundwater recharge that occurs in the Subwatershed flows from higher elevation to lower elevation within the underlying bedrock formations. Significant groundwater discharge is known to occur in the lower reaches of Cardinal Creek and within the Ottawa River, but can also occur where the surface elevation intercepts the water table. North of the escarpment along Watters Road and Old Montreal Road, Cardinal Creek and Tributary RV35 are known to flow into bedrock. Down gradient, these watercourses reappear as seeps and springs along the main channel of Cardinal Creek, tributaries to Cardinal Creek, and Tributary RV35 (AECOM 2009).

Minor groundwater discharge occurs from the overburden into Cardinal Creek and its tributaries. The extensive tile drainage network within the Subwatershed artificially discharges shallow infiltration to local watercourses, thus supplying another important source of flow.


Ottawa River
Cameron Street
Old Montreal Road
Old Montreal Road
Quigley Hill Road
Wilhaven Drive
NorthService Road
St. Joseph Boulevard
O'Toole Road
Frank Kenny Road
Innes Road
Cardinal Creek
Orleans
Beaton Road
Sarsfield Road
Dunning Road
French Hill Road
Regimbald Road
Trim Road
Frank Kenny Road
Wall Road
Giroux Road
Mer Bleue Road
Tenth Line Road
Legend
Flow Monitoring Site
Stream Network
Study Area
Subwatershed Boundary
Annual AES Surplus (mm)
270
273
276
283
290
313
336
376
Average AES Surplus over Greater Cardinal Creek Subwatershed = 297 mm
Produced by AECOM with data supplied under license by members of the Ontario GeoSpatial Data Exchange
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Greater Cardinal Creek Subwatershed Plan
Annual AES Surplus
Figure 2.5
AECOM
Ottawa
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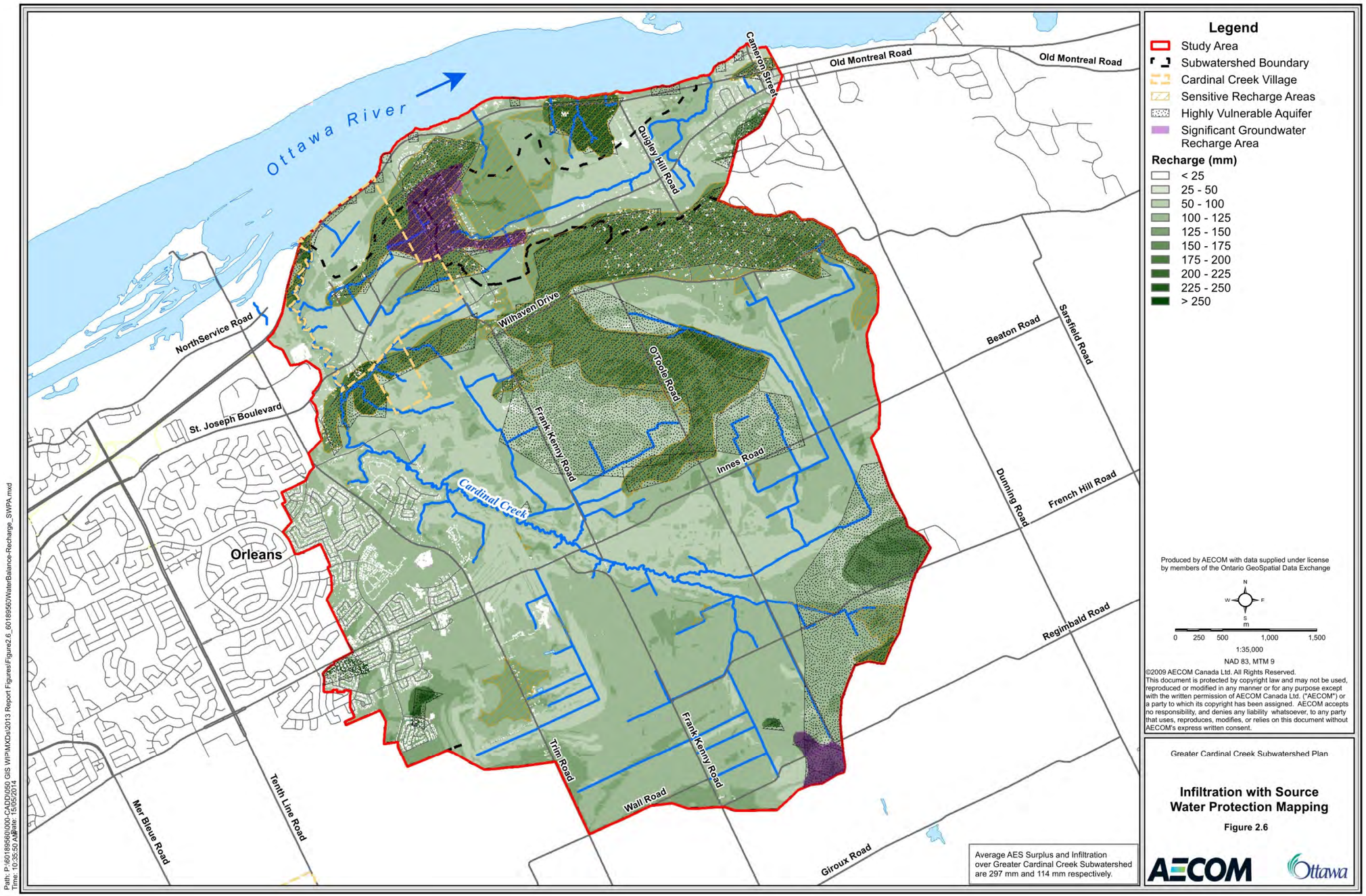
Ottawa River
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Cardinal Creek
Dunning Road
French Hill Road
Orleans
Regimbald Road
Trim Road
Frank Kenny Road
Wall Road
Tenth Line Road
Mer Bleue Road
Giroux Road
Average AES Surplus and Infiltration over Greater Cardinal Creek Subwatershed are 297 mm and 114 mm respectively.
Legend
Study Area
Subwatershed Boundary
Cardinal Creek Village
Sensitive Recharge Areas
Highly Vulnerable Aquifer
Significant Groundwater Recharge Area
Recharge (mm)
< 25
25 - 50
50 - 100
100 - 125
125 - 150
150 - 175
175 - 200
200 - 225
225 - 250
> 250
Produced by AECOM with data supplied under license by members of the Ontario GeoSpatial Data Exchange
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Greater Cardinal Creek Subwatershed Plan
Infiltration with Source Water Protection Mapping
Figure 2.6
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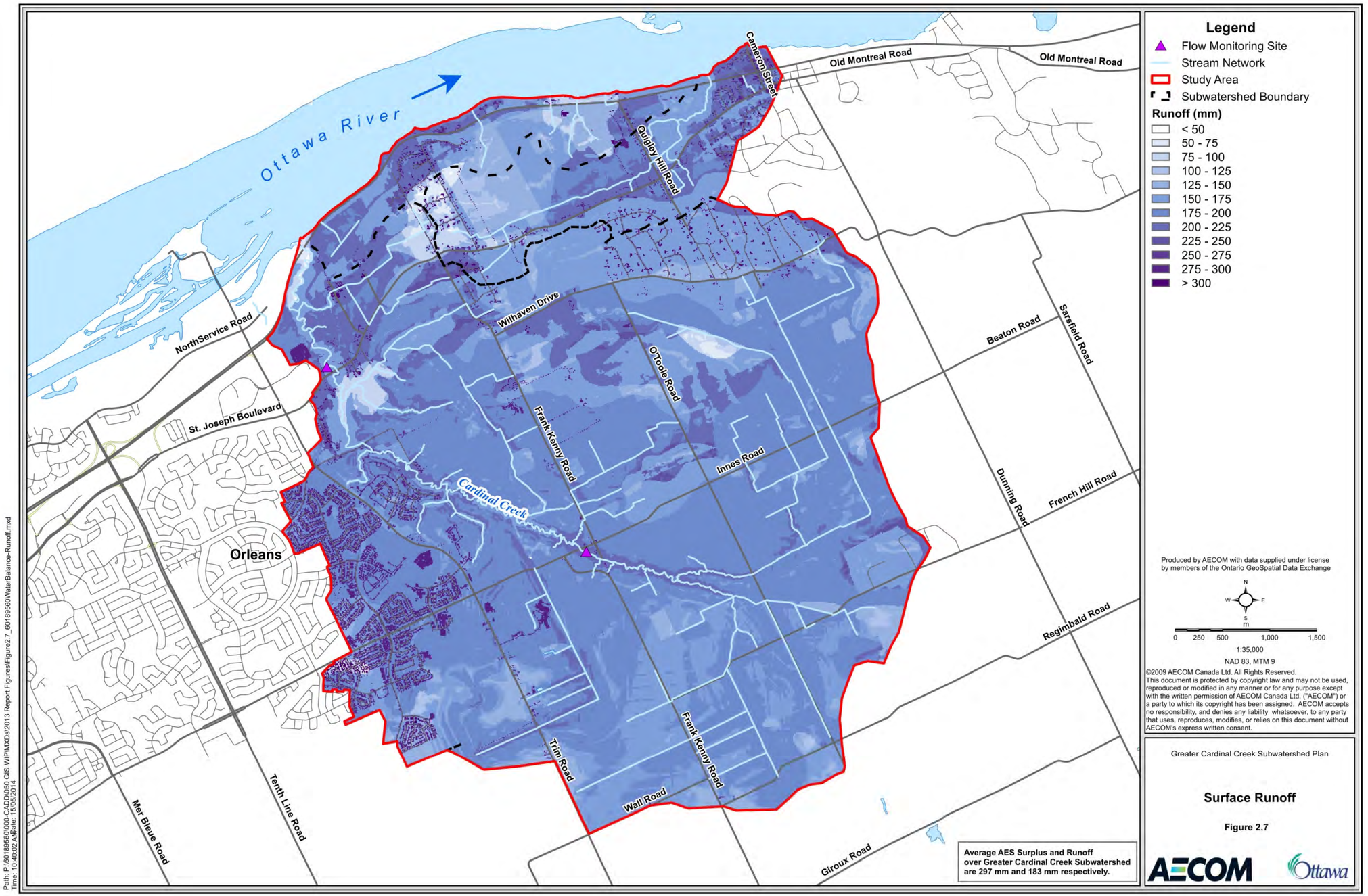
Ottawa River
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Old Montreal Road
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NorthService Road
St. Joseph Boulevard
O'Toole Road
Frank Kenny Road
Innes Road
Beaton Road
Sarsfield Road
Dunning Road
French Hill Road
Cardinal Creek
Orleans
Regimbald Road
Trim Road
Frank Kenny Road
Wall Road
Giroux Road
Mer Bleue Road
Tenth Line Road
Legend
Flow Monitoring Site
Stream Network
Study Area
Subwatershed Boundary
Runoff (mm)
< 50
50 - 75
75 - 100
100 - 125
125 - 150
150 - 175
175 - 200
200 - 225
225 - 250
250 - 275
275 - 300
> 300
Average AES Surplus and Runoff over Greater Cardinal Creek Subwatershed are 297 mm and 183 mm respectively.
Produced by AECOM with data supplied under license by members of the Ontario GeoSpatial Data Exchange
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NAD 83, MTM 9
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Greater Cardinal Creek Subwatershed Plan
Surface Runoff
Figure 2.7
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Ottawa
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2.4.4 Subwatershed Water Budget Update

The information that was produced as part of the source water planning effort by the RVCA enables a fuller understanding of the physical characteristics and hydrology/hydrogeology of the subwatershed. This understanding was used to refine the subwatershed water budget that was developed as part of the *Greater Cardinal Creek Subwatershed Study - Existing Conditions Report (AECOM 2009).* Based on a more in depth understanding of water movement within the subwatershed, the following refinements were incorporated into the original water budget that influences the division of water surplus into the infiltration and runoff components:

- Considerations for source water protection, both on a subwatershed scale and on the scale of the Mississippi-Rideau Source Protection Area. HVA's and SRGA's as determined from source protection planning were added to the features of the Subwatershed. Sensitive Recharge Areas (SRA's) specific to the Subwatershed were also determined.
- The effect that karst and solution enhanced bedrock joints and fractures have on infiltration and recharge rates was more accurately taken into account by raising the infiltration factors on these soils.
- The total annual infiltration rates (in mm/year or m/year) for the subwatershed area (in m^2) were compared against baseflow data of Cardinal Creek (in m^3/s or m^3/yr) collected from the Innes Road and Old Montreal Road stations between 2009 and 2012, to calibrate the infiltration factors. Minor adjustments were made to infiltration factors to better match baseflow values.
- The effect of soil water storage from the various surficial soil types and vegetation conditions was considered, rather than using a single average value for the subwatershed. Given the predominance of marine clay at surface, which has a high soil moisture holding capacity of around 200 to 300 millimetres (mm), using an average value for the watershed is still considered appropriate, but refining the soil moisture storage values to reflect the other soil types as per Environment Canada data provided through the Atmospheric Environment Service (AES) adds a higher degree of accuracy to the results. The resulting spatially varying AES surplus values (water surplus in mm/year) are used for the subsequent water budget analysis.

A summary of the salient points of the water budget prepared for the Subwatershed which takes into account the above note considerations is provided below. The spatial distribution of the annual water surplus, infiltration and runoff components across the subwatershed are graphical presented in ***Figures 2.5, 2.6 and 2.7***:

- Long term precipitation and climate data obtained for the Ottawa Airport CDA Climate Station, which has a period of record that extends over 106 years, gives an average annual precipitation amount of 877 mm – including both rainfall and snow.
- The application of the Thornthwaite and Mather Method in accordance with the Ministry of Environment Stormwater Guidelines yielded an average annual water surplus of 297 mm over the subwatershed, and an accompanying evapotranspiration value of 580 mm. The water surplus and evapotranspiration comprise of 33.9% and 66.1% of the average annual precipitation respectively.
- The outcome of this analysis produced an average depth of 114 mm (13.0 % of total precipitation) for the infiltration component and an average of 183 mm (20.9 %) for the surface runoff component.

2.5 Agricultural Lands

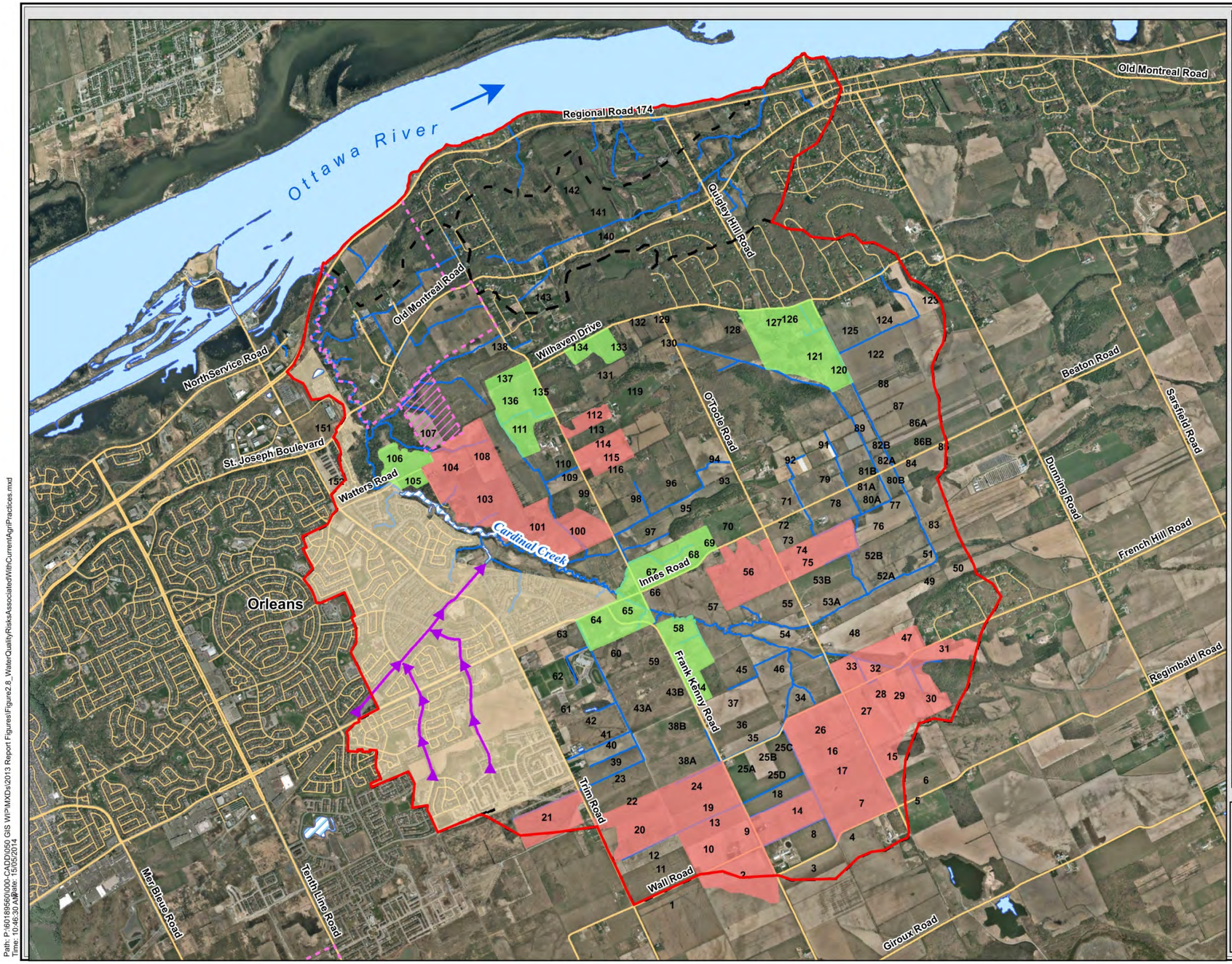
2.5.1 Summary of Field Investigations

In order to update the land use within the subwatershed and obtain further detail on the agricultural uses since the *Greater Cardinal Creek Subwatershed Study - Existing Conditions Report* (AECOM 2009) was published additional field reconnaissance were undertaken in April 2, 2011 and July 15, 2011.

The spring field visit conducted on April 2, 2011 was used to compare the crop grown in 2010 with that grown at the time of the last field reconnaissance conducted in 2008 in support of the *Existing Conditions Report.* The intention was to identify the fields that were growing the same crop, and therefore probably not part of a crop rotation, which was further confirmed as part of the July 15, 2011 field inspection, which also enabled identification of the current year's crops.

The field observations were based on the number of fields, not the actual area in cultivation. As fields are of varying size, the results are representative estimates. In 2008 it was possible to record land use from the roadway for 93% of the farmland fields; in early spring 2011, it was possible to record land use on only 86% of the fields, probably because there was less standing corn, which can be seen at greater distance from the roadway.

The individual fields which were examined are shown in ***Figure 2.8*** (number for the individual field crops), and the crops that were observed during the field reconnaissance in 2008 and 2011 are summarized in ***Table 2.10*** A summary of the notable observations that were made during the field visits are provided in the following.



Legend

- Subwatershed Boundary
- Catchment Boundary
- Urban Area
- Stormwater Management Ponds
- Urban Expansion Study Area (approved development)
- Additional Development Lands
- Storm Trunk Sewer
- Stream Network

Water Quality Risks Associated with Current Agricultural Practices

- Highest Risk - Tilled crops with rotations with no hay in 2008, 2010 & 2011
- Very Low Risk - Hay in 2008, 2010 & 2011

All other Farmland Moderate Risk - Tilled crops with hay in rotation and pasture

123 Agricultural Field ID

Agricultural Watersheds Associates, 2011

Basemapping from Ontario Ministry of Natural Resources

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Greater Cardinal Creek Subwatershed Plan

Subwatershed Management Plan

Water Quality Risks Associated with Current Agricultural Practices

Figure 2.8

AECOM Ottawa

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The field investigations revealed the following distribution of crop cultivation for the 2008 to 2011 period:

Table 2.10 Crop Distribution

Cultivated Crop	Percentage of Use (%)		
	2008	2010 (April 2011)	2011
Field Crop *(corn, soybean, cereal grains)*	50	49	56
Hay	29	36	36
Pasture	7	7	5
Abandoned	14	8	3

As can be noted from the table, in 2008 and 2010 (April 2011 observations), approximately 50% of farmland was in cultivated (tilled) crops. In 2011 this appeared to have increased to about 57%. This may be a reflection of increased commodity prices, leading farmers to plant more corn and soybeans than in previous years. Conversely, the area in hay (including abandoned land) was about the same in 2008 and 2010, approximately 43-44%, but fell to about 39% in 2011. As well, the area that was unused (e.g., hay that did not appear to have been harvested) and/or abandoned, was about 14% in 2008, but only 3% in 2011, supporting the same trend. This excludes one field in 2011 that had been converted to urban use since 2008.

a) Approximately 26% of the farmland appears to be used for *continuous* tilled crops. The absence of any hay crop on these fields in 2008, 2010 and 2011, does not mean it is *continuous* tillage, as no records exist of the crop in 2009. As well, there is a strong possibility that a forage or hay crop could be introduced in 2012 or subsequent years. However, this land is more likely to contribute to water quality problems than other land, because of the more frequent use of fertilizers, pesticides and tillage.

b) It was evident that at least 35% of the cultivated (cropped) land incorporated a forage (hay-based) rotation. A higher level may be practiced, as the observations are only based on a four year period, and hay or other forages may have been grown in 2009, or could be introduced into the rotations of other fields over a longer time-frame. This is a superior rotation to one that only includes tilled field crops, and is therefore of a more moderate risk to surface water quality.

c) In 2008 and 2010, approximately 7% of the farmland in the subwatershed was used for pasture. In the summer of 2011 this usage seemed to have dropped to about 5%. This change may not be significant, but may also reflect any decrease in livestock numbers in the subwatershed. Pasture is usually benign from a water quality perspective, provided that adequate fencing and buffers are maintained near watercourses. It can therefore be considered as having a moderate risk for water quality.

d) Approximately 23% of the farmland appears to be used for continuous hay. This land provides minimal risk to water quality.

e) During the April 2, 2011 field inspection, at least 27 fields, of a total of 70 cultivated (cropped) fields (39%), had been either plowed or heavily tilled during the fall of 2010. This represents approximately 19% of the total farmland in the subwatershed. These fields had limited or no crop residue on the surface to help protect against soil erosion. The remaining fields were either part of a no-till management plan, or had been left for spring tillage. Soil plowed in the fall, left with little or no residue, loses more soil to erosion than soil managed with any other type of tillage system *(Field Crop Production BMPs, OMAFRA, 1993).*

f) The number of fields without crop cover was reduced to only 2 fields (2.4% of cultivated area) during the site visit later in the year. Therefore the lands exposed to potential erosion were dramatically reduced in comparison to that noted in April 2, 2011 – 27 or 39% of the cultivated fields in April, 2011. This is to be expected, and indicates that the use of fallow land in the subwatershed is very low, which is positive in terms of surface water quality.

Cultivation occurring immediately adjacent to the roadway without appropriate buffers as required by BMP criteria.

g) The observations indicate that tractors and/or tillage equipment had been operated right into the ditch. Five of the 27 plowed or tilled fields (19%) had been worked very close to the roadside ditch; and nine of the 70 cultivated (cropped) fields (13%) had been planted close to the roadside ditch. This indicates a complete absence of buffer strips along these ditches. In many other cases, the buffer strips along drains and roadside ditches were so narrow as to be almost absent, with a high risk of surface runoff carrying unfiltered soil particles into the ditches. (*Buffer Strips BMPs, OMAFRA, 2004)*.

h) In addition, if pesticide (herbicide or insecticide) and fertilizer applications are being made in these areas close to open ditches, the risk of surface water contamination is high. One of the easiest ways to protect surface water is to maintain a buffer strip of vegetation between it and the cropped field. Buffer strips reduce the risk of runoff of pesticides into watercourses *(Field Crop Production BMPs, OMAFRA, 1993)*. Buffers along drains should be 10 m if used as a pesticide application setback *(Buffer Strips BMPs, OMAFRA, 2004).* However, in the case of any farmer who is required to have a Nutrient Management Plan (NMP) no materials can be applied within the 3 m vegetated zone *(Buffer Strips BMPs, OMAFRA, 2004).*

Manure pile that is closer to roadside ditch than indicated by BMP criteria.

i) During the April 2011 field, two farms were observed with manure piles in close proximity to open ditches, with a high risk of surface runoff carrying inadequately filtered manure particles and liquids into the ditches. New or expanded permanent manure storage facilities should be located with a flow path that is at least 50 m from the nearest surface water. *(Manure Management BMPs OMAFRA, 2005).*

j) One of the manure piles was removed by the time of the second site visit later in the year – likely spread on the nearby fields.

k) While no livestock were observed accessing streams or ditches, the existing buffer strips between livestock and the stream or ditch are likely inadequate for proper filtering of soil and manure runoff. Narrow buffers for drains and livestock exclusion should have a minimum width of 5 m for most situations *(Buffer Strips BMPs, OMAFRA, 2004).*

Upper end of municipal drain into which cattle have direct access

2.5.2 Water Quality Risks Associated with Current Agricultural Practices

The findings of the field investigations that were conducted enabled as assessment to be made of the potential risk that the current agricultural practices pose to the water quality of the watercourses that form the Cardinal Creek network.

Based on the current cropping practices the individual fields were assigned a low, moderate or high risk rating on the potential of having an adverse effect on the water quality in the receiving watercourses. The results of this analysis are presented in ***Figure 2.8*** and are summarized below. As previously, noted the field observations were based on the number of fields, not the actual area in cultivation. Given that fields vary in size, the results are intended to provide an overview of the general conditions within the subwatershed.

- The area that is in continuous use for hay accounts for approximately 23 % of the farmland and is the preferred usage for water quality considerations as it poses a low to very low risk for potentially adverse effects.
- The continuously tilled crop lands with no hay rotation, which constitute approximately 26% of farmland, represent the highest risk for potential adverse effects on water quality in the local watercourses.
- The remaining 51 % of the farmland generally involves tilled crops with hay in rotation and pasture and is considered to represent a moderate risk for potentially adverse effects to water quality in the local watercourses.

Fenced pasture with inadequate buffer strip that does not meet BMP criteria

2.6 Cardinal Creek Village

On July 17, 2013, Ottawa City Council approved an Official Plan Amendment to bring Urban Expansion Study Area 2 (as identified in the 2009 Comprehensive Official Plan Review, OPA 76), into the urban boundary. Subsequently, in early 2014, the General Manager for Planning and Growth Management approved a draft Plan of Subdivision for the Cardinal Village development, within the newly expanded urban area.

Although draft approval of the Cardinal Village Plan of Subdivision preceded the completion of the Greater Cardinal Creek Subwatershed Management Plan, it is consistent with the plan. In the development, review and approval of the development, both the proponent (Tamarack Homes) and the City (Development Review Services Branch, Policy Development and Urban Design Branch) made extensive use of the Existing Conditions Report, the Hydrological Model, the draft stormwater management guidelines, and other background reports and documentation. The development concept and draft plan of subdivision went through several significant changes as a result of environmental issues identified in the Subwatershed Study. This included a change in the proposed development boundary to exclude and to allow further study of a sensitive groundwater recharge area.

As part of its applications for the Official Plan Amendment and Draft Plan of Subdivision, Tamarack Homes conducted site-specific investigations of the natural heritage system features proposed for identification in the Terrestrial Inventory and the Existing Conditions Report. These investigations were summarized in Tamarack Homes' Environmental Impact Statement and Tree Conservation Report and resulted in a more definitive natural heritage system, as shown in ***Figure 2.9***.

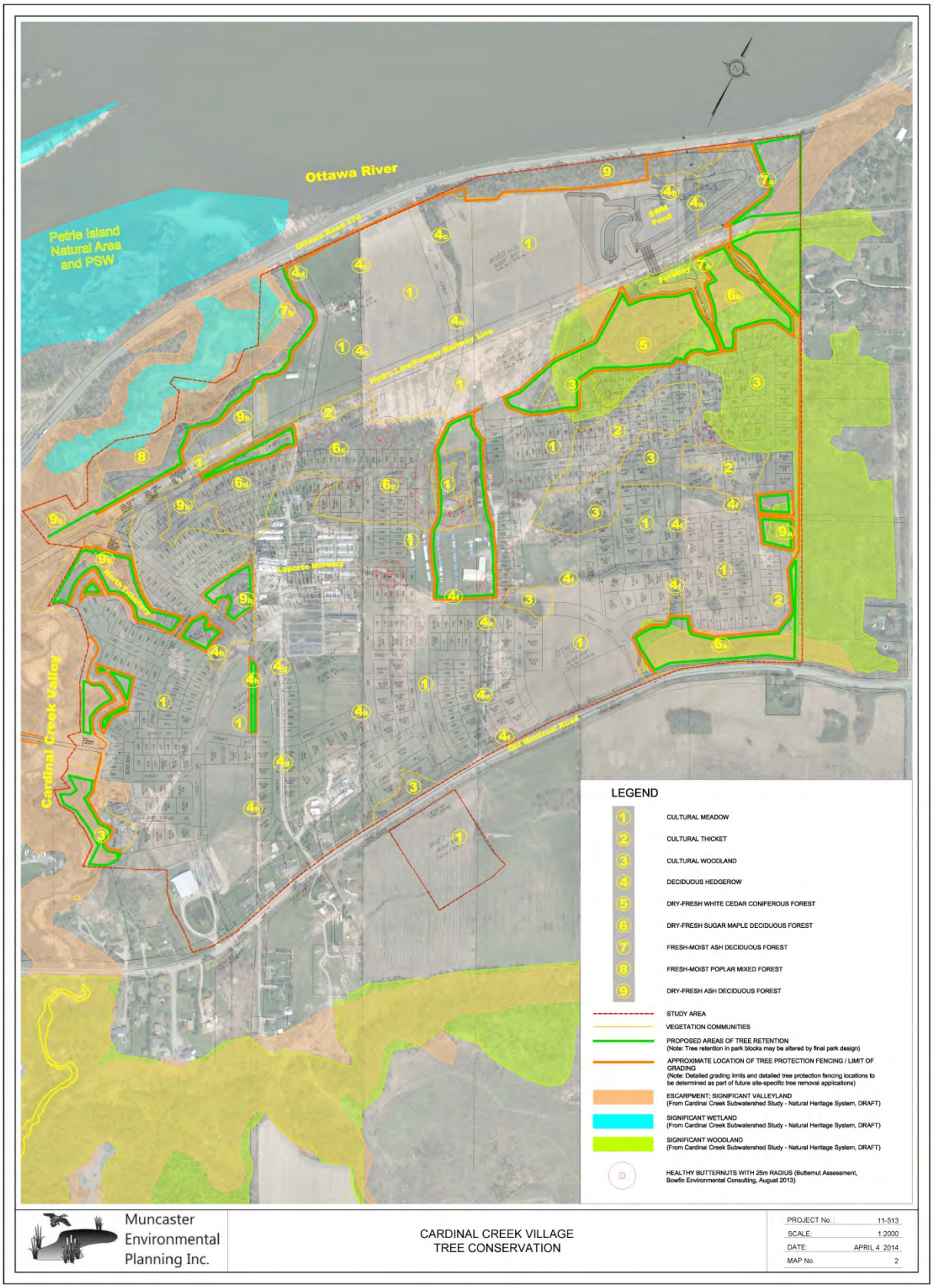


Figure 2.9 Cardinal Creek Village Natural Heritage System

3. Environmental Protection Objectives

3.1 General

The protection of the natural environment, and ensuring public health and safety is a key focus of the provincial, municipal and local levels of government. These principles are enshrined in the policy, guideline and practices documents of planning, regulatory and resource management agencies and departments. The land use and subwatershed planning processes are key mechanisms for achieving goals and objectives aimed at protection of the environmental and the public.

3.2 Province of Ontario (PPS)

At the provincial level, the government issues The Provincial Policy Statement (PPS) which is a statement of policies on land use planning. The intent is to provide direction for the entire province on matters of provincial interest related to land use planning and development, and to promote the provincial *policy-led* planning system. Local municipalities use the PPS to develop their official plans and to make decisions on planning matters. The current Provincial Policy Statement 2014 was issued under Section 3 of the *Planning Act* and comes into effect on May 1, 2014, replacing the previous Provincial Policy Statement 2005 of March 1, 2005.

The Provincial Policy Statement recognizes the complex inter-relationships among economic, environmental and social factors in planning and embodies good planning principles. It provides strong, clear policy direction on land use planning to promote strong communities, a clean and healthy environment and a strong economy (MMAH 2005). The document provides policies on key issues that affect our communities, including the protection of the environment and resources, and to ensure that development is not permitted in areas where site conditions or location may pose a danger to public safety or public health, or may result in property damage.

Specific to this Study are the policies under *Section 2 – Wise Use and Management of Resources,* and *Section* 3 - Protecting *Public health and Safety.* Specifically these policies pertain to *Natural Heritage* (Section 2.1), *Water* (Section 2.2), *Natural Hazards* (Section 3.1) *and Human-made Hazards* (Section 3.2).

The provincial policies pertaining to Natural Heritage, and Water are related to the protection (or enhancement) of the Province's natural resources for the long term, including significant wetlands, endangered and threatened species, woodlands, valleylands, habitats, groundwater and surface water, municipal drinking water sources, and designated vulnerable areas. In addition to a natural heritage system, municipalities are now required to identify a "water resources system" that maintains linkages and related functions among surface water, groundwater and natural features. The PPS 2014 continues to recognize the watershed as the *ecologically meaningful scale for planning*. The provincial policies pertaining to hazards are related to protection of public health and safety by directing development away from areas of natural hazard (i.e., flooding, erosion, dynamic beach areas, hazardous sites, etc.) and human-made hazards (i.e., mines, hazards; oil, gas and salt hazards; former mineral aggregate operations etc.).

3.3 City of Ottawa Official Plan

The Official Plan for the City of Ottawa was adopted in 2003, and updated through comprehensive reviews in 2009 and 2014. It provides a vision for the future growth of the City and a policy framework to guide its physical development to the year 2021. The document addresses matters of provincial interest defined by the Provincial

Policy Statement (PPS) under the Ontario Planning Act, and serves as a basis for a wide range of municipal activities (City of Ottawa, 2003).

The Official Plan forms one of the five-growth management plans that were developed to provide long-term strategic direction and form a comprehensive blueprint for the City of Ottawa and its communities. The growth plans were developed on the basis of seven guiding principles to ensure the City grows and evolves to meet the needs of its citizens, which are addressed by the Official Plan from a land use and community design perspective. The need to recognize and integrate the natural environment into the character of the City is identified by the principle entitled Green and Environmentally Sensitive City, which is addressed within the Official Plan by adherence to the following points.

- Planning on the basis of natural systems to protect and enhance natural processes and ecological functions (e.g., watershed planning, groundwater and surface water protection and greenspace polices).
- Policies are provided to protect natural diversity (e.g., urban and rural woodlands, wetlands, and wildlife habitat).
- Natural resources are designated and protected (e.g., agricultural land, minerals, and natural environment areas).
- Soil contamination is identified and addressed.

Section 2.4 of the Official Plan, entitled *Maintaining Environmental Integrity*, expresses the City's commitment to the integration of environmental stewardship into the land use decisions. The environment is recognize as consisting of the collection of support systems that make the lives of humans and other species possible, and extends beyond the tangible elements of earth, air, water and energy, to include the processes that maintain these elements and the interactions that occur among them.

In addition, policy statements in this section also include the City's intentions to undertake the required environmental studies in partnership with the Conservation Authorities and neighbouring municipalities in recognition that the municipalities share the same natural systems and impact those systems.

Subsection 2.4.3 outlines the City's reliance on watershed and subwatershed plans as the basis for achieving an integrated, ecosystem approach to land use planning based on the boundaries of a watershed/subwatershed. The over-arching goal of watershed/subwatershed plans is integrate environmental protection, conservation and restoration within land use practices and development to ensure the long-health health of the environment. The preparation of these plans includes the investigation of natural features and function of the watershed/subwatershed, such as, the river and stream system, groundwater resources and recharge areas, wetland areas, and terrestrial and aquatic habitats in order to:

- Document the existing condition of the natural systems within the watershed/subwatershed.
- Identify the significant woodlands, wetlands, wildlife habitat, and significant features and linkages within the watershed that need to be protected, along with surface and groundwater features.
- Assess the potential impacts of existing and future land use activities, including cumulative effects, and recommend measures to avoid or mitigate the identified potential effects.
- Identify opportunities to restore and enhance the natural system and promote compatible uses.
- Prepare an implementation strategy and agency responsibilities in this regard.

Subsections 2.4.1 to 2.4.5 also define other elements of the environment, describes their important and significance, and outlines specific policies aimed at their responsible use and protection through conservation and sustainable

practices. The elements of the natural environment that are discussed include: air quality and climate change; natural features and functions; groundwater management; and greenspaces.

3.4 Rideau Valley Conservation Authority

The Greater Cardinal Creek Subwatershed is located within the jurisdictional area of the Rideau Valley Conservation Authority (RVCA).

The RVCA partners with municipal, provincial and federal governments, and co-operates with landowners and interested local groups to undertake environmental protection programs that will leave a healthy and sustainable environment for future generations

The RVCA goals in regard to environmental protection and hazard policies to protect public safety and property include:

- Ensure that development is not permitted in areas where site conditions or location may pose a danger to public safety or public health, or result in property damage; and to encourage a co-ordinated approach to the use of land and the management of water in areas subject to flooding in order to minimize social disruption.
- Protect the quality and integrity of ecosystems, including air, water, land and biota.
- Encourage restoration or remediation to healthy conditions where quality and integrity have been diminished.

As part of the efforts to achieve these goals, the RVCA reviews development proposals (Municipal Planning) within the context of Sections 2.1 Natural Heritage, 2.2 Water and 3.1 Natural Hazards of the *Provincial Policy Statement* (PPS) under Section 3 of the *Planning Act*. They also regulate construction in environmentally sensitive areas such as wetlands, shorelines and waterways, and areas vulnerable natural hazard including erosion, flooding and unstable slopes (Ontario Regulation 174/06 — Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation).

Watershed/subwatershed based planning is a key planning approach that is advocated by the RVCA, who actively leads/participates on efforts in this regard. In 2005, the *Lower Rideau Watershed Study* report was published which involved a multi-agency effort led by the RVCA, which exemplifies the holistic view that is at the core of the watershed based planning approach. Some of the key environmental concerns and management approaches that were identified as part of that study have relevance for the Greater Cardinal Creek Subwatershed.

As noted in ***Section 2.2.2*** of this document, the RVCA is currently in the process of preparing Generic Regulations Limits (Mapping) along Cardinal Creek from the Ottawa River to O'Toole Road for the purposes of administering Ontario Regulation 174/06. Once completed this information serve a key role in the planning and other regulations programs and other watershed management activities that are conducted by RVCA.

3.5 Greater Cardinal Creek Subwatershed (the Subwatershed)

The following goals and objectives were developed for the Subwatershed Management Plan based on discussion with the City, input from the RVCA, and the recommendations of the Lower Rideau Watershed Study. They have been further refined to reflect the specific ecosystem features and characteristics of the local area, and are discussed in the following:

Goal	**1.0**	**To ensure the safety of subwatershed residents, users, property and natural resources with respect to natural hazards, such as flooding and erosion and human-mad hazards, such as contaminated sites.**
Objectives	1.1	Identify existing floodplain and erosion (i.e., unstable slopes) hazards, and incorporate appropriate land use designation and comprehensive zoning by-laws for prohibiting development within or adjacent to defined hazards.
	1.2	Identify existing flood and erosion problems (i.e., flood susceptible sites, undersized culverts, bank instability, etc.) and identify remedial works to reduce/eliminate the associated hazard.
	1.3	Promote land and water conservation through urban and rural management practices directed at reducing peak flows, minimizing soil and streambank erosion, and maintaining streamside vegetation.
	1.4	Incorporate stormwater management practices (SWMPs) for all new and existing development such that the quantity of runoff from urban areas is controlled to an appropriate level that does not increase the frequency, extent and duration of flooding and/or erosive conditions.
	1.5	Identify human-made hazards, such as contaminated lands, dumping sites and closed landfills and carry out remedial works to reduce/eliminate the associated hazard.
Goal	**2.0**	**To protect, maintain and enhance the fishery and associated aquatic communities (including benthic invertebrates) within the watercourse in the Greater Cardinal Creek Subwatershed.**
Objectives	2.1	Recognize and protect fish and fish habitat from development using appropriate land use designations, comprehensive zoning by-laws and restoration/rehabilitation initiatives.
	2.2	Maintain and improve water quality in the watercourses within the Greater Cardinal Creek Subwatershed through the application of appropriate management practices (e.g., urban stormwater management, agricultural/rural best management practices etc.) and municipal initiatives.
	2.3	Maintain, restore and enhance a natural vegetative canopy and riparian plantings within the Cardinal Creek subwatershed to provide temperature mitigation, food sources, and habitat.
	2.4	Maintain fish passage for mobile species by removing barriers that impede or restrict fish movement.
	2.5	Consider creation, restoration or enhancement of fish habitats (e.g., natural channel design, artificial wetland construction) as part of new land development (including infills) and/or municipal initiatives.
	2.6	Conduct fisheries, benthic invertebrate and habitat surveys to monitor the populations and species diversity of fish and aquatic communities at periodic intervals.
Goal	**3.0**	**To protect, maintain, and enhance the significant natural terrestrial features (land forest and wildlife) and ecological functions in the Subwatershed.**

Objectives

3.1 Protect significant natural features such as valleylands, woodlands, and stream corridors from inappropriate development using land use designations and comprehensive zoning by-laws.

3.2 Ensure that significant natural features are protected from the adverse impacts of development by recognizing adjacent land and the need for Environmental Impact Studies prior to disturbance.

3.3 Promote recognition that long-term balance of land uses and ecological functions would call for about 30% forest canopy cover.

3.4 Identify, maintain and enhance appropriate land management and linkages between natural areas (e.g., corridors that connect ravines and woodlands) using appropriate land use designations, comprehensive zoning, reforestation initiatives and good forestry practices.

3.5 Maintain and enhance significant subwatershed functions such as groundwater recharge/discharge, and wetland/valley storage.

3.6 Incorporate measures in development plans aimed at maintaining the existing natural water budget within the Subwatershed.

4. Recommended Management Strategies

4.1 General

The technical assessments completed in Phase 1 of the subwatershed Study and the updates included in this Sections 2, 3 and 4 of this document provide information on potential hazards and impacts to natural systems if land development and drainage is not managed properly. This information has been used to develop the following recommended management strategies.

4.2 Hazard Land Management

4.2.1 General

Risks to life and property have been identified as hazards in the technical assessments. The following management actions have been developed to mitigate those risks.

4.2.2 Stormwater Management

Management Action 1 – City to incorporate into applicable municipal planning and approval documents stormwater management design criteria as outlined in **Table 4.1** below.

Table 4.1 Stormwater Management Design Criteria

City Policies		GCCSMP Design Criteria	Additional Requirements
Water Quantity			
1. Objective: Reduce flood risk to public health and safety and to property.			
Greenfield Areas	Implement stormwater management measures, as required, that will ensure no increase in the regulatory flood elevation resulting from changes in land use.	i) *SWM Discharge to Cardinal Creek Tributaries & RV35* – Control post development peak flows to pre-development levels for all storms up to and including the 100 year storm (i.e., 2, 5, 10, 25, 50 and 100 year storms). ii) *SWM Discharge to Main Branch of Cardinal Creek (upstream of CCOM Pond)* – Control post development peak flows to pre-development levels for all storms up to and including the 100 year storm (i.e., 2, 5, 10, 25, 50 and 100 year storms). iii) *SWM Discharge to Main Branch of Cardinal Creek*	• Ensure consistency with City of Ottawa Sewer Design Guidelines and the MOE Stormwater Management Planning and Design Manual (2003). • Refer to attached ***Table 1*** and ***Figure 2.1*** for peak flow targets and locations. • Existing peak flow targets for RV35 to be determined by proponent. • The hydrology model (XPSWMM) developed as part of the Greater Cardinal

City Policies		GCCSMP Design Criteria	Additional Requirements
		(downstream of CCOM Pond) – No flood flow control requirements subject to confirmation that future peak flows do not negatively impact ,or reduce the level of service, of existing downstream infrastructure (e.g., road crossings). iv) *SWM Discharge to* Ottawa *River* – no flood flow control requirements.	Creek Subwatershed Management Plan must be updated to reflect proposed land use conditions and appropriate simulations completed to confirm that the existing flows presented in ***Table 1*** remain unchanged.
Infill & Redevelopment Areas	Allow infill and redevelopment while not exceeding the capacity of existing stormwater/storm drainage infrastructure.	Control post development peak flows to capacity of downstream stormwater / storm drainage infrastructure for all storms up to and including the 100 year storm (i.e., 2, 5, 10, 25, 50 and 100 year storms).	• Ensure compliance with City of Ottawa Sewer Design Guidelines and the MOE Stormwater Management Planning and Design Manual (2003).
All Areas	Prohibit development in natural hazard areas.	i) Prohibit development within natural hazard areas (i.e., Provincial Policy Statement (PPS)). ii) New development adjacent to natural hazard areas will require additional studies to confirm development limits and associated set-back requirements. ii) Locate SWM facilities outside natural hazard areas. iv) Minimize crossing of infrastructure within natural hazard areas through strategic planning and design (i.e., roads, utilities, etc.).	• Ensure compliance with City of Ottawa Sewer Design, Slope Stability, EIS Guidelines, and watercourse set-backs established as part of Greater Cardinal Creek Subwatershed Management Plan. • Detailed studies may include: floodplain analysis, geotechnical / slope stability analysis, fluvial geomorphological assessment and EIS. • Additional studies will be required to confirm existing natural hazard areas within RV35.
Water Quantity			
2. Objective: Reduce erosion impacts that are detrimental to property and stream habitat.			
Greenfield Areas	1) Delineate the limits of stream corridors to incorporate geotechnical and natural hazards, and ecological and fluvial geomorphological concerns.	i) Prohibit development within natural hazard areas , (i.e., PPS). ii) New development adjacent to natural hazard areas will require additional studies to confirm development limits and associated set-back requirements. iii) Locate SWM facilities outside natural hazard areas. iv) Minimize crossing of infrastructure within natural hazard areas through strategic planning and design (i.e., roads, utilities, etc.). v) Prohibit the direct discharge of storm drainage (i.e., minor/major system) along valley slopes. vi) Design storm outfalls to reduce erosive velocities and	• Ensure compliance with City of Ottawa Sewer Design, Slope Stability, EIS Guidelines, and watercourse set-backs established as part of Greater Cardinal Creek Subwatershed Management Plan. • Detailed studies may include: floodplain analysis, geotechnical / slope stability analysis, fluvial geomorphological assessment and EIS. • Additional studies will be required to confirm existing natural hazard areas within RV35.

City Policies		GCCSMP Design Criteria	Additional Requirements
		include appropriate erosion protection.	
	2) Implement stormwater management measures to mitigate the impacts of urban runoff on existing erosion rates.	i) *SWM Discharge to Cardinal Creek Tributaries & RV35* –A detailed fluvial geomorphic study will be required to determine erosion thresholds and associated extended detention requirements for frequent flow (erosion) control. ii) *SWM Discharge to Main Branch of Cardinal Creek (upstream & downstream of CCOM)* – A detailed fluvial geomorphic study will be required to determine erosion thresholds and associated extended detention requirements for frequent flow (erosion) control. iii) *SWM Discharge to Ottawa River* – No frequent flow (erosion) control required.	• Detailed erosion assessment to be completed using an approved continuous simulation hydrologic model.
Infill & Redevelopment Areas	1) Remediate erosion threats to public safety, infrastructure, and private and public property.	i) Carry out slope remediation at identified Priority 1 and 2 areas in accordance with GCCSP recommendations. ii) Implement monitoring program for identified Priority 3 areas in accordance with GCCSP recommendations.	• Ensure compliance with City of Ottawa Slope Stability Guidelines. • City led initiative.
	2) Incorporate habitat improvements to the extent possible when implementing erosion protection works.	At locations where erosion control works are being implemented, restoration works in the vicinity of the site should also be undertaken concurrently where opportunities have been identified.	
Water Quantity			
3. Objective: Preserve and/or re-establish a more natural hydrologic cycle.			
Greenfield Areas	Implement stormwater management measures that minimize or eliminate runoff from frequent events.	i) Existing infiltration rates and distribution that have been established based on a water budget assessment of the development area must be maintained. ii) Implement non-structural and structural Best Management Practices (BMPs) to meet above criteria.	• At a minimum, field investigations and monitoring should be conducted to confirm the extent and distribution of the infiltration rates within the *Sensitive Infiltration Areas (SIAs*) that have been established as part of the Greater Cardinal Creek Subwatershed Management Plan. • Detailed water budget assessment will be required to confirm site level infiltration strategy meets the design criteria.
Infill & Redevelopment Areas	Promote and implement retrofit stormwater management measures to reduce the volume	i) To the extent possible, provide for on-site retention of the first 5 mm of all rainfall events. ii) Implement non-structural and structural Best	

City Policies		GCCSMP Design Criteria	Additional Requirements
	of runoff to urban streams.	Management Practices (BMPs) to meet above infiltration/retention criteria.	
Water Quality			
1. Objective: Reduce the impact of non-point source runoff on receiving watercourses.			
Greenfield Areas	Implement stormwater management measures to improve the quality of runoff to acceptable levels.	i) Enhanced (Level 1) water quality treatment required for all storm runoff. ii) Existing infiltration rates and distribution that have been established based on a water budget assessment of the development area must be maintained. iii) Implement non-structural and structural BMPs to meet above criteria. iv) Preparation of detailed erosion & sediment control (ESC) plans required for all development areas. v) All ESC measures to be inspected and maintained until construction complete and upstream area stabilized.	• Ensure compliance with City of Ottawa Sewer Design Guideline. • Refer to SWMP Table 3.2 (MOE, March 2003) for water quality sizing requirements. • Refer to Erosion & Sediment Control Guideline for Urban Construction (GOGH CAs Dec 2006). • Refer to City of Ottawa Erosion & Sediment Control Guidelines for Construction Sites.
Infill & Redevelopment Areas	Promote and implement retrofit stormwater management measures to improve the quality of runoff from areas that developed without stormwater treatment.	i) Enhanced (Level 1) water quality treatment required for all storm runoff. ii) To the extent possible, provide for on-site retention of the first 5 mm of all rainfall events (ie, first flush). iii) Implement non-structural and structural BMPs to meet above criteria. iv) Preparation of detailed erosion & sediment control (ESC) plans required for all development areas. v) All ESC measures to be inspected and maintained until construction complete and upstream area stabilized.	• Ensure compliance with City of Ottawa Sewer Design Guideline. • Refer to SWMP Table 3.2 (MOE, March 2003) for water quality sizing requirements. • Refer to Erosion & Sediment Control Guideline for Urban Construction (GGHA CAs Dec 2006). • Refer to City of Ottawa Erosion & Sediment Control Guidelines for Construction Sites.
2. Objective: Eliminate contaminants originating from point sources.			
All Areas	Prevent the release of contaminants from point sources through the development approvals process.	Additional spills control required for higher risk land uses (i.e., gas stations, industrial, processing etc.).	• Ensure compliance with City of Ottawa Sewer Design Guideline.
Infill & Redevelopment Areas	Identify and eliminate the release of contaminants from point sources.	Retrofit higher risk land uses with additional spills control measures (i.e., gas stations, industrial, processing, etc.).	• Ensure compliance with City of Ottawa Sewer Design Guideline.

City Policies		GCCSMP Design Criteria	Additional Requirements
Valley and Stream Corridors			
1. Objective: Protect, enhance or rehabilitate natural features and functions of valley and stream corridors.			
Greenfield Areas	1) Implement stormwater management/drainage servicing solutions that do not impact natural features identified for protection.	i) No new development within the existing Natural Heritage System (NHS) areas (PPS). ii) Limit proposed infrastructure crossings within NHS areas (i.e., roads, utilities) through strategic planning. iii) Additional studies required for development adjacent to NHS areas to determine development limits and appropriate set-back requirements. iv) SWM facilities to be located outside of the boundaries of the Natural Heritage System (NHS). v) Prevent direct discharge of untreated storm runoff from the minor drainage system to NHS areas.	• Ensure compliance with City of Ottawa EIS Guidelines.
	2) Identify and promote the preservation of low order and/or headwater streams.	i) Prohibit development within identified stream corridor set-backs. ii) Maintain existing drainage patterns to the extent possible. iii) Maintain existing infiltration rates.	• Ensure compliance with City of Ottawa Sewer Design, Slope Stability, EIS Guidelines and watercourse set-backs established as part of Greater Cardinal Creek Subwatershed Management Plan.
	3) Promote the rehabilitation of degraded streams in combination with the implementation of stormwater management to maximize benefits to servicing solutions and habitat improvement.	i) Implement non-structural and structural BMPs to site land use and maintain existing drainage patterns. ii) At locations where erosion control or similar works are being implemented, available and approved restoration works for the same site should also be installed concurrently.	• Ensure compliance with City of Ottawa Sewer Design and EIS Guidelines.
	4) Acquire valley and stream corridors dedicated through the development approvals process.	All valley and stream corridors are to be dedicated to the City through the development approvals process.	
Infill & Redevelopment Areas	Incorporate habitat improvement works in conjunction with the implementation of erosion and/or flood protection works.	At locations where erosion control or similar works are being implemented, available and approved restoration works for the same site should also be installed concurrently.	

4.2.3 RVCA Regulation Mapping

Management Action 1 – RVCA Regulated Areas Mapping

- RVCA to complete Generic Regulation Mapping initiative in order that future development activities can be regulated within identified hazard lands. City to incorporate into applicable municipal planning and approval documents.

4.2.4 Slope Stability Strategy

Management Action 1 – Priority 1 sites

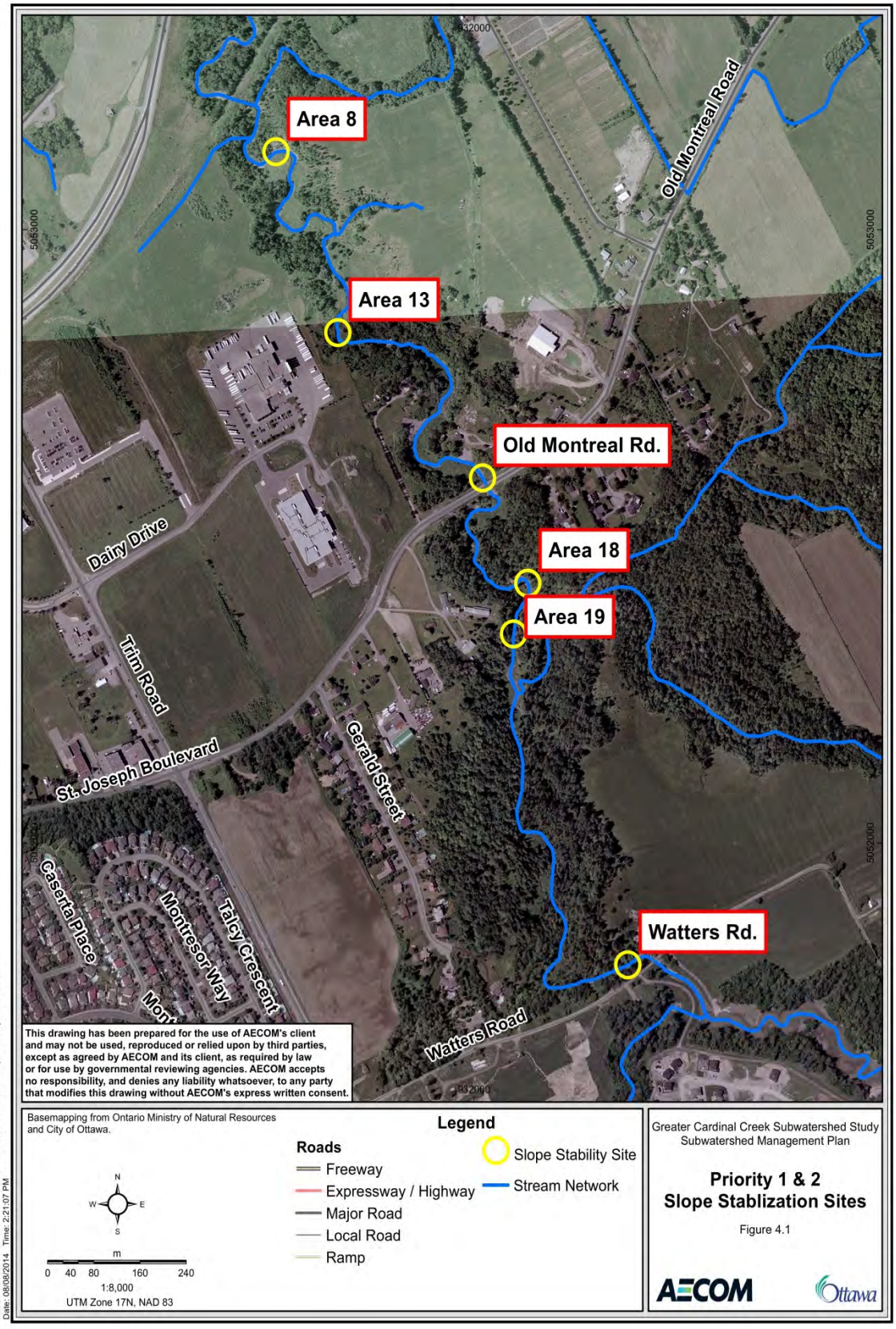
- Undertake detailed design and implementation of recommended slope stabilization works at Priority 1 Sites located at Old Montreal Road and Watters Road as shown on ***Figure 4.1***.

Management Action 2 – Priority 2 sites

- Undertake detailed design and implementation of slope stabilization works at identified Priority 2 Sites as shown on ***Figure 4.1***.

Management Action 3 – Monitoring

- Establish monitoring program for remaining Priority 2, Priority 3, and Priority 4 sites, as per the subwatershed monitoring strategy outline in Section 4.6.1.3.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Old Montreal Rd.
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Area 19
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Dairy Drive
Trim Road
St. Joseph Boulevard
Gerald Street
Casarta Place
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Greater Cardinal Creek Subwatershed Study
Subwatershed Management Plan
Priority 1 & 2
Slope Stablization Sites
Figure 4.1
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4.3 Natural Heritage System

4.3.1 General

The Natural Heritage System in the north portion of the subwatershed has greater functionality and supports higher biodiversity than elsewhere because of the higher amount of forest cover including some interior habitat and the close proximity of natural units that enable wildlife to move between blocks of habitat. If this amount of habitat can be retained, there are good possibilities to retain the current level of biodiversity and function.

The southern portion on the other hand, is already seriously compromised because of intensive agriculture, small percentage of forest cover, very limited terrestrial linkages and minimal riparian cover associated with watercourses. Much of the native biodiversity is already lost and restoring it will be challenging. Improving the linkages and amount of habitat are needed for this area to function as part of the system.

4.3.2 Stressors on the Natural Heritage System

The most significant future threat to maintaining the environmental functions and the current level of biodiversity is the ongoing development pressure. However, urban growth also presents an opportunity to protect or enhance the environment by having policies in place to direct development applications to incorporate natural linkages, and naturalized buffers to existing natural features.

Urban growth is accompanied by the demand for new roads that will further bisect the fragmented linkages. Each road crossing of a natural link creates an additional barrier and increases the potential risk for wildlife mortality from vehicle collisions. Each road crossing of natural features also creates disturbance and edge effect to the vegetation, and is a conduit for the spread of invasive plant species.

Specific natural heritage issues that require particular attention are as follows:

- Lack of protection for existing natural features, especially tableland woodlots.
- Potential for residential development in existing woodlots.
- Minimal riparian cover associated with the main Cardinal Creek channel south of Innes Road.
- Lack of natural linkage with core areas of habitat beyond the Subwatershed, especially to the south.

Some of the features that offer opportunities for enhancement are:

- Drainage features such as streams and even channelized intermittent streams can serve as a starting point for establishing continuous corridors.
- Cardinal Creek itself is a natural aquatic link that extends from the south limit of the subwatershed to the Ottawa River.
- Remnant continuous hedgerows along the Wishbourne Road allowance are also associated with a permanent channel and therefore form a good nucleus for a future habitat link between minor core areas.
- Woodlots that have experienced internal changes to accommodate estate residential development, although fragmented, retain the overall forest configuration and still retain some of the forest functions.

4.3.3 Management Strategy

Development is anticipated in portions of the Subwatershed, particularly within the urban boundary and the approved Cardinal Creek Village. Section 4.7 of the City's OP provides development policies that are intended to protect the Natural Heritage System. Accordingly, all land development activities should be conducted in a manner that supports/improves the natural features and their attendant functions. Appropriate measures should be incorporated into the management and control systems during the planning and design phases that are aimed at the protection/improvement of the following environmental features/functions.

- Increasing forest cover across the City.
- Maintaining and improving water quality.
- Maintaining base flows and reducing peak flows in surface water.
- Protecting and improving the habitat for fish and wildlife in stream corridors.
- Protecting springs, recharge areas, headwater wetlands, watercourses and other hydrological areas.
- Managing resources by using low-maintenance, natural solutions.

Management Action 1 – Policies

- The Natural Heritage System as identified in ***Section 2.3*** of this Plan should be included into the Official Plan document together with appropriate policies to ensure its protection and improvement where possible. Measures that should be taken in regard to protection/improvement include the following.
    - Maintain the current natural vegetation cover of the subwatershed.
    - Prevent any further loss or intrusion into component features.
    - Prevent any further fragmentation of linkages.
    - Prevent, and/or minimize, road crossings through linkages, particularly where there are watercourses.
    - Maintain or strengthen (i.e., widen) natural linkages that are bisected by roads. Although wildlife mortality is likely at these locations, some wildlife will still successfully move through, particularly late at night when there is minimal traffic.
    - Preserve smaller isolated woodlots where possible, if they are within new development applications
    - Where natural features abut rear yards, appropriate fencing should be installed to prevent incremental intrusion.
    - Incorporate natural features into municipal parks where feasible.
    - Use conservation easements to protect natural features on private lands.
    - Retain hedgerows in their entirety where possible. Priority should be given to retaining mature trees or tree clusters where it is not possible to retain entire hedgerows.
    - Endure naturalized or restored buffers are provided to natural features.
    - Incorporate wildlife crossing passages under Regional Road 174 in the vicinity of Cardinal Creek during any future modification of the highway or reconstruction of the existing culvert crossing.
    - Assess and evaluate opportunities for terrestrial natural habitat restoration within the context of the broader municipal natural heritage system strategy.
    - Promote existing incentive programs for landowner conservation actions: e.g., Conservation Land Tax Incentive Program, Ecogifts Program etc.

Management Action 2 – Development Review

- All new development applications must be supported by (but not limited to) the following studies/activities and shall address all requirements of the Official Plan policies.
    - Preparation of an Environmental Impact Statement on the potential effects on the NHS or on adjacent lands (Section 2.3.2), or to designated Significant Wetlands, Natural Environment Areas, Urban Natural Features and Rural Natural Features (Sections 2.3.4). The Environmental Impact Statement (EIS) will be required for any proposed development within 120 m of any features of the Natural Heritage System, which is consistent with Section 4.7.8 Policy 8 of the City of Ottawa OP. The requirements for completing an EIS are articulated in Section 4.7.8, Policy 11. It is anticipated that typically the EIS will recommend that development should be precluded within the Natural Heritage Features.
    - A screening for Karst features by a qualified person, and a more detailed assessment of hazards and hydrogeology where identified.
    - Tree Conservation Report for all plans of subdivision, plans of condominiums, and site plans
    - Appropriate setback from rivers, lakes, streams and other surface and water features adjacent to rivers, lakes, streams, and other surface water features, using the the CVC/TRCA Headwater Drainage Feature Guidelines (2013) and the Ecological Buffer Guidelines (Beacon Environmental 2012)
    - Preparation of a detailed erosion and sediment control plan for each phase of development proposals.
    - Appropriate assessment of the project under the Fisheries Act for potential for serious harm to fish, any associated review by the Department of Fisheries and Oceans, and details of any measures to avoid harm.
    - Any necessary permits from other agencies, especially permits under the Rideau Valley Conservation Authority regulations (Ontario Regulation 174/06).
    - Water balance studies to assess the potential reduction in infiltration rates and volumes, the potential effects on area watercourses and dependent features, and the appropriate management and mitigation measures to be implemented.
    - Comprehensive stormwater site management plans supported by detailed comprehensive modelling that is consistent with the methodologies presented in ***Section 2.2*** of this document.

Management Action 3 – Environmental setbacks and buffers should be identified and incorporated into the City's Official Plan document as follows.

- The RVCA is currently in the final phase of preparing *Flood and Generic Regulation Limits Mapping for Cardinal Creek* from Ottawa River to O'Toole Road, for the purposes of administering Ontario Regulation 174/06. The mapping will provide a regulatory basis for the main branch of Cardinal Creek based on a number of factors including flooding, erosion and steep slopes hazards. Following completion, the mapping and supporting policies should be included in the City's OP.
- The watercourse setbacks as identified in ***Section 2.3.2*** of this plan.
- Development setbacks should also be established from other Natural Heritage Features identified in ***Section 2.3.4*** and shown on ***Figure 2.4*** for inclusion in the City's OP. In particular the woodland features that relate to Escarpment, Natural Linkage and Significant Woodland will require setbacks that maintain the integrity of these features. Setbacks or naturalized buffers help protect woodlands by preventing edge effects from development which might otherwise cause stress to woody vegetation as well as promote the spread of invasive plant species that would compromise the biodiversity in the natural heritage system. In

addition to protecting the edge of tree crowns, setbacks protect the tree roots which may extend considerably out from the dripline of mature forests.

- A minimum setback of 15 m from the dripline of forest features is recommended to protect the natural integrity.

Management Action 4 – The City should pursue the following restoration opportunities within the Subwatershed.

- Natural restoration in buffers can enhance the effectiveness of narrow linkages such as the Wishbourne Road allowance and upper Cardinal Creek. It is important that suitable locally indigenous plant species that are suitable to the soil type are selected for restoration projects. Natural succession can also be a good option for naturalizing setbacks, particularly where there is an adjacent natural area that can provide a native seed source of propagules. Allowing succession to take its course may lead to dominance by non-native plant species; therefore monitoring and early employment of corrective action will help ensure a desirable complement of native species.
- The areas in ***Figure 2.4*** that have been identified as significant grassland have the potential to be restored or managed as grassland habitat. Grassland occurs in an early successional stage that requires some periodic disturbance such as fire or mowing. Without disturbance grassland will succeed to shrub thicket and eventually forest. A number of wildlife species including many birds and butterflies are dependent on grassland habitat; therefore its presence contributes to the biodiversity of the subwatershed. Ideally the significant grassland could be managed as a mosaic so that several stages of grassland and shrubland are always present. Implementation of this management action will require agreement and cooperation from the landowners, and partnership with an organization willing and able to carry out the necessary habitat management.

4.4 Groundwater Quality and Quantity Management

4.4.1 General

Identification and protection of groundwater resources is a requirement of the Provincial Policy Statement and the Official Plan. It is also a focus and objective of the *Mississippi-Rideau Source Protection Plan* (RVCA, 2013). Groundwater resources not only provide the primary drinking water supply in rural areas, but also maintain baseflows in streams and rivers, supporting fisheries and aquatic habitat. Groundwater discharge areas, such as seeps and springs, also provide significant habitat for plants and animals.

The following set of groundwater management actions have been developed.

4.4.2 Groundwater Quantity

Management Action 1 - Restrict development and site alteration within and adjacent to important groundwater features present within the Subwatershed.

- Important groundwater features include, but are not limited to: seepage areas, springs, and groundwater fed streams.
- Development and site alteration adjacent to important groundwater features must maintain a minimum undeveloped 30 m buffer to protect groundwater quantity.

Management Action 2 - Restrict development and site alteration within and adjacent to Sensitive Recharge Areas (SRAs) to maintain groundwater recharge rates within the Subwatershed.

- Groundwater recharge rates should be maintained at pre-development rates in SRAs.
- Development and site alteration within a SRA and within 120 m of a SRA is restricted unless a water budget and hydrogeological evaluation is undertaken that demonstrates that:
    - Groundwater recharge rates and volumes will be maintained or enhanced post development through on-site mitigation efforts;
    - Groundwater discharge or the groundwater flow regime that supports natural environmental functions will not be affected; and
    - Best management practices related to groundwater recharge and stormwater management in urban areas are utilized, including the use of Low Impact Development (LID).

Management Action 3 - Encourage development to implement practices to manage rainfall and infiltration 'on-site' before it enters a storm sewer.

- Implement a hierarchy of practices to maintain or enhance groundwater recharge, starting with 'on-site', then 'conveyance', and lastly 'end of pipe' solutions, with priority given to on-site solutions.
- The use of LID stormwater techniques is recommended.
- Development proposals should limit impervious area and consider the placement of pervious surfaces such as park, schools and open spaced to coincide with areas of higher soil permeability.

Management Action 4 - Restrict development and site alteration within and adjacent to terrestrial natural heritage features that also contribute to enhanced infiltration rates within the Subwatershed.

- Development and site alteration within or adjacent to features of the Natural Heritage System, which might otherwise permitted under Official Plan policies, is restricted unless an integrated hydrogeology and stormwater assessment demonstrates that:
    - Groundwater recharge rates and volumes will be maintained or enhanced post development through on-site mitigation efforts.

4.4.3 Groundwater Quality

Management Action 1 - Development and site alteration within a HVA and within 120 m of a HVA is restricted unless a hydrogeological evaluation is undertaken that demonstrates that:

- Groundwater quality will be maintained or enhanced post development; and
- Best management practices related to groundwater recharge and stormwater management in urban areas are utilized.
- Land uses are in accordance with the approved Mississippi – Rideau Source Protection Region Source Protection Plan.

Management Action 2 - Ensure that wells are properly abandoned as a condition of development approval.

- Development may be permitted only if the applicant demonstrates that all inactive wells will or have been be decommissioned in accordance with the *Ontario Water Resources Act* (*O.Reg 903).*

4.5 Agricultural and Rural Land Use Management

4.5.1 General

As discussed in Sections 2.5, agricultural land use within the Subwatershed presents several risks to the natural environment, primarily in regard to deteriorating water quality in the area streams and watercourses. The key areas of concern are summarized as follows.

a) The City of Ottawa's Five-Year Baseline monitoring of water quality (City of Ottawa, 2004) identified Cardinal Creek as one of the top seven locations of concern, based on high concentrations of phosphorus, *E. coli* and iron.

   Nutrients (phosphorus and nitrogen) are contributed by fertilizers, manure and eroded sediments. There is no agricultural activity that significantly contributes to elevated iron concentrations in drainage water, although iron compounds (iron ochre) are sometimes present in water discharged from sub-surface drains, especially in areas with acid soils.

b) The water quality data for the two rural catchments indicate suggest the effects of farming land usage is evident, particularly due to domestic livestock and nutrient use. The data for these catchments is also indicative of ongoing erosion, with headwater catchment CK24-005 showing consistently high levels of TSS.

c) There are several old abandoned barns in the Subwatershed which pose a potential risk to nearby streams and watercourses. Similarly, old, deteriorating farm buildings can also be a source of contamination from corroded fuel storage tanks and abandoned wells, which have not been properly decommissioned and can lead to groundwater contamination.

d) Many farmers store fertilizer and pesticide materials on their farms, which if not properly managed in regard to storage, handling and application may present a potential risk of negatively effecting receiving streams and watercourses.

4.5.2 Agricultural Land Management Measures and Strategy

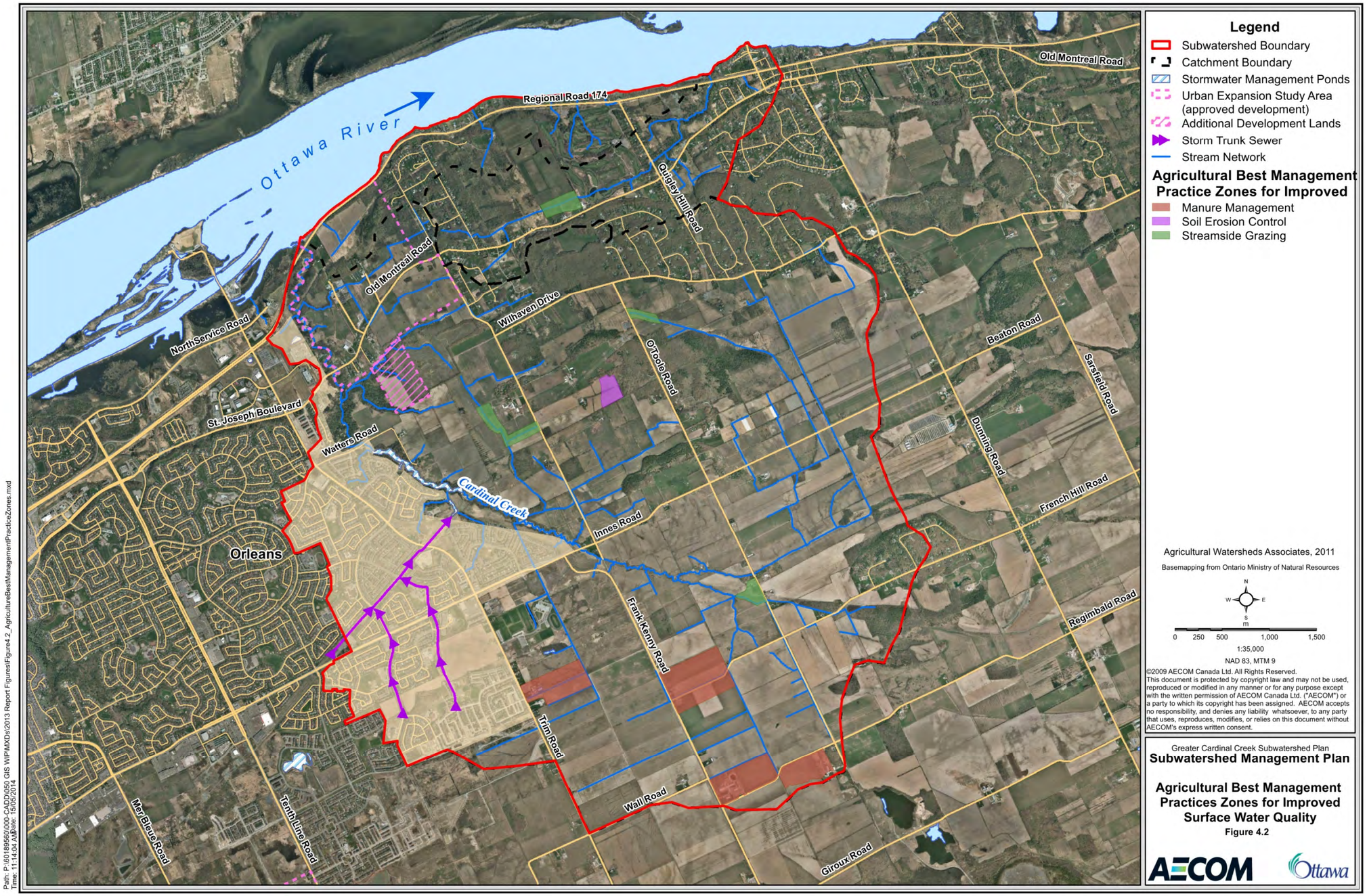
The Province of Ontario, in co-operation with the Federal Government, the Ontario Federation of Agriculture, the Ontario Cattlemen's Association, the Agricultural Adaptation Council, and other stakeholder groups, has published a series of manuals devoted to the description, selection and application of Best Management Practices (BMPs) for agriculture in Ontario. There are currently 25 titles in this series (with 22 still in print). The primary objective of these BMPs is to eliminate or reduce the negative impacts of agricultural practices on the environment – water, air, soil and natural habitats, although many are included because they improve farm profitability. Of the hundreds of BMPs that have been described in these manuals, a relatively small number are directly applicable to the issues of water quality in the Subwatershed. The most relevant ones have been added to the comments below. This is not meant to exclude others that may also be appropriate, but rather to place the BMP issue into the context of the Subwatershed, and to provide reasonable and manageable options.

In addition to the many BMPs recommended in the 25 BMP manuals, there are other legally required management practices that are prescribed under regulations that accompany the Ontario 2002 Nutrient Management Act. These relate to manure (including digested and composted manure, and washwater) storage, handling and field applications, and include many of the BMPs discussed below. As well, if *Non Agricultural Source Materials* (NASM) are used – primarily municipal sewage biosolids, but also includes biosolids from paper mills, food processing, and

septic tanks - then additional management practices are legally required under the Act. However, since there have been no municipal biosolids spread in the Subwatershed during the 4-year period from 2006 to 2009, for which data are available, according to the City of Ottawa website, details of the BMPs associated with biosolids application have not been included here. They can be found in the Ontario Ministry of Agriculture and Rural Affairs publication *Best Management Practices: Application of Municipal Sewage Biosolids to Cropland (2010*).

As a general guide, farmers who have more than 300 *animal nutrient units* in a year on the same *farm unit*, or who apply any NSAM, or who undertake any expansion or alteration to buildings and yards in which livestock are housed that require a building permit, must register, prepare and follow a Nutrient Management Plan (NMP) that identifies all required management practices. Each of these NMPs is specific to each farm, and considers soil physical and chemical properties, topography, hydrography, chemical composition of manures and NASMs, crops to be grown, etc. In this report, emphasis will be placed on BMPs that can be considered and adapted by the majority of farmers, including those who are not required to follow an NMP.

The following summary presents Management Actions based on the agricultural (BMPs) that should be applied in the Subwatershed with the objective of improving surface water quality. Appropriate locations for their application are presented in ***Figure 4.2***.



Legend

- Subwatershed Boundary
- Catchment Boundary
- Stormwater Management Ponds
- Urban Expansion Study Area (approved development)
- Additional Development Lands
- Storm Trunk Sewer
- Stream Network

Agricultural Best Management Practice Zones for Improved

- Manure Management
- Soil Erosion Control
- Streamside Grazing

Agricultural Watersheds Associates, 2011

Basemapping from Ontario Ministry of Natural Resources

N W E S

m

0 250 500 1,000 1,500

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NAD 83, MTM 9

Greater Cardinal Creek Subwatershed Plan

Subwatershed Management Plan

Agricultural Best Management Practices Zones for Improved Surface Water Quality

Figure 4.2

AECOM Ottawa

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Management Action 1 – Farming operations should adopt appropriate handling and application methods for fertilizer and pesticide use that achieves efficient use and protection of the environment.

- Fertilizer requirements for the crop to be grown should be determined from soil sampling and testing, adjusted for nutrients applied in manure (if applicable) and in residues of leguminous crops (nitrogen only). Details of procedures for soil, manure and plant tissue sampling and testing, and estimating leguminous crop contributions of nitrogen, are given in the manuals.
- To minimize the risk of fertilizer contamination of surface water recommend a minimum 3 m buffer strip (separation distance) should be established between application areas and any watercourse. This will reduce the risk of fertilizers being carried off the field in runoff water, or attached to soil particles that enter watercourses because of inadequate filtration of runoff water.
- The banding, or placement of the fertilizer close to the plant rows, will reduce concentrations of nutrients in runoff water when compared with the more common broadcasting of fertilizers on the soil surface before planting. Banding is usually done by planting equipment at the time of planting.
- Proper calibration of application equipment should be carried out on a regular basis to ensure that calculated application rates are not inadvertently exceeded due to inaccuracies in the application equipment.
- On-farm storage of fertilizer should use covered concrete storage and loading areas, located away from surface water and wells. Containment areas should be provided in case of spills.
- A pesticide applicators license must be obtained in order to purchase pesticides in Ontario.
- An Integrated Pest Management (IPM) should be developed and followed to minimize the use of pesticides. This involves the use of tillage and crop rotations to minimize the risk of weed and other pest problems, identifying pests correctly, monitoring their presence, and determining critical and economic thresholds before resorting to pesticide applications.
- Where pesticide materials (i.e., insecticides, herbicides, fungicides, etc.) are applied, a buffer strip of 15 m should be left between the treated area and the top of the bank along the watercourse.
- Pesticide spraying equipment should not be used when wind speeds exceed 10 km/h, to avoid spray drift onto non-target areas, or when rain is forecasted to minimize the risk of runoff.
- Pesticide storage structures should be at least 90 m from surface water and wells. They are not recommended to be located where depth to bedrock is shallow (e.g., bedrock < 1 m), where soils have high natural drainage rates (e.g., sands), and where the depth to the water table is less than recommended for the soil type. Structures should be specifically designed for pesticide storage, have proper signage, be locked, and no other materials should use the same space.
- The loading pads for pesticide mixing should be constructed to be impermeable to water, covered, and provide sumps for containment of spills and rinse water.
- Reference should be made to the following Best Management Practices documents which contain information and direction on appropriate handling, application and storage of fertilizers and pesticides - Ontario Ministry of Agriculture and Rural Affairs *Best Management Practices: Nutrient Management*, Revised 1997; *Best Management Practices: Pesticide Storage, Handling and Application, 1998; Best Management Practices: Managing Crop Nutrients, 2008;* and *Best Management Practices: Field Crop Production, (Undated).*

Management Action 2 – Farming operations adjacent to watercourse/ditches should include appropriate buffer strips and/or barriers to help minimize disturbances and provide water quality management benefits.

- At a minimum, a 3 m grassed buffer strips, but preferably a 5 m grassed buffer should be maintained along all ditches, to keep cropping practices and farm equipment away from surface water. The objective is to provide filtration of surface runoff to keep soil, nutrients and bacteria out of the water.
- Where manure is applied, buffer strips ranging from 3 m for solid manure incorporated immediately on soils with very low runoff potential, to a 30 m buffer strip for liquid manure applied to the surface of soils with a high runoff potential should be maintained.
- Where pesticide materials (i.e., insecticides, herbicides, fungicides, etc.) are applied, a buffer strip of 15 m should be provided between the treated area and the top of the bank along the watercourse.
- If sewage sludge biosolids are being applied, the recommended separation distance is 20 m.
- Where livestock are grazing or otherwise confined adjacent to a watercourse, fencing should be installed at least 5 m from the top of the bank, and a vegetated buffer strip should be maintained between the fence and the top of the bank.
- BMPs indicate that access can be allowed for grazing of riparian areas (including floodplains) provided that livestock density is low – i.e. preferably < 1.25 Nutrient Units (NU) per ha (< 0.5 NU/ac), grazing is for limited time periods (e.g., 3-4 days at a time), and that grazing is generally restricted to 2-3 weeks in the fall months when least damage will be done to stream banks. BMPs provide guidelines for situations where grazing is acceptable at other times of the year (by developing grazing management systems). Rest periods between grazing are recommended throughout the year. Access periods can also be allowed for the buffer strip (i.e., the vegetation between the fence and the watercourse).
- Fenced watercourses the provision of alternate water supplies where livestock do not have access to a permanent water tank is recommended. These include solar or wind powered pumps from a well or from the watercourse, nose pumps, ram pumps. Passive water supply can also be provided by dugout ponds or seepage troughs.
- Where water supply for the livestock is limited or unavailable without allowing drinking from the watercourse, it is recommended that access be controlled for watering purposes only. This applies for low-density grazing only – i.e. 2.5 Nutrient Units per ha/day or less. If necessary, several access points should be provided, to minimize impact at any one location. Fencing should extend into the water on either side of the access point, allowing only a small number of livestock to drink at one time. The access area should be reinforced with rocks or other erosion-resistant materials. These access points should not be used as crossings.
- Where crossings are required of livestock, structures consisting of bridges (wood, steel or concrete), culverts (steel or concrete), should be constructed over watercourses. Bed-level crossings of concrete or rock, or natural crossings where the bed consists of more than 50% coarse materials (i.e., gravel, > 2 mm diameter) can also be considered. The choice of crossing type depends on the width and depth of the watercourse, and on local soil conditions. Fencing should be provided for all crossings to keep livestock from straying into the watercourse. Bridges and culverts provide maximum protection for watercourses.
- Areas providing livestock water, feed and salt are located at least 50 m away from watercourses to minimize surface water contamination.
- Reference should be made to the following Best Management Practices documents which contain information and guidelines on buffer strips along watercourses and restricting livestock access to surface waters., which are published by the Ontario Ministry of Agriculture and Rural Affairs - *Best Management Practices: Buffer Strips, (undated)* and *Best Management Practices: Streamside Grazing (2007).*

Management Action 3 – Farming operations should incorporate appropriate manure management based on size and type of operation.

- Generally farms that exceed a threshold of numbers of livestock (300 animal nutrient units/y), and farms that have recently undergone expansion, or re-construction of facilities that require a building permit, fall under the Nutrient Management Act (NMA). Under the NMA specific management practices are prescribed under the regulations, including manure storage, application rates and timing, which must be followed.
- All other farms should adopt and implement best management practices that have been developed for both solid and liquid forms of manure.
- Storages structures for both solid and liquid manure should have a minimum capacity to contain the manure produced over at least 240 days, which is commonly the maximum number of days in the year that manure should not, or cannot, be applied. Certain circumstances may dictate the need for additional storage capacity due to application days being further limited, such as steeply sloping fields with clay soils, excessively sandy soils, soils that are shallow over bedrock, and soils with high risk of compaction.
- A minimum 50 m flow path should be maintained between the manure storage structure and the nearest surface water, and storage structures should not be located within 15 m of a drilled well, or 30 m from any other type of well, except for municipal wells where the separation distance should be 100 m. As well, manure storages should not be located within the 100 year flood line, unless a special permit is obtained under the Conservation Authorities Act.
- To protect against surface and groundwater contamination storage for solid manure should include the use of walled concrete pads that are either covered to exclude rain and snowmelt, or have a separate liquid collection system to contain rain and snowmelt seepage. Open earthen manure storages can be used as both temporary (i.e., short-term in-field manure piles) and year-round storages, provided that the type and depth of soil material is suitable. Liquid manure storages are generally earthen, open concrete or steel, or covered concrete. Earthen storages must be lined with clay or plastic to prevent seepage. BMPs for siting are the same as for solid manure.
- Manure sampling and analysis and estimates of nutrient availability to plants should be undertaken to and compared with estimates of nutrients required to produce the expected crop yield to determine appropriate manure application rates, which should not exceed the anticipated uptake of available nutrients in the manure by the crop.
- Manure not be applied on frozen or snow-covered ground, and should be incorporated into the soil within 24 hours if applied when no crop is growing. As well, a separation distances between manure application and any watercourse should be maintained, ranging from 3 m for solid manure incorporated immediately on soils with very low runoff potential, to 30.5 m for liquid manure applied to the surface of soils with a high runoff potential. In addition, it is recommended that the soil surface be loosened with tillage equipment before liquid manure is applied, to increase absorption by the soil and reduce runoff. Further restrictions are recommended where soils already have high phosphorus levels.
- Reference should be made to the following Best Management Practices documents which contain information and guidelines on keeping manure away from surface water and help reduce nutrients and bacteria (e.g., E. coli) from contaminating the subwatershed. Manure management practices, which are published by the Ontario Ministry of Agriculture and Rural Affairs - *Best Management Practices: Streamside Grazing, 2007*; *Best Management Practices: Manure Management*, Revised 1997; and Best Management Practices: Livestock and Poultry Waste Management (Undated).

Management Action 4 – Farming operations should adopt appropriate tillage and crop management practices that minimize the potential for soil erosion.

- Minimizing tillage (minimum tillage) through mulch tillage in the fall, or the use of no-till, to maximize crop residue cover is preferred for minimizing the soil erosion. The aim is to retain at least 30% crop residue on the surface after planting the next crop. This involves the use first of harvesting machinery that spreads post-harvest residues as evenly as possible over the soil, then tillage machinery that maintains as much of this residue on the surface as possible, while providing adequate disturbance for the soil type. For mulch tillage this can mean using a chisel plow, followed by a cultivator prior to planting. This can reduce soil erosion by as much as 74% following corn, 32% following soybeans, and 72% following wheat, when compared with conventional plowing. Where the soil conditions permit, using no-till can reduce soil erosion by 92%, 64% and 96% following these three crops, respectively.
- The proper application of crop rotations by alternating row crops with solid-seeded crop should be followed to help reduce soil erosion and runoff. Rotations that include leguminous forage, such as alfalfa and clovers, increase the effectiveness of the rotation. Fall-seeded cereals in the rotation, such as winter wheat or rye, provide winter cover that further reduces runoff and erosion.
- Where field crops are grown on sloping land adjacent to watercourse, the use of buffer strips, terracing, contour cropping, cross-slope tillage, grassed waterways, drop-control structures, etc., should be adopted.
- Reference should be made to the following Best Management Practices documents which contains information and guidelines on soil erosion control, which are published by the Ontario Ministry of Agriculture and Rural Affairs - *Best Management Practices: Field Crop Production", (undated).* Given the soil, topographic and crop production conditions in the Cardinal Creek subwatershed, it is reasonable to focus on BMPs that primarily address water erosion (rather than wind or tillage erosion) under field crop production on relatively level clay and clay loam soils.

Management Action 5 - Ensure that abandoned wells are properly decommissioned.

- The decommissioning of a drilled well should include the removal of the well casing and the use of cement or bentonite slurry used to plug the entire depth of the well. If the old casing cannot be removed, it should be cut off at least 3 m below the soil surface, and the bottom of the excavation filled with plugging material before backfilling.
- For large diameter wells (e.g., dug wells, common on older farmsteads) the bottom should be sealed with 0.3 m of bentonite and the remainder of the well should be filled with clean clay to within 3 m of the ground surface. Another layer of bentonite should then be placed on top of the clay, before filling to remaining space with clean soil. The surface should be left mounded up to prevent surface water collecting over the old well.
- Reference should be made to *Ontario Water Resources Act* (*O.Reg 903)* and the following Best Management Practices documents which contain information and guidelines on securing abandoned and unused wells through plugging and sealing, which are published by the Ontario Ministry of Agriculture and Rural Affairs - *Best Management Practices: Water Management, (1994),* and *Best Management Practices: Water Wells, 1997.*

Table 4.2 Recommended Best Management Practices

Issue	Location	Best Management Practice	Source: OMAFRA publications *Best Management Practices*
High concentrations of phosphorus, E.	Entire agricultural area of the Cardinal Creek	Estimated fertilizer required for the crop should not be exceeded.	A Phosphorus Primer: Best Management Practices for

Table 4.2 Recommended Best Management Practices

Issue	Location	Best Management Practice	Source: OMAFRA publications *Best Management Practices*
coli and iron (representative of nutrient, bacterial contamination and metal contamination respectively)	Subwatershed	Establish minimum 3 m buffer strip (separation distance) between fertilizer application areas and any watercourse.	Reducing Phosphorus from Agricultural Sources, 2011; Nutrient Management, Revised 1997; "Managing Crop Nutrients", 2008
	Portions of subwatershed with livestock housing and manure storages	Manure storages should be of sufficient size to contain the manure produced over at least 240 days.	Manure Management, 2005; and Livestock and Poultry Waste Management (out of print).
		There should be a minimum 50 m flow path between manure storages and the nearest surface water, and they should not be located within 15 m of a drilled well, and 30 m from any other type of well	
		Solid manure storages should use walled concrete pads that are either covered to exclude rain and snowmelt, or have a separate liquid collection system to contain rain and snowmelt seepage.	
		Liquid manure storages are generally earthen, open concrete or steel, or covered concrete. Earthen storages must be lined with clay or plastic to prevent seepage.	
	Portions of subwatershed with tilled fields	There should be a minimum 50 m flow path from open earthen manure storages to the nearest surface water	Manure Management, 2005; and Livestock and Poultry Waste Management (out of print).
		Manure application rates should not exceed the anticipated uptake of available nutrients in the manure by the crop	
		Manure should not be applied on frozen or snow-covered ground, and should be incorporated into the soil within 24 hours if applied when no crop is growing.	
		Separation distances between manure application and any watercourse should be maintained, ranging from 3 m for solid manure incorporated immediately on soils with very low runoff potential, to 30.5 m for liquid manure applied to the surface of soils with a high runoff potential.	
		A minimum 3 m grassed buffer strip, but a preferred 5 m, should be maintained along all ditches to keep cropping practices and farm equipment away from surface water	"Buffer Strips, 2004
		BMPs that optimize tillage practices would recommend that mulch tillage (minimum tillage) in the fall, or the use of no-till, be considered to maximize crop residue cover, and that the use of crop rotations will reduce soil erosion and runoff.	Field Crop Production, (1993, out of print); Soil Management, 1994
		Surface drainage outlets should include drop pipes and rock chutes designed to transfer surface water to a receiving channel with minimum risk of erosion	Cropland Drainage, 2011
	Fields with sub-surface (tile) drainage	Appropriate pipe materials and rock aprons to maintain the stability of the outlet and reduce risk of erosion in the receiving channel.	
	Portions of subwatershed with tilled fields on moderately sloping soils	BMPs including terracing, contour cropping, cross-slope tillage, grassed waterways,	Field Crop Production, (1993, out of print); Soil Management, 1994
	Portions of subwatershed with livestock grazing	BMPs for livestock grazing recommend a 5 m buffer strip between the top of a ditch bank and a fence that excludes the livestock from entering the ditch or watercourse.	Streamside Grazing, 2007
		BMPs for livestock exclusion from water, with possible access points for watering if no other water source is available	
	Farms with fertilizer storage	BMPs recommend that fertilizer storage areas have covered concrete storage and loading areas.	Nutrient Management, (revised 1997- out of print); Nutrient Management Planning, 2007

Table 4.2 Recommended Best Management Practices

Issue	Location	Best Management Practice	Source: OMAFRA publications *Best Management Practices*
The data for two agricultural catchments suggest inputs from farm practices, particularly with respect to domestic livestock and nutrient management.	Subwatershed upstream of sample sites CK24-701 and 801	All of the BMPs listed above are appropriate in these portions of the subwatershed where they apply.	
Additional issues	Farms with abandoned wells	Secure abandoned and unused wells through plugging and sealing using cement, bentonite and clay appropriately.	Water Well, 2003
	Farms with pesticide storage	Pesticide storages should be at least 90 m from surface water and wells	Pesticide Storage, Handling and Application, 1998
		Structures should be specifically designed for pesticide storage, have proper signage, be locked, and no other materials should use the same space	
		Loading pads should be constructed that are impermeable to water, covered, and provide sumps for containment of spills and rinse water	

4.6 Monitoring and Stewardship

4.6.1 Monitoring

4.6.1.1 Environmental Programs Framework

Table 4.1 of the Existing Conditions Report included recommendations for consideration in the final subwatershed management plan with respect to environmental rehabilitation, enhancement and monitoring. These recommendations encompassed protection and improvement of both the terrestrial and aquatic natural heritage systems. They also spoke generally to the development of a monitoring program for the subwatershed within the context of the City's overall environmental monitoring programs and priorities.

Since completion of the Existing Conditions Report in 2009, Ottawa has begun restructuring the way that it protects and manages its natural environment. The restructuring has included the publication of the Characterization of Ottawa's Watersheds, which provides a synopsis of the City's environmental data, a summary of key environmental issues, and a conceptual framework for the City's environmental and natural heritage objectives. The 2009 Comprehensive Official Plan Review (OPA 76) included a complementary set of environmental and natural heritage system policies to bring the City's Official Plan into better compliance with the Provincial Policy Statement 2005. The draft Water Environment Strategy, developed in consultation with the Conservation Authorities, provides direction on implementation of the City's water protection policies. It includes a comprehensive review of the responsibilities and commitments of the Conservation Authorities, other government agencies, and different City departments with respect to water protection. The overall intent of this restructuring is to make the implementation of water protection policies within the City, by all responsible organizations, more efficient and more effective.

This approach recognizes at least three scales of land use planning and monitoring: the city-wide scale, the watershed scale, and the subwatershed scale. These scales are reflected in the policies and practices of the different agencies. For example, the City's baseline water monitoring network provides a rough comparison of water quality parameters across the City's watersheds and subwatersheds, but may not include sufficient monitoring stations to isolate problems to particular catchment areas. At the watershed scale, water monitoring by the

Conservation Authorities can identify specific problem areas within a watershed or subwatershed, but may not have the resolution to localize contaminant point sources. At the local scale, subwatershed management plans (or, in some cases, environmental management plans) may include recommendations for targeted water monitoring programs to identify contaminant point sources or to diagnose the causes of chronic water quality issues. A similar recognition of scale now exists with respect to natural heritage system identification and mapping. The City has begun to map and monitor the natural heritage system at the broadest scale, focusing on those features and elements that can be identified and delineated through air photo interpretation, such as significant woodlands, significant wetlands and significant valleylands. This information feeds into the corporate environmental reporting process, as well as updates to the Characterization of Ottawa's Watersheds and the Official Plan schedules. At a watershed scale, the Conservation Authorities have begun to prepare and publish regular watershed report cards, which provide a more precise breakdown of environmental information, such as the length and quality of riparian cover. At the subwatershed scale, the City identifies locally-significant features of the natural heritage system, such as significant wildlife habitat, potential habitat for endangered or threatened species, or unusual ecological communities. Explicit recognition of these different planning and monitoring scales facilitates more co-operative, integrated and effective programs.

4.6.1.2 Aquatic Monitoring Framework and Recommendations

In preparation for the Greater Cardinal Creek Subwatershed Study, the City of Ottawa conducted intensive water quality and fish sampling in Cardinal Creek and the unnamed creek RV35 (which enters the Ottawa River immediately west of the Village of Cumberland) in 2006 and 2007. Two sites also included sampling of macro-invertebrates, although the limited data did not suffice for meaningful analysis. In addition, the City Stream Watch Program conducted stream assessments and fish sampling along the main channel of Cardinal Creek in 2008. The results and implications of those sampling programs appear in the Existing Conditions Report. Since that time, the Rideau Valley Conservation Authority has re-assessed the classification of municipal drains in the Cardinal Creek subwatershed, based upon a more complete sampling program. As a result, a number of drains have been reclassified as sensitive, coldwater features (Type A drains, Appendix E).

In the future, the City will continue to monitor water quality and macro-invertebrates at two sites on the main channel of Cardinal Creek, as part of its baseline monitoring program: CK24-002 (Old Montreal Road) and CK24-003 (Innes Road). It will also continue to monitor water quality and macro-invertebrates on Tributary RV35, at site CK78-01 (Hwy 174). The data from these sites will allow the City to track and report on the general water quality within the watercourses in comparison to trends in other City rivers and streams.

The City Streamwatch Program has included Cardinal Creek in its workplan for 2014, with subsequent re-evaluations planned every five years. The work plan has been expanded to include assessment of headwater watercourses. The assessment methodology covers both in-stream and riparian (*i.e.* shoreline) habitat condition, general bank condition and stability, basic water quality indicators, and fish community sampling. This information forms the basis of individual subwatershed condition reports and feeds into the Conservation Authority watershed monitoring and report card process. The City and Rideau Valley Conservation Authority will continue to use this information to monitor long-term trends in the condition of the subwatershed and to identify any emerging issues. Targeted monitoring of water quality and aquatic habitat should also occur in support of any the stream rehabilitation or enhancement projects recommended below. Ideally, monitoring should occur one year prior to the initiation of any project, and two-to-three years following completion of a project. As discussed below, funding of such projects should include the cost of the additional monitoring and analysis of the resulting data.

Management Action 1: Water Quality and Aquatic Habitat Monitoring

- The Water Environment Protection Unit will continue baseline water quality and aquatic habitat monitoring at two sites as part of the City's baseline monitoring program.
- The City Streamwatch Program will continue to monitor and evaluate Cardinal Creek as part of its on-going program.
- The City or the Conservation Authority will conduct targeted monitoring of water quality and aquatic habitat in support of any stream rehabilitation or enhancement projects.

4.6.1.3 Geotechnical Monitoring Framework and Recommendations

The Existing Conditions Report identified 37 locations along the main channel of Cardinal Creek that required action or monitoring with respect to bank or slope instability. The report recommended three sites for immediate stabilization, remediation or mitigation measures. It recommended another three sites for erosion protection work. These six locations are addressed in Section 4.2.4 of this report, through the Municipal Class Environmental Assessment process. The remaining 30 locations were recommended for either survey monitoring (using erosion pins or benchmarks) or visual monitoring.

Under the City's restructured water environment programs, the Water Environment Protection Unit (WEP) has responsibility for watercourse inventories, including erosion surveys and monitoring. It is developing a system for tracking, prioritizing and carrying out watercourse inventories through a City-wide asset management approach. The Land Use and Natural Systems Unit will provide WEP with the locations of the 30 proposed erosion monitoring sites, along with the supporting geotechnical reports, for incorporation into the watercourse inventory program.

Management Action 2: Geotechnical Monitoring

- Land Use and Natural Systems will provide the Water Environment Protection Unit with the locations of the 30 proposed erosion monitoring sites on Cardinal Creek.
- The Water Environment Protection Unit will incorporate the 30 sites into its watercourse inventory and asset management framework.

4.6.1.4 Natural Heritage Monitoring Framework and Recommendations

Section 2.3 of this report identifies the proposed natural heritage system of the Greater Cardinal Creek Subwatershed. It consists primarily of existing natural heritage features, in addition to some recommended restoration areas. Most of these natural heritage features already appear in Official Plan Schedules A (Rural Policy Plan), B (Urban Policy Plan) and L1 (Natural Heritage System East). Following approval of this subwatershed management plan by Council, the City's Planning and Growth Management Department will study the need for an Official Plan Amendment to add locally significant features to Schedule L1 (Natural Heritage System East).

The City will monitor the natural heritage system for any gross changes through its aerial photography and landcover mapping program. The City flies new aerial photography every three years, in support of a number of programs (*e.g.* infrastructure maintenance, forest planning). Beginning with the 2011 aerial photography, the City has begun a program of conversion of the imagery to landcover mapping. This landcover mapping is critical for natural heritage planning, effective review of developments, and corporate reporting.

The City does not have a comprehensive system for monitoring the ecological integrity of natural heritage features. A volunteer-based monitoring program (similar to the City Streamwatch Program) may be included as part of a larger framework of natural heritage stewardship activities being developed by the City's Land Use and Natural Systems

Unit for consideration by Planning Committee and City Council in 2014. In the absence of such a program, the City will continue to rely upon aerial photography and landcover mapping to identify areas requiring site-specific investigation by the City or other agencies.

Targeted monitoring of natural heritage features should also occur in support of any of the natural habitat restoration and enhancement projects recommended below. The funding of such projects should include the cost of such monitoring and data analysis/interpretation.

Management Action 3: Natural Heritage System Monitoring

- The Planning and Growth Management Department will study the need for an Official Plan Amendment to revise Schedule L1 (Natural Heritage System East) to include the locally significant features identified in the subwatershed study.
- The City will monitor gross changes in natural landcover in the subwatershed through its City-wide landcover mapping program.
- The City will conduct targeted natural heritage surveys and monitoring in support of any natural heritage enhancement or restoration projects.

4.6.2 Stewardship

4.6.2.1 Targeted Stewardship Activities for Protection of Aquatic Ecosystems

The Existing Conditions Report identified several catchments of concern with respect to the integrity of aquatic and riparian habitat, as well as several general issues of concern. However, aquatic field work in support of the Existing Conditions Report was limited almost entirely to the main channel of Cardinal Creek. Consequently, other areas or issues of concern may exist, which will need to be identified in the future through the monitoring programs discussed above.

4.6.2.2 Catchments and Reaches Requiring Stewardship, Restoration or Enhancement

The Existing Conditions Report identified three catchments where water quality monitoring or the geomorphic assessment had suggested environmental problems. It identified a fourth catchment where recent, significant tree cutting was expected to increase runoff, instability and erosion within a significant valley. Analysis of aerial photography and the geomorphic assessment suggest two sections of the Cardinal Creek main channel that might benefit from restoration and rehabilitation.

Catchment TRI14 (North Tributary, Cardinal Village).

The Geomorphic Assessment of Existing Conditions (Existing Conditions Report, Figure 2.24) identified the lower portion of this tributary as being in poor condition. The proposed stormwater and infrastructure plan for the Cardinal Village development will entomb the upper portion of this tributary, change the total catchment area, discharge stormwater to it through a stormwater interceptor, and re-align a portion of the lower creek. In support of these changes, the proponent is required to improve the geotechnical and geomorphic stability of the lower tributary, and to maintain or improve the quality of its aquatic and riparian habitat. The proponent is working with the Rideau Valley Conservation Authority on the necessary mitigation and compensation plans.

Catchment TRH1 – TRH5 (South Tributary, Cardinal Village).

This tributary was not assessed for the Existing Conditions Report, due to problems of access. Nonetheless, the Existing Conditions Report noted the removal in 2009 of a large forested area in the headwaters of this tributary. This loss of forest was expected to increase of runoff in the watercourse for several years, resulting in increased erosion, increased bank and channel instability, export of sediments and nutrients, and a general degradation of aquatic habitat. Subsequent investigations in association with the Cardinal Village development proposal have confirmed issues of channel and bank instability. They have also identified concerns with respect to the presence of karstic bedrock in the headwater areas, and the potential that development on that bedrock could reduce groundwater discharge and baseflows in the tributary. As a result of these concerns, the current Cardinal Village proposal has been restricted to the less-sensitive areas north of the tributary. In addition, the development proponent is carrying out a substantial study program on the tributary, consistent with the recommendations of this management plan, which will guide the final stormwater and infrastructure plan. The final plan will maintain or improve the geotechnical, geomorphic and aquatic habitat conditions in the tributary.

Catchment TRB1 – TRB5 (John Smit's Drain, Wall Road and Frank Kenny Road).

Water quality monitoring of this catchment revealed levels and patterns of sedimentation, *E. coli* contamination and abnormal nutrient enrichment often associated with poorly controlled runoff from agricultural land uses. Schedule A of the Official Plan designates the catchment as an Agricultural Resource Area. The watercourses consist almost entirely of agricultural and roadside ditches. The predominant land use is cash cropping. The surficial geology consists mostly of clays and silts, with a low infiltration potential. A small area of sand and gravel extends into the southern part of the catchment. The area appears to have a high density of tile drains (***Figure 2.8***).

Watercourse buffers are often prescribed as a best management practice for such situations. High resolution aerial photography suggests that buffers in this catchment range between 1 m and 3 m. As discussed in Section 2.5.1, some fields provide no watercourse buffers. Although outreach and stewardship activities should emphasize the desirability of providing at least a 3 m buffer (see Section 4.5), property owners will likely resist any greater setback. Anecdotal evidence suggests that farmers in Ottawa and Eastern Ontario are moving toward smaller setbacks, in response to high cash crop prices and technologies that allow more precise planting and harvesting (*e.g.* GPS agricultural guidance systems).

However, tile drain outlet controls offer high potential for implementation and effectiveness in this catchment. These low-cost devices regulate the discharge of water from agricultural tile drains. Installed near the outlet of the drains, they allow farmers to regulate moisture levels in their fields. Opening the outlets in the autumn or spring allows farmers to lower groundwater levels and dry their fields, providing access for planting or harvesting. Partially or completing closing the outlets in the summer allows farmers to maintain beneficial soil moisture, retaining nutrients and protecting against drought, while still allowing proper drainage during large storm events. Research by Agriculture Canada and the South Nation Conservation Authority has demonstrated both significant water quality benefits, as well as increased crop yields. Exports of ammonium, nitrates and phosphorous to watercourses have been shown to decline approximately 60% with the installation of tile drain controls, while yields of corn and soybeans increase 3% and 4% respectively. In the Agriculture Canada studies, tile drain controls paid for themselves in approximately four years, with installation costs of $200/ha comparing very favourably to increased annual returns of $55/ha for corn and $21/ha for soybeans (Agriculture and Agri-Food Canada). Tile drain control structures have a lifespan of approximately 25 years (Agriculture and Agri-Food Canada).

This catchment area encompasses approximately 280 ha. The cost of installing tile drain outlet controls over the entire catchment would be approximately $56,000 assuming take-up by all landowners. The Ottawa Rural Clean Water Grant Program will cover 50% of the cost of installation of tile drain outlet controls, up to a maximum of $1,000. Unfortunately, adoption of tile drain outlet controls has been slow in Ottawa, despite the obvious benefits

and grant program. Consequently, this management plan recommends that: (a) the City supplement funding for tile drain outlet controls from the Rural Clean Water Grant Program beyond the 50% and $1000 limits for this catchment area; (b) the City work with the Rideau Valley Conservation Authority, the Ontario Federation of Agriculture, and the Ontario Soil and Crop Improvement Association to promote tile drain outlet controls in the area.

Management Action 1: Support for Tile Drain Outlet Controls

- Environmental Services, Planning and Growth Management, the Rural Affairs Office and the Rideau Valley Conservation Authority will work with willing partners to promote the use of tile drain controls outlets in this catchment.
- Environmental Services, Planning and Growth Management, the Rural Affairs Office and the Rideau Valley Conservation Authority will discuss and evaluate the potential for targeted funding of tile drain outlet controls in this catchment, beyond the current limits of the Rural Clean Water Grant Program.

Catchment TRC1 – TRC11, C1 (Scharfe Drain, Borden Scharfe Drain, Mercier Drain, William Hayes Drain, Cardinal Creek North Branch).

As with the previous catchment area, water quality monitoring revealed chronic issues of sedimentation, *E. coli* contamination, and abnormal nutrient enrichment. This is a larger catchment area, with a greater range of soils and land uses. Although the Official Plan designates most of the catchment as Agricultural Resource Area, the north-central portion of the catchment contains a large area of woodland. The woodland lies overtop shallower, higher bedrock, covered by sand, gravel, and glacial till (an old Champlain Sea beach ridge), which support more permeable soils. It is associated with an adjacent, slightly lower wetland on organic soil. This suggests that the wetland is a long-standing feature, supported by groundwater seepage from the woodland area. The remainder of the catchment contains predominantly clay soils. The Rideau Valley Conservation Authority has classified the main watercourse in the catchment, the Mercier Drain, as sensitive, coolwater fish habitat.

The Mercier Drain catchment and the adjacent Scharfe Drain catchment also appear to contain about 850 ha of agricultural tile drainage. They could benefit from the targeted promotion of tile drain outlet controls, and financial support beyond the 50% and $1000 limits under the Rural Clean Water Grant Program.

Aerial photography suggests that cattle access and other land uses could be exacerbating or accelerating erosion issue along the lower reaches of the catchment area (TRC11, C1, C1A). These reaches would benefit from encouragement and targeted financial support for the establishment of appropriate watercourse fencing and alternative methods of livestock watering.

Cardinal Creek Main Channel, Reaches C3 to C5

Immediately upstream and downstream of Innes Road, Cardinal Creek meanders within a shallow valley. Overhead and in-stream cover appears sparse. The geomorphic assessment classified the condition of this creek section as only “fair”, with moderate to extreme erosion and five notable valley wall contacts. Several minor tributaries and swales enter the creek along this length, contributing to erosion and gully formation. The creek provides cool water aquatic habitat, with both pool and riffle features.

This section of the creek would benefit from the restoration of riparian vegetation, both on the stream banks and on the floodplain. Much of the reach is owned by the City, particularly on the south bank. The wide, riparian valley is not suitable for agriculture and, consequently, private property owners may be receptive to a rehabilitation program within that limit. Such a program would be designed to provide additional shade to the creek, to improve riparian and aquatic habitat, and to help stabilize the stream banks and valley walls. Restoration could be implemented through the Green Acres tree planting program, the City Streamwatch Program or targeted restoration projects.

Management Action 2: Restoration of Riparian Vegetation

- Environmental Services, Forestry Services, Planning and Growth Management and the Rideau Valley Conservation Authority will work with willing landowners on the restoration of riparian vegetation along reaches C3 to C5 of the Cardinal Creek Main Channel.

4.6.2.3 Terrestrial

Most of the Mercier Drain runs within the City-owned, unopened Wishbourne Road right-of-way (ROW). The ROW supports a dirt track used by adjacent farmers to access their fields and by other residents as a rural pathway. The ROW provides an opportunity for additional riparian plantings on both sides of the Mercier Drain (particularly the west side) to increase shade and to protect the coolwater fish habitat. This would require the agreement and collaboration of the Municipal Drain Unit, possibly including modification of the Drain Engineer's report. It would also benefit from the agreement and cooperation of the adjacent farmers, who use the right-of-way to access their fields, and whose tile drains depend upon effective drain maintenance.

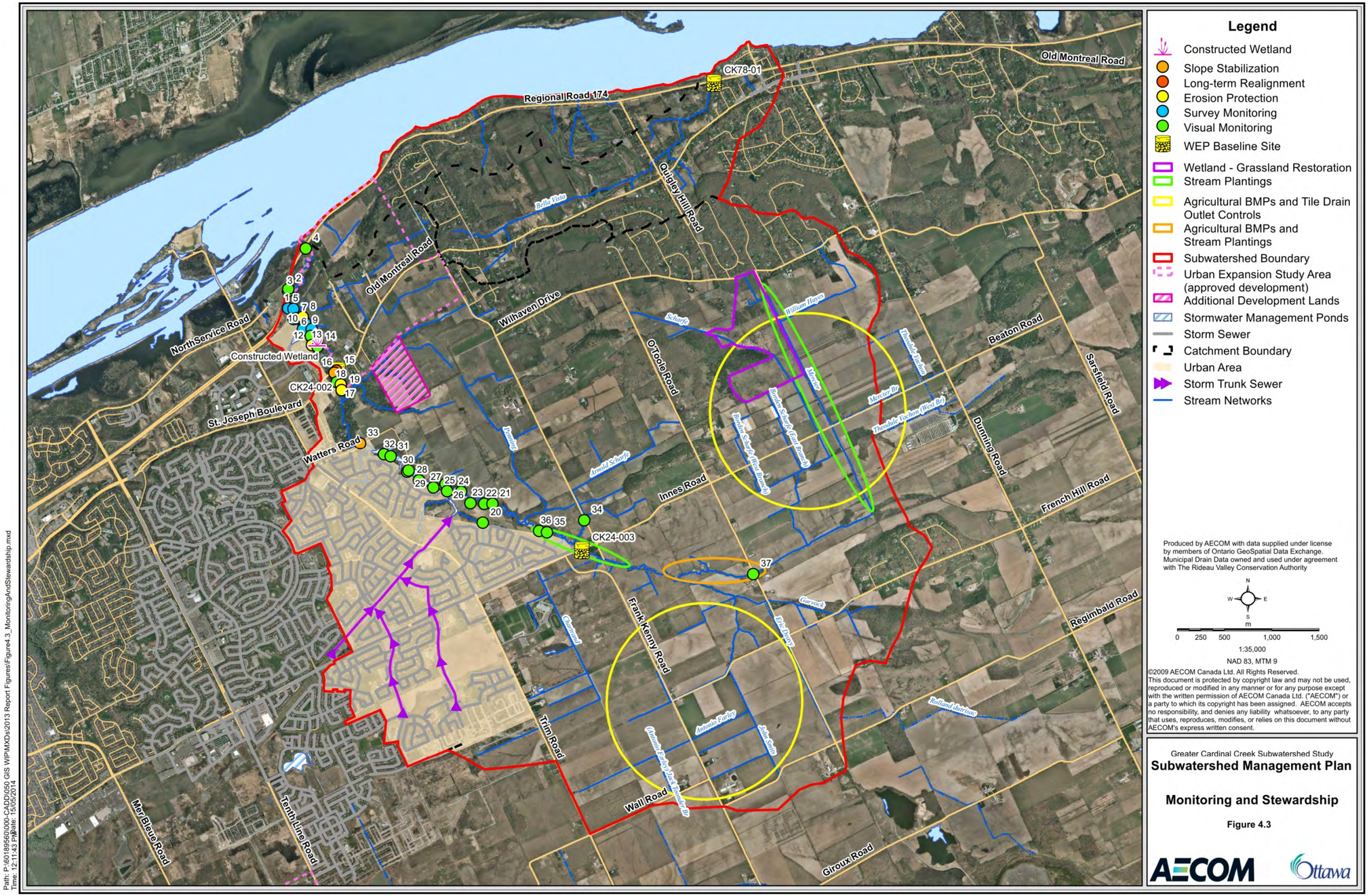
The Scharfe Drain originates in a locally-significant wetland on the west side of the Wishbourne Road Right-of way, between Innes Road and Wilhaven Drive. The fields adjacent to the wetland appear poorly drained and less-intensively farmed than the surrounding cropland. They were also found to support more than the median number of declining grassland and open-country birds (Marshall Macklin Monaghan 2007) for the local landscape, suggesting potential as significant wildlife habitat or habitat of endangered and threatened species. As discussed in the Natural Heritage section, this area should be investigated for protection, restoration and stewardship as a combined wetland – upland natural area. This would require agreement with the property owner[s] and third party, such as Ducks Unlimited Canada or a land trust. It would also require a modification of the Drain Engineer's report. The City would need to invest in the project, either in fee-simple acquisition of the property, purchase of a conservation easement, or a long-term lease. In addition to the natural heritage benefits, improvement of the wetland should enhance aquatic habitat in the Scharfe Drain through moderation of peak flows, prolongation of baseflows, and improved water quality.

Management Action 1: Enhancement of the Wishbourne Road ROW and the Mercier Drain as a natural landscape linkage

- Environmental Services, Forestry Services, Planning and Growth Management and the Rideau Valley Conservation Authority will discuss and consider additional riparian plantings along the Mercier Drain.

Management Action 2: Wetland and Grassland Restoration on the Scharfe Drain.

- Planning and Growth Management will contact the property owner[s] to assess their support for the proposal.
- Planning and Growth Management will contact Ducks Unlimited and other similar organizations to assess their support and interest as a possible partner in the project. This assumes a willing property owner.
- Planning and Growth Management, Environmental Services, the Rideau Valley Conservation Authority and a willing partner will meet to assess the feasibility of the project (assumes a willing partner).
- Planning and Growth Management and Environmental Services will develop and bring forward a project proposal and charter for consideration (assumes that the project is viable).



Legend

- Constructed Wetland
- Slope Stabilization
- Long-term Realignment
- Erosion Protection
- Survey Monitoring
- Visual Monitoring
- WEP Baseline Site
- Wetland - Grassland Restoration
- Stream Plantings
- Agricultural BMPs and Tile Drain Outlet Controls
- Agricultural BMPs and Stream Plantings
- Subwatershed Boundary
- Urban Expansion Study Area (approved development)
- Additional Development Lands
- Stormwater Management Ponds
- Storm Sewer
- Catchment Boundary
- Urban Area
- Storm Trunk Sewer
- Stream Networks

Produced by AECOM with data supplied under license by members of Ontario GeoSpatial Data Exchange. Municipal Drain Data owned and used under agreement with The Rideau Valley Conservation Authority

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Greater Cardinal Creek Subwatershed Study

Subwatershed Management Plan

Monitoring and Stewardship

Figure 4.3

AECOM Ottawa

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5. References

AECOM Canada Ltd., 2009:
Greater Cardinal Creek Subwatershed Study, Existing Conditions Study. City of Ottawa.

Brunton, F.R. and Dodge, J.E.P. 2008. Karst map of Southern Ontario, including Manitoulin Island; Ontario Geological Survey, Groundwater Resource Study 5.

Canadian Council of Ministers of the Environment, 2007:
Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table, Update 7.1, December 2007.

Chapman L.J. and D.F. Putnam, 1984:
The Physiography of Southern Ontario. Ministry of Natural Resources, Ontario Geological Survey.

City of Ottawa, 2009:
Emerald Ash Borer. <http://www.ottawa.ca/residents/healthy_lawns/forestry/eab/ index_en.html>. Last verified: June 22, 2009

City of Ottawa, 2004:
Baseline Surface Water Quality Program Technical Report Five-Year Analysis 1998 Through 2002 – Volume I of II. City of Ottawa, Water Environment Protection Program.

City of Ottawa, 2003:
Official Plan.

Conservation Ontario, 2010:
Integrated Watershed Management, Navigating Ontario's Future.

Coote D.R. and L.J. Gregorich (editors), 2000:
The Health of Our Water, towards sustainable agriculture in Canada. Research Branch, Agriculture and Agri-Food Canada.

Credit Valley Conservation Authority and the Toronto and Region Conservation Authority, 2013:
Evaluation, Classification and Management of Headwater Drainage Features Guidelines.

Cumming Cockburn Limited, 2000:
Update to Master Drainage Plan, City of Cumberland, East Urban Community Expansion Area (August, 2000).

Cumming Cockburn Limited, 2001:
Supplementary Report to the Master Drainage Plan "and Environmental Assessment Study Report," City of Cumberland, East Urban Community Expansion Area (May, 2001).

David Schaeffer Engineering Ltd. *et al.,* 2013:
Cardinal Creek village Concept Plan.

Derry, Michener, Booth and Wahl, 1989:
Limestone Industries of Ontario, Volume II – Limestone Industries and Resources of Eastern and Northern Ontario. Ontario Ministry of Natural Resources, Ontario Geological Survey.

Environment Canada, 1995:
State of the Environment Database. http://www.ec.gc.ca/soeree/English/default.cfm. Last verified. June 22, 2009.

Fleming R. and J.N. Candau, 2000:
Insect and disease disturbance regimes. Pp. 141 - 162 *in* Ecology of a Managed Terrestrial Landscape: Patterns and Processes of Forest Landscapes in Ontario. *Edited by* A.H. Perera, D.L. Euler and I.D. Thompson. UBC Press, Vancouver, B.C.

Fulton, R.J. and S.H. Richard, 1987:
Chronology of late Quaternary events in the Ottawa region; in Quaternary Geology of the Ottawa Region, Ontario and Québec, Fulton, R.J., (ed.), Geological Survey of Canada, paper 86-23.

Gadd, N.R., 1987:
Geological setting and Quaternary deposits of the Ottawa region, in Quaternary Geology of the Ottawa Region, Ontario and Québec, Fulton, R.J., (ed.), Geological Survey of Canada, paper 86-23.

Gartner Lee Limited, 2006:
Discussion Paper on Balanced Water Budget Policy for New Development. Toronto and Region Conservation Authority.

Gehrels, J. and G. Mulamottil, 1990:
Hydrologic processes in a southern Ontario wetland. Hydrobiologia 208: 221- 234.

Geomorphic Solutions, 2007:
Cardinal Creek Geomorphic Assessment (April, 2007). City of Ottawa.

Golder Associates Limited, 1990:
Erosion Study and Slope Stability Evaluation, Cardinal, Township of Cumberland, Ontario (January, 1990).

Golder Associates Limited, 1991:
Geotechnical Evaluation, Cardinal Creek Karst Area, Watters Road, Township of Cumberland, Ontario (June, 1991).

Government of Canada, 2009a:
Forest Invasive Alien Species: Asian Longhorned Beetle. http://www.exoticpests.gc.ca/ins_details_eng.asp?pestType=ins&lang=en&geID=1000095. Last verified: June 22, 2009.

Government of Canada, 2009b:
Forest Invasive Alien Species: Beech Bark Disease. http://ravageursexotiques.gc.ca/dis_mal_details_eng.asp?pestType=dis&lang=en&geID=9. Last verified: June 22, 2009.

Government of Canada, 2009c:
Forest Invasive Alien Species: Butternut Canker. http://ravageursexotiques.gc.ca/dis_mal_details_eng.asp?pestType=dis&lang=en&geID=1000093. Last verified: June 22, 2009.

Judge, K.A. and M. Haviernick, 2002:
Update COSEWIC status report on the grey fox *Urocyon cinereoargenteus* in Canada, *in* COSEWIC assessment and update status report on the grey fox *Urocyon cinereoargenteus interior* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

Keddy, C., 1994:
Information Report No. 1: Forest History of Eastern Ontario. Eastern Ontario Model Forest.

Kricher, J. and G. Morrison, 1988:
Eastern Forests. Peterson Field Guide. Houghton Mifflin.

Marshall Macklin Monaghan, 2007:
Greater Cardinal Creek Terrestrial Inventory – Final Report: Volumes 1 and 2 (May, 2007). City of Ottawa.

McGee B., H. Berges and K. Callow, 2004:
Survey of Pesticide Use in Ontario, 2003: Estimates of Pesticides Used on Field Crops, Fruit and Vegetable Crops, and Other Agricultural Crops. Ontario Ministry of Agriculture and Food, Guelph, Ontario.

McNeely Engineering Consultants Limited, 1992:
Master Drainage Plan, Township of Cumberland, East Urban Community Expansion Area (December, 1992).

Ministry of Agriculture, Food and Rural Affairs, 2011:
A Phosphorus Primer.

The Ministry of Agriculture and Food, Best Management Practices Series
<http://www.omafra.gov.on.ca/english/environment/bmp/series.htm#1>

BMP 21 – Agroforestry Series Volume 2: Establishing Tree cover, 2009
BMP 23 – Application of Municipal Sewage Biosolids to Cropland, 2010
BMP 15 – Buffer Strips, 1994
BMP 25 – Cropland Drainage, 2011
BMP 22 – Deadstock Disposal, 2009
BMP 01 – Farm Forestry and Habitat Management, 1992
BMP 02 – Field Crop Production, 2012 reprinted
BMP 10 – Fish and Wildlife Habitat Management, 1996
BMP 17 – Greenhouse Gas Reduction in Livestock Production System, 2006
Horticultural Crops (out of print)
BMP 09 – Integrated Pest Management (1996)
BMP 08 – Irrigation Management (Revised 2004)
Livestock and Poultry Waste Management (out of print)
BMP 16 – Manure Management, 2005
BMP 20 – Managing Crop Nutrients, 2008
BMP 11 – No-Till: Making it Work, 1997
BMP 14 – Nutrient Management Planning, 2007
BMP 13 – Pesticide Storage, Handling and Application, 1998
BMP 06 - Soil Management, 1994
BMP 19 – Streamside Grazing, 2007
BMP 07 – Water Management, 1993
BMP 12 – Water Wells, 2003 revised

Ministry of the Environment and Energy and Ministry of Natural Resources, 1993:
Subwatershed Planning.

Ministry of the Environment and Energy, 1994:
Stormwater Management Practices Planning and Design Manual (June, 1994).

Ministry of the Environment, 2003:
Stormwater Management Planning and Design Manual (March, 2003).

Ministry of the Environment, 1994:
Water Management Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of Environment and Energy.

Ministry of Municipal Affairs and Housing, 2005:
Provincial Policy Statement.

Ministry of Natural Resources, 2012:
Significant Wildlife Habitat Ecoregion 6E Criterion Schedule.
http://publicdocs.mnr.gov.on.ca/View.asp?Document_ID=21842&Attachment_ID=45644

Ministry of Natural Resources, 2010:
Natural Heritage Reference Manual for Natural Heritage Policies of the Provincial Policy Statement 2005 Second Edition. Queens Printer for Ontario, Toronto.

Ministry of Natural Resources, 2008:
Letter from K. Standeven, Acting District Ecologist for Kemptville District MNR, to City of Ottawa, dated October 23, 2008.

Ministry of Natural Resources, 2000:
Significant Wildlife Habitat Technical Guide: Appendix C List of Area Sensitive Species and Key References. Queens Printer for Ontario, Toronto.

Ministry of Natural Resources, 1991:
Cardinal Creek Karst ANSI - Earth Science Inventory Checklist.

Mississippi – Rideau Source Protection Region. 2011. Assessment Report: Rideau Valley Source Protection Areas. http://www.mrsourcewater.ca/assessment_report/report_R.html. Last verified: May 29, 2014.

Significant Wildlife Habitat Ecoregion 6E Criterion Schedule.
http://publicdocs.mnr.gov.on.ca/View.asp?Document_ID=21842&Attachment_ID=45644

Natural Heritage Information Centre, 2002:
The Big Picture 2002. http://nhic.mnr.gov.on.ca/MNR/ nhic/projects/BP/bigpict_2002_main.cfm. Last verified: June 30, 2009.

Nature Conservancy of Canada, 2005:
Great Lakes Conservation Blueprint for Biodiversity. http://science.natureconservancy.ca/resources/resources_w.php?Key=great+lakes+conservation+blueprint. Last verified: June 30, 2009.

Niblett Environmental Associates Incorporated, 1992:
Township of Cumberland, East Urban Community Expansion Area, Master Drainage Plan – Environmental Evaluation (January, 1992).

Paul Wisner & Associates Incorporated, 1992:
Hydrologic and Water Quality Studies for the Cardinal Creek Master Drainage Plan – Volume II (1992)

Paul Wisner & Associates Incorporated, 1992:
Hydrologic, Water Quality and Hydrogeologic Studies for Sizing and Comparison of Stormwater Management Alternatives, Expansion, Township of Cumberland, Master Drainage Plan, Phase II – Volume 1(1992).

Paul Wisner & Associates Incorporated, 1992:
Stormwater Design Plan – Cardinal Creek Business Park (July, 1992). Township of Cumberland.

Robinson Consultants Inc. and Aquafor Beech Limited, 2005:
Lower Rideau Watershed Strategy. Rideau Valley Conservation Authority.

Rideau Valley Conservation Authority, 2009:
City Stream Watch 2008. http://209.5.125.108/IM/Documents/Aquatics/City_Stream_Watch/2008_City_Stream_Watch_final_report.pdf. Last verified: June 30, 2009.

Singer, S.N., C.K. Cheng and M.G. Scafe, 2003:
The Hydrogeology of Southern Ontario. Ontario Ministry of the Environment, Environmental Monitoring and Reporting Branch.

Statistics Canada, 2007:
2006 Census of Agriculture. http://www.statcan.gc.ca/ca-ra2006/release-diffusion-eng.htm. Last verified: June 22, 2009.

Toronto and Region Authority and Credit Valley Conservation Authority, 2011:
Low Impact Development Stormwater Management Planning and Design Guide.

Thompson, I.D., 2000:
Forest Vegetation of Ontario. Factors Influencing Landscape Change. Pp. 30 – 53 *in* Ecology of a Managed Terrestrial Landscape: Patterns and Processes of Forest Landscapes in Ontario. *Edited by* A.H. Perera, D.L. Euler and I.D. Thompson. UBC Press, Vancouver, B.C.

Worthington Groundwater, 2013:
Evaluation of Karst at Cardinal Creek Village.