Stoney Creek Subwatershed Study

Main Report
May 24, 1995

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Dear Messrs. Standish and Goldt:

Final Report - Stoney Creek Subwatershed Plan

We are pleased to submit the final report for the Stoney Creek Subwatershed Study. The report consolidates earlier documentation that summarized the results of the Phase II, III, and IV investigations.

The focus of this report is the documentation of the process and studies which lead to the selection of the recommended Plan which is detailed in Part D of the report. This report should be read in conjunction with other documents prepared during the course of the London Subwatershed Studies program, namely:

i) The Technical Appendix summarizing the findings of the Detailed Studies;

ii) The London Subwatershed Studies Implementation Plan;

iii) The Draft Terrestrial Resource Strategy; and


The recommended Subwatershed Plan for Stoney Creek represents a blueprint for not only sustaining, but enhancing the natural resources of the subwatershed. The development of the Plan involved the collective effort of a skilled Technical Team supplemented by thoughtful input and direction provided by members of the Technical Advisory Committee, citizens, interest groups, agency staff and representatives of the development industry.

We have enjoyed working with you and other members of the Technical Advisory Committee on this interesting study and trust that the findings of this study will benefit the strategic planning initiative of Vision '96.

Yours very truly,

PARAGON ENGINEERING LIMITED

Jack Gorrie, M.A.Sc., P. Eng.

JG/sc

Encl.
Stoney Creek Subwatershed Study

Main Report

Paragon Engineering Limited in association with:

Gore & Storrie Limited
Golder Associates Ltd.
Ortech Corporation
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MacNaughton Hermsen Britton Clarkson Planning Limited
Archaeological Research Associates Ltd.
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PREFACE

The City of London and the Upper Thames River Conservation Authority (UTRCA) jointly initiated the preparation of a subwatershed plan for the Stoney Creek Subwatershed, as well as other subwatersheds in the London Area. Provincial agencies, City and Township staff, interest groups and public representatives were also actively involved in the study. Subwatershed plans are an essential component of the Vision '96 planning for the City of London. The subwatershed studies provided an opportunity to develop an ecosystem based planning approach which will serve as a basis for future planning decisions. The key ingredients in the development of a successful ecosystem planning vision for the subwatersheds include the following:

- Understanding natural systems and their inter-relationships;
- Understanding watershed uses and development pressures;
- Recognition of agency and landowner issues;
- Identifying rehabilitation and enhancement opportunities;
- Determining appropriate management and monitoring strategies; and
- Formulating creative planning guidelines.

A number of reports were completed as part of the subwatershed process including:

- Background Report - Phase I, Marshall Macklin Monaghan Limited, October 1993
- Water Quality and Quantity Monitoring Program Results, UTRCA, July 1994.
- Phase II/III - Detailed Studies/Management Alternatives (Draft), Part 1 of 2, Paragon Engineering Limited, October 1994.
- Technical Appendix, Paragon Engineering Limited

The following report is the main document which summarizes all of the above with the exception of the implementation report which will be bound under separate cover.

The Subwatershed Study Consulting Team for the Stoney Creek Subwatershed was as follows:

- Paragon Engineering Limited (Prime Consultant)
- Gore & Storrle Limited
- Hough Stansbury Woodland Naylor Dance Limited
- MacNaughton Hermens Briton Clarkson Planning Limited
- Ortech Corporation
- Golder Associates Ltd.
- Archaeological Research Associates Ltd.
ACKNOWLEDGEMENTS

The Consulting Team gratefully acknowledges the assistance of all agencies, TAC members and individuals who provided input to the study. Specifically, we would like to acknowledge the following individuals and organizations.

Technical Advisory Committee (TAC)

- Mr. Rick Goldt - UTRCA
- Mr. Bill Diver - UTRCA
- Mr. Ron Standish - City of London
- Mr. Brian Turcotte - City of London
- Mr. Doug Stanlake - City of London
- Ms. Bertha Kricher - City of London
- Ms. Nancy McMinn - City of London
- Ms. Sally Colman - Ministry of Natural Resources
- Mr. Harald Schraeder - Ministry of Natural Resources
- Mr. Stewart Thormley - Ministry of Environment & Energy
- Mr. Bob Aggerholm - Ministry of Environment & Energy
- Mr. Bill Armstrong - Ministry of Environment & Energy
- Mr. Henry Komarek - London Development Institute
- Mr. Scott Oliver - Ontario Ministry of Agriculture & Food
- Mr. Roger Moyer - Ministry of Municipal Affairs, London Region
- Mr. Doug Duffin - Agricultural Advisory Committee Representative
- Ms. Jennifer LeBlanc - EEPAC
- Mr. David Matthews - Patrick, Sweet & Associates
- Ms. Joni Anderson - Township of London
- Mr. Edward Emery - Public
- Mr. Brian A. Goudeseune - Public
- Mr. Bill DeYoung - Public

Appreciation is particularly extended to Mr. Ron Standish of the City of London Vision '96 office and Mr. Rick Goldt of the Upper Thames River Conservation Authority for their guidance and leadership throughout the study. The participation of the landowners and citizens of the watershed who provided input during public meetings is respectfully acknowledged.
EXECUTIVE SUMMARY

The Stoney Creek Subwatershed Plan has been prepared to provide broad direction to the City of London, the Upper Thames River Conservation Authority, review agencies, developers, citizens and interest groups regarding measures required to maintain and enhance features, functions and linkages of the Stoney Creek subwatershed in anticipation of future growth to occur as a result of the recent annexation of lands by the City of London.

The Subwatershed Plan identifies areas which should be protected or conserved as a Natural Heritage System, criteria for future urban development, conservation and management practices, and specific projects and programs to improve current subwatershed conditions and increase awareness about what is needed to sustain the features, functions and linkages of the Stoney Creek subwatershed.

Subwatershed Plan Goals and Objectives

The following goals and objectives of the Stoney Creek Subwatershed Plan were developed through public consultation early in the London Subwatershed Study process:

1. To protect, enhance and/or restore the watershed ecosystem through cost effective and environmentally sound strategies;

2. To make the planning and approvals process more efficient by providing clarity, information and a watershed context for watershed stakeholders; and

3. To provide an ecosystem approach to the planning and management of existing and future land uses.

Subwatershed Study Phasing and Reports

The Stoney Creek Subwatershed Study was completed in five phases summarized in the following table:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Focus of Study</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>Background Review</td>
<td>October 1993</td>
</tr>
<tr>
<td>Phase II</td>
<td>Detailed Studies</td>
<td>October 1994</td>
</tr>
<tr>
<td>Phase III</td>
<td>Development of Alteration Strategies</td>
<td>December 1994</td>
</tr>
<tr>
<td>Phase IV</td>
<td>Finalization of Recommended Subwatershed Plan</td>
<td>March 1995</td>
</tr>
<tr>
<td>Phase V</td>
<td>Development of Implementation Plan</td>
<td>May 1995</td>
</tr>
</tbody>
</table>

The first phase involved the collection of background information and preparation of the Terms of Reference for the Phase II to V investigations. The completion of each study phase included the preparation of Draft Reports which were reviewed and commented on by members of the Technical Advisory Committee. This Final Report consolidates the Phase II, III and IV reports and incorporates comments and suggestions made by reviewers of the earlier Draft documents.

Additional detailed information on the Phase II Detailed Studies has been prepared under separate cover, in a Technical Appendix document. As well, a separate report summarizing the Implementation Plan for all of the London subwatersheds was prepared as part of the Phase V work program.
Detailed Studies

Ten detailed studies were undertaken to inventory, monitor, model and map features, functions and linkages found in the Stoney Creek subwatershed. Detailed Studies were completed for the following:

1. Land Use
2. Geology/Hydrogeology
3. Fluvial Geomorphology
4. Surface Water Hydrology
5. Rural Point and Non-Point Source Pollution
6. Water Quality
7. Aquatic Resources
8. Terrestrial Resources
9. Archaeological Resources
10. Infrastructure

The detailed study findings were subsequently synthesized to establish an understanding of how the features, functions and linkages are currently sustained in the Stoney Creek Subwatershed. The synthesis identified alternative management measures to maintain or enhance attributes of the subwatershed in anticipation of future development in the subwatershed and to address current problems noted during the course of completing the detailed studies.

Management Units

Based on the physiographic, geologic, land use and environmental quality conditions, the Stoney Creek subwatershed was divided into the following four management units:

MU1 - Rural Upper Reaches
MU2 - Eastern Central Reaches
MU3 - Western Central Reaches
MU4 - Lower Developed Reaches

Four distinct management areas in the subwatershed can be defined by physiographic, geologic, land use and environmental quality conditions. The management areas represent the rural upper reaches of Stoney Creek (Management Unit 1, or MU1), the eastern central reaches within the future development area (MU2), the west central reaches within the future development area (MU3), and the lower reaches in the existing development area (MU4).

Streams in MU1 are all first and second order, and almost all are agricultural drains. Streams in MU1 are highly degraded or support no fish species. Low baseflows in these streams provides limited opportunities to enhance these streams.

Streams in MU2 are mostly third order streams which are predominantly natural and of good water quality. MU2 supports the healthiest aquatic communities in Stoney Creek, and is amongst the best in all of the subwatersheds in London. These reaches support a Type III fish community and Type II benthic invertebrate community. There is good potential to increase the quality of the streams in this unit by improving instream cover. However these streams are highly susceptible to increases in temperature due to loss of riparian vegetation or diminished groundwater discharge, and increased inputs of nutrients or sediments.

MU3 contains two tributaries that discharge into Stoney Creek which are severely degraded and support only Type IV and V aquatic communities. Watercourses in this area flow from channelized reaches in rural areas to storm sewers in urban areas. The low baseflow, poor water quality, limited riparian vegetation, channelization, bank hardening and drop structures provide little opportunity to enhance these watercourses. If they are further degraded, however, they may not be capable of supporting any aquatic community, and may impact downstream conditions.
MU4 is the main channel of Stoney Creek which flows through the built-up area in channelized reaches. The creek is a fourth order stream, that is of fairly high quality which supports a Type III aquatic community. This reach supports the greenside darter and central stoneroller, which are provincially significant. This reach can be improved by increasing riparian and instream cover and by naturalizing portions of the channel. It also has the potential to be degraded by changes in land use practices in other upstream management unit areas.

**Alternative Subwatershed Management Strategies**

The following three alternative strategies for the Stoney Creek Subwatershed were considered:

1. Maintain the existing ecosystem;
2. Moderate enhancement of the ecosystem functions; and
3. Significant enhancement of the ecosystem functions.

The alternative for the "maintenance of the existing ecosystem functions" would entail appropriate best management practices and land use restrictions designed to maintain and protect the existing systems in the subwatershed. Ecosystem functions including surface water and groundwater interaction, fisheries habitat and water quality, terrestrial habitat, and corridor linkages would be addressed.

The alternative for "moderately enhancing existing ecosystem functions" can be broken down into two major categories. The two categories are to enhance the aquatic ecosystem and the terrestrial system. These alternatives include the identification of candidate areas for rehabilitation, candidate areas for terrestrial enhancement, improvement in the aquatic environment and associated habitat potential, and rehabilitation of tableland woodlots in order to enhance their function in providing terrestrial habitats.

The alternative for the "significant enhancement of the ecosystem functions" builds on the moderate enhancement alternative described above. Further rehabilitation of existing ecological features as well as the creation of new ecological features from both an aquatic and terrestrial perspective, are provided for in this level of enhancement.

**Evaluation of Alternative Subwatershed Management Strategies**

The three alternative management strategies were evaluated with respect to the following criteria:

i) Technical Consideration;
ii) Environmental Benefits;
iii) Land Requirements/Impacts;
iv) Cost;
v) Agency Acceptance; and
vi) Public Acceptance.
Each of the management actions contained in the alternative subwatershed management strategies were ranked as:

**High:** Important to Plan success; highly effective; widespread or important site specific applicability; immediately implementable with likelihood of rapid results; general support.

**Medium:** Important to plan success; moderately or highly effective; general applicability; implementable over the long term; general support to limited resistance.

**Low:** Less important to plan success; moderately to highly effective; less important site specific or general applicability; implementable over the long term or beyond current planning horizon; moderate support to limited resistance.

Input to the ranking of management strategies by the Technical Advisory Committee resulted in the majority of recommended management activities being directed towards significant enhancement of ecosystem functions.

**Recommended Stoney Creek Subwatershed Plan**

The recommended Subwatershed Plan for the Stoney Creek Subwatershed consists of a series of management actions, which when applied together will provide a holistic strategy for meeting the Goals and Objectives of the Subwatershed Plan. The recommendations of the Subwatershed Plan fall within the following four categories:

i) Constraint Areas;

ii) Development Criteria;

iii) Conservation and Management Practices;

iv) Specific Projects and Programs.

i) **Constraint Areas**

Recommendations are made with respect to:

a) Category 1 lands - where development is prohibited.

b) Category 2 lands - where the extent of permissible development must be determined through the completion of an Environmental Impact Assessment Study (EIS).

ii) **Development Criteria**

Recommendations are made with respect to:

a) Storm water management criteria for urban development.

b) The need for environmentally sensitive site planning techniques.

c) Erosion and sedimentation control requirements for construction sites, and subsequent inspection and monitoring requirements.
iii) Conservation and Management Practices

Recommendations are made with respect to:

a) Practices that should be implemented to reduce point source pollution in the rural areas.
b) Practices that should be implemented to control non-point source pollution in the subwatershed.

iv) Specific Project and Programs

Recommendations are made with respect to:

a) Non-structural programs required to improve current subwatershed conditions.
b) Capital projects required to improve current subwatershed conditions.
PART A

STUDY CONTEXT
PART A - STUDY CONTEXT

A1.0 INTRODUCTION

A1.1 Background

The City of London has embarked upon a comprehensive process which will establish priorities and plans for the city as it moves into the 21st Century. The need for such planning results from legislation approving London's annexation of lands from adjacent municipalities in January 1993. The City is preparing a number of plans including, among others, a new Official Plan. A study on subwatersheds is one of several initiatives needed to support the Official Plan.

The City of London, in partnership with the Upper Thames River Conservation Authority, the Kettle Creek Conservation Authority, and neighbouring township therefore undertook a series of subwatershed studies for the creeks and streams which fall within or adjacent to the new city boundary defined by the recent annexation. The subwatershed studies identified important natural resource features, and development strategies to protect and enhance these features as land use change occurs. The subwatershed studies have established plans for management of the subwatersheds and provide input to the City's Official Plan review which is being conducted under the Vision '96 program. Thirteen subwatersheds were investigated, including:

- Stoney Creek;
- Pottersburg Creek;
- Crumlin Drain;
- Medway Creek;
- Stanton Drains;
- Mud Creek;
- Sharon Creek;
- Upper Dodd Creek;
- Kettle Creek; and
- Several reaches of the Thames Valley lands.

The City of London and the Upper Thames River Conservation Authority retained Paragon Engineering Limited to undertake the subwatershed study for Stoney Creek, which is summarized in this report.

A1.2 The Subwatershed Plan Process

Bill 75 (City of London Annexation Act) received Royal Assent on December 10, 1992. It established lands to be annexed from the Town of Westminster, the Township of Delaware, North Dorchester and West Nissouri. The Act stated that the City of London shall prepare and adopt an Official Plan (by January 1, 1996) for the lands annexed to the City. In keeping with current Provincial direction, the City of London is preparing the subwatershed studies as input to the preparation of the Official Plan for the recently annexed areas. The recommendations and guidelines resulting from the Subwatershed Plans will form the environmental basis on which the Official Plan and subsequent secondary plans will be developed.

The subwatershed studies were being completed in the following five phases:

- Phase I - Background Review
- Phase II - Detailed Studies
- Phase III - Develop Management Alternatives
- Phase IV - Recommended Management Plan
- Phase V - Implementation and Monitoring
The background review completed in the first phase was undertaken City-wide on all subwatersheds and was completed in 1993. The first phase report included the preparation of Terms of Reference for the individual and grouped subwatershed studies to be completed in Phases II to V. Phase II began in December of 1993 and continued through the summer of 1994. This phase involved data collection, field studies and modelling which allowed the teams to develop an understanding of how each subwatershed functions and what the major problems and limitations are. Through the course of Phase II, public workshops and meetings were held in order to draw from local experience and develop goals and objectives for the Subwatershed Plans.

Phase III began in late summer of 1994 and involved the development of alternative management actions which would address existing problems, prevent future ones, and provide improvements to strengthen the existing ecosystem. Consideration of the latter was necessary because of impacts that have occurred resulting from previous land use practices. The various management actions were organized into a series of alternative strategies, for the purpose of evaluation. The results of the Phase II studies, the possible management actions, alternative strategies and evaluation criteria were documented in an Interim Report completed in October 1994. A summary of the information, including the alternatives and evaluation criteria, were presented to the public through meetings held in November 1994.

Subsequent to the November meetings, evaluations of the different management actions and alternative strategies were conducted by the subwatershed teams. These were submitted to the Technical Advisory Committee for comment. Through the subwatershed team recommendations, meetings with the TAC and discussions with individual agencies, a series of recommended Subwatershed Plans evolved. While the individual plans differ in some details because of the differences between the subwatersheds, the overall content and recommendations of the plans are similar. A description of the evaluation criteria and consultation process used to arrive at the recommended Subwatershed Plan is provided in Section D of this report and is followed by an overall description of the Subwatershed Plan (including graphical and tabular presentations).

A1.3 Subwatershed Location and Study Area

The Stoney Creek subwatershed extends over an area of approximately 38 km². Map A1 illustrates the location of Stoney Creek and its watershed in relation to the City of London and several other local watersheds. Approximately 40 percent of the watershed lies within the boundaries of the City of London. At this time, about 10 percent of the watershed has been urbanized, mainly in the lower part of the watershed. Lands upstream of the existing development are predominantly agricultural, while extractive industrial lands represent a large portion of land use in the southeast part of the watershed.

The lower reaches of the creek, from the Thames River north to just west of Adelaide Street remain as a natural channel. Continuing west and upstream, the creek has been reconstructed as a grass-lined channel to the upstream limits of existing development. Continuing upstream from the existing limits of development are three tributaries, the majority of which remain in their natural state, with the exception of a few field drains that have been realigned for agricultural purposes.
A2.0 SUBWATERSHED MANAGEMENT APPROACH

A2.1 General

Subwatershed management and planning recommendations for the Stoney Creek subwatershed have been developed using an ecosystem approach. An ecosystem approach to subwatershed management is based on the fact that the natural features and functions of a subwatershed are linked by the movement of water. Changes in the subwatershed that affect this movement of water may, in turn, affect the natural features and functions. Impact assessment of land use change in a subwatershed must consider these fundamental relationships. This relationship is best described, in a general fashion, by the subwatershed concept as illustrated in Figure A1.

A2.1.1 Subwatershed Hydrology

The hydrologic cycle incorporates the concepts of precipitation, surface water runoff, infiltration, groundwater flow and evapotranspiration. The City of London generally receives 800 to 1000 mm of precipitation annually. When this precipitation falls on the landscape, some of the water infiltrates into the soil to become part of the groundwater system. The remainder of the precipitation becomes runoff and forms surface water systems on top of the landscape. To complete the cycle, water is evaporated by the energy from sunlight from surface water systems and transpired by terrestrial vegetation to be put back into the atmosphere.

The water that infiltrates into the groundwater system generally takes one or two pathways through the shallow groundwater system and/or the deeper groundwater system. Groundwater movement in the shallow groundwater system is typically in a lateral direction and will usually follow the topographic features of the landscape. Shallow groundwater will often discharge to surficial water features like wetlands or streams. The deeper groundwater systems are more regional in nature and typically represent regional water supplies. Groundwater flow in the deeper systems need not obey local topographic features, but are most often controlled by more prominent features of a landscape.

The balance between the amount of water that infiltrates into the soil and the amount of water that runs off forming surface water systems, is unique to each subwatershed. The balance is determined by several factors:

i) Soil type which is derived from quaternary geology or surficial geology;

ii) Surface topography; and

iii) Land cover (vegetation and development).

Areas of deep sands and gravel are very permeable and consequently act as areas of high infiltration and groundwater recharge. Conversely, areas of clay and silty clay tills are of low permeability and contribute little to groundwater recharge. Landscapes with dense vegetation tend to promote infiltration of rainfall into the soil, however, these same areas will also promote higher levels of evapotranspiration of water back into the atmosphere.

These basic processes of infiltration, runoff and groundwater discharge are important hydrologic functions in the subwatershed. The relationship between areas of surface water infiltration and ground water discharge is an important ecosystem linkage.
A2.1.2 Subwatershed Aquatic and Terrestrial Resources

Natural features of a subwatershed include both aquatic and terrestrial resources. The aquatic resources including fish and invertebrates have an obvious dependence on the subwatershed hydrology. An inventory and analysis of the aquatic resources of a subwatershed is often used as an indicator of the environmental quality within the subwatershed. Certain aquatic species have exacting habitat requirements and are relatively intolerable to pollutant inputs. The presence of these types of species typically indicate a more healthy aquatic ecosystem. Other aquatic species have less exacting requirements and are more tolerant to pollutant inputs. The prominence of these species in the subwatershed aquatic system is indicative of a more degraded system. The quality of the aquatic ecosystem can vary throughout the subwatershed as well, usually depending on upstream land uses. As a general rule, the presence of a diversity of species is considered healthy.

Terrestrial resources in a subwatershed may not be entirely dependent on the hydrologic system, however, they are indirectly linked to the subwatershed hydrology. The presence of vegetation can influence the balance between the amount of water that infiltrates into the soil and the amount of water that runs off in surface water systems. Some vegetation species are indicative of high groundwater tables or wet areas in a subwatershed. Others are more typical of a more dryer soil strata. Vegetation and terrestrial resources also provide wildlife habitat. Many birds and animals depend solely on these terrestrial features for their habitat. Similar to aquatic species, some terrestrial species have more exacting habitat requirements than others. For example, some bird species require larger forest patches that provide a forest interior habitat. The interior habitat is separated from areas that undergo edge effects and influences from urban development and open spaces. Subwatershed ecosystems will typically contain a range of habitats that provide sanction for a range of terrestrial species.

A2.2 A Framework for the Subwatershed Ecosystem

The hydrologic processes, the aquatic resources, and the terrestrial resources in a subwatershed define a unique set of ecosystem functions, attributes, and linkages. The definition of how a subwatershed works in terms of its functions, attributes and linkages provides an overall framework for an assessment of the subwatershed ecosystem in a holistic manner.

Functions are earth and life science processes in the landscape. For example, earth science functions include groundwater recharge and discharge. Life science functions include the provision of wildlife habitat.

Attributes are components of the environment considered to be "special" such as rare species or particularly sensitive populations or habitats.

Linkages are the relationships between the natural landforms and the aquatic and terrestrial resources. For example, stream valley corridors link the upper reaches of the subwatershed to its confluence with the riverine system.

A generic list of subwatershed functions, attributes and linkages is provided in Table A.1.
### TABLE A.1

Subwatershed Functional Assessment

<table>
<thead>
<tr>
<th>Functional Component</th>
<th>Functional Description</th>
<th>General Information Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydrological</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>groundwater recharge</td>
<td>degree of infiltration; dependent upon surficial geology, land use and other considerations on a catchment basis.</td>
<td>geological mapping, catchment boundaries, climatological information.</td>
</tr>
<tr>
<td>groundwater discharge</td>
<td>seepage areas, largely confined to valleylands or wetland areas of tableland.</td>
<td>valleyland limits and wetland information from background sources (Conservation Authorities, OMNR maps).</td>
</tr>
<tr>
<td>flood storage and conveyance</td>
<td>valleylands and wetlands; the latter have varying degrees of functional capability depending upon site specific characteristics.</td>
<td>Conservation Authority flood and fill line mapping; aerial photograph delineation of major valley system limits.</td>
</tr>
<tr>
<td>water quality modification</td>
<td>capability to retain and/or transform quality of overland runoff; dependent upon watercourse and riparian vegetation characteristics.</td>
<td>assessment of permanence of watercourse and degree of vegetative cover.</td>
</tr>
<tr>
<td><strong>Biological</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>erosion control</td>
<td>influence of vegetative cover in maintaining steep slopes limiting erosion; mostly contained within valleyland limits.</td>
<td>watercourse temperature and other aquatic &quot;indicators&quot; of integrity (i.e. presence/absence of species.</td>
</tr>
<tr>
<td>wildlife habitat</td>
<td>terrestrial and aquatic habitats available to support both flora and fauna; this is a strong reflection of biodiversity.</td>
<td>valley limits; flood and fill line mapping.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>natural vegetation cover and patterns within landscape: OMAF and Forest Resource Inventory mapping with limited field verification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>aquatic ecosystem characteristics (i.e. coldwater vs. warmwater, permanent vs. ephemeral or intermittent).</td>
</tr>
</tbody>
</table>
## TABLE A.1

### Subwatershed Functional Assessment

<table>
<thead>
<tr>
<th>Functional Component</th>
<th>Functional Description</th>
<th>General Information Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B - Attributes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rare species</td>
<td>spot locations of individuals and populations of rare species.</td>
<td>OMNR, Conservation Authorities, NGO inventories, databases and rare species mapping.</td>
</tr>
<tr>
<td>critical wildlife habitat</td>
<td>concentrations of species dependent upon a particular area for local, regional or provincial population health.</td>
<td>ESA, life science, ANSI reports.</td>
</tr>
<tr>
<td>unusual vegetation communities</td>
<td>relict community which is unusual on landscape level in term of composition and/or structure.</td>
<td>information regarding deer concentration areas, heronries, migratory stopovers, etc.</td>
</tr>
<tr>
<td>unusual landforms and fossil assemblages</td>
<td>bedrock outcrops, landforms of interest from research, education and conservation perspectives.</td>
<td>ESA, life science, ANSI reports.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>earth science, ANSI reports; landscape terrain evaluation.</td>
</tr>
<tr>
<td><strong>C - Linkages</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dispersal and movement corridors</td>
<td>terrestrial linkages include vegetated valleyland corridors, contiguous tableland tracts of forest and hedgerows.</td>
<td>vegetation patterns on the landscape and watercourse locations and characteristics; major hedgerows identified from photograph spot-checking.</td>
</tr>
<tr>
<td>hydraulic connections</td>
<td>aquatic corridors including watercourses and waterbodies.</td>
<td>general temperature and water quality information along with an assessment of background data for presence or absence of indicator species (continuous vs. discontinuous) along a corridor.</td>
</tr>
<tr>
<td></td>
<td>groundwater recharge areas and discharge areas are linked by the hydraulic properties of the soil.</td>
<td></td>
</tr>
</tbody>
</table>
Management of a subwatershed from an ecosystem perspective must address these functional components. Maintenance of the subwatershed functions, attributes and linkages would typically maintain the existing environmental quality. Enhancement of particular functions and/or linkages could improve the environmental quality of the subwatershed. An understanding of how these functional components work together will identify candidate areas for rehabilitation and/or improvement. An evaluation of the subwatershed management options, along with discussions and consensus building among the stakeholders will lead to a recommended Subwatershed Plan that, when implemented, can maintain and enhance the subwatershed functions, attributes and linkages.

A2.3 Potential Impacts of Development on Subwatershed Functions, Attributes and Linkages

A2.3.1 Hydrologic Functions

Changes in land use can affect the natural balance of runoff and infiltration for an area. When lands are developed, the landscape generally becomes more impermeable as a result of increased areas of roofs, roads, driveways and parking lots. Different types of development vary in the amount of landscape that is covered by impermeable surfaces. For example, a commercial development, such as a shopping mall, covers a large portion of the landscape by impermeable surfaces. Single family residential developments put impermeable surfaces over a smaller portion of the landscape and estate residential development has even less impermeable area.

The potential impacts of development on water resources are, therefore, primarily influenced by three factors:

a) The amount of landscape that will be developed;

b) The percentage of the landscape that will be covered by impermeable surfaces; and

c) The ability of surficial soils to infiltrate surface water.

The resulting impacts of urbanization (change from a permeable landscape to one which is impermeable) are generally viewed as negative, if not mitigated, because:

a) It reduces the amount of infiltration to recharge the groundwater system. This could affect the use of the aquifer as a drinking water supply and could reduce groundwater discharge to streams, affecting the biological resources and assimilative capacity of the stream; and

b) It increases the amount of storm water runoff, which can increase the amount of water in a stream after a storm (peak flow) and the length of time that flows are elevated (bankfull duration). Both of these are harmful in that they can result in increased flooding, erosion, damage to fish habitat, and risk to human health and safety.

Different subwatersheds respond to development stress in different ways. For example, the maintenance of infiltration is most important in areas where there is an aquifer used for drinking water supply or a fishery dependent on groundwater discharge. Also, the extent to which storm water flows will be increased is dependent on local climatic conditions: in areas where storm volumes are generally small in size, such as in Southern Ontario, some decrease in permeability can generally be accommodated without greatly influencing runoff quantities.
These potential changes to the subwatershed hydrology must be understood before preparing a subwatershed management strategy. A number of hydrologic models are used to determine the response of the subwatershed to rainfall events under existing conditions and under future development scenarios. A comparison of the response under the future development scenario to the response under existing conditions allows the determination of the changes in the hydrologic cycle that could occur.

Development can also have a negative effect on water quality. As land use change occurs, changes in pollutant loadings can also occur which affect the quality of both surface and groundwater. Runoff from developed land has generally been found to carry higher loadings of certain types of pollutants than runoff from undeveloped areas. These may include:

a) Road salt;
b) Chemicals from commercial (e.g., gas stations, dry cleaners), industrial and transportation sources; and
c) Lawn fertilizers and pesticides.

On the other hand, some pollutant loadings may be decreased with land development. For example, agricultural chemicals, sediment and nutrient loads may be reduced when certain types of agricultural land are urbanized.

A2.3.2 Potential Impacts on Aquatic and Terrestrial Functions, Attributes and Linkages

Aquatic Resources

A change in the balance between infiltration and runoff can have significant effects on the baseflow in streams. A reduction in the baseflow may change the water temperature as well as the amount of water available for aquatic habitat during drier periods of the year. Some fish species are dependent upon groundwater discharge to streams to provide a suitable habitat. Development that occurs without regard for the maintenance of this balance between infiltration and runoff has the potential to negatively impact such fisheries.

Changes in water quality as a result of development can also impact the subwatershed aquatic resources. Many substances are toxic to aquatic life. For example, heavy metals including arsenic, cadmium, copper, lead, mercury, silver and zinc, among others, are toxic to aquatic life in concentrations above certain threshold limits. Sources of heavy metals could include runoff from roads and industrial discharges.

Nutrients, including agricultural fertilizers, can also impact the aquatic habitat. Typical nutrients include nitrogen compounds, phosphorus and potassium. A particular form of nitrogen known as un-ionized ammonia, is toxic to aquatic life. A major source of this form of nitrogen is runoff from lands on which manure has been spread. Other nutrients, such as phosphorus and potassium, tend to promote algal growth in the receiving waters. Prolific algal growth can decrease dissolved oxygen levels in creeks, rivers and other waterbodies. Aquatic species are dependent on a certain level of dissolved oxygen to be available for their metabolism.
Terrestrial Resources

Land use change can also impact wildlife habitat. An obvious impact is the direct loss of habitat through removal of trees and vegetation or channelization of streams. This scenario leads to a total net loss of habitat in the ecosystem. This is not a desirable result.

Encroachment of development on areas providing terrestrial habitat can also have a negative impact. Changes in the habitat microclimate (wind speed, temperature, lighting, noise) can impact the suitability of a natural area to continue to function as wildlife habitat.

Some species of vegetation are dependent upon groundwater levels. Changes in groundwater levels can result if development plans do not account for the balance between infiltration and runoff and the potential to impact vegetation. For example, inappropriate development adjacent to a wetland has the potential to lower the groundwater table, and subsequently change the availability of water to the wetland vegetation. The wildlife dependent upon the wetland vegetation as habitat would also be impacted.

A3.0 POLICY FRAMEWORK

Development of the Stoney Creek Subwatershed Plan (SCSP) has been predicated on the existing policy framework for the natural environment. The Subwatershed Plan contains many recommendations intended to guide future planning and management in the Stoney Creek watershed, including land use planning.

The SCSP recommendations have been developed to be consistent with the Comprehensive Set of Policy Statements that have been issued under Section 3 of the Planning Act, as well as other guidelines and policies concerned with the management of physical and ecological features and processes.

The Comprehensive Set of Policy Statements cover a broad range of policy areas affecting matters of provincial interest and the contents for Subwatershed Plans summarized in Table A.2. In addition to the policies noted in Table A.2, a number of other policies, documents and guidelines that have guided recommendations in the SCSP are summarized in Table A.3.

The Stoney Creek Subwatershed Management Study has been carried out during a period in which fundamental changes have been made to the way planning is undertaken in the Province of Ontario. The timing of the release of the SCSP document finds itself in a transition period, after the time when the Comprehensive Set of Policy Statements apply, but includes various planning documents and development proposals which are not subject to the Comprehensive Set of Policy Statements due to grandfathering under the earlier planning process.

Before the Comprehensive Set of Policy Statements came into effect, many of the policies contained in it were applied by the Province, local municipalities or review agencies, while commenting on planning documents or reviewing development proposals. Consequently, although changes in the submission requirements of proposed developments may have changed since the Comprehensive Set of Policy Statements came into effect on March 28, 1995, many of the policies affecting subwatershed planning and related development considerations had already applied.
<table>
<thead>
<tr>
<th>Policy #</th>
<th>Content for Official Plan</th>
<th>Content for Watershed or Subwatershed Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.1</td>
<td>Groundwater and surface water</td>
<td>surface and groundwater quality and quantity</td>
</tr>
<tr>
<td>A1.2, A1.4</td>
<td>Natural heritage systems, features and areas</td>
<td>Natural systems linkages and functions</td>
</tr>
<tr>
<td>A1.3</td>
<td>Fish habitat</td>
<td>Fisheries management</td>
</tr>
<tr>
<td>A2</td>
<td>Wetlands</td>
<td>Ecological integrity and carrying capacity</td>
</tr>
<tr>
<td>A3.3</td>
<td>Hazardous and contaminated sites</td>
<td>Enhancement and rehabilitation of natural features</td>
</tr>
<tr>
<td>A3.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3.2</td>
<td>Flooding and erosion</td>
<td>Storm water management; protection of valley systems.</td>
</tr>
<tr>
<td>A3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B5.0</td>
<td>Servicing and infrastructure</td>
<td>Areas suitable for development; best management practices for subdivision design</td>
</tr>
<tr>
<td>B7.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B10</td>
<td>Development in rural areas</td>
<td>Servicing needs; availability of sewers and water</td>
</tr>
<tr>
<td>B12</td>
<td>Public access to public land and water bodies</td>
<td>Management practices for open space and greenspace corridors</td>
</tr>
<tr>
<td>B13</td>
<td>Significant landscapes, vistas and ridge lines</td>
<td>Areas suitable for development; natural systems and linkages; enhancement and rehabilitation of natural features</td>
</tr>
<tr>
<td>E1</td>
<td>Site design, landscaping, infrastructure and building design</td>
<td>Conservation opportunities for water, energy and the built environment</td>
</tr>
<tr>
<td>E3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td>Mineral aggregates</td>
<td>Natural systems linkages and functions</td>
</tr>
</tbody>
</table>

NOTE:

Above based upon: Watershed Planning Initiative Science and Technology Task Group (LURA Group, 1995)
<table>
<thead>
<tr>
<th>Document/Policy Guidelines</th>
<th>Relevant Agency/Agencies</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Bill 75 - City of London Annexation Act</td>
<td>City of London</td>
<td>1992</td>
</tr>
<tr>
<td>ii) London Middlesex Act</td>
<td></td>
<td>1992</td>
</tr>
<tr>
<td>iii) Official Plan Objectives (Ontario Regulation No. 479/93)</td>
<td>Province of Ontario</td>
<td>1993</td>
</tr>
<tr>
<td>v) Policy Statement-Floodplain Planning and in particular the One-Zone and Two-Zone policies for floodplains</td>
<td>MMA/MNR</td>
<td>1988</td>
</tr>
<tr>
<td>vi) Fill, Construction and Alterations to Waterways Regulations (Ontario Regulation 154/86 as amended by 631/88), which identifies Upper Thames River Conservation Authority jurisdiction</td>
<td>UTRCA</td>
<td>1988</td>
</tr>
<tr>
<td>vii) Subwatershed Planning</td>
<td>MOEE/MNR</td>
<td>1993</td>
</tr>
<tr>
<td>viii) Integrating Water Management Objectives into Municipal Planning Documents</td>
<td>MOEE/MNR</td>
<td>1993</td>
</tr>
<tr>
<td>viii) Water Management on a Watershed Basis: Implementing an Ecosystem Approach</td>
<td>MOEE/MNR</td>
<td>1993</td>
</tr>
<tr>
<td>ix) The Department of Fisheries and Oceans for the Management of Fish Habitat and particularly the principle of &quot;No Net Loss of Habitat&quot;</td>
<td>Department of Fisheries and Oceans</td>
<td>1986</td>
</tr>
<tr>
<td>x) Guidelines on the Use of Vegetative Buffer Zones to Protect Fish Habitat in an Urban Environment</td>
<td>MNR</td>
<td>1987</td>
</tr>
<tr>
<td>xii) The Interim Storm Water Quality Control Guidelines</td>
<td>MNR/MOEE</td>
<td>1991</td>
</tr>
<tr>
<td>xiv) Fish Habitat Protection Guidelines for Developing Areas</td>
<td>MNR</td>
<td>1994</td>
</tr>
<tr>
<td>Document/Policy Guidelines</td>
<td>Relevant Agency/Agencies</td>
<td>Date</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>xvi) Comprehensive Set of Policy Statements</td>
<td>MMA</td>
<td>1994</td>
</tr>
<tr>
<td>xvii) Ontario Food Land Guidelines</td>
<td>OMAF</td>
<td>1978</td>
</tr>
<tr>
<td>xo) Technical Guidelines, Erosion and Sediment Control</td>
<td>MNR</td>
<td>1989</td>
</tr>
</tbody>
</table>

NOTE:

1) Also covered/replaced by the Comprehensive Set of Policy Statements under Section 3 of the Planning Act.
A4.0 SUBWATERSHED MANAGEMENT GOALS AND OBJECTIVES

As a result of public consultation carried out early in the London Subwatershed Study process, a number of goals, policies and objectives were identified, which are summarized in Table A.4. The main goals and objectives the Subwatershed Plan are:

i) To protect, enhance and/or restore the watershed ecosystem through cost effective and environmentally sound strategies;

ii) To make the planning and approvals process more efficient by providing clarity, information and a watershed context for watershed stakeholders; and

iii) To provide an ecosystem approach to the planning and management of existing and future land uses.

A5.0 PUBLIC PARTICIPATION

The London Subwatershed Studies benefited from public participation and consultation throughout Phases II to V. This important study component was coordinated by the Upper Thames River Conservation Authority for the Stoney Creek Subwatershed Study. The public participation component consisted of:

- Notification of subwatershed planning activities in three newsletters;
- Presentation of subwatershed findings at four public meetings;
- Discussion of subwatershed planning issues at one workshop; and
- Public involvement in six Technical Advisory Committee meetings and review and comment on the subwatershed planning study reports.

A6.0 REPORT LAYOUT

Part B of this report summarizes the results of the detailed studies completed for the Stoney Creek subwatershed. The detailed studies identify the functions, attributes and linkage features and characteristics found in the subwatershed. Part C of this report considers the management goals, policies and objectives with respect to the unique characteristics of the Stoney Creek subwatershed and presents a range of management alternatives for the subwatershed. The recommended Subwatershed Plan and process used in selecting management alternatives are presented in Section D. Study Conclusions and Recommendations are presented in Section E. An Implementation Plan of the recommended Subwatershed Plan for Stoney Creek has been completed as part of an overall document guiding implementation of the Subwatershed Plan recommendations for all subwatersheds in the City of London, and is bound under separate cover.
<table>
<thead>
<tr>
<th>Goal No. 1: To protect, enhance and/or restore the watershed ecosystem through cost effective and environmentally sound strategies.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A.</strong> Maintain, and where possible, enhance aquatic resources associated with the subwatersheds.</td>
</tr>
<tr>
<td><strong>Objective A1:</strong> Maintain groundwater supplies and baseflow through preserving or enhancing soil infiltration recharge rates, protecting existing recharge/discharge areas and tributaries which supply or receive groundwater, and managing water taking permits.</td>
</tr>
<tr>
<td><strong>Objective A2:</strong> Maintain or enhance the quality of both groundwater and surface water and reduce sediment loading to watercourses, through erosion and siltation control, maintenance or enhancement of riparian vegetation, rehabilitation of existing erosion prone areas, and control of nutrients, contaminants, litter and trash, from both urban and rural sources.</td>
</tr>
<tr>
<td><strong>Objective A3:</strong> Maintain or reduce existing erosion potential through the control of storm runoff, and where practical, restoration of valley walls, streambanks and watercourses to a natural and stable condition.</td>
</tr>
<tr>
<td><strong>Objective A4:</strong> Maintain or enhance the aquatic habitat of the watercourses, by managing and possibly restoring natural vegetative canopy, protecting critical habitats, implementing specific habitat improvements and ensuring an acceptable flow regime.</td>
</tr>
<tr>
<td><strong>Objective A5:</strong> Maintain or enhance water quality through the implementation of appropriate Best Management Practices on the land in order to support reasonable aquatic and human use of the watercourses. Optimize patterns of future urbanization to enhance natural areas through innovative urban design, and effective storm water management and stream management practices.</td>
</tr>
<tr>
<td><strong>Objective A6:</strong> Minimize agricultural pollution through the use of appropriate Best Management Practices on the land.</td>
</tr>
<tr>
<td><strong>B.</strong> Maintain, and where possible, enhance significant terrestrial resources within the subwatersheds.</td>
</tr>
<tr>
<td><strong>Objective B1:</strong> Preserve and manage woodlots which are important to the ecological health of the subwatershed.</td>
</tr>
<tr>
<td><strong>Objective B2:</strong> Maintain or enhance the extent, structure and function of significant natural features including wetlands, areas of natural and scientific interest (ANSlAs) and environmentally significant areas (ESAs).</td>
</tr>
<tr>
<td><strong>Objective B3:</strong> Maintain or enhance a linked greenspace system which incorporates regulated and other significant natural resource features such as watercourses, wetlands, and significant upland wooded areas, which perform important ecological functions.</td>
</tr>
<tr>
<td><strong>Objective B4:</strong> Preserve the integrity of natural areas by encouraging urban designs that fit into and mesh with the character of the natural areas, by limiting utility crossings and use of the stream valleys as utility corridors, where practical, by establishing setbacks and buffers as appropriate, and by controlling public access to the natural areas in a manner which protects the more sensitive natural features.</td>
</tr>
<tr>
<td><strong>Objective B5:</strong> Maintain or enhance existing plant and wildlife habitat.</td>
</tr>
<tr>
<td><strong>C.</strong> Minimize the risk to life and property due to flooding and preserve (or re-establish, within reason) natural floodplain functions.</td>
</tr>
<tr>
<td><strong>Objective C1:</strong> Control runoff such that it does not unnecessarily increase flood risk and mitigate existing potential flood risk where feasible.</td>
</tr>
<tr>
<td><strong>Objective C2:</strong> Ensure no increase in flood risk to structures in the floodplain and employ appropriate land use controls and performance standards to control development in flood prone areas.</td>
</tr>
<tr>
<td><strong>Objective C3:</strong> Utilize a range of urban and rural storm water management practices directed towards maintaining a natural hydrologic response to rainfall and runoff. Such practices may include where appropriate, consideration of floodplain lands for the implementation of storm water management practices, where there is a clear benefit and where natural functions will be maintained.</td>
</tr>
</tbody>
</table>
### TABLE A.4, continued

**Subwatershed Goals, Sub-Goals, and Objectives**

<table>
<thead>
<tr>
<th>Goal No. 2:</th>
<th>To make the planning and approvals process more efficient by providing clarity, information and a watershed context for watershed stakeholders.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.</td>
<td>Effectively manage the database necessary to protect the ecosystem and aid with decision making.</td>
</tr>
<tr>
<td><strong>Objective D1:</strong></td>
<td>Collect and integrate data on the ecosystem to facilitate decision making.</td>
</tr>
<tr>
<td><strong>Objective D2:</strong></td>
<td>Compile all information generated as part of the Subwatershed Planning Study.</td>
</tr>
<tr>
<td><strong>Objective D3:</strong></td>
<td>Input to a data management system which can be readily updated as additional data is collected.</td>
</tr>
<tr>
<td><strong>Objective D4:</strong></td>
<td>Ensure that the data management system is accessible for use in all future studies and impact assessments.</td>
</tr>
<tr>
<td>E.</td>
<td>Develop flexible guidelines directed at implementing future land use changes within the framework of the Subwatershed Plan.</td>
</tr>
<tr>
<td><strong>Objective E1:</strong></td>
<td>Develop an Implementation Guideline Document to clearly define the types of analyses required to support future development applications.</td>
</tr>
<tr>
<td><strong>Objective E2:</strong></td>
<td>Streamline approvals through coordinated agency review effort.</td>
</tr>
<tr>
<td><strong>Objective E3:</strong></td>
<td>Allow flexibility in the design of urban development leading to ecological benefits.</td>
</tr>
<tr>
<td><strong>Objective E4:</strong></td>
<td>Minimize storm water management facilities through coordination of adjacent or regional land development activities.</td>
</tr>
<tr>
<td><strong>Objective E5:</strong></td>
<td>Develop procedures to assist in resolving conflicts between agency guidelines and policies based on the recommendations of the Subwatershed Plans.</td>
</tr>
</tbody>
</table>

### TABLE A.4, continued

**Subwatershed Goals, Sub-Goals, and Objectives**

<table>
<thead>
<tr>
<th>Goal No. 3</th>
<th>To provide an ecosystem approach to the planning and management of existing and future land uses.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective F1:</strong></td>
<td>Endeavour to include public involvement in all aspects of subwatershed management, planning and implementation.</td>
</tr>
<tr>
<td><strong>Objective F2:</strong></td>
<td>Respond to the need for community access to the natural environment by increasing the number of access points to publicly owned natural areas.</td>
</tr>
<tr>
<td><strong>Objective F3:</strong></td>
<td>Clarify public responsibilities and opportunities related to management of the subwatershed.</td>
</tr>
<tr>
<td><strong>Objective F4:</strong></td>
<td>Balance diverse public interests related to the protection of the natural environment, access to greenspace systems, urban development, and preservation of heritage features.</td>
</tr>
<tr>
<td><strong>Objective F5:</strong></td>
<td>Develop implementation strategies to address the use of greenspace lands as part of park dedication.</td>
</tr>
<tr>
<td><strong>Objective F6:</strong></td>
<td>Develop procedures for ongoing monitoring of subwatershed characteristics to evaluate the success of the management plan.</td>
</tr>
</tbody>
</table>
PART B

DETAILLED STUDIES
PART B  -  DETAILED STUDIES

This chapter provides a brief description of existing subwatershed features, functions and linkages based on the findings of detailed studies completed in the following areas of study:

i) Land Use;
ii) Geology/Hydrogeology;
iii) Fluvial Geomorphology;
iv) Surface Water Hydrology;
v) Rural Point and Non Point Source Pollution;
vii) Water Quality;
ix) Aquatic Resources;
viii) Terrestrial Resources;
b) Archaeological Resources; and
x) Sanitary Sewage Collection System.

The discussion in the following subsections is based on excerpts from the Detailed Study reports which are provided in the Technical Appendix. The findings of each of the Detailed Studies have been used to synthesize an understanding of features, functions and linkages of the current ecosystem of Stoney Creek, which is detailed at the end of this chapter.

B1.0 LAND USE

Land use in the Stoney Creek subwatershed is summarized in Table B.1. Currently, less than 15 percent of the subwatershed areas is designated as urban development of which most is in residential use in the City of London (13%), located in the lower part of the watershed. The balance of land use in the watershed is primarily agricultural or rural, located in the headwater areas except for 536 ha of land (about 14%) in the southeast corner of the watershed, which is designated as an extraction industrial area.

The land use pattern in the subwatershed is typical of most subwatersheds in the City of London and in Southern Ontario, with concentrated development occurring in the lower watershed area. What is somewhat unique to this area is the extent of extraction industrial area (gravel pits). The current extent and location of urban development in the watershed (and community expansion area noted as C in Map B1) should limit the impact of increased imperviousness area that results from development to the lower reach of the creek. Hence, current (and future) land uses in the subwatershed, combined with the appropriate management measures should limit the extent of possible potential impacts due to urban development (i.e. flooding, erosion and sedimentation etc.).

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Area (ha)</th>
<th>Percent of Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Residential</td>
<td>484</td>
<td>12.9</td>
</tr>
<tr>
<td>Agricultural/Rural</td>
<td>2707</td>
<td>72.3</td>
</tr>
<tr>
<td>Ballymote Hamlet</td>
<td>17</td>
<td>0.5</td>
</tr>
<tr>
<td>Extractive</td>
<td>536</td>
<td>14.3</td>
</tr>
<tr>
<td>Total</td>
<td>3744</td>
<td>100.0</td>
</tr>
</tbody>
</table>
B2.0 GEOLOGY/HYDROGEOLOGY

The Detailed Study of geology and hydrogeology of the Stoney Creek subwatershed was undertaken using a combination of field study data (from mini-piezometer and seepage metres), and published reports and data (MOEE well drilling records, Pleistocene and Quaternary Geology maps). Groundwater modelling was used to estimate infiltration rates to the shallow and deep groundwater systems.

B2.1 Quaternary Geology

The Stoney Creek subwatershed is dominated by the Arva Moraine and deltaic gravel deposits. The Arva Moraine transects the subwatershed in an east-west direction at approximately the 7th Concession, just north of the City of London boundary. The moraine consists of sandy silt tills with similar deposits flanking the moraine in the northern portion of the subwatershed.

The deltaic gravel deposits are prevalent on the east side of the main branch of Stoney Creek. These deposits are predominantly gravel with some sand. Two other areas of sand and gravel outwash deposits exist west of the main branch of Stoney Creek. The first is just east of Adelaide Street north of Fanshawe Park Road and the second is on the west side of Highbury Avenue at Ballymore.

Overburden thicknesses generally range between 25 and 45 metres, overlying a limestone bedrock.

B2.2 Hydrogeology

Groundwater supplies are available in both the overburden and in the bedrock, although the majority of the existing wells (63%) obtain water from confined overburden sources.

Shallow groundwater flow typically follows surface topography. Therefore, shallow groundwater flow within the subwatershed is towards Stoney Creek. The more permeable deltaic gravel deposits on the east side of the subwatershed likely make higher contributions to baseflow relative to the less permeable soils in the west and north.

B2.3 Groundwater Modelling

The groundwater modelling for the subwatershed consisted of two numerical models as well as a groundwater balance. A plan view numerical model was used to partition infiltration to either the deeper, regional groundwater system or the shallow (local) groundwater system. This model considered the aerial distribution of sandy soils and the less permeable till soils across the subwatershed area. The model assumes that the shallow or local groundwater system all discharges to Stoney Creek and its tributaries. The regional groundwater flow system discharges to the Upper Thames River.

A cross-sectional numerical model was used to simulate groundwater flow in cross-section. This model provided a means of estimating the amount of groundwater discharge per length of tributary.

A water balance calculation was carried out for the Stoney Creek Subwatershed which partitioned rainfall to infiltration and runoff. The infiltration was subsequently partitioned to the shallow groundwater system and the deeper, more regional groundwater system. The assumption was made that the shallow groundwater system discharged to Stoney Creek and its tributaries. The water balance approach utilized the results of the numerical models and the field studies.
The Stoney Creek subwatershed receives approximately 900 mm of rain per year. Approximately 10 percent of this water infiltrates into the ground and becomes part of the groundwater system. The remaining 90 percent of the rainfall either runs off to the surface water system or is taken up through evapotranspiration. Of the 10 percent that infiltrates into the groundwater system, approximately 30 percent enters the deeper or regional groundwater system and the remaining 70 percent remains part of the shallow or local groundwater system. It is this local groundwater system that is responsible for groundwater discharge to Stoney Creek and its tributaries. It is estimated that in the eastern area of the subwatershed where sand and gravel deposits exist, infiltration rates are twice that (i.e. 20% of precipitation total) of the remaining subwatershed areas that are covered by clayey tills.

B3.0 FLUVIAL GEOMORPHOLOGY

A fluvial geomorphology study was carried out in 1994 with the following main objectives:

- To classify the fluvial geomorphology of Stoney Creek by following the Rosgen (1994) method and to categorize the fluvial geomorphology of the drainage basin through morphometric measures and the creek system through hydraulic geometry relations;
- To determine sediment characteristics of bed and bank material;
- To identify, assess, and measure erosion along Stoney Creek; and
- To determine the stability of the channel through identification of threshold indices with respect to the movement of bed material.

B3.1 Fluvial Geomorphology

Stoney Creek was divided into six reaches (illustrated on Map B2), based on channel conditions and land use characteristics. For these reaches, initial measurements from recent air photos and 1:10,000 topographic maps were made, followed by site specific field work. The results are values or ranges for the classification criteria of entrenchment, width/depth ratio, sinuosity, slope, and channel materials which are presented in Table B.2.

The capital letter under classification column represents the main stream type. The stream types of B and C are common in Southern Ontario and are relatively stable. The number indicates channel material, with a high value indicating fine material, and low values very coarse material. The 5 represents sand, 4-gravel, and 3-cobbles. The lower case letter is a sub-class indicating an unusual condition, in this case, lower than normal channel slope given the stream type. The C5 classification is highly sensitive, given the gradient, width/depth ratio and sandy channel material.

Estimates of bankfull flow capacity were made using field measurements and hydraulic calculations at the four cross-section locations noted in Map B2 (plus one location 50 m downstream of S4 to cover a pool-riffle cycle). Table B.3 summarizes the bankfull flow capacity of Stoney Creek at each of the noted cross-sections.

B3.2 Sediment Characteristics

Bed and bank materials were analyzed using field and laboratory analysis. The sediment in the drainage basin and, more specifically, the material along the bed and banks of channel, exert a strong influence on channel pattern and cross-sectional shape. Information on sediment characteristics is necessary in assessing and determining sensitivity to erosion and ease of transport of bed material. The orientation pattern and distribution of bed material provide an indication of flow conditions and previous sediment movement.
<table>
<thead>
<tr>
<th>Reach</th>
<th>Entrenchment</th>
<th>Width/Depth</th>
<th>Sinuosity</th>
<th>Slope (%)</th>
<th>Channel Material</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Headwaters, east of Highbury to Sunningdale</td>
<td>1.3 to 2.0</td>
<td>8 to 12</td>
<td>1.02</td>
<td>0.43</td>
<td>sand</td>
<td>B5c</td>
</tr>
<tr>
<td>2) Headwaters, west of Highbury to confluence with main channel</td>
<td>2.0 to 2.5</td>
<td>10 to 14</td>
<td>1.02</td>
<td>0.5</td>
<td>coarse sand</td>
<td>C5</td>
</tr>
<tr>
<td>3) Sunningdale Rd. to lined channel west of Highbury</td>
<td>1.8 to 2.5</td>
<td>8 to 14</td>
<td>1.17</td>
<td>0.32</td>
<td>gravel</td>
<td>B4c</td>
</tr>
<tr>
<td>4) Lined channel 1.4 km north of Fanshawe Rd. to Adelaide</td>
<td>1.4 to 2.0</td>
<td>12 to 16</td>
<td>1.03</td>
<td>0.13</td>
<td>cobble concrete</td>
<td>B3c</td>
</tr>
<tr>
<td>5) Adelaide St. to 800 m north of Windermere Rd.</td>
<td>&gt;2.0</td>
<td>8 to 10</td>
<td>1.06</td>
<td>0.28</td>
<td>sand</td>
<td>B5c</td>
</tr>
<tr>
<td>6) 800 m north of Windermere to N. Thames River</td>
<td>&gt;2.0</td>
<td>15 to 18</td>
<td>1.11</td>
<td>0.67</td>
<td>cobbles</td>
<td>C3</td>
</tr>
<tr>
<td>Cross-Section *</td>
<td>Bankfull Width (cm)</td>
<td>Bankfull Mean Depth (cm)</td>
<td>Bankfull Velocity (m/s)</td>
<td>Bankfull Discharge (m³/s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------</td>
<td>--------------------------</td>
<td>-------------------------</td>
<td>--------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4-down</td>
<td>888</td>
<td>49.4</td>
<td>1.5</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4</td>
<td>887</td>
<td>57.8</td>
<td>1.0</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3</td>
<td>670</td>
<td>83.8</td>
<td>1.2</td>
<td>6.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td>380</td>
<td>46.2</td>
<td>0.6</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>630</td>
<td>53.9</td>
<td>0.6</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE:

* Refer to Map B.2
- The bankfull discharge has a return interval frequency of approximately 1.5 years.
Field observations of bed material revealed four mid-channel bars, indicating a stable environment and creek system, with a good balance of flow and sediment transport. The variability in bed material sizes is a function of the location of cross-sections at riffles and pools. Sites S2 and S1 were located at, or near, riffles, accounting for the coarse material. At meanders, point-bars were well developed, again indicating a stable environment. Site S3 is the least stable, located in a long run, which appears to be excavated. Particle sizes varied from large boulders to sand, with a mean size of 17 mm. This may result in above average scour of bed. Armouring of the bed was generally not observed, leaving only larger particles along the bed. This is common in urban areas and is evident through increased particle size in the downstream direction and the lack of a sub-pavement or a very coarse pavement.

Field analysis of bank material and bank conditions was completed to determine erosion characteristics and sensitivity of the stream banks to change in flow regime. Generally, the bank material along Stoney Creek was found to be consistent with Quaternary deposits in the basin. Finer sediments found at sections S1 and S2 represent alluvial and flood deposits. Additional information on bank erosion characteristics is provided in the Technical Appendix.

B3.3 Channel Erosion

Erosion as a means of sediment supply is a natural river process, necessary to maintain channel stability. Changes to flow regime, sediment inputs and channel form lead to excessive erosion to channel bed and banks. Table B.4 lists locations where channel erosion was evident during the 1994 field program and provides a description of the erosion problem.

Thresholds for movement of material were calculated using sediment characteristics and fluvial geomorphology information. It was found that bed material at sites S4-down, S3 and S1 will move at conditions below bankfull. The most sensitive location was found to be S3, due to steep slopes, coarse material and a lack of riparian vegetation. Additional details on the fluvial geomorphology, sediment characteristics and erosion assessment are provided in the Technical Appendix.

B3.4 Summary

Based on the results of the fluvial geomorphology study discussed above, it is apparent that the physical conditions and attributes of Stoney Creek are quite variable. This a function of the underlying soils, flow regime and urban environment. Based on the fluvial geomorphology classification, the channel is stable, although some of the headwaters are sensitive to disturbance. Critical velocities for the movement of bed material are lower than bankfull velocities at three cross-sections and significantly lower at two of those sites, which indicates that these reaches may be particularly sensitive to increases in flow rates or runoff volumes.

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headwaters, east of Clark Sd. Rd. and north and south of Medway Road</td>
<td>Bank erosion from a lack of vegetation and livestock</td>
</tr>
<tr>
<td>West of Highbury and north of Medway Road</td>
<td>Bank erosion from cattle grazing and trampling banks</td>
</tr>
<tr>
<td>Southwest of Adelaide and Sunnigndale Road</td>
<td>Bank erosion from culvert</td>
</tr>
<tr>
<td>East of Highbury, north of Fanshawe Park Road</td>
<td>Bank erosion due to entrenched of channel and cattle access</td>
</tr>
<tr>
<td>North and south of Windermere Road</td>
<td>Erosion along outside banks of meanders, due to higher flows, lack of vegetation and slightly incised channel</td>
</tr>
</tbody>
</table>

TABLE B.4

Erosion Areas - Stoney Creek
B4.0 SURFACE WATER HYDROLOGY

The main objectives of the Detailed Hydrologic Study were:

- To inventory current drainage conditions in the subwatershed;
- To collect field measurements of flow data;
- To prepare an event-based hydrologic model for calculation of peak flow conditions; and
- To prepare a continuous hydrologic model for synthesizing general flow conditions and sedimentation characteristics.

B4.1 Current Drainage Conditions

Drainage in the Stoney Creek subwatershed consists of natural reaches, urbanized reaches, and agricultural reaches. Agricultural and urban uses have influenced drainage conditions in most of the subwatershed. Agriculture is the most prominent land use in the upper reaches, and as a result, many of the headwater tributaries have been channelized as agricultural drains and receive input from tile drains. The lower reaches of the watercourse are somewhat natural, however, they do receive storm water runoff from adjacent urban development. Drainage features are illustrated in Map B3.

Natural Channel Reaches

Stoney Creek has remained largely unaltered in two distinct areas of the subwatershed. One area is located at the downstream end of the subwatershed, from about 200 m west of Adelaide Street downstream to the confluence with the North Thames River. In this reach, the average channel slope is about 0.3 percent. For-the-most-part, erosion is limited due to the presence of cobbles which dominate the bed and banks. Riparian vegetation is generally natural, except for manicured parkland areas which encroach on the creek's banks.

The second area where the creek has remained in a natural state is in the band of land between the urbanized part of the watershed (about 1 km west of Highbury Avenue) and the agricultural lands to the north which have improved drainage through a system of tile drains connected to a series of municipal drains. Within this area there are three channel reaches which have remained in a natural state including:

i) The reach that starts at the confluence of Talbot, Wonnacott, Talbot Award, Harris Award and Ballymote East drains and extends to Highbury Avenue. This portion of Stoney Creek flows primarily through agricultural lands and exhibits a gentle meandering flow path. There are very few trees lining the channel and the banks appear well vegetated and stable;

ii) The reach which begins just south of County Road No. 28 and extends east of Highbury Avenue where it combines with Reach 1. This reach is fed by the Armitage Drain which is the primary agricultural drain for this section of Stoney Creek. Dense vegetation in addition to a number of trees occupy the majority of both banks along this reach; and

iii) The reach which begins at the confluence of Reach 1 and 2 at Highbury Road and extends southwest to the limit of the existing urban development. Cattle access to Stoney Creek, just west of Highbury Avenue, could impact stream water quality and bank erosion. The vegetative buffer along this reach varies from open pasture to thick vegetation.
The Terrestrial Component Study identified several wetlands within the Stoney Creek Watershed. The most noticeable are within the stream valley located to the east of Highbury Avenue. These wetlands provide natural storage that effectively attenuates runoff through these channel reaches. Several other wetland pockets are scattered throughout the watershed.

**Urbanized Channel Reaches**

Map B3 illustrates the extent of urbanized channel reaches in the Stoney Creek subwatershed. These reaches of Stoney Creek have been reconstructed as grass-lined channels. There is a well defined low flow channel with broad overbanks and little riparian cover. An in-line pond has developed above Fanshawe Park Road.

**Agricultural Channel Reaches**

As illustrated on Map B3, a substantial part of the Stoney Creek subwatershed is drained by tile drains and Municipal Drains. These drainage features have a significant effect on the hydrologic characteristics of the watershed, primarily because they intercept potential groundwater recharge. This results in increased flow shortly after a runoff event and reduced baseflow during dry weather periods.

**B4.2 Measured Flow Conditions**

Measured flow information for Stoney Creek was available from September 1988 to September 1993 from continuous monitoring gauges which the UTRCA had installed at Highbury Avenue and at Windermere Road, and from spot measurements of baseflow carried out during the course of the Subwatershed Studies. A detailed summary of flow measurements is provided in the Technical Appendix.

To summarize the streamflow monitoring data, maximum flow measured at the Windermere Road gauge was 11.49 m³/s, which is just less than the 5-year peak flow (See Section B4.3). Flow measurement data available at Highbury Avenue and Windermere Road indicates that the creek is continuously flowing along the main channel, while spot measurements indicated that some of the tributaries have intermittent flow.

**B4.3 Hydrologic Modelling - Peak Flow Analysis**

The INTERHYMO hydrologic computer model was used for modelling the hydrologic response of Stoney Creek and its tributaries during a range of design storm events ranging from the 1:2-year to 1:250-year return period design storm events. The event simulation modelling involved the completion of the following components:

i) Model Set-up - this component involved discretization of the subwatershed into smaller subcatchments for which land cover, soils and topographic conditions were determined for calculations of runoff hydrographs;

ii) Model Calibration - this component involved calibration of model input parameters such that peak runoff rates measured in the field could be reasonably predicted using the hydrologic model; and

iii) Calculation of design flows - this component involved executing the calibrated hydrologic model using the range of design rainfall storms to determine peak flow runoff rates and volumes at points of interest throughout the subwatershed.

Details of the above three components of the peak flow modelling are provided in the Technical Appendix.
Table B.5 summarizes the peak flow conditions for a range of design storm events for Stoney Creek at Highbury Avenue, just upstream of Fanshawe Park Road and at the confluence of Stoney Creek and the North Thames River. The results summarized in Table B.5 indicate that in areas upstream of the main developed area of the watershed, larger peak flows result from a combination of rainfall and snowmelt events, while at points downstream of the main developed area, the larger peak flows result from extreme rainfall events alone. The peak flows were used as inputs to the HEC-2 hydraulic model which was used to calculate flood elevations. In this manner, existing flood elevations for the Regulatory Storm were calculated for the Stoney Creek subwatershed. The Regulatory floodline is based on the 250 year design storm. The flood elevations resulting from this storm were utilized to generate floodplain mapping for the subwatershed, and represent constraint areas for development, based on the Provincial Policy Statement for Hazard Lands.

B4.4 Hydrologic Modelling - Continuous Simulation

The QUALHYMO hydrologic computer model was used for modelling the hydrologic response of the Stoney Creek subwatershed to a long-term record of precipitation and temperature data. The main objective of the continuous simulation model was to establish existing erosion indices at the cross-section locations which were analyzed in the Fluvial Geomorphology Detailed Study. Results of this detailed analysis are provided in the Technical Appendix.

B4.5 Other Hydrologic Analysis

A low flow analysis for Stoney Creek was undertaken to determine the low flow conditions which could occur under extreme drought conditions. An understanding of low flow conditions in the Stoney Creek subwatershed is important to assess baseflow maintenance, aquatic habitat conditions, water quality and assimilation characteristics. A number of techniques can be used to estimate design low flows, but the most common method applied involves the use of long-term hydrometric data records. Unfortunately, hydrometric data available for Stoney Creek is limited. Consequently, in order to assess the design low flow conditions, hydrometric records at nearby Water Survey of Canada (WSC) gauges on Wye Creek, Waubuno Creek and Medway Creek were used to determine the design low flows for Stoney Creek (at the confluence with the North Thames River). The design low flows, summarized in Table B.6, indicate that even under extreme drought conditions, some flow in Stoney Creek is maintained.
### TABLE B.5

Event Simulation Peak Flow Summary
Under Existing Conditions

<table>
<thead>
<tr>
<th>Location</th>
<th>Runoff Generated by Rainfall Event (m³/s)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Runoff Generated by Rainfall-Snowmelt Event (m³/s)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Return Period</td>
<td>2-year</td>
<td>5-year</td>
<td>25-year</td>
<td>100-year</td>
<td>250-year</td>
<td>2-year</td>
<td>5-year</td>
<td>25-year</td>
</tr>
<tr>
<td>At Highbury Avenue</td>
<td></td>
<td>1.3</td>
<td>3.7</td>
<td>7.9</td>
<td>14.3</td>
<td>17.7</td>
<td>5.2</td>
<td>9.3</td>
<td>14.7</td>
</tr>
<tr>
<td>Just Upstream of Fanshawe Park Road</td>
<td></td>
<td>2.4</td>
<td>3.7</td>
<td>6.8</td>
<td>13.8</td>
<td>17.1</td>
<td>5.1</td>
<td>9.2</td>
<td>14.9</td>
</tr>
<tr>
<td>At Confluence with North Thames River</td>
<td></td>
<td>7.8</td>
<td>12.7</td>
<td>20.8</td>
<td>27.2</td>
<td>28.1 *</td>
<td>5.3</td>
<td>9.7</td>
<td>15.8</td>
</tr>
</tbody>
</table>

**NOTE:**

* An aerial reduction of approximately 94 percent was used.
- 2 to 100-year storms were not aerial reduced.

---

### TABLE B.6

Design Low Flows - Stoney Creek

<table>
<thead>
<tr>
<th>Month</th>
<th>Monthly 7Q₂₀ (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>0.025</td>
</tr>
<tr>
<td>June</td>
<td>0.007</td>
</tr>
<tr>
<td>July</td>
<td>0.004</td>
</tr>
<tr>
<td>August</td>
<td>0.002</td>
</tr>
<tr>
<td>September</td>
<td>0.002</td>
</tr>
</tbody>
</table>

**NOTE:**

* 7Q₂₀ - 7 day average flow to occur once in twenty years.
B5.0 RURAL POINT AND NON-POINT SOURCE POLLUTION

Lands within the Stoney Creek subwatershed predominantly support agricultural activities. The activities contribute to overall rural runoff quality and stream loading through both non-point (soil and crop management practices) and point (acute infrastructural and livestock management practices) sources.

The detailed study and evaluation of rural non-point and point source loading involve completion of both inventory and analytical tasks. A number of essential objectives were identified and applied to develop a clear understanding of the spatial distribution of loading sources and their relationship to rural land use within the subwatershed. These objectives included:

1) The identification of current livestock and tillage management practices and cropping patterns;

2) An assessment of the contribution of these practices and patterns to stream loading in terms of the physical character of the land base on which they are performed; and

3) An evaluation of the effectiveness and practicality of implementing various remedial prescriptions and their application in the optimum reduction of loading through management initiatives.

The study commenced with an inventory and mapping of factors that potentially contribute to stream loading. Background information, including environmental studies, literature and data pertaining to subwatershed agricultural characteristics and activities was compiled. Reconnaissance level field surveys were conducted to verify, update and expand on this information. Assessments were made of the compatibility of the activities observed with the land base in terms of their potential contribution to loading or runoff quality. Information was compiled in a GIS base and an overall characterization of potential loading under existing conditions was made. Areas of concern were then identified with respect to the relative impact magnitude and significance of agricultural operations in relation to watershed biophysical attributes. Quality improvement opportunities were determined through analytical modelling and the hypothetical application of a series of BMPs at areas of concern throughout the subwatershed.

The following sections summarize the results of the inventory and analysis completed to fulfill the requirements of objectives 1 and 2. The evaluation and identification of opportunities for improving rural non-point and point loading sources and water quality in the Stoney Creek subwatershed are summarized in Part C, and detailed in the Technical Appendix.

B5.1 Subwatershed Agricultural Land Use and Tillage Practices

The predominant agricultural activity in the Stoney Creek subwatershed is the growing of common field crops such as winter and spring grains, corn and soybeans. The crops are grown both on a cash basis or as feed in support of the numerous dairy and beef livestock operations distributed throughout the rural areas of the subwatershed. No traditional or recently-established locations of specialty or market garden produce are evident.

The current study included a field verification and updating of the OMAF Land Use Systems Maps for the subwatershed. The update revealed that the mapping had generally retained its validity, particularly in the more rural portions of the subwatershed. Some notable exceptions were observed that are particularly relevant to the determination of potential annual soil loss.

The major changes observed were:

- The area of continuous row cropping systems had increased slightly, mostly replacing corn and/or mixed rotational systems;
Pasture systems in some areas had undergone cultivation, mostly to grain or mixed systems, or had become idle lands, although a marked increase in smaller, intense grazing areas was observed in some areas otherwise predominantly under continuous row crop; and

The urban-rural fringe, land use change had been particularly dynamic, with built-up areas and traditional areas of aggregate extraction near Fanshawe expanding to displace idle agricultural land uses. In addition, apparent changes in land tenure in this area from traditional farm operator to speculative investment had increased the incidence of idle land grazing areas and more intensive cropping from the traditional rotation-type systems.

These changes in the Stoney Creek subwatershed are outlined in Table B.7. Current (1994) Agricultural Systems in the subwatershed are depicted in Map B4.

During field surveys, an inventory of in-place remedial and conservation practices was made. The locations of areas of conservation tillage, grassed waterways and buffer strips were noted and mapped. The locations of practices that may enhance erosion and sediment loading were also noted.

The locations and character of in-place remedial and best management practices are shown in Map B5. Also shown are areas currently in need of remedial and best management practice applications to reduce sediment loading to the surface waterways and drains. Many of these latter areas contain headwater beds that are presently tilled and under crop production during the growing season. Grassed waterway systems in these locations would greatly reduce the amounts of sediments and nutrients entering the water system from field runoff. Headwater beds are those areas of primary water confluence from surrounding surfaces at the highest points of elevation within a subwatershed. Stream channels are typically poorly defined and flow is intermittent and restricted mostly to time of freshet or runoff.

B5.2 Non-Point Source Pollution

This section identifies the relative contributions of land management and cropping practices to stream loading under current conditions. Potential Average Annual Soil Loss and Delivery Ratios were estimated under cropping and management factors in light of the subwatershed's inherent soil, landform and natural vegetation character. An Environment Canada model based on the Universal Soil Loss Equation was used to estimate surface soil erosion and sediment delivery ratios. Specific details of the modelling are provided in the Technical Appendix.

Table B.8 summarizes the potential soil losses based on the up-to-date agricultural land use mapping, and provides a comparison against potential soil loss based on the 1983 land use information. Map B6 illustrates the distribution of potential soil loss throughout the agricultural areas of the subwatershed.

Table B.9 outlines the soil losses predicted in the Stoney Creek subwatershed under tillage conditions of total conventional, current conservation, and total conservation practices.

Under current (1994) conditions within the subwatershed, conservation tillage practices occur on about 200 ha, or 10 percent of the cultivated agricultural land base. Conservation tillage practices presently account for an overall 3 percent reduction in potential soil loss on an annual basis. Reductions are greatest in areas of continuous row cropping systems on lands of medium potential soil loss (11%) and in areas of corn systems on lands of medium potential soil loss (2%). Areas of very high and high potential annual soil loss were mostly devoid of conservation tillage practices.
<table>
<thead>
<tr>
<th>Agricultural Land Use Classification</th>
<th>1983</th>
<th>1994</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>% of Total</td>
<td>Area (ha)</td>
<td>% of Total</td>
</tr>
<tr>
<td>Continuous Row Crop</td>
<td>819.98</td>
<td>21.9</td>
<td>916.54</td>
</tr>
<tr>
<td>Corn System</td>
<td>879.84</td>
<td>23.5</td>
<td>617.32</td>
</tr>
<tr>
<td>Mixed and Mixed Grain</td>
<td>453.71</td>
<td>12.1</td>
<td>530.09</td>
</tr>
<tr>
<td>Hay and Grazing Systems</td>
<td>179.65</td>
<td>4.8</td>
<td>251.46</td>
</tr>
<tr>
<td>Idle Land (5-10 years)</td>
<td>183.73</td>
<td>4.9</td>
<td>149.02</td>
</tr>
<tr>
<td>Idle Land (10+ years) and Hay Systems</td>
<td>201.21</td>
<td>5.4</td>
<td>133.19</td>
</tr>
<tr>
<td>Forest</td>
<td>333.38</td>
<td>8.9</td>
<td>333.38</td>
</tr>
<tr>
<td>Extractive and Built-Up Areas</td>
<td>694.38</td>
<td>18.5</td>
<td>814.88</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3745.88</strong></td>
<td><strong>100.0</strong></td>
<td><strong>3745.88</strong></td>
</tr>
<tr>
<td>Potential Soil Loss Classification</td>
<td>1983</td>
<td>1994</td>
<td>Change</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>Area (ha)</td>
<td>% of Total</td>
<td>Area (ha)</td>
</tr>
<tr>
<td><strong>Very High</strong> (&gt;11 t/ha/yr)</td>
<td>209.99</td>
<td>5.6</td>
<td>232.77</td>
</tr>
<tr>
<td><strong>High</strong> (7-11 t/ha/yr)</td>
<td>78.73</td>
<td>2.1</td>
<td>708</td>
</tr>
<tr>
<td><strong>Medium</strong> (2-7 t/ha/yr)</td>
<td>1895.72</td>
<td>50.6</td>
<td>1892.59</td>
</tr>
<tr>
<td><strong>Low</strong> (&lt;2 t/ha/yr)</td>
<td>845.72</td>
<td>22.6</td>
<td>&lt;1690</td>
</tr>
<tr>
<td><strong>Unclassed</strong></td>
<td>715.72</td>
<td>19.1</td>
<td>---</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3745.88</td>
<td>100.0</td>
<td>13235</td>
</tr>
</tbody>
</table>
### TABLE B.9

**Predicted Annual Soil Losses (tonnes)** and Reductions Possible Through Adoption of Conservation Tillage

<table>
<thead>
<tr>
<th>Cropping System</th>
<th>All Conventional Tillage</th>
<th>Current (1994) Conservation Tillage</th>
<th>All Conservation Tillage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Continuous Row Crop</td>
<td>1685</td>
<td>0</td>
<td>3424</td>
</tr>
<tr>
<td>Corn Rotational System</td>
<td>749</td>
<td>0</td>
<td>2470</td>
</tr>
<tr>
<td>Mixed Grain System</td>
<td>95</td>
<td>79</td>
<td>490</td>
</tr>
<tr>
<td>Mixed Rotational System</td>
<td>23</td>
<td>321</td>
<td>1877</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>253</td>
</tr>
<tr>
<td>Total</td>
<td>2552</td>
<td>400</td>
<td>8514</td>
</tr>
</tbody>
</table>

**NOTES:**

* Very High - >11 t/ha/yr
  High - 7-11 t/ha/yr
  Medium - 2-7 t/ha/yr
  Low - <2 t/ha/yr
A determination of reduction in soil loss under conditions of conservation tillage throughout the subwatershed was made so as to illustrate the degree of sediment load reduction possible through shifts to best management practices within the Stoney Creek subwatershed. Table B.10 outlines the potential reductions in soil losses achievable as a percentage of overall soil loss reduction in relation to the amount of land base on which the system and soil loss classification is found. Greatest response and benefit from efforts to reduce sediment loading through conservation tillage initiatives would be realized through the targeting of areas having the greatest potential for reduction on the smaller land bases. Upon further examination of results presents in Table B.10, the greatest amounts of soil loss take place on a relatively small proportion of land. For example, a move towards conservation tillage practices within all remaining and unpracticing continuous row cropping would realize almost a half (i.e. 46.1%) of the overall potential reduction but need extend only to a quarter (25.2%) of the land base. If all corn rotational systems were further included, almost 75 percent of the total potential soil loss reduction could be achieved by delivering conservation tillage programs to under half (i.e. 45.9%) of the total unbuilt area of the subwatershed. A significant proportion (24.8%) of the total potential soil loss reduction could be achieved, however, by targeting first the continuous row crop and corn systems within the very high soil loss classification, which constitutes a relatively small (7.5%) of the subwatershed agricultural land use base. A further 27.8 percent of the maximum potential soil loss reduction could be achieved by targeting continuous row crop systems in medium soil loss classification areas, but this would extend to a full 20 percent of the subwatershed’s land base. Further targeting to other areas would realize a decreasing benefit in terms of the smaller reductions obtainable over larger land bases.

Current (1994) Sediment Load Priority Management Areas for the Stoney Creek subwatershed are depicted in Map B7. The map locates priority management areas and assumes no remedial measures are in-place. In this format, areas of priority management which are integral to relevant long term sediment load control are identified. If appropriate remedial measures are currently in place, monitoring of the higher priority areas should be performed to ensure the measures' continued integrity, effectiveness and potential for enhancement.

Two general areas of high priority management are identified. Common characteristics of the two areas are rolling topographies and proximity to receiving streams. In the eastern region of the subwatershed, a series of high priority areas are associated with steeply sloping streambanks and adjacent older eroded channels located north of the Fanshawe extraction area. The larger, contiguous area of high priority management in the western reaches of the subwatershed is associated both with steeply sloping streambanks and adjacent rolling and complex landform under agricultural crop production.

Areas of medium priority management generally form three east-west bearing bands across the subwatershed. These areas are associated with mid-reaches of the various Stoney Creek tributaries. Slopes are generally long but are of a gentler pitch. Continuous row cropping and corn systems compose the main land uses.

Low management priority areas for sediment load predominate in headwater regions of the Stoney Creek tributaries. Topographies are generally flat to depressional and many areas are under permanent forest cover. Agricultural land uses in these areas are mostly mixed rotational, hay and grazing systems.

B5.3 Rural Point Loading Sources

This section of the report identifies the relative contributions of livestock management and supporting infrastructure to coliform and phosphorus loading under current and hypothetical remedial conditions. Livestock stream access and milhouse waste were considered as continuous inputs. Manure storage/feedlot runoff and manure spread runoff were considered as pulse or rainfall event contributors.
<table>
<thead>
<tr>
<th>Cropping System</th>
<th>Soil Loss Classification</th>
<th>% Reduction</th>
<th>% Land Base</th>
<th>% Reduction</th>
<th>% Land Base</th>
<th>% Reduction</th>
<th>% Land Base</th>
<th>% Reduction</th>
<th>% Land Base</th>
<th>Total</th>
<th>% Reduction</th>
<th>% Land Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Row Crop</td>
<td>Very High</td>
<td>18.3</td>
<td>5.2</td>
<td>---</td>
<td>---</td>
<td>27.8</td>
<td>20.0</td>
<td>---</td>
<td>---</td>
<td>46.1</td>
<td>25.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>20.9</td>
<td>18.4</td>
<td>---</td>
<td>---</td>
<td>27.4</td>
<td>20.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
<td>2.4</td>
<td>3.7</td>
<td>1.4</td>
<td>1.2</td>
<td>4.6</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>Corn Rotational System</td>
<td>Very High</td>
<td>6.5</td>
<td>2.3</td>
<td>---</td>
<td>---</td>
<td>20.9</td>
<td>18.4</td>
<td>---</td>
<td>---</td>
<td>27.4</td>
<td>20.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>0.1</td>
<td>0.1</td>
<td>1.9</td>
<td>1.2</td>
<td>15.8</td>
<td>14.3</td>
<td>4.1</td>
<td>8.4</td>
<td>21.9</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>Mixed Grain System</td>
<td>Very High</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>8.5</td>
<td>---</td>
<td>16.1</td>
<td>---</td>
<td>24.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other and Existing</td>
<td>Very High</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>8.5</td>
<td>---</td>
<td>16.1</td>
<td>---</td>
<td>24.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conservation Tillage</td>
<td>Medium</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>25.3</td>
<td>7.9</td>
<td>2.3</td>
<td>1.5</td>
<td>66.9</td>
<td>64.9</td>
<td>5.5</td>
<td>25.7</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

* Very High - >11 t/ha/yr  
High - 7-11 t/ha/yr  
Medium - 2-7 t/ha/yr  
Low - <2 t/ha/yr
B5.3.1 Clean-up Rural Beaches (Curb) Model

The CURB model used in this study for estimating point source contributions is based on formulas developed from the UTRCA (Hayman, 1988) from a Pollution from Livestock Operations Predictor (PLOP) developed by Ecologistics Limited (1988). Changes and generalizations were required to these models in the current study because some of the more detailed site specific and operator survey information was unavailable at the current study's level of reconnaissance.

The UTRCA CURB model endeavours to consider all sources of coliform and phosphorus inputs associated with rural point sources, including septic systems and sewage, and urban non-point sources. On site investigation and interviews were not conducted in the current study and therefore the level of detail was limited to that available from roadside reconnaissance and interpretation. Livestock access, milhouse wastes, manure/feedlot runoff and manure spreading information was gathered and recorded with a data collection emphasis on those livestock operations within 150 m of a watercourse.

A summary of average values depicting typical operation inputs of the various sources is provided in Table B.11. Within the Stoney Creek subwatershed, a total of 13 livestock operations were identified and of which 11 were within 150 m of an open watercourse and 12 were considered of potential high priority ranking.

B5.3.2 Point Loading Source Model Results

The CURB model results provide estimates of daily and annual pollutant loading rates. Detailed model results are provided in the Technical Appendix. A general discussion on the effect of point sources is provided below.

Of the sources considered, livestock access contributes 95 percent of the raw fecal coliform input on a continuous daily basis and 93 percent annually in spite of its consideration as an input for only 180 days of a given year. During an event situation, livestock access contributes more than 64 percent of total raw coliform input. On an annual basis, raw coliform input from livestock access of 180 days exceeds total event-related input by an additional order of magnitude. It is apparent that livestock access can be a major contributor to raw fecal coliform inputs in comparison to other considered sources in the Stoney Creek subwatershed.

Total Phosphorus

Milhouse wastes contribute 83 percent of total phosphorus input on a daily continuous basis and 95 percent of continuous input annually. During a single event condition, manure/feedlot runoff may contribute 65 percent of total input phosphorus. On an annual basis, however, milhouse wastes appear to be the largest single contributor of the sources considered, providing 95 percent of total continuous input and 4 times in excess of annual total pulse inputs.

B5.3.3 Priority Management Areas

The assessment of priority ranking to a given livestock operation was performed by first determining an average or typical situation within the subwatershed (Table B.11) and then comparing individual operations to this information. Emphasis was placed on those operations within 150 m of the watercourse and livestock head above the subwatershed average. In consideration of a potential inconclusive assessment of milhouse waste contributions at the reconnaissance level, all apparent dairy operations were identified. Overt evidence of in-place remedial measures was considered in the overall ranking.
<table>
<thead>
<tr>
<th>TABLE B.11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary of Survey Information from Identified Potential High Priority Livestock Operations within the Stoney Creek Subwatershed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subwatershed Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (Agricultural Land Base)</td>
</tr>
<tr>
<td>Livestock Operations (#)</td>
</tr>
<tr>
<td>Density (#/km²)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Livestock Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sites (#)</td>
</tr>
<tr>
<td>Average Length of Access (m)</td>
</tr>
<tr>
<td>Average Animal Units</td>
</tr>
<tr>
<td>Density (#/km²)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Milkhouse Washwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge Sources (#)</td>
</tr>
<tr>
<td>Density (#/km²)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feedlot/Manure (150 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources (#)</td>
</tr>
<tr>
<td>Density (#/km²)</td>
</tr>
<tr>
<td>Average Storage Area (m³)</td>
</tr>
<tr>
<td>Potential High Priority Farms</td>
</tr>
<tr>
<td>Density (#/km²)</td>
</tr>
</tbody>
</table>
Continuous Loading

Livestock Access

Unhindered livestock access to Stoney Creek tributaries was observed at 8 of the 13 livestock operations in the subwatershed (Map B8). Of the 8, 4 access locations supported herds in excess of the average herd size of 24 head. These 4 locations may provide up to 75 percent of the total raw fecal coliform input related to livestock access in the subwatershed.

Milkhouse Wastewater

Five livestock operations in the subwatershed support dairy cattle breeds although observation at the reconnaissance level could not confirm milkhouse infrastructure at all of these locations. Four of the five operations were located within 150 m of a streamcourse (Map B8). If untreated direct discharge or baseflow of milkhouse wastewater from these operations is assumed, then their contributions to overall point source phosphorus input on an annual basis may reach 73 percent of the sources considered.

Pulse or Event Loading

Feedlot/Manure Storage

Ten livestock operations have manure storage or feedlot areas ranging in size from approximately 100 to 400 m² and are located within 150 m of an open watercourse. Up to eight of these operations have the potential for runoff occurrence with five of these having feedlot/storage areas in excess of average for the subwatershed. These five operations, however, have been identified as high priority for reasons other than potential manure/feedlot runoff sources.

Spills

No agricultural operation-related spills have been reported to the MOEE in the Stoney Creek subwatershed in the past two years.

At this level of study, MOEE reports of spills are the best available source of information. No indications of recent spills were forthcoming during field survey. A better idea of the extent of spills and particularly those that go unreported will require more in-depth study and landowner contact together with some moral suasion to reduce the report compelling thresholds.

Manure Spread

The spreading of livestock manure on fields is an economic, environmentally sound and beneficial fertility and soil management practice if conducted in a logical and responsible manner. Problems arise mainly from overspreading (i.e. too many animal units per unit area) or the application in proximity to a receiving surface watercourse. The estimated livestock unit to farm acreage ratio is 0.3 which is less than the "best" rating of 0.5 as provided by OMAFRA (1994). No farms were assessed as being priority on the basis of coliform or phosphorus inputs resulting from the spreading of manure.
LEGEND

POTENTIAL PRIORITY FARMS – POINT SOURCES

- LIVESTOCK ACCESS AND WITHIN 150m (> AVERAGE # HEAD)
- LIVESTOCK ACCESS AND WITHIN 150m (< AVERAGE # HEAD)
- WITHIN 150m WITH ACCESS CONTROLLED
- DAIRY

LOCATIONS AND CHARACTER OF IDENTIFIED POTENTIAL HIGH PRIORITY POINT SOURCES WITHIN THE STONEY CREEK SUBWATERSHED

STONEY CREEK SUBWATERSHED STUDY

PROJECT NO. 1-5215
SCALE: AS SHOWN
DATE: MAY 1995
MAP B8
B5.4 Summary and Conclusions

An inventory of agricultural land use, land base and agricultural activities was undertaken in the Stoney Creek subwatershed for the purposes of modelling the contribution of rural point and non-point sources to stream loading.

Recent changes in cropping systems and in the area of land base on which they are performed have resulted in an increased annual soil loss from the most highly susceptible areas. While total potential soil losses from agricultural areas have fallen in the past ten years by 2 percent, the size of the land base from which they are derived has fallen by 2.9 percent. This land base is composed of soils with a low potential for loss, however, indicating that potential annual soil losses on an areal basis throughout the subwatershed have actually increased. Conservation tillage practices are currently in use at a number of areas in the subwatershed, but could be further extended to a number of key areas to realize a substantial reduction in actual sediment loading to surface waters. A program targeting continuous row cropping and corn rotational systems in areas of very high potential soil loss may realize a quarter of the soil loss reductions possible and need to cover less than a tenth of the agricultural land base. If best management tillage practices were extended to all operations, a reduction of 35 percent in potential annual soil losses could be realized, bringing annual losses to about 8500 tonnes or an average of 2.9 tonnes per year for each hectare of non-urban land.

Riparian buffer strips and forests are best management practice land uses deemed effective in reducing stream loading. In the Stoney Creek subwatershed, riparian character is mostly appropriate for the effective filtering of surface loading sediments. Some headwater areas where tillage is occurring through the streambed would benefit from the establishment of grassed waterways.

A number of agricultural operations in the subwatershed were identified as potential point source contributors. Of the sources considered, livestock access contributes more than 90 percent of the raw fecal coliform input on both a continuous daily and annual basis. Four of the eight access areas identified may provide up to 75 percent of this input. Of the point sources considered, milkhouse waste may contribute up to 95 percent of annual continuous phosphorus loading.

The Stoney Creek subwatershed is undergoing dynamic shifts in the area of its urban-rural fringe. Changes in land tenure and economies are influencing land use and the contributions of rural point and non-point source loadings. While it is apparent that efforts have been made to mitigate many of the traditional source problem locations, a continued program in key rural areas of the subwatershed would further improve the quality of water entering the urban reaches of Stoney Creek.
B6.0 WATER QUALITY

A detailed water quality monitoring program was carried out by the Upper Thames River Conservation Authority for the Stoney Creek subwatershed. This section summarizes the results of the UTRCA monitoring program.

A summary of the water quality monitoring program for Stoney Creek is presented in Table B.12. Surface water samples were taken at four locations between August 1993 to June 1994. The sampling locations on Stoney Creek included:

- Station 1 East branch on Sunningdale Road (Sty. E);
- Station 2 West branch, west of Highbury Avenue, on Sunningdale Road (Sty. W);
- Station 3 Highbury Avenue Gauge (Sty. H); and
- Station 4 Windermere Road Gauge (Sty. L).

Sampling events covered both wet weather and dry weather conditions, that in part, explains the wide range in parameter values measuring during the monitoring program.

The water quality monitoring program tested the water samples for a wide-array of parameters. The parameter results in Table B.12 were selected since they are typically the ones most impacted by land use change. The parameters can be broken down into the following classes:

- Bacteria;
- Nutrients;
- Heavy metals;
- Dissolved oxygen; and
- Water temperature.

As shown in Table B.12, stations one, two and three which are all situated in agricultural areas, exhibit a higher maximum count and range of E. Coli bacteria than station four which is situated in an urban setting. Agricultural land use is dominated by cultivated crops and pasture which could provide bacteria inputs into the system.

Nutrients such as nitrate and total phosphorus are an essential element for aquatic life. However, excessive amounts of nutrients can lead to uncontrolled algae and plant growth. High levels of nutrients are most often associated with agricultural land use. The water quality sampling indicated that nitrate median concentrations were higher in rural areas and that phosphorus concentrations remained relatively consistent between the four stations. However, total phosphorus was well in excess of the recommended 0.03 mg/l for all four locations. Total phosphorus has the most stringent guideline and is typically the limiting factor with respect to algae growth.

Generally, higher metal concentrations can be associated with urban land use. The sampling indicated a higher trend in the median concentration of metals in the more urban areas. The exception to this trend was lead which remained constant. This indicates that the existing urban setting is having a larger impact on the heavy metal concentrations in Stoney Creek than the rural setting.

The maximum water temperature recorded was 23°C. This occurred at Highbury Avenue in June of 1994 and corresponded to a dissolved oxygen concentration of 7.0 mg/l. The dissolved oxygen concentration ranged from a low of 2.8 mg/l in August of 1993 (Station 1) to a high of 14.4 mg/l (Station 4) in February of 1994. Generally, a threshold range of dissolved oxygen for which coldwater fish species can survive is between 5 to 9.5 mg/l. Stoney Creek, in general, had dissolved oxygen levels within the recommended guidelines for cold water species (Water Quality Report, UTRCA, 1994).
<table>
<thead>
<tr>
<th>Water Quality Parameter</th>
<th>Provincial Guidelines</th>
<th>National Guidelines</th>
<th>Min</th>
<th>Max</th>
<th>Med</th>
<th>Min</th>
<th>Max</th>
<th>Med</th>
<th>Min</th>
<th>Max</th>
<th>Med</th>
<th>Min</th>
<th>Max</th>
<th>Med</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. Coli Bacteria (mg/l)</td>
<td>100</td>
<td>--</td>
<td>50</td>
<td>14100</td>
<td>220</td>
<td>10</td>
<td>7300</td>
<td>390</td>
<td>50</td>
<td>3500</td>
<td>410</td>
<td>80</td>
<td>2600</td>
<td>400</td>
</tr>
<tr>
<td>Suspended Solids (mg/l)</td>
<td>--</td>
<td>&lt; 10% of background levels (aquatic)</td>
<td>12.4</td>
<td>118.0</td>
<td>19.6</td>
<td>7.7</td>
<td>117.0</td>
<td>22.5</td>
<td>9.6</td>
<td>47.5</td>
<td>14.8</td>
<td>19.5</td>
<td>91.6</td>
<td>29.6</td>
</tr>
<tr>
<td>Ammonia (mg/l)</td>
<td>--</td>
<td>0.08 - 2.5 (temp + pH dependent)</td>
<td>0.007</td>
<td>0.1</td>
<td>0.017</td>
<td>0.005</td>
<td>0.117</td>
<td>0.040</td>
<td>0.000</td>
<td>0.126</td>
<td>0.054</td>
<td>0.005</td>
<td>0.140</td>
<td>0.025</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>--</td>
<td>10.0 (drinking water)</td>
<td>0.1</td>
<td>7.3</td>
<td>4.5</td>
<td>1.6</td>
<td>5.6</td>
<td>5.0</td>
<td>1.5</td>
<td>5.6</td>
<td>2.6</td>
<td>1.1</td>
<td>4.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Total Phosphorus (mg/l)</td>
<td>0.03</td>
<td>--</td>
<td>0.007</td>
<td>0.165</td>
<td>0.054</td>
<td>0.016</td>
<td>0.265</td>
<td>0.082</td>
<td>0.013</td>
<td>0.140</td>
<td>0.052</td>
<td>0.010</td>
<td>0.215</td>
<td>0.080</td>
</tr>
<tr>
<td>Potassium (mg/l)</td>
<td>--</td>
<td>--</td>
<td>2.0</td>
<td>2.9</td>
<td>2.2</td>
<td>1.6</td>
<td>2.8</td>
<td>2.4</td>
<td>1.8</td>
<td>2.9</td>
<td>2.4</td>
<td>1.9</td>
<td>3.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Copper (ug/l)</td>
<td>5 ug/l (Aquatic)</td>
<td>1.0 mg/l (drinking water)</td>
<td>0.002</td>
<td>0.008</td>
<td>0.003</td>
<td>0.002</td>
<td>0.008</td>
<td>0.002</td>
<td>0.002</td>
<td>0.008</td>
<td>0.007</td>
<td>0.002</td>
<td>0.043</td>
<td>0.008</td>
</tr>
<tr>
<td>Iron (mg/l)</td>
<td>0.3 (aquatic)</td>
<td>0.3 (aquatic &amp; drinking water)</td>
<td>0.027</td>
<td>2.37</td>
<td>0.291</td>
<td>0.059</td>
<td>3.260</td>
<td>0.320</td>
<td>0.140</td>
<td>2.020</td>
<td>0.344</td>
<td>0.080</td>
<td>2.990</td>
<td>0.590</td>
</tr>
<tr>
<td>Lead (mg/l)</td>
<td>0.025 mg/l (aquatic)</td>
<td>0.05 mg/l (drinking water)</td>
<td>0.015</td>
<td>0.060</td>
<td>0.015</td>
<td>0.015</td>
<td>0.080</td>
<td>0.015</td>
<td>0.015</td>
<td>0.060</td>
<td>0.015</td>
<td>0.015</td>
<td>0.060</td>
<td>0.015</td>
</tr>
</tbody>
</table>
### TABLE B.12

Summary of Water Analysis at Four Stations
On Stoney Creek
(August 1993 - June 1994)

<table>
<thead>
<tr>
<th>Water Quality Parameter</th>
<th>Provincial Guidelines</th>
<th>National Guidelines</th>
<th>Station Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Station 1</td>
</tr>
<tr>
<td>Manganese (mg/l)</td>
<td>--</td>
<td>0.05 (aesthetics)</td>
<td>0.004</td>
</tr>
<tr>
<td>Zinc (mg/l)</td>
<td>0.03 (aquatic)</td>
<td>5 (drinking water)</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.03 (aquatic)</td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>4 (warm water)</td>
<td>6 (warm water)</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>5 (cold water)</td>
<td>9.5 (cold water)</td>
<td>(Aquatic Life)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(aquatic life)</td>
<td></td>
</tr>
<tr>
<td>Water Temperature ($^\circ$C)</td>
<td>--</td>
<td>--</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**NOTES:**
- Exceeds provincial guidelines.
- Min = Minimum
- Max = Maximum
- Med = Median
- -- = data not available
1. Where a range has been specified, concentrations vary due to temperature and pH.
2. Where a range has been specified, concentrations vary due to CaCO$_3$ concentrations.
Based on the summary presented herein and the water quality and quantity monitoring program results from the UTRCA, the water quality in Stoney Creek is typical for the land uses within the subwatershed. Nutrients are elevated throughout the subwatershed. This, combined with the high bacteria counts in the upper reaches of the subwatershed, supports the findings of the detailed study on Rural Point and Non Point Source Pollution. Agricultural land uses in the upper reaches of the creek system are likely responsible for elevated nutrients and bacteria loadings.

The urban areas of the subwatershed tended to have higher heavy metal concentrations. This is indicative of typical urban runoff.

Although some parameters are elevated, the documentation indicated that Stoney Creek consistently maintained a higher water quality in relation to the other creeks with regard to clarity, biochemical oxygen demand (BOD), dissolved oxygen (DO), total solids, turbidity, total Kjeldahl, nitrate, total phosphorus, calcium, calculated hardness, sodium, aluminum, strontium and vanadium.

**B7.0 AQUATIC RESOURCES**

The detailed study of aquatic resources involved extensive field sampling and analysis of benthic macroinvertebrates and fish found in watercourses throughout the Stoney Creek subwatershed. The inventory and analysis of aquatic resources was completed by BEAK Consultants Limited (1994).

The main objectives of the aquatic resources detailed study were to:

1) Use quantitative and qualitative sampling to evaluate the existing fisheries, fish habitat and benthic invertebrates in Stoney Creek and its tributaries;

2) Identify significant fisheries components (i.e. spawning and nursery habitat, migration routes, rare and sportfish etc.);

3) Use benthic-invertebrates information to describe the health of the subwatershed; and

4) To prepare an overall strategy for aquatic resources in the subwatershed which identifies opportunities for protection, enhancement and/or restoration that is consistent with future development in the subwatershed.

The following is a brief summary of the results of the field studies completed by BEAK (1994) which addresses objectives 1, 2 and 3. (Strategies for aquatic resources protection, enhancement and/or restoration are discussed in Parts C and D). For more detailed information on aquatic resources management in Stoney Creek, refer to BEAK (1994).

**B7.1 Benthic Invertebrates**

Benthic invertebrates were sampled at the 14 locations noted in Map B9. Sampling locations were based on the results of field reconnaissance that considered stream order, adjacent land use, point source locations and stream morphology. Two reference stations (R1 and R2) also sampled were selected on the basis of the extent of riparian cover, and represented healthy benthic macroinvertebrate communities.
Data analysis techniques used consisted of biotic indices and statistical applications. Briefly they are summarized as:

**Biotic Indices**

- Number of taxa per sample, number of taxa per station, and taxa density (per m²);
- Presence or absence of indicator species;
- EPT index (used as a relative measure of pollution-sensitive invertebrates);
- Bio Map Water Quality Index (WQI);
- Percent contribution of dominant taxa;
- Hydropsychidae/trichoptera index; and
- Percent abundance of shredders.

**Statistical Applications**

- Cluster analysis for grouping stations with similar features;
- Discriminant analysis;
- Correlation-matrix analysis for relating observations with land use;
- Bivariate plots for determining the linearity of relationships with land use; and
- Multiple-regression analysis for use in predicting biotic metrics.

Table B.13 summarizes the methodology used to classify invertebrate communities.

**Water Quality Index Results**

The Water Quality Index ratings at the sampling stations in Stoney Creek are summarized in Table B.14. Based on the WQI ratings, water quality was generally considered unstable or impaired, and at Station B13, severely impaired.

**Cluster analysis Results**

The results of the benthic invertebrate sampling for all subwatersheds were compiled for cluster analysis. All of the Thames River stations were grouped together in Cluster 1 (healthy communities). Three Stoney Creek stations (8, 9 and 14) were grouped in Cluster 2 with Stanton Drain stations. These stations exhibited the healthiest benthic invertebrate communities in all of the subwatersheds, having the highest mean EPT (Ephemeroptera (mayflies), Plecoptera (stoneflies) and Tricoptera (caddisflies) index and WQI values. The Stoney Creek stations within this cluster were characterized by sensitive species of mayflies (*Paraleptophlebia*), caddisflies (*Chimarra*), riffle beetles (*Ectopria nervosa*) and midges (*Diamesa*).

Stoney Creek stations 1 and 16 were grouped in Cluster 3 and stations 2 and 3 were grouped in Cluster 4. Clusters 3 and 4 were characterized by similar communities and attributes. However, Cluster 3 represents slightly healthier communities based on greater numbers of mayflies and stoneflies and higher WQI values.
<table>
<thead>
<tr>
<th>TABLE B.13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework of Aquatic Ecosystem Goals and Objectives</td>
</tr>
<tr>
<td>For London Area Subwatershed Management Plans</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Restoration/Rehabilitation/Enhancement</th>
<th>Mitigation/Protection</th>
<th>Degradation/Disturbance/Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type IA</strong></td>
<td><strong>Type IIA</strong></td>
<td><strong>Type III</strong></td>
</tr>
<tr>
<td>Intolerant Coldwater Community</td>
<td>Highly Diverse</td>
<td>Moderately Tolerant</td>
</tr>
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**INVERTEBRATES**

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At least four of the following:
- Amphinemura
- Leuctra
- Haploperla
- Ectopria
- Heterotrissocladius
- Eukiefferiella
- Phryacophila

At least five of the following:
- Acroenuria
- Isoperla
- Taeniopteryx
- Paraleptophlebia
- Serratella
- Chironurus
- Phryacophila
- Diamesa
- Lumbriculus variegatus
- Turbellaria
- Eukiefferiella

At least six of the following:
- Turbellaria
- Baetis
- Caenis
- Stenacron
- Tricorythodes
- Cheumatopsyche
- Hydropsyche
- Neophyax
- Optioservus
- Stenemis
- Micropsectra
- Simuliidae

At least four of the following:
- Sialis
- Berosus
- Cheumatopsyche
- Hydropsyche
- Dubrapha
- Procezus
- Cryptochironomus
- Paratanytarsus
- Rheotanytarsus
- Chaetocladius
- Hemerodromia
- Helobdella

At least five of the following:
- Nais pardalis/bretschleri
- Limnodrilus
- hoffmeisteri
- L. claparedianus
- Tubifex
- Sparganophilus
- Berosus
- Procezus
- Chironomus
- Physella

**NOTES:**

1) Blacknose shiner, sand shiner, Rosyface shiner, river chub.
2) Hornyhead chub, emerald shiner, common shiner, blacknose shiner, striped shiner, spottail shiner, Rosyface shiner, spotfin shiner, sand shiner, redfin shiner, blacknose dace, longnose dace, mimic shiner.
3) Fathead minnow, northern redbelly, bluntnose minnow, goldfish, creek chub, brassy minnow, golden shiner.
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</table>
Station 13 grouped within Cluster 5, indicating that this was the most impaired station in the subwatershed. The invertebrate community at Station 13 was dominated by pollution-tolerant oligochaetes (81%) and was characterized by the lowest WQI value. Cluster 5 stations are the most impaired of those in all of the subwatersheds. Their mean EPT Index and WQI values were significantly (p < 0.05) lower than other clusters, and the percent of the community represented by oligochaetes was significantly (p < 0.05) higher.

B7.2 Fish Populations

BEAK Consultants Limited completed a fisheries study of Stoney Creek in 1994. Sampling was completed at the ten locations noted in Map B9. Detailed information regarding sampling locations and protocols is available in the Aquatic-Resources Management report prepared by BEAK (1994).

The BEAK fisheries data was evaluated with the use of an Index of Biotic Integrity (IBI). IBI analysis incorporates a range of ecological characteristics (species richness and composition, trophic composition, etc.), as described by 11 metrics (number of native fish species, number of darter species, proportion of omnivorous cyprinids, etc.). The attributes are assigned values of 5, 3, or 1, from "best" to "worst", according to whether the value is similar to, deviates from, or differs strongly from expected values. Expected values were determined based on published literature sources. Sites of highest quality have the highest scores, typically in the range of 49 to 55. Based on the scores, health categories are assigned ranging from "excellent" to "very poor". Table B.15 summarizes the IBI results at the ten sampling locations. The smallmouth bass is the only game fish present, and it occurred at stations 1 and 2. Although most of the fish communities were dominated by minnow species, there were significant numbers of darters and centrarchids at some stations. Station 4 supported no fish, but this site is a hardened channel with low baseflow and a series of drop structures.

Of the nine stations that supported fish, the IBI results indicated that three stations exhibited good health, four (2, 6, 7 and 8) were fair, and two (3 and 10) were poor.

Two provincially significant fish species were documented in Stoney Creek: central stoneroller and greenside darter. The stoneroller was found at stations 1, 5, 7, 9 and 10 while the presence of greenside darter was confirmed at stations 1, 2, 5 and 7.

For each of the five target fish species, A Habitat-Suitability Index (THSI) was developed based on existing models which were modified for the London subwatershed study area. The five fish species were largemouth bass (Micropterus salmoides), smallmouth bass, rainbow trout, brown trout, and green sunfish (Lepomis cyanellus). The THSI models use up to 16 habitat variables which are grouped into 5 habitat components including stream morphology, riparian habitat, instream cover, water temperature, and flow. The geometric mean of these components at each reach was used for the models; however, it should be noted that the THSI analyses did not include potentially important habitat components such as water quality and predator-prey interactions. In addition, it should be noted that the quality of data used for the THSI models was highly variable or absent; and as a result, relatively subjective professional judgement was used to derive some of the input values. Results of the THSI analyses are detailed in the report prepared by BEAK.

Based on the analyses for the fish sampling stations and habitat assessments, reaches of Stoney Creek and its tributaries were classified with one of the stream types in Table B.16. Map B10 illustrates the stream-type by reach, based on criteria in Table B.16 and the invertebrate criteria (Table B.13). The stream-type classifications are intended to represent potential self-sustaining communities.
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<tr>
<td>Catch per Unit Effort</td>
<td>10.1</td>
<td>12.4</td>
<td>12.2</td>
<td>0.0</td>
<td>18.7</td>
<td>10.1</td>
<td>31.7</td>
<td>9.9</td>
<td>15.0</td>
<td>12.2</td>
</tr>
<tr>
<td>IBI Score</td>
<td>43</td>
<td>39</td>
<td>23</td>
<td>0</td>
<td>43</td>
<td>37</td>
<td>39</td>
<td>33</td>
<td>43</td>
<td>29</td>
</tr>
<tr>
<td>Health</td>
<td>Good</td>
<td>Fair</td>
<td>Poor</td>
<td>No Fish</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Fair</td>
<td>Good</td>
<td>Poor</td>
</tr>
</tbody>
</table>

B.40
<table>
<thead>
<tr>
<th>Restoration/Rehabilitation/Enhancement</th>
<th>Mitigation/Protection</th>
<th>Degradation/Disturbance/Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type IA Intolerant Coldwater Community</td>
<td>Type IB Tolerant Coldwater Community</td>
<td>Type IIA Highly Diverse Warmwater Community</td>
</tr>
<tr>
<td></td>
<td>Type IIB Diverse Warmwater Community</td>
<td>Type III Moderately Tolerant Warmwater Community</td>
</tr>
<tr>
<td>Type IV A Tolerant Warmwater Community</td>
<td>Type IVB Highly Tolerant Warmwater Community</td>
<td>Type V No Aquatic Community</td>
</tr>
</tbody>
</table>

**FISHERIES**

Minimum of one of the following fish species:
- brook trout
- sculpin
- brook lamprey

Minimum of one of the following fish species, including at least 6 of the following:
- rainbow trout
- chinook salmon
- brown trout
- northern hog sucker
- pike
- smallmouth bass
- Iowa darter
- longear sunfish
- yellow perch
- walleye
- intolerant minnows¹
- stonecat

Minimum of 14 fish species, including at least 4 of the following:
- northern hog sucker
- pike
- smallmouth bass
- longear sunfish
- Iowa darter
- yellow perch
- walleye
- intolerant minnows¹
- stonecat

Minimum of 10 fish species, including at least 2 of the following:
- pumpkinseed/bluegill
- largemouth bass
- blackside darter
- greenside darter
- redhorse
- central stoneroller
- insectivorous minnows²

Minimum of 4 fish species, including at least 1 of the following:
- green sunfish
- rock bass
- black crappie
- white sucker
- gizzard shad
- johnny darter
- omnivorous minnows³

Minimum of 1 of the following fish species:
- carp
- goldfish
- brown bullhead
- brook stickleback
- central mudminnow

No fish present.

**NOTES:**

1) Blacknose shiner, sand shiner, rosiface shiner, river chub.
2) Hornyhead chub, emerald shiner, common shiner, blacknose shiner, striped shiner, spottail shiner, rosiface shiner, spotfin shiner, sand shiner, redfin shiner, blacknose dace, longnose dace, mimic shiner.
3) Fathead minnow, northern redbelly, bluntnose minnow, goldfish, creek chub, brassy minnow, golden shiner.
Overall, the quality of Stoney Creek is relatively high. The higher order (3 and 4) streams in the Stoney Creek subwatershed generally are Type IIB or III streams. The main stream upstream from the Thames River to Fanshawe Park Road is an important spawning area for minnows, suckers, redhorse, darters and smallmouth bass, and may have the potential to support rainbow trout. The subcatchment south and west of Ballymote has a relatively good baseflow and some stations support healthy invertebrate populations indicating unimpaired water quality. The main stem of Stoney Creek and its tributaries upstream of Fanshawe Park Road generally have coarse substrates, good baseflow and consistently high biotic integrity. Station 7 at Highbury Road is an important spawning area for central stoneroller.

Changes in Fisheries Classification System

In March of 1994, the MNR published the *Fish Habitat Protection Guidelines for Developing Areas* which presented a revised methodology for classifying fisheries habitat. Unfortunately, the aquatic resources component of the study was too far along to revise all of the previously completed work. For this reason, it was decided to make use of the previous MNR Classification System. However, to allow translation of fisheries habitat from the old to the new Classification System, the following general guideline can be applied to watercourses in the Stoney Creek subwatershed.

<table>
<thead>
<tr>
<th>Community Type</th>
<th>Habitat Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIB, III, IV</td>
<td>1</td>
</tr>
<tr>
<td>IVA, IV, V, IVB</td>
<td>2</td>
</tr>
<tr>
<td>V, IVB</td>
<td>3</td>
</tr>
</tbody>
</table>

Type 1 habitats are defined as critical for the maintenance of productive capacity of the management unit, and require a high level of protection from the effects of development. Type 1 habitats are generally important, as reproductive habitats and fish community utilization may vary considerably on a seasonal basis. Type 1 habitats are generally healthy, stable systems which require little in the way of restoration or rehabilitation.

Type 2 habitats are defined as important but less critical to productive capacity than Type 1 habitats. The Type 2 habitats are generally more common than are Type 1 habitats, and may represent degraded Type 1 habitats which may warrant restoration, enhancement or rehabilitation. These habitat require a moderate level of protection from development activities, but also may have great potential for restoration or enhancement to increase productive capacity in a management unit.

Type 3 habitats are defined as having low productive capacity and do not have reasonable potential for enhancement or restoration. While these habitats are generally extremely degraded, some do support aquatic communities, or potentially affect the productive capacity of aquatic communities in downstream reaches.

B7.3 Limiting Factors

Despite the relatively high quality of the Stoney Creek subwatershed, there are a number of factors limiting the aquatic community, which include:

- Tributaries draining the urbanizing area in the vicinity of Fanshawe Park Road and Adelaide Road degrade the main stem of Stoney Creek, although it does recover farther downstream;
• The Northcrest and Northdale tributaries are degraded and most are channelized; many are completely enclosed in stormwater drains. These tributaries also have very low baseflow and are intermittent. Because of the poor water quality in these reaches, they have the potential to degrade downstream reaches of Stoney Creek;

• In the upper reaches of the main stem of Stoney Creek, many of the first and second order watercourses have been channelized. There are also point and non-point nutrient sources from agricultural practices that impair water quality in some local areas; and

• There are three local areas where active streambank erosion is occurring.

B8.0 TERRESTRIAL RESOURCES

B8.1 Background and Terrestrial Wetland Policy Development

The terrestrial and wetlands component of the subwatershed plan builds on the Draft Terrestrial Resource Strategy (DTRS) prepared by Terra Geographical Studies Inc. (1994) and incorporates field data collected by the Upper Thames River Conservation Authority (UTRCA) and by Jane Bowles and her field assistants.

The DTRS summarizes policies that protect or may affect terrestrial and wetland resources, and one of the primary objectives of the DTRS is to provide a basis for land use policies to protect, enhance and restore ecosystems within the subwatersheds. In addition to simply using existing policies to achieve this objective, the DTRS summarizes the current state of knowledge of landscape ecology principles. Discussions are provided on biodiversity, wetlands, woodlands, riparian vegetation and stream corridors, and hedgerows. Potential effects of development on terrestrial and wetland ecosystems are also summarized in the DTRS.

The DTRS notes that the amount of natural habitat in all thirteen subwatersheds currently being studied by the City of London is lower than the majority of southern Ontario, which is typically 15 to 25 percent. Therefore, the DTRS recommends that all existing natural areas be protected, where feasible, and that efforts be made to naturalize additional areas.

All vegetation patches 4 ha and larger were mapped in the DTRS. This size was selected based on a literature review, plus the fact that this is the minimum size woodlot that may provide habitat for forest interior species.

The vegetation patches that were mapped were not restricted to forests and wetlands. Meadows, old fields, shrublands, prairies, and savannahs are also included.

Patches smaller than 4 ha were mapped by the DTRS if they met one of the following conditions:

• A patch less than 4 ha is located 100 m or less from a mapped patch if the land between the patches is absent of any permanent disturbance which may act as a permanent barrier to flora or fauna (e.g. roads, railroads, buildings).

• A patch less than 4 ha is located 100 m or less from another patch smaller than 4 ha if the total area of the two or more patches is 4 ha or more, and there is no permanent disturbance between the patches.

Areas such as naturalizing land (such as abandoned farm land), agricultural land, watercourses, and utility corridors are not considered to be permanent barriers to movement of flora and fauna among patches.
After the release of the DTRS, vegetation patches were examined in the field to determine if additional patches should be included in the mapping, and if all mapped patches were still present.

The DTRS mapped zones and areas within the City of London. Zones are broad areas with similar characteristics due to existing policies, environmental considerations, or the distribution of vegetation patches within them. The areas are the vegetation patches mapped by the UTRCA.

Four types of zones and four area types were defined by the DTRS. Table B.17 summarizes the types of zones and areas, and recommendations that may be associated with each type. The zones and areas are defined in more detail below.

**Type A Zone**

Type A zones (See Table B.17) are areas where existing provincial policies or guidelines provide clear guidance for the protection of features and systems, or allow protective measures to be taken by controlling development. Type A zones contain one or more of the following features:

- A provincially significant wetland;
- A provincially significant life sciences Area of Natural or Scientific Interest (ANSI);
- Regional floodplains as indicated by regulatory floodline mapping,
- A setback of 30 m from coldwater streams and 15 m from other watercourses.

**Type B Zone**

Type B zones are areas where there are strong reasons for promoting the retention, restoration, and replacement of natural vegetation on the basis of subwatershed water-related processes. They are defined as follows:

- Stream corridors as defined by OMNR (1991) and supported by the Comprehensive Set of Policy Statements (OMMA, 1994). This definition includes the following:
  - The stream;
  - Floodplain'
  - Stream valley walls'
  - Riparian vegetation and habitat; and
  - Related source areas such as springs and seepage areas

It is recommended that the OMNR (1991) definition of stream corridor be expanded to include areas within mapped fill lines and the outer limit of those mapped patches defined as partly or entirely riparian.

- Other bases as defined and supported by interdisciplinary discussions at the subwatershed level, notably areas of groundwater discharge and recharge.
<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Recommendations Which May Be Associated With Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A Zone</td>
<td>Zone for which there exist specific provincial policies: e.g. 15 m strip along streams and regulated floodplain.</td>
<td>Retention of any existing vegetation. Top priority areas for restoration and replacement.</td>
</tr>
<tr>
<td>Type B Zone</td>
<td>Zone along stream corridors (as specified in OMNR, 1991, recommendations) of specific importance to water-related process.</td>
<td>Retention of any existing vegetation. Second priority areas for restoration and replacement.</td>
</tr>
<tr>
<td>Type C Zone</td>
<td>Zone between sufficiently close Type 1, 2 and/or Type 3 areas, not necessarily along stream corridors.</td>
<td>Third priority areas for restoration and replacement.</td>
</tr>
<tr>
<td>Type D Zone</td>
<td>Zone outside of Type A, B, or C Zones.</td>
<td>No specific policy recommendations except general policies which apply to all zones.</td>
</tr>
<tr>
<td>Type 1 Area</td>
<td>Vegetation patch which includes Life Science ANSI, Class 1-3 wetland, or ESA (Candidate ESA within City of London).</td>
<td>Complete protection of functions and feature including scoped EIS for developments in proximity.</td>
</tr>
<tr>
<td>Type 2 Area</td>
<td>Vegetation patch which meets does not meet the criteria for Type 1, 2, or X.</td>
<td>Retention including scoped EIS for certain developments in proximity.</td>
</tr>
<tr>
<td>Type 3 Area</td>
<td>Vegetation patch which is isolated (not within 100 m of other patches and not connected by Type C Zone), not in Type A or B Zones, and is either old field, early successional woodland, or plantation.</td>
<td>Retention, restoration, or replacement.</td>
</tr>
<tr>
<td>Type X Area</td>
<td>Vegetation patch within City of London boundaries which might meet Candidate ESA status but for which site access was refused.</td>
<td>Requirement that study be conducted before development near these areas to determine if they qualify as either Type 1 or 2 Areas.</td>
</tr>
</tbody>
</table>

Source: DTRS
Type C Zone

Type C zones are areas where there are strong reasons for promoting the retention, restoration, and replacement of natural vegetation on the basis of terrestrial biology features not primarily related to water-related processes but complementary to these. Type C zones are defined as follows:

- Areas between vegetation patches where restoration and replacement of natural vegetation would result in a reduction of fragmentation and a marked increase in the effective size of the resulting unified patch.

- Potential upland corridors which would connect upland patches to the connected system defined by the Type A and B zones. Corridor width should be a minimum of 100 m and preferably 200 m or more.

- Areas where there is a need for increased width of riparian corridor to provide terrestrial linkage functions. Corridors 15 to 30 m wide along some watercourses may not provide an adequate corridor for some terrestrial features.

- Areas where designation as a Type C zone would provide benefits to the terrestrial and wetland system. These would be special cases that do not meet any of the previous three points. Rationale for these will be explained in subwatershed studies.

Type D Zone

The Type D zone is all areas outside of Zones A, B, and C.

Type 1 Area

A Type 1 Area is a vegetation patch which contains features recognized as biologically significant by other specified studies. A vegetation patch is a Type 1 Area if it is one or more of the following:

- A provincially significant wetland;

- A provincially significant life sciences ANSI;

- A candidate ESA within the City of London boundaries; and

- A Significant Natural Area, as defined by Hilts and Cook (1982), outside of the City of London boundaries.

Type 2 Area

A Type 2 Area is a vegetation patch which does not meet the criteria for Type 1, 3 or X areas. These are the majority of patches identified by the DTRS. They include all patches along stream corridors, all wetlands, and most tableland forest patches.
Type 3 Area

A Type 3 Area is isolated, not in Type A or B zones, and is either old field, early successional woodland, or plantation. A vegetation patch is a Type 3 Area if it meets all of the following criteria and it is not a Type 1 or X area:

- The vegetation patch is isolated (i.e. more than 100 m from the closest patch, or separated by a road, railroad, or other built structure) and likely to remain isolated (i.e. it has not been connected by a Type C Zone in the DTRS or the subsequent subwatershed analysis).
- The vegetation patch is located entirely out of Type A or B zones.
- The vegetation patch consists primarily (>80%) of old field, early successional woodland, or plantation.

Type X Area

A Type X Area is one that might be a Type 1 Area after additional field work. A vegetation patch is a Type X Area if it meets all of the following criteria:

- It is not a Type 1 Area based on existing data.
- It is located within the City of London boundaries.
- It was considered to be of Candidate ESA potential, but field work was not possible because of access refusal by all or most of the landowners.

The DTRS presented a map of the entire study area (all 13 subwatersheds) which depicted the patches and zones, and maps were also plotted for each individual subwatershed. The DTRS did not differentiate among Type 1, 2, 3, and X vegetation patches. This analysis was completed by the UTRCA. The UTRCA and Terra Geographic Studies Inc. jointly determined which vegetation patches satisfied one or more of the criteria as an ESA.

B8.2 Woodlots, Wetlands and Vegetation

Map B11 shows the location, size and shape of the 49 larger patches of natural vegetation present in the Stoney Creek subwatershed. The combined area of the patches is approximately 449 ha, which represents about 12 percent of the subwatershed, making the Stoney Creek watershed slightly less forested than Middlesex County (13.5%). Natural areas are primarily associated with stream corridors, or are remnant woodlots in the middle of concessions.

Unlike some of the London subwatersheds, the natural areas are relatively well connected. Those along stream corridors are frequently in close proximity, and they are often connected by grassy areas that permit wildlife movement among patches. Many of the tableland woodlots are also situated close together in agricultural land uses. These areas have the capability of supporting more species than isolated areas of the same size, as some wildlife species with large home ranges may incorporate more than one patch into their territory. Close proximity of tableland woodlots also allows movement of mammals among patches. Nonetheless, there are many opportunities to improve connections among natural areas and to improve individual sites. This is examined in Part C of the Subwatershed Plan.

Patch size is a critical factor in determining what wildlife species a natural area can support. The percentage of patches occurring in the various size thresholds are summarized below in Table B.18.
The majority of patches are too small to support forest-interior species. There are, however, two large areas of 30 ha (patch 2017) and 69 ha (patch 2030) that have the potential to support some forest-interior and area-dependent species. There are also three patches over 20 ha in area, and another four that are approaching 20 ha. With appropriate management, these areas could be enhanced for sensitive species.

Most of the Stoney Creek natural areas are immature to intermediate-aged deciduous woodlots. Common dominant or co-dominant tree species are red or white ash, red or silver maple, sugar maple, white elm, and oaks. There are, however, a few stands dominated by cedar and there may occasionally be tamarack mixed among the cedars. There are small areas that have been planted with coniferous trees, and large willows dominate in some riparian areas.

Map B11 also indicates patch area types and Zone Types A, B and C as identified in the DTRS. Ten (almost 20%) of the patches have been identified as Category 1 areas. These are areas 2018 to 2026, and 2030.

<table>
<thead>
<tr>
<th>Patch Size</th>
<th>Percentage of Patches</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4 ha</td>
<td>44.0</td>
</tr>
<tr>
<td>4 to 9 ha</td>
<td>26.0</td>
</tr>
<tr>
<td>10 to 29 ha</td>
<td>26.0</td>
</tr>
<tr>
<td>30 to 49 ha</td>
<td>2.0</td>
</tr>
<tr>
<td>50 to 99 ha</td>
<td>2.0</td>
</tr>
<tr>
<td>≥100 ha</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The Fanshawe Wetlands Complex is situated within patches 2021 to 2026, although these areas also contain upland habitats. This is a provincially significant wetland that is predominately mixed cedar and cedar-tamarack swamp, although there are areas of shrub and deciduous treed swamp, and cattail marsh. Seven significant plant species have been documented in the wetland: the provincially rare harbinger-of-spring and striped violet, and the regionally significant bristle-leaf sedge, prairie sedge, hard-stemmed bulrush, water avens, and white water-crowfoot. A short-eared owl was observed flying and roosting in the wetland, and this species has recently been designated provincially significant.

Patches 2018 to 2026 and 2030 comprise Candidate ESA complex. They contain the Fanshawe Wetland Complex as well as the other patches along Stoney Creek and the Ballymote Tributary. The candidate ESA complex fulfills five of the seven Environmental and Ecological Planning Advisory Committee (EEPAC) ESA criteria:

- Distinctive or unusual communities;
- Large size;
- Community diversity;
- Migratory corridor/links communities; and
- Rare species.

Internal buffers of 100 and 200 m were applied to all of the patches (Map B11). As can be seen, there is very little forest-interior habitat in the subwatershed. There are 15 patches of habitat 100 m or farther from the parent patch edges located in 14 different woodlots. These total about 40.6 ha, or 1.1 percent of the subwatershed. Thus, habitat for forest-interior species is very limited in the Stoney Creek subwatershed, and almost half of this habitat is situated in a single patch (2030).

Patch 2030 also contains the only forest habitat that is situated 200 m from an edge. The amount of habitat available to deepwoods species is 4.7 ha, or 0.1 percent of the subwatershed.

B8.3 Wildlife

A list of the wildlife species found in the subwatershed (Table B.18) has been compiled based on the field work conducted by Jane Bowles, which only includes bird species that probably nested in the subwatershed. It should be emphasized that the wildlife list is probably far from complete. Field work was conducted only in a sub-sample of patches, with an emphasis on forested habitat. Grasslands, disturbed areas and developed areas were under-represented in the inventory. In addition, many secretive species such as small mammals were probably overlooked by the inventory.

In all, a total of 81 wildlife species were recorded: 8 amphibians, 1 reptile, 63 breeding birds, and 9 mammals. The amphibian, reptile and mammal species are all common, both locally and in Southern Ontario.

One of the bird species that probably bred in the subwatershed is provincially significant. The short-eared owl was found in Patch 2026, which is part of the Fanshawe Wetland complex. This species nests in extensive areas of grasslands, bogs, or fens.

As would be expected, based on the habitat present, forest-interior birds are relatively rare in the subwatershed. Species that appear to be absent as breeders from the Stoney Creek subwatershed include Ruffed Grouse, Pileated Woodpecker, Red-breasted Nuthatch, Brown Creeper, Winter Wren, Veery, Hermit Thrush, Yellow-throated Vireo, Black-throated Green Warbler, Black-and-white Warbler, Northern Waterthrush, and Scarlet Tanager.

Only five forest-interior or area-sensitive bird species were documented during the breeding season. The Wood Thrush was seen in four patches, the Hairy Woodpecker occurred in three woodlots, and the Yellow-bellied Sapsucker, Blue-gray Gnatcatcher, and Ovenbird were documented once each.

Patch 2030, the largest in the subwatershed and the only woodlot with interior area farther than 200 m from an edge, supported four of the five area-sensitive or forest-interior species (all but Ovenbird). The other patches supporting these specialized species were 2017 (Hairy Woodpecker, Wood Thrush), 2019 (Wood Thrush), 2024 (Hairy Woodpecker), and 2047 (Ovenbird). These patches all contained forest-interior habitat, or were very close to a large forest.

The Purple Finch was documented in Patch 2025, which is part of the Fanshawe Wetland complex. This species may be locally rare in the London area.

Nine significant plant species have been found in the Stoney Creek subwatershed (Table B.19). These include two that are provincially and nationally rare, one that is rare in the old Southwestern Region of MNR, and six that are rare in Middlesex County. Significant plant species occurred in Patches 2019, 2021, 2025, 2026 and 2030.
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Redback Salamander</td>
<td>Plethodon cinereus</td>
</tr>
<tr>
<td>American Toad</td>
<td>Bufo americanus</td>
</tr>
<tr>
<td>Spring Peeper</td>
<td>Hyla crucifer</td>
</tr>
<tr>
<td>Gray Treefrog</td>
<td>Hyla versicolor</td>
</tr>
<tr>
<td>Striped Chorus Frog</td>
<td>Pseudacris triseriata</td>
</tr>
<tr>
<td>Green Frog</td>
<td>Rana clamitans</td>
</tr>
<tr>
<td>Wood Frog</td>
<td>Rana sylvatica</td>
</tr>
<tr>
<td>Northern Leopard Frog</td>
<td>Rana pipiens</td>
</tr>
<tr>
<td>Snapping Turtle</td>
<td>Chelydra serpentina</td>
</tr>
<tr>
<td>Green Heron</td>
<td>Butorides virescens</td>
</tr>
<tr>
<td>Canada Goose</td>
<td>Branta canadensis</td>
</tr>
<tr>
<td>Wood Duck</td>
<td>Aix sponsa</td>
</tr>
<tr>
<td>Mallard</td>
<td>Anas platyrhynchos</td>
</tr>
<tr>
<td>Red-tailed Hawk</td>
<td>Buteo jamaicensis</td>
</tr>
<tr>
<td>Kildeer</td>
<td>Charadrius vociferus</td>
</tr>
<tr>
<td>Spotted Sandpiper</td>
<td>Actitis macularia</td>
</tr>
<tr>
<td>American Woodcock</td>
<td>Scolopax minor</td>
</tr>
<tr>
<td>Rock Dove</td>
<td>Columba livia</td>
</tr>
<tr>
<td>Mourning Dove</td>
<td>Zenaida macroura</td>
</tr>
<tr>
<td>Black-billed Cuckoo</td>
<td>Coccyzus erythropthalmus</td>
</tr>
<tr>
<td>Eastern Screech-Owl</td>
<td>Otus asio</td>
</tr>
<tr>
<td>Great Horned Owl</td>
<td>Bubo virginianus</td>
</tr>
<tr>
<td>Short-eared Owl</td>
<td>Asio flamineus</td>
</tr>
<tr>
<td>Ruby-throated Hummingbird</td>
<td>Archilochus colubris</td>
</tr>
<tr>
<td>Red-bellied Woodpecker</td>
<td>Melanerpes carolinus</td>
</tr>
<tr>
<td>Yellow-bellied Sapsucker</td>
<td>Sphyrapicus varius</td>
</tr>
<tr>
<td>Downy Woodpecker</td>
<td>Picoides pubescens</td>
</tr>
<tr>
<td>Hairy Woodpecker</td>
<td>Picoides villosus</td>
</tr>
<tr>
<td>Northern Flicker</td>
<td>Colaptes auratus</td>
</tr>
<tr>
<td>Eastern Wood-Pewee</td>
<td>Contopus virens</td>
</tr>
<tr>
<td>Willow Flycatcher</td>
<td>Empidonax traillii</td>
</tr>
<tr>
<td>Great Crested Flycatcher</td>
<td>Myiarchus crinitus</td>
</tr>
<tr>
<td>Eastern Kingbird</td>
<td>Tyrannus tyrannus</td>
</tr>
<tr>
<td>Tree Swallow</td>
<td>Taenopyga bicolor</td>
</tr>
<tr>
<td>Bank Swallow</td>
<td>Riparia riparia</td>
</tr>
<tr>
<td>Cliff Swallow</td>
<td>Hirundo pyrrhynota</td>
</tr>
<tr>
<td>Barn Swallow</td>
<td>Hirundo rustica</td>
</tr>
<tr>
<td>Blue Jay</td>
<td>Cyanocitta cristata</td>
</tr>
<tr>
<td>American Crow</td>
<td>Conus brachyrhynchos</td>
</tr>
<tr>
<td>Black-capped Chickadee</td>
<td>Parus atricapillus</td>
</tr>
<tr>
<td>White-breasted Nuthatch</td>
<td>Sitta carolinensis</td>
</tr>
<tr>
<td>House Wren</td>
<td>Troglytes aedon</td>
</tr>
<tr>
<td>Blue-gray Gnatcatcher</td>
<td>Polioptila caerulea</td>
</tr>
<tr>
<td>Common Name</td>
<td>Scientific Name</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>Wood Thrush</td>
<td>Hylocichla mustelina</td>
</tr>
<tr>
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<td>Northern Oriole</td>
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**MAMMALS**

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**NOTE:**

* Introduced Species
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<tr>
<td>Carex lurida</td>
<td>Sallow Sedge</td>
<td>R1</td>
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<tr>
<td>Carex praemum</td>
<td>Prairie Sedge</td>
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<td>SW</td>
<td>2030, 2019</td>
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<td>digitalis x C. laxiculmis)</td>
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<tr>
<td>Erigenia bulbosa</td>
<td>Harbinger-of-Spring</td>
<td>CA ON</td>
<td>2019</td>
</tr>
<tr>
<td>Geum rivale</td>
<td>Water Avens</td>
<td>R2</td>
<td>2026</td>
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<tr>
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<td>White Water Crowfoot</td>
<td>R2</td>
<td>2021</td>
</tr>
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<td>Hard-stemmed Bulrush</td>
<td>R3</td>
<td>2026, 2021</td>
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<tr>
<td>Viola striata</td>
<td>Striped Violet</td>
<td>CA ON</td>
<td>2019</td>
</tr>
</tbody>
</table>

**NOTES:**

- **R4** Rare in Middlesex County, 4 Sites
- **SW** Rare in the Old Southwest Region of OMNR
- **CA** Nationally Rare
- **ON** Provincially Rare
B9.0 ARCHAEOLOGICAL RESOURCES

The archaeological assessment background study for the study area resulted in the identification of 15 registered and one unregistered archaeological sites. As well, examination of published and unpublished studies of built heritage for the study areas have resulted in the identification of 64 locations of standing or extinct buildings. The standing structures represent the 19th to early 20th century architectural development of the London area, particularly of the rural and early urbanized communities such as Ballymote and Geary's Corners. The extinct structures, and the locations of the early settlers noted in the study area represent potential historic archaeological sites. Map B12 notes the location of many of these sites. A listing of archaeological and potentially significant historical sites is provided in the Technical Appendix.

B9.1 Historical Development

Based on existing data from the prehistoric and historic periods, there were notable peaks in development activity (i.e. clearing/draining) that can be used to explain some existing subwatershed conditions. The Iroquoian period (AD 900-1500) saw swidden agriculture, which involved clearing of fields for crops/gardens. Pioneer plants, such as white pine, moved into the open spaces when these lands were abandoned (particularly in the sandy areas). Later, during the early European period (1820-1850), there was a lot of tree clearing, but Stoney Creek was not used for water power (mill) facilities. The late European period (1850-1900) saw urbanization, particularly of the lower reaches of the creek. This period also saw continued land clearing, channelization, and infilling, which in turn caused increased streamflows and erosion.

The 19th century developments of the lands of the subwatershed were done without proper planning, and the cumulative effects have slowly been addressed in the last two decades by better (pro-active) awareness of conservation practices. It would be almost impossible (due to costs and other factors) to restore the study area to its pre-European condition, however, with continued positive rehabilitation, we have restored the subwatershed to conditions which reflect some 19th and 20th century conditions, without negative aspects such as uncontrolled flooding/erosion, and sewage runoff. As well, undertakings, such as aggregate extraction, are rehabilitated to approved planned conditions (i.e. agricultural) under existing legislation.

B9.2 Site Specific Studies

Further archaeological studies are needed to assist in predicting potential heritage resource impacts in the study areas. Studies are required because much of the undeveloped lands in the middle reaches of the Stoney Creek subwatershed are under pressure in the form of residential and industrial developments as the City of London expands to urbanize areas now within its 1993 boundaries. Other pressures on potential archaeological resources include aggregate extraction in parts of the subwatershed. These and other development impacts may unknowingly damage or destroy unregistered archaeological sites. It would therefore be appropriate for any development proposals in the study area be subject to a required cultural heritage resource assessment prior to any soil disturbances, at the planning stage. This assessment process would be funded by the proponents (public and private sector), and all cultural resources would be inventoried (i.e. archaeological sites, built heritage), and heritage management options would be developed (i.e. preservation or mitigation). Cultural heritage assessments should also be required for so-called "previously developed lands" in the 19th century communities of Geary’s Corners and Ballymote, particularly if the "previous development" involved impacts which did not strip topsoil or otherwise deeply disturb soils. It has been proven that in many urban settings where development occurred prior to 1960, archaeological remains have remained intact below road beds, yards and infilled lands.
B10.0 SANITARY SEWAGE COLLECTION SYSTEM

B10.1 General

The developed area in the Stoney Creek subwatershed within the former City of London municipal boundary is serviced by an existing sanitary sewer system. The many kilometres of mostly 2.4 m to 6.1 m diameter concrete or PVC (plastic) pipe, at depths ranging from 8 to 20 feet and installed in a granular trench, collect sanitary sewage from the existing homes and commercial establishments within the watershed.

The trunk sewer in the Adelaide Street/Fanshawe Park Road area generally follows the Stoney Creek watercourse, which is standard for the design of sanitary sewer systems, to an existing pumping station at the downstream end of the creek on the north branch of the Thames River. The size of the sanitary drainage area in the Stoney Creek subwatershed is estimated to be approximately 700 hectares.

Originally, the first residential development area in Stoneybrook in the Tennant Avenue area was serviced by septic tank systems. Those systems have been abandoned since the early 1970s, with the installation of sanitary sewers such that there would be little if any present risk of groundwater contamination.

There would also be little risk of ground water contamination from the sewage collection system that might result from exfiltration. Generally, due to the low sewage flow conditions relative to the pore pressures of the groundwater within the soils surrounding the sewers, groundwater tends to infiltrate to the sanitary sewer system, and accumulate in volume along the length of the collection system. This infiltration can occur throughout the system from the house connection to the downstream outlet including cracks at manholes or pipe joints along the system.

Groundwater infiltration to sanitary sewer systems can be a problem in some areas for the sewer system operating authority which in this case is the City of London. The volumes of clean water that accumulate in the system tend to be higher during extended periods of wet weather, sometimes causing the theoretical gravity capacity of the sewers to be exceeded. In that case, the system can become surcharged which could result in exfiltration. Generally, any exfiltration or groundwater flow to the sewer system would tend to follow the granular trench of the pipes.

More importantly, however, during periods of sewer system surcharge, loss of sewage to the local surface watercourse can occur, sometimes through different means. At certain critical locations on the system, the surcharging could be significant enough to overflow at one or two manhole locations which might bring some hydraulic relief to the system and reduce the risk of upstream basement flooding, but would result in discharge of raw sewage to the environment.

To prevent basement flooding, sewer operating authorities will sometimes install high-level connections or overflows from the sanitary sewer to the adjacent storm sewer or directly to the local watercourse to relieve the sewer system during storm events. In addition, to prevent flooding of the downstream pumping station and/or upstream basements, pumping stations are often designed with overflows to the surface water system. It is noted that approvals for such facilities are governed by the Environmental Protection Act and tend to be permitted as an alternative to basement flooding where it cannot otherwise be prevented.

Under previous standard design practices in London and elsewhere in Ontario, the footing drain around the basement foundation of houses was connected to the sanitary system. This practice was followed primarily for cost reasons due to the ease of connection of the weeping tile to the sanitary service to the home, and to avoid enlarged and/or deepened storm sewer systems.
Alternative design practices have now been in place in London since approximately 1985 to reduce the impact of wet weather on the trunk sanitary sewers and the sewage treatment plants. New homes are required to connect their footing drain and other clean water connections to the local storm sewer. The City of London has adopted this design practice by-law, due to the problems encountered with basement flooding and overflows of pumping stations and treatment works during extended wet weather periods. House footing drains are now connected to a sump pump in the home which discharges any groundwater collected to the surface or directly to a pipe connection to the local storm sewer system which are often now installed for that purpose.

B10.2 Existing Subwatershed Conditions

In the Stoney Creek Subwatershed, due to a number of factors including topography, soil conditions and the recentness of development, groundwater infiltration or incidental storm water collection by the sanitary sewer system has not been a serious problem. The older residential areas within the subwatershed, constructed prior to 1985, would have the footing drain connections to the sanitary sewer system. Due to the factors listed above, however, groundwater collection by those weeping tiles has not been significant in this area of the City.

It should also be noted that as houses age over five years following construction, the ground dewatering that occurs through the footing drain system tends to be complete unless the lot grading around the house is poor and is sloped to the foundation and/or the footing drain collects roof runoff at the downspout areas. Again, this is not a problem in the Stoney Creek residential developed areas of the subwatershed as it is in other parts of the City of London.

Accordingly, sanitary sewer system surcharging and manhole or pumping station overflows to the storm sewer or the surface water system are not problems in this area of the City. The downstream pumping station which lifts the collected sewage into the Adelaide sewage treatment plant has always been able to manage the volumes of incoming sewage flow.

It is noted that with the proposed expansion of the residential development areas within the Stoney Creek subwatershed, the capacity of the sewer system and the pumping station will continue to be upgraded. There are also plans to eliminate the pumping station on the north side of the Thames River to be replaced with a siphon under the river to a new pumping station to be constructed at the Adelaide sewage treatment plant.

B11.0 SUMMARY OF THE EXISTING STONEY CREEK SUBWATERSHED ECOSYSTEM

This section of the report is intended to synthesize the information presented in the detailed studies into a common framework that can be used in identifying alternative management measures in the development of the Stoney Creek Subwatershed Management Plan. The ecosystem framework presented earlier including subwatershed functions, attributes and linkages, is used to describe how the Stoney Creek Subwatershed works.

B11.1 Stoney Creek

Stoney Creek is a tributary of the North Branch of the Thames River which has its confluence with the Thames River in the City of London. Above this confluence, the North Branch is characterized by moderate depths and valley gradients. Stoney Creek has its headwaters in lands of the Arva Moraine and flows generally southwards through this landform, having its confluence with the North Branch of the Thames River in the City of London. The watershed has a moderate slope of 0.8 percent. The northern third of the watershed drains glacial deposits of sandy silt till originating from ground moraines, with a small pocket of lacustrine sand silt and clay in the north central area of the upper reaches. The central portion of the watershed is dominated by outwash gravels and sands on the west, and deltaic gravel and sand deposits on the east. The southwest corner of the watershed and pockets in the central area of the basin comprise sandy silt tills of the Arva Moraine.
The drainage network through the northern till areas is sparse and intermittent, with these tributaries tending to join the main branch along the interface of the till and sand and gravel units. Through the middle and lower reaches of the creek, the main channel follows the contact between the sand and gravel outwash deposits to the west and the beach and deltaic gravel deposits to the east. This range of physiographic units is reflected in the bed material comprising Stoney Creek. The geomorphological assessment indicated that the upstream station, located in the upper reaches, and draining primarily sandy silt tills of the Arva Moraine had a pavement mean grain size of 0.7 mm and a sub-pavement mean grain size of 0.13 mm, reflecting the generally fine grained materials comprising the sediment supply to the stream. The next downstream sampling location south of the City of London annexation boundary, had a pavement mean grain size of 93 mm, with a sub-pavement grain size of 14 mm, reflecting the contributions of the gravelly deposits to the east and localized steepening of tributary inflows. The remaining cross-sections, near the confluence, indicated pavement sizes ranging from 17 to 57 mm, and sub-pavement grain sizes ranging from 3 to 11 mm. This gradual change in grain size distribution of the bed materials reflects hydraulic sorting of the channel substrate as gradients tend to flatten towards the mouth, combined with urban impacts in the downstream reaches that result in the removal of finer sediment due to a general increase in frequent flows sufficient to move these materials. Sediment transport tends to be supply limited, with localized erosion sites and sediment sources caused by lack of buffer strips and/or livestock access, natural erosion due to channel and meander migration, and other localized areas of erosion due to man-made impacts such as culvert discharges.

Although the upper reaches exhibit intermittent characteristics because of the limited groundwater discharge from the fine-grained parent materials, the southern two-thirds of the stream receive a strong baseflow component from local groundwater discharge through the underlying sand and gravel material.

B11.2 Subwatershed Functions

Figure B1 provides a conceptual illustration of some of the features and natural processes occurring in the Stoney Creek subwatershed. Subwatershed functions are described below in terms of hydrological functions and biological functions.

B11.2.1 Hydrological Functions

Groundwater Recharge

Groundwater recharge is an important hydrologic function in that it replenishes the groundwater system. High permeability soils (sands and gravels) tend to infiltrate a higher amount of rainfall and thus perform a high level of groundwater recharge. Less permeable soils (silts and clays) tend to generate more runoff as opposed to infiltration and thus perform less of groundwater recharge function.

The soils of the Stoney Creek subwatershed are relatively permeable. Particularly, the deltaic gravel deposits in the eastern portion of the watershed have the highest infiltration rates across the whole subwatershed. Annual infiltration totals in these sands and gravels is approximately twice that of the surrounding tills.

Groundwater Discharge

Groundwater discharge plays an important role in supplying baseflow to the watercourses. Groundwater discharge occurs when groundwater seeps from the soil to the surface water system. Discharge is typically prevalent along the valley walls of stream corridors, through the stream bed itself and in wetlands. The rate of groundwater discharge will depend on the soil type and the driving head in the discharge area.
Flood Storage and Conveyance

Conveyance of storm water in a manner that does not present a risk to human health and safety is desirable for watercourses near areas of development. The hydrologic and hydraulic modelling carried out on the subwatershed resulted in the delineation of a floodplain for the Regulatory Storm event. The modelling indicated that the regional flows were contained within the stream valley with little risk to human health and safety.

From a fluvial geomorphological standpoint, the preliminary function of the watercourse is to transport sediment through the streamcourse system. Erosion and sedimentation processes are common in any watercourse, and it is the event driven flows that transport this sediment load through the system. The Stoney Creek subwatershed system appears to be relatively efficient at accomplishing this function.

Water Quality Modification

Water quality modification functions pertain to the ability of vegetation to filter contaminants (primarily sediment) from surface water runoff. Riparian vegetation also functions to shade the surface water aiding in the maintenance of cooler water temperatures. Vegetated buffer strips along the watercourses provide this water quality modification function. Wetlands can also provide a water quality function through the uptake of nutrients in the wetland vegetation. Riparian vegetation characteristics throughout the subwatershed are variable. Some of the first and second-order tributaries in the headwater areas have limited buffer areas, and in some locations are actively cultivated. However, for much of the central subwatershed area and in the lower reaches, Stoney Creek is buffered by natural and planted vegetation.

B11.2.2 Biological Functions

Erosion Control

An erosion control function is performed by the ability of vegetation to increase the soils tolerance to erosion caused by either water or wind. The root network of vegetation plays a key role in erosion protection. Cropping practices in agricultural areas help to control soil erosion and the subsequent sediment deposition in nearby watercourses. Riparian vegetation along the streambanks and within the stream corridor help to control erosion of the streambank along much of Stoney Creek.

Wildlife Habitat

The provision of habitat for wildlife is a critical function that has obvious sensitivities to land use change. Both terrestrial and aquatic habitats play prominent roles in the watershed ecosystem. Forested areas provide habitat for both birds and animals; wetlands provide habitat for a unique range of species; and the watercourses within the subwatershed provide habitat for a variety of aquatic species.

Terrestrial

The terrestrial resources detailed study for the Stoney Creek subwatershed study identified 51 forested patches within the Stoney Creek subwatershed. The patches varied in size from less than 4 hectares to several greater than 50 hectares. Within the newly annexed area, 21 of these forested patches exist. Thése Patch numbers are summarized in Table B.21 and are located on Map B11.
TABLE B.21
Forested Patches Within Annexed Area
(Future Development Area)

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<tr>
<td>2019</td>
<td>3044</td>
</tr>
<tr>
<td>2020</td>
<td></td>
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NOTE: Insensitive development in these areas could result in the direct loss of these forested patches.

Aquatic

The various watercourses within the Stoney Creek subwatershed provide habitat to support a variety of warmwater fish species. The main reach upstream from the Thames River to Fanshawe Park Road is an important spawning area for minnows, suckers, red horse, dashers and small mouth bass, and it has the potential to support rainbow trout. The subcatchment south and west of Ballymote has a relatively good baseflow and some reaches support healthy invertebrate populations indicating unimpaired water quality. The main stem of Stoney Creek and its tributaries upstream of Fanshawe Road generally have coarse substrate, good baseflow and a consistently high biotic integrity. Two provincially significant fish species were documented in Stoney Creek: central stone roller and greenside darter. The central stoneroller is a member of the minnow family. In Canada, it occurs only within the Thames River drainage system upstream of London. Thus, the populations in the Thames River system are of national significance.

The greenside darter is also restricted to southwestern Ontario and the largest Canadian population is in the Thames River. It prefers streams with a coarse substrate and a good sequence of pools and riffles. High turbidity and sedimentation are deleterious to this species.

B11.3 Subwatershed Attributes

B11.3.1 Rare and/or Endangered Species

Rare and endangered species often have exacting requirements for habitat in order to continue in existence. Both the central stone roller and the greenside darter are provincially significant fish species. The short-eared owl (provincially significant species) was observed flying over and roosting in the Fanshawe Wetlands.

B11.3.2 Unusual Vegetation

Unusual vegetation communities are typically valued greater than common types of vegetation. The Fanshawe Wetlands harbour two provincially rare, and five regionally significant plant species.
B11.3.3 Unusual Landforms

Unusual landforms are often documented as Areas of Natural and Scientific Interest (ANSI). An example of an unusual land form is the Niagara Escarpment. There are no similar landforms in the Stoney Creek subwatershed. The results of the Archaeological Study component did identify some existing and some potential sites of archaeological significance.

B11.3.4 Critical Habitat Areas

Forest patches 2017 and 2030 have potential to support some forest interior and area dependent species.

B11.4 Subwatershed Linkages

B11.4.1 Dispersal and Movement Corridors

Terrestrial wildlife movement corridors typically occur along contiguous tracts of forested land. These tend to be in forested stream valley corridors or along connected tracts of tableland forests. Terrestrial linkages can cross watershed boundaries and provide linkages to the surrounding bio-region. Aquatic linkages include migratory watercourses for fish.

Map B11 identifies Type A zones. These zones support wildlife dispersal and movement functions. These zones are also coincidental with watercourses and therefore support movement of aquatic species.

B11.4.2 Hydraulic Linkages

Linkages can also be evident between areas with high infiltration functions and the areas of groundwater discharge. This important linkage defines a clear relationship between land use and the maintenance of base flow.

Figure B1 presents a conceptual summary of the Stoney Creek Subwatershed ecosystem and supporting hydraulic linkages.

B11.5 Subwatershed Management Units

In order to further refine the analysis of existing conditions in Stoney Creek, the subwatershed has been broken down into management units for ease of description and for the evaluation of development management strategies in Part C of this report.

The delineation of the management units (MU) was based on several factors including:

- Physiography;
- Geology;
- Land Use; and
- Environmental Quality.

The management units are illustrated on Map B13 with MU1 corresponding to the rural upper reaches of Stoney Creek, MU2 representing the eastern central reaches within the future development area, MU3 representing the western central reaches also within the proposed development area and MU4 corresponding to the lower reaches of Stoney Creek in the existing developed area.
B11.5.1 Rural Upper Reaches (MU1)

MU1 comprises the agricultural headwaters of Stoney Creek. The streams are all first and second order and almost all of them are agricultural drains. The streams can be placed into three types: permanently-flowing drainage ditches, intermittently-flowing ditches, and intermittent headwaters without a well-defined channel.

MU1 supports Types IV and V aquatic communities (Map B14): i.e. those that are highly degraded or support no fish species. The streams are characterized by low baseflow, few pools or instream cover, low gradient, straight channels, soft substrates, and limited riparian vegetation. However, many of the streams are so small that they are adequately shaded by grasses or the bank of the ditch. Because of the low baseflow, there are limited opportunities to enhance these streams. These streams could be further degraded through increased inputs of nutrients or reductions in baseflow due to loss of riparian vegetation or changes in land use.

B11.5.2 Eastern Central Reaches (MU2)

Management Unit 2 contains significant outwash sands and till and is important for groundwater recharge. It is therefore critical for maintenance of baseflow in MU2, as well as in the downstream unit MU4. MU2 contains mostly third order streams, including the Ballymote Tributary and the main stem of Stoney Creek. Because of the coarse nature of the substrate, there has been little need for improved drainage, and the channel is predominantly natural. The unit contains a few first and second order streams, most of which are intermittent. They are, for the most part, either channelized or have no well-defined channel. These latter watercourses flow continually only for a short period in the spring, and many of them have agricultural crops planted in the channel.

The third order streams are generally of good quality, and support a Type III fish community and many support a Type II benthic invertebrate community. Many of the fish communities are very close to a Type II community, but lack either smallmouth bass or sufficient species (14) to achieve this level.

The confluence of Stoney Creek and the Ballymote Tributary is located just above Highbury Avenue and becomes a fourth order stream. It exhibits high quality and biotic integrity, and is a Type II aquatic community. Stoney Creek at Highbury Avenue is an important spawning area for the central stoneroller as well as for numerous minnow and sucker species.

The Ballymote Tributary and an unnamed tributary originating in the Fanshawe Wetland exhibit high baseflow and support invertebrate species that are typically associated with cool water and groundwater discharge.

MU2 supports the healthiest aquatic communities in Stoney Creek and, along with Stanton Drain, the best quality of all of the subwatersheds. Therefore, it is critical to ensure that these resources are not impaired.

There is good potential to increase the quality of the streams in this unit by improving instream cover. With appropriate management, some streams could support smallmouth bass and others are currently borderline coldwater streams. These watercourses are highly susceptible to increased temperatures due to loss of riparian vegetation or diminished groundwater discharge. Increased inputs of nutrients or sediments could significantly affect aquatic invertebrate and fish populations.
B11.5.3 Western Central Reaches (MU3)

MU3 contains two tributaries which flow into Stoney Creek within the former City of London boundary. The Northcrest Tributary originates west of Adelaide Road near the Agriculture Canada London Research Centre. It flows through subdivisions and stormwater facilities, entering Stoney Creek about 1.5 km upstream of its mouth. The watershed is 20 percent urban, and development may eventually increase to 40 percent.

The upper portions of the Northdale Tributary flow through agricultural lands. Most of the tributaries have been channelized and, in the existing urban areas, it is completely enclosed in stormwater drains. This subcatchment may eventually become 80 percent urban.

Both of these tributaries are intermittent and therefore support either no fish or only those that are adapted to persisting in isolated pools during low-flow periods. The benthic invertebrate community is dominated by pollution-tolerant taxa, with a complete lack of stoneflies and only the most tolerant species of mayflies and caddisflies. The majority of invertebrates present are adapted to high levels of organic enrichment, low flows and soft substrates.

The tributaries in MU3 are severely degraded and support only Type IV and V aquatic communities. Significant limitations include low (or no) baseflow, poor water quality, limited riparian vegetation, channelization, bank hardening, drop structures, and other stormwater management facilities. There is little opportunity to enhance these watercourses. If they are further degraded through nutrient and sediment inputs, higher peak flows, lower baseflows, or additional channelization, they may not be capable of supporting any fish populations.

Although MU3 supports no aquatic resources of significance, it is critical that water quality not be allowed to degrade further. This would have the potential to decrease the quality of MU4. Further degradation may result in MU3 being no longer able to support any fish species.

B11.5.4 Lower Developed Reaches (MU4)

MU4 is the main channel of Stoney Creek from its mouth at the North Thames River to upstream of Fanshawe Park Road to include the channelized portion of the creek north of Fanshawe Park. The creek is a fourth order stream through this reach, receiving three small intermittent streams just north of Windermere Road. Upstream of Adelaide and a short distance downstream, the stream has been channelized, although the banks have not been hardened. In this reach, stream banks are predominantly coarse-mowed grass or lawn, although there are some trees in the floodplain downstream of Adelaide and north of Fanshawe Park Road. The remainder of the channel, downstream to the mouth, is natural. Most of the floodplain is treed, primarily with white ash, white elm, trembling aspen, willow and black walnut.

Being the downstream management unit, it is the end receiver of all inputs to the watercourses. MU4, therefore, reflects the health of the entire subwatershed.

This reach of Stoney Creek is of fairly high quality. The main stem of the creek is a Type III community (moderately tolerant warmwater community). Relatively intolerant fish species such as smallmouth bass and northern hogsucker are present, and the presence of young-of-the-year indicates that there is spawning and nursery habitat for smallmouth bass, redhorse, and a variety of minnow, sucker and darter species. This reach of Stoney Creek supports the greenside darter and central stoneroller, both of which are provincially and nationally significant.

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The benthic invertebrate assemblage indicates an unstable warmwater community. Although some sensitive species of water-penny beetles and midges are present, the more intolerant species of mayflies, stoneflies and caddisflies are notably absent.

Limiting factors to aquatic resources in MU4 appear to be instream cover, siltation, warmwater discharges, and reduced riparian cover in areas. It also has the potential to be degraded by changes in land use practices in other management units. This reach of Stoney Creek can be improved by increasing riparian and instream cover, and by naturalizing portions of the channel.
PART C

DEVELOPMENT AND EVALUATION OF ALTERNATIVE SUBWATERSHED MANAGEMENT STRATEGIES
PART C - DEVELOPMENT AND EVALUATION OF ALTERNATIVE SUBWATERSHED MANAGEMENT STRATEGIES

C1.0 IMPACT ASSESSMENT

This section of the study report addresses the potential impacts of future land use changes on the features, functions and processes of the Stoney Creek Subwatershed. The potential impacts will result from changes in the hydrogeologic and surface water systems, as well as a result of development adjacent to the proposed Greenspace System.

C1.1 Future Land Use

Two development scenarios were considered in the assessment of the subwatershed sensitivity to development (See Map C1). The first scenario (20 year forecast) included development of lands between Fanshawe Park Road and Sunningdale Road. The second (ultimate) development scenario included urbanization of the subwatershed up to the new City of London municipal boundary. The two scenarios were specifically evaluated in the Detailed Hydrologic Study.

C1.2 Stoney Creek Subwatershed Sensitivity to Development

The sensitivity of the Stoney Creek subwatershed was evaluated based on the existing subwatershed ecosystem functions, attributes and linkages. The following sections describe these sensitivities.

C1.2.1 Subwatershed Functions

Water Balance

Urbanization of the subwatershed will tend to change the water balance, particularly in the areas underlain by sands and gravels. The hydrogeologic models predicted marginal change in the balance between infiltration and runoff areas in the whole watershed. Figure C1 summarizes these impacts to the water balance. A comparison of Figure C1 to Figure B1 will allow the reader to compare future conditions to existing conditions. However, the impact could be quite significant on a local basis where certain reaches of Stoney Creek flow through sand and gravel areas. These reaches could experience up to a 50 percent reduction in baseflow, should development occur without regard for this hydrologic function. The reach of Stoney Creek that passes through Ballymote could experience such impacts on a local basis.

Peak Flow Impacts

The alternative land use scenarios were applied to the event simulation model to estimate the potential impact of land use changes on peak flow rates generated by the various design storms. The results are presented in the Technical Appendix. The existing condition flows (at the mouth of Stoney Creek) for the 2.5, 25, 100 and 250 year range from 7.8 to 28.1 m³/s. This is contrasted to 19.4 to 78.8 m³/s and 24.0 to 103.8 m³/s for the 20 year forecast (High Density) and ultimate conditions (High Density), respectively. Future development of the Stoney Creek subwatershed, without peak flow attenuation, will significantly impact the magnitude of the corresponding flows. Based on a review of the findings, the following are concluded:

i) High density ultimate development conditions would more than triple the magnitude of the peak flows; and

ii) Low density ultimate development conditions would more than double the magnitude of the peak flows.
Flow Duration

Existing flow conditions in MU4 currently exceed a discharge rate of 0.20 m$^3$/s 3.5 percent of the time. This can be contrasted with 4.1 percent and 4.4 percent of the time for the 20 year forecast and ultimate condition scenarios, respectively. It was concluded that as the amount of urban area increases, so does the duration and frequency of runoff in Stoney Creek (See the Technical Appendix for modelling results).

Erosion Indices

The existing conditions model indicated that some erosion potential currently exists. In contrast, for the ultimate conditions model, erosion potential increased by as much as an order of magnitude (See Technical Appendix for modelling results).

Sediment Loading

Existing conditions indicated that a suspended solids concentration of 500 mass units/m$^3$ is exceeded 0.16 percent of the time. The corresponding values for the medium density 20 year forecast and ultimate conditions models was 0.25 percent and 0.22 percent, respectively. These results imply that the frequency of higher suspended solids and concentrations will increase marginally in areas that undergo development.

Flood Risk

Regulatory Flood elevations for both existing and ultimate conditions were calculated for Stoney Creek. Under existing conditions, there are no houses within the Regulatory floodplain. However, under ultimate development conditions, 15 structures are located within the floodplain. These structures are all localized both upstream and downstream of the Fanshawe Park Road crossing. Flow control measures, such as storm water management facilities, sized for the Regulatory Storm are not recommended for future development since the impact on existing structures is limited to 15 buildings. Alternatively, it is suggested that site-specific protection measures or consideration of a Two Zone Policy Area be reviewed in this location.

Aquatic and Terrestrial Habitat

Impacts on terrestrial habitat can be quantified by the number and quality of forested patches impacted. There is a potential to impact 21 forest patches. Aquatic habitat would also be impacted indirectly through an increase in pollutant loadings and a reduction in baseflow.

C1.2.2 Subwatershed Attributes and Linkages

The central stoneroller and greenside darter could be impacted in several ways. Loss of habitat through stream channelization or increased erosion could occur. Degraded water quality could also result from an increase in urban runoff could which further causes impact to these species.

The regionally and provincially significant plant species found in the Fanshawe Wetlands would be impacted if any of the wetland area was lost.
Map C2 illustrates the areas that are most sensitive to future development. The forested patches either contain rare plant species or are large enough to provide forest interior habitat. Approximate areas of sand and gravel deposits are also delineated on Map C2, representing groundwater recharge areas that are important to the baseflow of Stoney Creek.

C1.3 Opportunities to the Modify Subwatershed Hydrology

Analyses have been completed to test the sensitivity of the subwatershed and its hydrologic response to various watershed management practices. Management practices tested for each subwatershed included:

- Peak flow attenuation;
- Extended detention for water quality treatment;
- Incorporation of infiltration practices; and
- Increasing existing forest-cover by a factor of 2.

These management practices primarily impact the hydrologic cycle portion of the subwatershed ecosystem. The ecosystem components that would potentially benefit from these management practices are illustrated on Figure C1. The remaining sections of this chapter describe the sensitivities, opportunities and constraints of the subwatershed and the various management units.

Flood Risk

Flood risk can be managed by ensuring that peak flows are attenuated for the 2 to 100-year return period storms as development proceeds. Based on impervious ratios of 35 and 50 percent respectively, volumes required for peak flow attenuation would range from 200 to 300 m$^3$/ha, respectively.

Flow Regime/Erosion Indices

Section C1.2.1 described the nature of the increases in flow duration and erosion potential that would result from future development. These flow characteristics can be modified with the incorporation of extended detention storage in storm water management facilities. Extended detention can take several forms, including wet ponds, dry ponds, and possibly even constructed wetlands. Extended detention volumes necessary to modify the flow regime and reduce post-development erosion indices range from 70 to 130 m$^3$/ha of development for the scenarios considered. This volume would be in addition to the volume required for peak flow attenuation. With the implementation of peak flow control and infiltration, erosion indices (See Figure C2) will be considerably reduced. In addition, flow duration values would approach existing conditions.

Groundwater/Infiltration

Analyses were carried out to investigate the impact of infiltration practices on the subwatershed hydrology. In an effort to protect future groundwater quality, it would be reasonable to assume the infiltration of only roof top runoff, as this runoff would be relatively clean. The analysis indicated that the existing infiltration in the Stoney Creek subwatershed could not be maintained with the incorporation of infiltration practices for roof runoff. The distribution of the sand and gravel deposits and the relatively high existing infiltration rates makes maintenance of existing infiltration difficult. However, lot level infiltration facilities designed to infiltrate the first 20 mm of roof runoff could achieve 85 percent of the original infiltration in the subwatershed.
Ultimate Condition Represented by 35% Impervious
20mm of Rooftop Runoff was Infiltrated
25mm Event - 24 Hr Draindown (Water Quality)
Map C3 illustrates existing infiltration potential in Stoney Creek.

The use of a combination of infiltration practices, extended detention storage, and peak flow attenuation would allow the most efficient use of best management practices for subwatershed management. The volume requirements stated above for flow duration and peak flow attenuation could be reduced by as much as 30 percent with the incorporation of infiltration practices. However, site specific hydrogeological investigations will be required to specifically determine the infiltration capability on a lot-by-lot basis.

**Forest Cover**

An analysis was carried out on the impact of an increase in forest cover on the subwatershed hydrology. Forest cover can impact both peak flow and the evapotranspiration portion of the water balance.

The analysis indicated that the doubling of the existing area of forest cover in the Stoney Creek subwatershed would have a negligible impact on peak flows at the outlet of the subwatershed. On a local basis, the impact of increased forest cover would be an approximate 25 percent decrease in the peak flow generated from a 25 mm storm. The effect of this decrease is lost as the flow is routed down through the subwatershed to the outlet.

Further analysis indicated that the increased forest-cover has the most beneficial impact when carried out in less permeable or till like soils. Increasing forest cover in a tighter till soil would also increase the evapotranspiration portion of the water balance. However, the infiltration portion of the water budget surplus is maintained or even increased. In this case, the direct runoff portion of the water budget surplus is decreased, with beneficial effects on peak flow control and erosion potential.

Increased forest-cover in sand and gravel type soils will increase the evapotranspiration component of the water balance, thus reducing the surplus available for infiltration and runoff. Furthermore, the amount of loss to evapotranspiration outweighs the increase that would be gained in infiltration potential.

**C2.0 ALTERNATIVES FOR SUBWATERSHED MANAGEMENT**

**C2.1 Background**

The intent of this section is to provide the information required to arrive at a preferred management strategy for the Stoney Creek Subwatershed. A menu of alternatives that address a range of management objectives from maintaining the existing ecosystem functions to significant enhancement of existing ecosystem functions is provided. Finally, this section of the report provides an evaluation of the alternatives based on their ability to meet the subwatershed goals and objectives as well as their practicality for implementation. The subwatershed management strategy is based on a number of principles:

i) The subwatershed management strategy must be founded on the ecology of the subwatershed;

ii) The strategy must provide a reasonable range of alternatives for subwatershed management; and

iii) The strategy must allow quantitative targets for subwatershed management to be set.
C2.2 Alternatives for Subwatershed Management

In keeping with the principles mentioned above, management alternatives will fall into three categories. These are:

- Maintenance of the existing ecosystem functions;
- Moderate enhancement of the ecosystem functions; and
- Significant enhancement of the ecosystem functions.

The alternative for the "maintenance of the existing ecosystem functions" would entail appropriate best management practices and land use restrictions designed to maintain and protect the existing systems in the subwatershed. Ecosystem functions including surface water and groundwater interaction, fisheries habitat and water quality, terrestrial habitat, and corridor linkages would be addressed.

The alternative for "moderately enhancing existing ecosystem functions" can be broken down into two major categories. The two categories are to enhance the aquatic ecosystem and to enhance the terrestrial system. These alternatives would include the identification of candidate areas for rehabilitation, candidate areas for terrestrial enhancement, improvement in the aquatic environment and associated habitat potential, and rehabilitation of tableland woodlots in order to enhance their function in providing terrestrial habitats.

The alternative for the "significant enhancement of the ecosystem functions" builds on the moderate enhancement alternative described above. Further rehabilitation of existing ecological features as well as the creation of new ecological features from both an aquatic and terrestrial perspective, are provided for in this level of enhancement.

C2.3 Management Strategy Components

The following sections describe the implementation requirements and benefits of the three alternatives described above. Table C.1 provides a summary of the management requirements under the categories of flood potential, flow regime/erosion potential, groundwater/infiltration resources, water quality, aquatic resources and terrestrial resources. The reader should be aware that these six categories (types of ecosystem functions) are inherently linked to each other in the real ecosystem. This connectivity is not captured when portrayed in a categorized tabular format.

Each of the management strategies are being described in a cumulative manner. In other words, the significant enhancement also includes the moderate enhancement and maintenance alternatives previously described. This is to avoid unnecessary reiteration.

C2.3.1 Alternative 1 - Maintain Ecosystem Functions

The detailed studies carried out on the subwatersheds outlined the functions performed by the various subwatershed components. Maintenance of these functions would maintain the status quo of environmental quality within the subwatershed. This alternative could also be described as a "no net loss" scenario, particularly as it relates to aquatic and terrestrial habitat (See Map C4).
<table>
<thead>
<tr>
<th>Flooding Potential</th>
<th>Flow Regime, Erosion Potential</th>
<th>Groundwater Infiltration</th>
<th>Water Quality</th>
<th>Aquatic Resources</th>
<th>Terrestrial Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintain Ecosystem Function</td>
<td>• no increase in flood risk volume control flow duration control maintain erosion indices fix existing erosion sites</td>
<td>• peak flow attenuation infiltration rate no increase risk to groundwater quality</td>
<td>• maintain existing temperature regime do not aggravate existing nutrients and bacteria problem areas</td>
<td>• maintain natural channels where they exist maintain fish and benthic communities maintain existing stream classification</td>
<td>• maintain existing riparian vegetation and headwater woodlots maintain Type I and II forest patches maintain wetlands and ESAs</td>
</tr>
<tr>
<td>Moderate Enhancement of Ecosystem Function</td>
<td>• reduce flood risk in existing development areas reduce floodplain width in areas to be developed</td>
<td>• modify flow duration to dampen response to storms reduce erosion indices encourage conservation tillage in high and medium priority areas rehabilitate existing ploughed swales to grassed waterways</td>
<td>• enhance infiltration reduce risk to ground water contamination</td>
<td>• limit livestock access to stream clean-up point source agricultural sites retrofit existing storm water management facilities public education increase frequency of street cleaning</td>
<td>• remove barriers to fish movement retrofit agricultural drains to incorporate meanders restore pool-riffle sequences improve stream classification</td>
</tr>
<tr>
<td>Significant Enhancement of Ecosystem Function</td>
<td>• same as above</td>
<td>• divert existing storm sewers to Thames River same as above encourage planting in tighter (till) soils</td>
<td>• same as above</td>
<td>• treat storm water prior to discharge to stream (existing)</td>
<td>• rehabilitate existing gabion lined channels to a natural state re-naturalize channels create new aquatic habitat further improve stream classification</td>
</tr>
</tbody>
</table>

C.11
Flood Risk

Important existing hydrologic functions include the conveyance of storm water, provision of storm water storage, and water quality modification. Management strategies in support of these functions include a reduction in post-development peak flows to meet pre-development peak flows, and maintenance of the natural features of the watercourses in order to maintain their role in flow attenuation and storm water storage. On a management unit basis, this translates to the following:

i) For the rural upper reaches (MU1), maintenance of the existing flood risk will require only that development not occur within the delineated floodplain;

ii) For the eastern (MU2) and western (MU3) central reaches, maintenance of existing flood risk can be assured by the attenuation of post-development peak flows to pre-development levels for the 2 to 100-year return period storms; and

iii) Given the location of the lower reaches (MU4) at the outlet of the subwatershed, further development in this particular management unit will not increase the flood risk unless development occurs within the delineated Regulatory floodplain. Therefore, no action is required to maintain the existing flood risk. Re-development or intensification in areas contributing flow to tributaries of Stoney Creek should be required to comment on potential impacts to downstream flooding.

Flow Regime/Erosion Potential

The primary fluvial geomorphological function is movement of water and sediment. The creek system, pattern and shape are derived from the movement of water and sediment. In-channel forms such as pools and riffles, allow storage and release of water and sediment throughout the year. The fluvial geomorphology of the creek has been classified and described as either stable or degraded. Stable reaches or sections become degraded if the movement or balance between water and sediment is altered. Controls should be recommended for development to ensure sediment loadings do not increase from existing levels. On a management unit basis, the above translates to:

i) For the rural upper reaches (MU1), the existing flow regime and erosion potential can be maintained by ensuring that the existing riparian vegetation stays in place and that agricultural practices continue in the same manner as they do now;

ii) For the eastern (MU2) and western (MU3) central reaches, the existing flow regime and erosion potential can be maintained by incorporating extended detention facilities into storm water management plans to ensure that runoff volumes are controlled. Extended detention should be provided for the 25 mm storm. Infiltration practices should be incorporated as development proceeds. Site specific infiltration will allow the reduction of volume required to attenuate the 25 mm storm; and

iii) Maintenance of the flow regime and erosion potential in the lower reaches (MU4) can only be accomplished by addressing these same issues in the three upstream management units, that is MU3, MU2, and MU1.
Groundwater/Infiltration

An important hydrogeological function in the subwatershed is the infiltration and subsequent discharge of groundwater. Rainfall infiltrates into surface soils, replenishing groundwater aquifers, which in both subwatersheds are used to supply water for domestic, agricultural and industrial uses. Groundwater discharge provides a steady baseflow of cool, clean water to area watercourses.

Maintaining the existing balance of groundwater recharge and discharge is a key component in protecting local sensitive ecosystems such as wetlands, fish spawning areas, and woodlots. Areas which are the most sensitive to disruption of the groundwater recharge/discharge function are those where permeable soils (sands and gravels) occur at or near the ground surface. Urban development in these areas could potentially cause a decrease in infiltration, resulting in a lower groundwater table and a decrease in groundwater discharge to nearby watercourses or wetlands. Maintenance of the groundwater recharge/discharge function would include the incorporation of infiltration practices in conjunction with future development in areas of permeable soils.

Maintaining the chemical quality of local groundwater resources is also a significant issue for both subwatersheds, especially in the rural areas where groundwater is an important source of drinking water. Maintenance of the groundwater resource during urban development would include land-use planning to avoid placing high risk urban activities (such as petroleum outlets or users of industrial chemicals) in sensitive areas.

The infiltration analysis assessed as part of the detailed studies indicated that infiltration cannot be maintained at its existing levels for the Stoney Creek Subwatershed. However, there is the opportunity to maintain 85 percent of existing infiltration through the incorporation of lot level infiltration practices as development proceeds. This specifically translates into the following on a management unit basis:

i) The rural upper reaches (MU1) are located primarily on tills, and as a result, groundwater and infiltration measures are not a management alternative;

ii) For the eastern (MU2) and western (MU3) central reaches, an estimated 85 percent of the existing infiltration for the subwatershed can be maintained through the incorporation of lot level infiltration practices as development proceeds; and

iii) Soils in the lower reaches (MU4) are not conducive to infiltration, therefore, groundwater and infiltration are not considered.

Water Quality

Water quality is of primary importance to the aquatic resources. Water quality facilities designed to address the more frequent (25 mm or less) events should be incorporated in any future development. On a management unit basis, this translates into the following:

i) For the rural upper reaches (MU1), water quality issues can be addressed by ensuring that lot level water quality controls are incorporated with any new development that occurs within this particular management unit;
ii) In order to maintain the existing water quality for the eastern (MU2) and western (MU3) central reaches, lot level water quality controls should be incorporated as development proceeds. These controls are similar to those for flow regime and erosion potential. As well, existing erosion sites (as identified in Section B3.0) in this management unit should be remediated. This will prevent further degradation of the water quality; and

iii) Lot level water quality control should be incorporated in any new development that takes place within the lower reaches (MU4).

Aquatic Resources

No net loss of aquatic habitat is a general policy of the Canada Fisheries Act (DFO, 1986). Management strategies would include the delineation of sensitive aquatic habitats and subsequent protection of these areas as well as requirements for habitat replacement should future land use impact existing habitat areas. Some reaches of the subwatersheds continue to undergo degradation as a result of existing development. The ability of the stream course to provide aquatic habitat is being lost in these areas. Maintenance of the existing system in this case would entail a minimum of rehabilitation along these impacted reaches of the subwatersheds. The above translates into the following:

i) Although the rural upper reaches (MU1) supports no aquatic resources of significance, it is important to maintain it so that the eastern central reaches (MU2) will not be degraded. This can be achieved by:

   • Maintaining existing headwater woodlots; and
   • Establishing appropriate source controls for new developments.

ii) In order to ensure the maintenance of the eastern central reaches (MU2), and hence the lower urban reaches (MU4):

   • Development and resource extraction proposals must demonstrate that groundwater recharge will not be diminished;
   • Riparian and natural tableland vegetation should be retained;
   • No permanent channel alterations should occur;
   • There should be no changes in stream water quality or quantity as a result of agriculture, urbanization, or resource extraction;
   • Existing erosion problems on the main stream should be corrected; and
   • Wetlands should be maintained, as they may be situated in groundwater discharge areas.

iii) To maintain the aquatic resources in the western central reaches (MU3), stringent control of storm water quality and quantity will be required for new development.
iv) To maintain the existing conditions of the lower reaches (MU4), the following unit specific measures must be completed:

- Maintain existing riparian vegetation;
- Plan new developments so that there is no net increase in peak flows, water temperature, nutrients or sediments in the stream (i.e. 20 mm event), and no decline in baseflow; and
- Maintain the existing channel.

Perhaps even more importantly, aquatic resources in other management units must be maintained if the quality of MU4 is to remain stable.

Terrestrial Resources

No net loss of terrestrial features would also be required in order to maintain the existing ecosystem functions. The terrestrial resource strategy identified terrestrial features that were valued for their habitat. These features would be maintained and protected. Other terrestrial features were considered to be somewhat common. These features could be modified or replaced only if no net loss of terrestrial habitat was achieved.

The maintenance of ecosystem functions can be further facilitated through the strategic planning for a city-wide interconnected open space system including stream valley corridors, tableland parkland and connecting linkages. This would allow for the establishment of buffers between new development and natural areas, protection of remnant woodland areas, wetlands and aquatic habitats, and the provision of Open Space areas in which to incorporate storm water management areas and infiltration facilities. In addition, opportunities would be provided for recreation purposes, such as nature observation and recreational trails development.

The above indicated that the Type 1 and 2 patches found throughout the subwatershed (MU1, MU2, MU3 and MU4) should be maintained. If they are further fragmented, additional wildlife species will disappear from the subwatershed. Type 3 patches are less important and they may be sacrificed, but only if suitable and at least equal habitat is provided elsewhere.

C2.3.2 Alternative 2 - Moderate Enhancement of Ecosystem Functions

Flood Risk

Moderate enhancement of the conveyance properties of Stoney Creek, leading to a reduction in flood risk can be accomplished by providing over control for the 100-year and other return period storms. However, since there is no development proposed for the upper rural reaches coupled with the fact that flood risk is not an issue presently, nor is anticipated to be in the future, this is not recommended at this time (See Map C5).

Flow Regime/Erosion Potential

Opportunity for the moderate enhancement of the existing erosion potential exists only in the rural areas (MU1) where there is an opportunity to:

i) Limit livestock access to the stream thereby reducing streambank degradation;
ii) Encourage conservation tillage in high and medium potential sediment load areas; and

iii) Encourage the establishment of buffer strips and riparian habitat along streams.

Moderate enhancement of the remaining central and lower reaches (MU2, MU3, MU4) is not an option at this time.

Groundwater/Infiltration

Moderate enhancement of existing infiltration is not applicable to the rural upper reaches (MU1) since they lie outside of the City of London lands.

For the central reaches (MU2 and MU3), existing infiltration cannot be maintained as development proceeds, therefore, enhancement of infiltration is not possible. However, impacts to infiltration can be minimized utilizing infiltration practices previously described.

Since infiltration practices are likely non-existent in the lower developed reaches, it may be possible to disconnect roof leaders from the storm sewer system to rear yard ponds or infiltration trenches and areas where existing development overlies sand and gravel. These areas are shown on Map C3.

Water Quality

Moderate enhancement of Stoney Creek water quality has been identified as an attainable enhancement goal. This translates into the following (on a management unit basis):

i) For the upper rural reach (MU1) and the eastern central reaches (MU2), moderate enhancement would involve:
   - Follow up on feedlot and manure storage facilities that have been identified as priority sites; and
   - Further investigate if milklake wastewater is being discharged to watercourses, and encourage proper management of discharges if necessary.

ii) For the western central reaches (MU3) and lower reaches (MU4) moderate enhancement would entail:
   - Increasing the frequency of street cleaning to minimize the amount of solids in the storm water; and
   - Retrofitting existing storm water management facilities to improve water quality.
Aquatic Resources

Enhancement of the aquatic system would entail improvement in water quality and the habitat provisions function of the stream course. The management strategy would include the identification of reaches within the subwatersheds that have the most potential for improvement. These would likely be the reaches of the subwatersheds that are found in the more permeable soils. The detailed aquatic studies found that the most limiting feature of the subwatersheds was the lack of baseflow. Therefore, stream course reaches where baseflow could be improved through infiltration practices would be prime candidates for rehabilitation.

Planting of riparian vegetation in areas where vegetation does not exist would also improve the aquatic system. Vegetation would provide shading to the watercourse which would improve the temperature as well as provide a food source to the aquatic ecosystem. Riparian vegetation would also enhance the stability of creek banks, thus reducing erosion potential. The above translates into the following on a management unit basis:

1) The rural reaches (MU1) are essentially all first and second order drainage ditches, many of which are intermittent. The following management practices are suggested to moderately enhance aquatic resources in MU1.

- When drain clean-out is required, Drainage Engineers should be encouraged to consider a meandering channel with vegetated banks as opposed to straight channels. The meandering channels tend to be more stable and therefore require less frequent maintenance. At the same time, they have a greater potential to provide aquatic habitat.

- Encourage the establishment of grassed waterway systems in intermittent headwater streams that are presently tilled and under crop production.

2) The following management practices are suggested to moderately enhance aquatic resources of the eastern central reaches (MU2).

- There are a few locations where livestock has direct access to streams. These are predominantly on the first and second order streams in the unit, some of which are intermittent. Nonetheless, the Conservation Authority should continue its agricultural programs and encourage these landowners to restrict livestock access. These sites have been identified in Section B5.0 of this report.

- Conservation tillage practices should be encouraged in the areas that have been identified as high and medium potential sediment load areas (See Map B7). This has the potential to significantly reduce sediment and phosphorus loading to the stream.

- Most farmers have left a buffer area along streams, and some have planted trees in adjacent areas. These practices should be encouraged.

- The majority of the main stream has well-established riparian vegetation. There are a few areas where this can be improved.
Encourage the establishment of grassed waterway systems in intermittent headwater streams that are presently tilled and under crop production.

3) The western central reaches (MU3) are significantly degraded and are unlikely to ever be of high quality even with intensive management. However, it is imperative that they do not become more degraded, as this has the potential to affect the quality of the lower reaches (MU4). The main reasons for the present degradation in MU3 are low baseflow, channelization and hardening. The following management practices may moderately enhance the aquatic resources of MU3.

- Initiate an education system for existing landowners to discourage use of lawn fertilizers and chemicals and washing cars where runoff will go directly into the storm water system. The program could also be extended to include management of pet wastes, direction of eavestrough flows onto lawns, etc. Similar programs have been used effectively by some municipalities to assist in the reduction of storm water volume and improvement in its quality.

- Design new storm water management facilities to remove solids and nutrients to levels compatible with Type 2 habitats as defined by OMOEE. Where feasible, thought should be given to using constructed wetlands as part of storm water management designs.

- Design new developments to minimize storm water runoff by encouraging features such as backyard swales, ponding of water on rooftops and in parking areas, curbless streets, perforated piping, and constructed infiltration areas, where feasible. New developments should be designed to minimize the area that becomes impervious.

4) The following management practices are suggested to moderately enhance aquatic resources in the lower developed reaches (MU4).

- Revegetate open areas along the channel, or allow natural succession to proceed. The primary area that would benefit is from Adelaide Street to the upstream end of the unit, although there is an area near Sprucedale Avenue that could be improved with additional riparian cover. The Friends of Stoney Creek have already initiated this work, and it is also being used as an educational program. It is recognized that this will have to be done in a manner which does not reduce the ability of the stream to convey peak flows without causing flooding.

- Encourage landowners living adjacent to the stream to reduce or eliminate the use of chemicals and fertilizers on their lawns, and to leave a natural area along the stream as opposed to mowing to its edge.
The channelized portion of the stream upstream of Adelaide Street is relatively uniform with very few riffles or pools. Habitat could be greatly enhanced by applying natural channel design techniques to diversify habitat and create pools. This could possibly be done by a volunteer group with technical advice provided by the Conservation Authority or MNR. This type of project may also be eligible for funding as a Community Fisheries Involvement Program (CFIP). It would need to be carefully planned to ensure that it does not induce flooding and that in-stream work does not block upstream movement by fish.

Terrestrial Resources

Two strategies have been developed to moderately enhance terrestrial resources: improving riparian habitat and increasing the amount of forest-interior habitat.

The plans deviate somewhat from the recommendations of the DTRS. The DTRS defined Type C Zones, which were areas between closely-spaced patches, and recommended that these zones be naturally-vegetated to connect patches. In many cases, the connections were narrow and were essentially all edge habitat, and naturally vegetating them would result in the loss of agricultural land.

Therefore, we have not included many of the Type C Zones in our vision of a moderately enhanced subwatershed. The addition of more edge habitat to join forests may be counter-productive. This creates more habitat for edge species such as white-tailed deer and common species of passerine birds. Although it is desirable to have healthy deer populations, they are greatly increasing in numbers and have the potential to become overabundant. Linking patches has the potential to allow the spread of weed species from one woodlot to another. For those patches that currently support forest-interior bird species, the connections frequently do not create more habitat for these sensitive species. Indeed, they may be adversely affected by improving habitat for edge species and predators.

From an ecological restoration perspective, it is frequently better to increase the size and improve the shape of existing woodlots, or even to create new patches, rather than to create corridors. As specified in the DTRS, corridors should be a minimum width of 100 m, and even these will appear as entirely edge from a bird’s perspective. A 100 m wide, 1 km long corridor will consume an equal sized 10 ha of land, but will provide no forest-interior. In contrast, a 10 ha square will provide a 1.4 ha of forest-interior.

In addition to recommending tree planting in riparian corridors, the size and shape of existing woodlots would be improved. Emphasis is on patches that presently contain forest-interior habitat, or those where forest-interior can be created utilizing a minimum of land.

Grassland and old-field habitats are becoming scarce in southern Ontario, as they are often considered to be of low biological value. Yet many of the wildlife species that depend on these habitats are declining. Although less is known about grassland birds than forest birds, there are also area-sensitive and field-interior wildlife species. Some examples include Northern Harrier, Upland Sandpiper, Northern Bobwhite, Loggerhead Shrike and Henslow's Sparrow. Even many grassland birds that are perceived to be common, such as Eastern Meadowlark and Bobolink, are declining.
Within the terrestrial enhancement areas shown on the figures, there is opportunity to create grassland and old-field habitat. Thus, the enhancement zones should not be considered to entirely represent forest habitat. It has been calculated as forest habitat to indicate the amount of forest-interior habitat that could be created. The restoration of the gravel extraction areas in the Stoney Creek subwatershed will provide excellent opportunities for creating old-field and grassland habitats.

Other habitat types that could be considered for restoration or enhancement are prairie and savannah. Only a small remnant of the original extent of these habitats remains in southern Ontario, and work by people such as Mary Gartshore demonstrates that creation of these habitats is possible.

Additional opportunities for the enhancement alternative of ecosystem functions can be found within an expanded greenspace system. This would include the incorporation into the open space system of utility corridors, such as pipelines and hydro corridors, abandoned rail and road rights-of-way and drainage areas, and the protection or re-establishment of hedgerows and fencerows, through new development areas or within the existing agricultural areas. The revegetation of these corridors would enhance habitat linkages between tableland woodlot areas and the creek valley corridors, while providing for increased recreational opportunities such as trails development.

Excluding the riparian strips, the moderate enhancement for the Stoney Creek subwatershed results in the addition of 101.4 ha of forest cover. This brings the total forested area to 560.3 ha, or 15 percent of the subwatershed. The amount of forest 100 m or more is increased from 43.5 ha to 133.4 ha, which represents 3.6 percent of the subwatershed, a 200 percent increase over present conditions. The amount of forest interior 200 m or more also increases to 0.8 percent of the subwatershed compared to the existing 0.1 percent.

Rural Areas

Section B5 identified a number of agricultural practices that are likely contributing pollutants to the Stoney Creek system. Programs or strategies designed to address these concerns could help to improve the overall environmental quality of the Stoney Creek system.

C2.3.3 Alternative 3 - Significant Enhancement of Ecosystem Functions

This section describes the management strategies that would be required to significantly enhance the ecosystem functions for the subwatershed management units. It should be noted that the management strategies are being described in a cumulative manner. In other words, the significant enhancement described in this section also includes the moderate enhancement described and the maintenance alternatives described previously (See Map C6).

Significant enhancement of ecosystem functions primarily reflects the creation of new aquatic and terrestrial habitat. However, a number of other areas have been identified as strategies that can be undertaken to significantly enhance the ecosystem and have been listed where appropriate.

Flow Regime/Erosion Potential

The creation or restoration of meanders and pool-riffle sequences would entail strategies for protecting banks and reducing scour to the bed. This would reduce erosion while restoring or enhancing natural water and sediment conveyance.
Water Quality

Measures considered as significant enhancement would include retrofitting of existing storm water management facilities, end of pipe treatment on existing storm sewers, and creation of new wetland complexes.

Specific water quality measures which could be applied to the lower developed reaches (MU4) include:

- Treatment of existing storm water discharges prior to discharge to Stoney Creek. This could either be an at-source or end-of-pipe solution.

- Divert storm water away from Stoney Creek to another receiving body such as the North Thames River. The potential effects of this on flows in Stoney Creek would have to be considered.

Aquatic Resources

Specific management strategies as they apply to the management of aquatic resources include the following:

i) The eastern central reaches (MU2) are of relatively high quality and, short of a program to reforest most of this area, there are few opportunities to significantly enhance MU2. Because it is a small stream, there are few deep pools, and this makes it generally unsuitable for species such as smallmouth bass and rock bass. Natural channel design techniques could provide habitat for these species. This would also achieve the objective of upgrading the higher-order streams in this unit from a Type 3 to a Type 2 aquatic community.

ii) The following management practices are suggested to significantly enhance aquatic resources in the lower developed reaches (MU4):

- Convert the channelized portion of the stream back into a natural channel. This would entail encouraging or allowing the stream to meander within its floodplain and introducing a properly-spaced sequence of pools and riffles. In essence, this could involve excavating and shaping the channel, and possibly introducing a more suitable substrate such as cobbles.

The area that would benefit most is from Adelaide Street to the upstream extent of this unit. Care would be necessary to ensure that the flood capacity of the channel was not diminished, and that sediments were not introduced into the stream. The project would have to be very carefully designed to ensure that the resultant stream was stable and not erosion-prone.

With a good pool-riffle ratio, appropriate instream cover addition, and well-established riparian cover, this reach of Stoney Creek would have the potential to provide spawning habitat for smallmouth bass, central stoneroller and other minnows, suckers, and darters. Depending upon water temperatures achieved by more complete shading of the stream, and the depth of the pools that are provided, this reach could possibly support rainbow trout.
The re-naturalization of this reach would result in almost the entire main stem of the stream being natural, from the upper areas of MU3 to the mouth of Stoney Creek.

The potential aquatic communities types that could be achieved as a result of the significant enhancement are illustrated on Map C7.

**Terrestrial Resources**

The significant enhancement of terrestrial resources focuses on enlarging existing patches even more than the previous alternative. In the Stoney Creek subwatershed, it is suggested that lands zoned for aggregate extraction be rehabilitated to grassland once the aggregate resources have been removed.

In the Stoney Creek subwatershed, the significant enhancement alternative results in the addition of another 133 ha of forested area. The subwatershed would be 18.5 percent forested. The subwatershed would contain 202.1 ha of forested land 100 m or farther from the Creek's edge and 87 ha 200 m from the Creek's edge, corresponding to 5.4 and 2.3 percent of the subwatershed, respectively. These enhancements are illustrated on Map C6.

**C2.3.4 Summary**

A summary of the three management strategy components (by management unit) pertaining to flood potential, flow regime/erosion potential, groundwater infiltration, water quality and aquatic resources is provided in Table C.2.

Terrestrial resources have been analyzed on a subwatershed basis (as opposed to by management unit) with the various strategies appearing in Table C.3.

Part D of the report summarizes the approach used at arriving at the preferred plan, which is also detailed in Part D.
| TABLE C.2 |
|------------------|------------------|------------------|------------------|
| Summary of Alternatives for Subwatershed Management |
| | Upper Reaches Rural Area (MU1) | Eastern Central Reaches Development Area (MU2) | Western Central Reaches Development Area (MU3) | Lower Reaches Existing Developed Area (MU4) |
| Hydrologic Targets | | | | |
| Flow Duration | N/A | match existing hydrograph timing | match existing hydrograph timing | N/A |
| Peak Flow Attenuation | N/A | post to pre | post to pre | N/A |
| Erosion Indices | N/A | match existing indices | match existing indices | N/A |
| Runoff Volumes | N/A | match existing runoff volumes | match existing runoff volumes | N/A |
| Infiltration | N/A | match or augment existing | match or augment existing | augment existing |
| Hydrologic Strategies | | | | |
| Grasped Waterways (km) | 2.4, 10, 21 (1) | 0, 1, 2 | N/A | N/A |
| Peak Flow Attenuation (m³/ha) | N/A | 250 | 250 | N/A |
| Extended Detention (m³/ha) | N/A | 100 | 100 | N/A |
| At-Source Controls (m³/ha) (rear yard ponding, grassed swales, etc.) | N/A | 100 | 100 | N/A |
| On-lot Dry Wells (mm of runoff from impervious surfaces) | N/A | 25 | 20 | roof runoff |
| Disconnection of Roof Leaders (%) | N/A | 100 | 100 | 0, 50, 75 |
| Drain Maintenance | continue periodic maintenance | continue periodic maintenance | periodic maintenance | N/A |

NOTE:
1) 0, 0, 0 refers to actual numbers corresponding to the three potential levels of management:
- maintain existing environmental quality;
- moderate enhancement; and
- significant enhancement.
### TABLE C.2

Summary of Alternatives for Subwatershed Management

<table>
<thead>
<tr>
<th>Water Quality Targets (2)</th>
<th>Upper Reaches Rural Area (MU1)</th>
<th>Eastern Central Reaches Development Area (MU2)</th>
<th>Western Central Reaches Development Area (MU3)</th>
<th>Lower Reaches Existing Developed Area (MU4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Sediment (mg/l)</td>
<td>&lt;150, &lt;75, &lt;50 (2)</td>
<td>&lt;150, &lt;75, &lt;50</td>
<td>&lt;150, &lt;75, &lt;50</td>
<td>&lt;150, &lt;75, &lt;50</td>
</tr>
<tr>
<td>Total Phosphorus (mg/l)</td>
<td>&lt;0.1, &lt;0.07, &lt;0.03 (2)</td>
<td>&lt;0.1, &lt;0.07, &lt;0.03</td>
<td>&lt;0.1, &lt;0.07, &lt;0.03</td>
<td>&lt;0.1, &lt;0.07, &lt;0.03</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>&lt;0.1, &lt;0.05, &lt;0.03 (2)</td>
<td>&lt;0.1, &lt;0.05, &lt;0.03</td>
<td>&lt;0.1, &lt;0.05, &lt;0.03</td>
<td>&lt;0.1, &lt;0.05, &lt;0.03</td>
</tr>
<tr>
<td>Nitrile (mg/l)</td>
<td>&lt;8.0, &lt;3.0, &lt;1.0 (2)</td>
<td>&lt;8.0, &lt;3.0, &lt;1.0</td>
<td>&lt;8.0, &lt;3.0, &lt;1.0</td>
<td>&lt;8.0, &lt;3.0, &lt;1.0</td>
</tr>
<tr>
<td>Fecal Coliform (counts per 100 ml)</td>
<td>&lt;150, &lt;100, &lt;50 (2)</td>
<td>&lt;150, &lt;100, &lt;50</td>
<td>&lt;150, &lt;100, &lt;50</td>
<td>&lt;150, &lt;100, &lt;50</td>
</tr>
<tr>
<td>EPT Index</td>
<td>2, 2-5, 2-5</td>
<td>5-13, 8-13, &gt;10</td>
<td>3, 3-5, 3-5</td>
<td>8, 10, &gt;10</td>
</tr>
<tr>
<td>WQI Score</td>
<td>Not measured, 6-10, 6-10</td>
<td>10-11, 10-12, &gt;12</td>
<td>4, 6, 6-10</td>
<td>9, 10-12, &gt;12</td>
</tr>
<tr>
<td>Percent of Point Sources Remediated</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
</tr>
</tbody>
</table>

### Water Quality Strategies

| Percent Cattle Access Points Eliminated | 0, 60, 100 (5) (3) | 0, 50, 100 (4) | N/A | N/A |
| Percent Milkhouse Waste Discharges Eliminated | 0, 50, 100 (2) (3) | 0, 67, 100 (3) | N/A | N/A |
| Percent of Manure Storage Problems Eliminated | 0, 50, 100 (4) (3) | 0, 50, 100 (4) | N/A | N/A |
| Percent of Septic Fields Inspected within 30 m Buffer (4) | 0, 50, 100 (to be determined) | 0, 50, 100 | 0, 50, 100 | N/A |
| Percent of Erosion Priority Areas Addressed through Conservation Tillage | 0, 50, 100 | 0, 50, 100 | 0, 50, 100 | N/A |

**NOTES:**

2) Parameter concentrations are for discharge targets.
3) (5) is the number of occurrences in management unit.
4) Faulty septic systems are to be replaced.
<table>
<thead>
<tr>
<th>Water Quality BMPs</th>
<th>Upper Reaches Rural Area (MU1)</th>
<th>Eastern Central Reaches Development Area (MU2)</th>
<th>Western Central Reaches Development Area (MU3)</th>
<th>Lower Reaches Existing Developed Area (MU4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent SWM Facilities Retrofitted</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Percent Landowners Receiving Educational Material</td>
<td>25, 50, 100</td>
<td>25, 50, 100</td>
<td>25, 50, 100</td>
<td>25, 50, 100</td>
</tr>
<tr>
<td>Percent Priority Areas In Conservation Tillage</td>
<td>25, 50, 100</td>
<td>25, 50, 100</td>
<td>25, 50, 100</td>
<td>N/A</td>
</tr>
<tr>
<td>Percent of Farms with Environmental Management Plans</td>
<td>10, 25, 50</td>
<td>10, 25, 50</td>
<td>10, 25, 50</td>
<td>N/A</td>
</tr>
<tr>
<td>Percent Streambank Treed (buffers)</td>
<td>10.9, 25.1, 38.1</td>
<td>71.3, 81.7, 81.7</td>
<td>14.2, 18.4, 18.4</td>
<td>29.6, 63.0, 63.0</td>
</tr>
<tr>
<td>Percent Streambank Grassed or In Shrubs</td>
<td>8.2, 44.3, 33.3</td>
<td>22.2, 18.3, 18.3</td>
<td>25.5, 21.3, 21.3</td>
<td>14.8, 0.0, 0.0</td>
</tr>
</tbody>
</table>

**Aquatic Habitat Targets**

<table>
<thead>
<tr>
<th>Fishery Type</th>
<th>Upper Reaches Rural Area (MU1)</th>
<th>Eastern Central Reaches Development Area (MU2)</th>
<th>Western Central Reaches Development Area (MU3)</th>
<th>Lower Reaches Existing Developed Area (MU4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV-V, IV-V, IV&lt;sup&gt;(5)&lt;/sup&gt;</td>
<td>II-V, II-V, II-V</td>
<td>IV-V, IV-V, IV-V</td>
<td>IV-V, IV-V, IV-V</td>
<td>II-V, II-V, II-V</td>
</tr>
</tbody>
</table>

**Aquatic Habitat Strategies**

| Distance of Stream Provided with Rock Weirs (km) | 0, 0, 0 | 0, 0, 0, 0 | 0, 0, 0 | 0, 0, 0, 0 |
| Distance of Channel Naturalized (km) | 0, 0, 0 | 0, 0, 0 | 0, 0, 0 | 0, 0, 0 |
| Percent of Barriers to Fish Movement Removed | 0, 50, 100 | 0, 50, 100 | 0, 50, 100 | 0, 50, 100 |

**NOTE:**

5) IV-V, IV-V, IV<sup>(5)</sup> Where two fishery types are given for one management level, they refer first to the main branch and second to the tributary.
<table>
<thead>
<tr>
<th>TABLE C.3 Terrestrial Resources Summary</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrestrial (1)</td>
<td></td>
</tr>
<tr>
<td>Percent Natural Area</td>
<td>14, 19, 38 (2)</td>
</tr>
<tr>
<td>Percent Forest</td>
<td>12.3, 15.0, 18.5</td>
</tr>
<tr>
<td>Percent Forest 100 m or Greater from Edge</td>
<td>1.2, 3.6, 5.4</td>
</tr>
<tr>
<td>Percent Forest 200 m or Greater from Edge</td>
<td>0.1, 0.8, 2.3</td>
</tr>
<tr>
<td>Percent Prairie and Savannah</td>
<td>0, 0, 3.6</td>
</tr>
<tr>
<td>Percent Grassland and Old Field</td>
<td>0, 0, 7.9</td>
</tr>
<tr>
<td>Retaining Regulated Floodplain</td>
<td>2.8</td>
</tr>
</tbody>
</table>

NOTES:

1) All percentages are of the total subwatershed area.
2) 0, 0, 0 refers to actual numbers corresponding to the three potential levels of management:
   - maintain existing environmental quality;
   - moderate enhancement; and
   - significant enhancement.
PART D

SUBWATERSHED MANAGEMENT PLAN
PART D - SUBWATERSHED MANAGEMENT PLAN

D1.0 EVALUATION CRITERIA AND CONSULTATION PROCESS

The Stoney Creek Subwatershed Management Plan identifies the management requirements and implementation framework which will be necessary to maintain, protect and enhance the natural attributes and linkages in the Stoney Creek subwatershed. The subwatershed Management Plan has been prepared to be consistent with planning requirements for the Vision '96 program.

This part of the final report discusses the process used in arriving at the Subwatershed Plan; describes the main components of the Subwatershed Plan; and details the preferred set of management actions recommended in the Subwatershed Plan.

D1.1 Evaluation Criteria

Different management actions and alternative strategies were presented in Part C. In developing a recommended Subwatershed Plan, these alternatives were evaluated against a set of criteria developed for all subwatershed group studies. A listing and a brief description of the evaluation criteria are provided below:

Technical Considerations: Each potential management action or option was evaluated for technical feasibility. This included consideration of physical limitations for specific options (e.g. soil capacity for infiltration), usefulness or effectiveness, and limitations in the ability to implement actions. The latter limitations were established based on experience in other areas, and did not generally preclude the selection of the option but rather pointed to the need for improvement in program delivery.

Environmental Benefit: The overall environmental benefits ascribed to each option were established based on the problems that exist, the predicted results of implementing the action and experience with its application in other areas. It should be recognized that while each action results in specific benefits, it is the cumulative effect of a combination of actions which improves ecological integrity and results in the largest environmental benefit.

Land Requirements/Impacts: Many of the possible actions require the use of land which could be used for other purposes. Other management actions have impacts on the current use of the land (e.g. for agriculture). Each action was therefore evaluated in terms of its land requirements or land use impacts. The emphasis within the City of London in lands affected by the new Official Plan, was on land requirements outside of regulated areas. The emphasis outside the City was on impacts to current land use practices.

Cost: Cost estimates were made and used in the evaluations of options which would involve public funding. Actions that would be implemented by the private sector were not costed because the majority of actions, for example, storm water quality and quantity facilities are required by provincial regulations or guidelines. Costs were not established for lands to be included in a natural heritage system, although the area of these lands (of different types), were documented and used in evaluating the strategies.

Agencies Acceptance: The Subwatershed Plan was prepared under a partnership involving municipal and provincial agencies, each of which has mandates, regulations and guidelines. Each option was therefore evaluated in terms of the anticipated support and acceptance which could be expected from the different agencies.
Public Acceptance: Two public meetings were held prior to the evaluation of alternatives. In addition, the Technical Advisory Committee included public representatives who had participated in the study process since the beginning of Phase II. Based on the input received from these sources, the potential options were evaluated based on expected public support and acceptance. The evaluation sought to capture a sense of the general public’s priorities, while recognizing that landowners will have specific concerns for options which may affect their lands.

Ranking of Management Actions

Each of the management actions contained in the Subwatershed Plan is recommended for implementation. It is recognized however, that some actions are more important, more effective, or easier to successfully implement than others. The recommended Subwatershed Plan therefore contains a column which indicates the relative ranking of the action within the plan. The ranking represents the subwatershed team’s judgement of the importance of the action to the successful implementation of the plan. It is an aggregate rank, determined by considering the importance and effectiveness of the action, the ability to implement in the short term or long term, the comprehensiveness of application and the support for implementation.

High: Important to Plan success; highly effective; widespread or important site specific applicability; immediately implementable with likelihood of rapid results; general support.

Medium: Important to plan success; moderately or highly effective; general applicability; implementable over the long term; general support to limited resistance.

Low: Less important to plan success; moderately to highly effective; less important site specific or general applicability; implementable over the long term or beyond current planning horizon; moderate support to limited resistance.

The evaluation criteria listed above formed the basis for recommending the elements of a preliminary Subwatershed Plan. In most cases (excepting physical infeasibility) the evaluations did not result in discarding action immediately. Rather, the results for the evaluations were used as input to the consultation process which led to the selection of a Draft Subwatershed Plan for Stoney Creek which has since been finalized in consultation with the TAC members.

D1.2 Subwatershed Plan - Consultation Process

The consultation process involved a public open house and public meeting held on November 22, 1994, as well as a series of meetings with the Technical Advisory Committee. A slide presentation of the subwatershed was provided at the onset of the public meeting. The objective of the open house and public meeting was to obtain public opinion with respect to:

- Specific comments relating to any of the alternative management strategies;
- The importance of each component, for example, aquatic resources within each alternative management strategy; and
- The importance or ranking of each of the following criteria: technical feasibility, public acceptance, environmental enhancement, cost, land requirements, used in the evaluation process.

Meetings that were subsequently held with the Technical Advisory Committee were used to further elaborate on each of the strategies and to bring consistency to the approaches used by each of the consultant teams working on each of the studies.
A number of comments were received during the subwatershed study process from both agencies and the public sector. Every effort was made to incorporate these comments into the final document. However, due to the wide range of interests in the subwatershed, comments were often of a competing or conflicting nature and therefore some compromises were necessary. Comments dealing with site specific issues were difficult to incorporate and often beyond the scope of this study, and hence where appropriate recommendations were made for future study requirements.

D2.0 SELECTION/DESCRIPTION OF THE RECOMMENDED PLAN

D2.1 Selection of Recommended Plan

The recommended Subwatershed Plan is described in Section D3 and is illustrated on Map D1. The recommended Subwatershed Plan is similar, with the exceptions noted in Section D3, to the significant level of enhancement plan as defined in Part C. The rationale for selecting the recommended Subwatershed Plan is provided below.

**Technical Considerations:** It is felt that technically any of the three alternative plans could be achieved. Therefore, this criteria does not have considerable influence in selecting a preferred plan.

**Environmental Benefit:** The environmental benefit of the recommended plan is considerable, in that an attempt will be made, in the long term, to restore or enhance many of the environmental resources that once existed within the subwatershed. These include:

- A healthy and functional terrestrial ecosystem capable of supporting various species of plants, birds and wildlife;

- A healthy aquatic ecosystem supporting a cool water fishery in some reaches, a diverse warm water fishery in the main stream, and a tolerant warm water fishery in most other continuously flowing tributaries;

- Protection/restoration of the stream, over the long term, such that protection of public/private property is achieved and aquatic/terrestrial targets are met;

- Long term reduction of key water quality parameters (total phosphorus, total solids and bacteria) necessary to meet the above objectives;

- Protection of existing groundwater supplies (from a quantity and quality perspective); and

- Protection of the existing levels of flood protection and level of convenience against flooding at crossings.

**Land Requirements/Impacts:** The recommended Subwatershed Plan ensures that lands that are necessary to meet the above noted environmental benefits are set aside. These areas include significant terrestrial features, and lands for storm water management facilities. The requirement for additional lands such as non-significant vegetation features will be determined as Area Plans, Draft Plan or Site Plan studies are conducted.

**Cost:** The majority of the costs associated with any of the strategies is related to the construction of storm water management facilities. These facilities are required for any of the three alternative plans. The remaining costs, will likely be borne by the public sector. However, rural stakeholders may be required to absorb some portion of the costs associated with rural management options. Discussions with both the regulatory agencies and the public suggested that effort should be spent to define funding alternatives, such that the recommended Subwatershed Plan, as described, can be implemented.
Agency Acceptance: The recommended Subwatershed Plan, as described, is consistent with the preference of a majority of the agencies which participated on the TAC. Considerable discussion was held with the TAC, especially with respect to the selection of a preferred Terrestrial Strategy.

Public Acceptance: Through the series of open houses and public meetings and questionnaires, the public indicated that the environmental health of Stoney Creek was important. Furthermore, the public indicated that enhancement of the existing ecological health of Stoney Creek is something that should be done through the recommendations of the Subwatershed Plan. These two points were considered in selecting the recommended Subwatershed Plan.

D2.2 General Description of the Plan Recommendations

The following subsections provide a description of what the recommended Subwatershed Plan has been prepared to achieve with respect to the various plan components. The sections describe general considerations of maintaining or enhancing terrestrial and aquatic ecology, stream morphology, flooding, groundwater, and water quality conditions in the subwatershed.

D2.2.1 Terrestrial Ecology

The strategy builds on the Draft Terrestrial Resource Strategy (DTRS), and interpretative and field data compiled by UTRCA and Bowles (1994). The DTRS summarizes policies that protect or may affect terrestrial and wetland resources. One of the primary objectives of the DTRS was to provide a basis for land use policies to protect, enhance and restore ecosystems within the subwatersheds. In addition, the DTRS summarized the current state of knowledge of landscape ecology principles. The DTRS noted that the amount of natural habitat in all thirteen subwatersheds is lower than the majority of southern Ontario, and recommended that all natural areas be protected wherever possible. In order to increase the extent of natural areas, the DTRS recommended a balanced strategy of retention, restoration and replacement of existing features, and also management of lands adjacent to terrestrial features. Following discussions with members of the TAC and the subwatershed consultants, it was agreed that the terrestrial features and other lands serving key ecosystem functions should be subdivided as follows:

Category 1: All Provincially Significant Areas (PSAs) and Environmentally Sensitive Areas (ESAs within the City boundaries), areas within floodlines or fill lines, and adjacent to or contiguous to designated streams; and

Category 2: Other remaining vegetation patches not in Category 1 and of more significance than the remaining terrestrial patch designation (i.e. > 4 ha), all areas serving an important recharge function, terrestrial corridors and anti-fragmentation areas, and vegetation areas contiguous to non-designated streams.

Remaining Terrestrial Patches: Includes other terrestrial patches for which regard should be given.

Both Category 1 and 2 features would be identified in the Official Plan schedules. Category 1 would be identified for protection/enhancement/restoration and transfer into public ownership. Category 2 would be identified for protection/enhancement/restoration through other mechanisms and possibly replacement with appropriate compensation and mitigation.

Category 1 areas constitute a high proportion of the vegetation patches in the subwatershed (See Table D.1). Overall, the patches constitute approximately 198 ha or 5.3 percent of the subwatershed. Many of these are associated with watercourses and several are at the headwaters of tributaries.
<table>
<thead>
<tr>
<th>Patch No.</th>
<th>Contiguous to A Designated Watercourse</th>
<th>Candidate ESA</th>
<th>Provincially Significant Wetland</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>2006</td>
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<td>2035</td>
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<tr>
<td>2038</td>
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</table>
Category 2 areas contain other patches and anti-fragmentation terrestrial areas that link some closely-adjacent Category 2 patches and increase the core area of some of the Category 1 areas. An extensive Category 2 zone has been identified which indicates areas of high recharge potential (anti-fragmentation areas are further discussed in Section D3).

In the southeastern portion of the subwatershed, extensive areas are designated for aggregate extraction. As part of the rehabilitation plan for these areas, the natural heritage strategy recommends that extensive grasslands and natural prairies and savannahs be established. These habitats are rare in all of the subwatersheds and extensive grassland and prairies will support many plant and wildlife species that are scarce. An examination of the vegetation data collected by the original surveyors circa 1820 indicates that much of this area was open plains and tall grasses, suggesting that it was a mixture of oak savannahs and big bluestem prairies.

D2.2.2 Aquatic Ecology

The aquatic resources of Stoney Creek are of relatively high quality. Specific management techniques that have been recommended to further enhance aquatic ecology include planting riparian vegetation and establishing buffer areas along watercourses, establishment of grassed waterways in headwater tributaries, elimination of point sources of contaminants, reduction of non-point sources, remediation of problem erosion sites, and re-naturalization of selected reaches of the creek. These strategies are outlined in more detail in Table D1.

D2.2.3 Stream Morphology

The detailed studies carried out as part of the subwatershed planning process described the fluvial geomorphology of the Stoney Creek subwatershed system. The Stoney Creek system is considered to be relatively stable, however, increased runoff volumes and velocities that would result from urbanization would impact the stream morphology. With this in mind, the Subwatershed Plan recommendations include detention volumes designed to moderate the flow characteristics of the Stoney Creek as development proceeds. Recommendations are also made for the stabilization of existing erosion areas within the Stoney Creek system. With the implementation of erosion control measures as development proceeds, combined with the rehabilitation proposed under Special Programs and Stream Bank Erosion projects, an enhanced level of stream morphology will result.

D2.2.4 Flooding

The Stoney Creek system is sensitive to increases in peak flow, particularly in the main stem upstream of Fanshawe Park Road. As a result of this sensitivity, peak flow attenuation for the 2 to 100-year return period storms will be recommended for those areas of the Stoney Creek subwatershed that are to be urbanized. The recommended Subwatershed Plan provides the peak flow attenuation volumes on a per hectare basis that would be required to achieve this target.

Flow control measures, such as storm water management facilities, sized for the Regulatory Storm are not recommended for future development since the impact on existing structures is limited to 15 buildings. Alternatively, it is suggested that site-specific protection measures or consideration of a Two Zone Policy Area be reviewed in this location. For this reason, 100-year SWM control was deemed appropriate as opposed to Regulatory SWM. Potentially, these flood damage centres both upstream and downstream of Fanshawe Park Road could be zoned as Two Zone policy areas.
D2.2.5 Groundwater

The detailed studies summarized in Part B of the Subwatershed Plan identified significant areas within the Stoney Creek system where permeable soils (sands and gravels) are present. It was further illustrated that a significant portion of water infiltrating these soils results in groundwater discharge to the Stoney Creek system. This groundwater discharge function provides important baseflow during drier periods of the year in order to sustain the aquatic communities in the Stoney Creek system.

Urbanization in areas where permeable soils are presented has the potential to reduce the volume of water that infiltrates and subsequently discharges through the groundwater system to the creek system. Recommendations of the Subwatershed Plan, therefore, must be designed to maintain this groundwater infiltration and discharge system as much as possible.

The Subwatershed Plan indicates areas where infiltration augmentation should be incorporated into the design of future development. The plan also suggests infiltration performance criteria as development proceeds.

D2.2.6 Water Quality

Water quality sampling carried out as part of the detailed studies indicated that nutrients and bacteria were a concern in the Stoney Creek system. Existing land uses in the Stoney Creek subwatershed are responsible for the present water quality in the creek system. The Stoney Creek system has existing urbanized areas without water quality controls, agricultural operations with the potential to discharge bacteria and nutrient laden runoff, and rural residential development with on-site sewage disposal systems also with the potential to discharge nutrients and bacteria. The Subwatershed Plan therefore must provide recommendations to address these areas. The goal of the Subwatershed Plan, in the long term, is to reduce the nutrient and bacteria loadings to the Stoney Creek system. The plan recommendations described in Section D3 provide water quality criteria for future urban development, as well as programs and opportunities to reduce loadings to the Stoney Creek system in the rural parts of the subwatershed.

With the implementation of storm water quality facilities to coincide with urban development along with the reduction of sediment, phosphorus and bacterial loadings within the rural community, the health of benthic communities will improve in Stoney Creek. In addition, increased recreational opportunities and overall Creek aesthetics will be added benefits.

D2.2.7 Summary

The Subwatershed Plan includes measures that are proposed to:

- Significantly enhance terrestrial and aquatic ecology;
- Reduce erosion indices, bankfull frequencies and flow duration;
- Control flooding;
- Maintain infiltration; and
- Improve water quality and flow characteristics in the existing agricultural and urban development areas.
D3.0 THE RECOMMENDED PLAN

D3.1 Introduction

The recommended Subwatershed Plan for Stoney Creek consists of a series of management actions, which when applied together will provide a holistic strategy for meeting the Goals and Objectives and the environmental targets. The Subwatershed Plan will protect and enhance the natural resources of the subwatershed and reduce the impacts of existing land uses, while ensuring that future development proceeds in a manner which does not impair the key functions of the physical and biological systems which support the watersheds integrity. The complex task of providing this protection requires the use of many types of management actions. The recommended actions are grouped under the following headings:

- Designation of Constraint Areas;
- Development Criteria;
- Conservation and Management Practices; and
- Specific Projects and Programs.

D3.1.1 Constraint Areas

The designation of a system of natural areas of biological or physical importance is fundamental to the implementation of the Subwatershed Plan. These areas are termed "constraint areas" because restrictions are placed on development or land use change, either prohibiting development entirely or requiring additional studies to determine if they can be developed, while preserving the important features and functions of the area. The restriction of land use in these areas performs one or more of the following functions:

- Prevents encroachment and direct physical damage to key natural systems;
- Enhances two or more natural areas by providing a physical connection between them; and/or
- Prevents land use change at a scale and in a manner which would exceed the capacity of the subwatershed to sustain both human use and natural systems and functions.

Two types of constraint areas are provided for in the Subwatershed Plan. No development would be permitted in the following types of areas:

- Provincially significant wetlands;
- ANSIs;
- Candidate ESAs (subject to City adoption as ESAs);
- Lands within the Regulatory floodline or fill line, as appropriate;
- Other designated stream corridors’; and
- Riparian vegetation areas contiguous to a designated watercourse.

* No buffer or corridor widths are specified for the stream corridors. Corridor widths are to be determined at the Area Plan level.

Utility crossing and roadways would only be permitted after completion of an Environmental Assessment.
It is not the intent that Category 1 be interpreted as being entirely consistent with the Comprehensive Set of Policy Statements (CSPS) associated with Bill 163 at this stage. Refinements to ensure appropriate consistency will occur as the Official Plan is formulated. At this time, the strict definition of development used by the CSPS, which includes grading and the placement of fill, is to be applied only in provincial significant wetlands, ANSIs, and Candidate ESAs (subject to City adoption as ESAs). Development within the Regulatory floodline and outside of provincially significant areas, ANSIs and ESAs is regulated by the flood plain management policies. For other Category 1 areas within the fill lines, it is possible that new parks or other recreational Open Space uses may be appropriate. It is intended that these types of uses be permitted in such areas if any Environmental Impact Study (EIS) is completed and shows that there would not be a significant loss of features or function.

In addition to the Category 1 areas, a second group of areas (Category 2) would be protected, subject to more detailed studies such as an Environmental Impact Study (EIS-specific type dependent upon Natural Heritage category), Area Plans or hydrogeologic study. The detailed studies could result in a reduction of the area to be protected, specification of special development criteria, replacement or other compensation, or an upgrade of a specific area to a “no development” status. The types of areas included in this category would include:

- All remaining vegetation patches > 4 ha;
- Riparian vegetation contiguous to a non-designated watercourse;
- Anti-fragmentation zones varying from more vegetated areas which cluster existing patches to high priority erosion areas or sediment producing areas which may be included within the anti-fragmentation area (See Table D.2 for justification of the selection of the anti-fragmentation areas);
- Corridors and buffers outside of the Category 1 areas;
- Significant recharge/dischARGE areas; and
- Grassland and prairie lands which were simply a designation that was utilized as the best use of the lands with urbanization or non-urbanization impacts not being investigated. This would be an element subject to an EIS dealing specifically with these lands in a future study.

The protection of these areas would be achieved through their designation in the City's Official Plan, with its attendant policies. The Constraint Areas recommended in the plans are shown in Map D1 and summarized in Table D.3. The system of Constraint Areas constitutes the physical structure of a Natural Heritage Strategy for the subwatersheds.
<table>
<thead>
<tr>
<th>Stoney Creek Subwatershed Study</th>
<th>Rationale for Anti-Fragmentation Areas</th>
</tr>
</thead>
</table>
| Between the northern arm of Patch 2017 | ▶ Improves woodlot shapes  
▶ Increases woodlot size  
▶ Increases amount of forest-interior habitat  
▶ Linkage to other anti-fragmentation areas, to patch 2031, and to corridor recommended in the Medway Creek subwatershed. |
| Beside Patch 2029 | ▶ Improves woodlot shapes  
▶ Increases woodlot size  
▶ Increases amount of forest-interior  
▶ Existing area is old-field habitat  
▶ Buffer to tributary |
| Around Patch 2030 | ▶ Improves woodlot shapes  
▶ Increases woodlot size  
▶ Greatly increases amount of forest-interior  
▶ Connection to a corridor recommended in the Medway Creek subwatershed  
▶ Contains some areas of medium potential sediment delivery |
| Adjacent to Patch 2031 | ▶ Greatly improves woodlot shape  
▶ Increases woodlot size  
▶ Large increase in the amount of forest-interior  
▶ Buffer to tributary  
▶ Linkage to patch 2017 and to corridor recommended in the Medway subwatershed  
▶ Contains areas of high potential sediment delivery |
| Around Patch 2038 | ▶ Links patches 2037, 2038 and 2039  
▶ Improves woodlot shape  
▶ Increases woodlot size  
▶ Large increase in the amount of forest-interior  
▶ Contains areas of high potential sediment delivery |
| Around Patches 2046 and 2047 | ▶ Links the two patches  
▶ Improves woodlot shape  
▶ Increases woodlot size  
▶ Large increase in the amount of forest-interior |
<table>
<thead>
<tr>
<th>Practices</th>
<th>Technical Considerations</th>
<th>Environmental Benefits</th>
<th>Costs</th>
<th>Agency Acceptance</th>
<th>Public Acceptance</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constraint Areas - Category 1</td>
<td></td>
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<tr>
<td>• Provincially Significant Wetlands</td>
<td>• protected through zoning and MNR policies</td>
<td>• natural heritage core areas • terrestrial habitat • hydrologic balance • bio-diversity</td>
<td>44 ha</td>
<td>Current Policy</td>
<td>Yes</td>
<td>High</td>
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<tr>
<td>&gt; Fanshawe wetlands complex</td>
<td></td>
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<tr>
<td>• ANSIs</td>
<td>N/A</td>
<td></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>&gt; None in watershed</td>
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<tr>
<td>• Candidate ESAs</td>
<td>• protected through zoning</td>
<td>• protects ecologically important areas</td>
<td>50 ha</td>
<td>None</td>
<td>Direction from EEPAC</td>
<td>Yes</td>
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<tr>
<td>&gt; None existing</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>&gt; 1 ESA complex proposed</td>
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<tr>
<td>• Lands within Regulatory Flood or Fill Line</td>
<td>• protected through zoning</td>
<td>• natural heritage core area • backbone for linkages • hydrologic balance • aquatic habitat protection • terrestrial corridors and habitat • reduces flood risk</td>
<td>156 ha of land designated as Regulatory Flood Plain • Fill line extensions will constrain additional lands</td>
<td>N/A</td>
<td>Current Policy</td>
<td>Yes</td>
</tr>
<tr>
<td>• Designated Stream Corridors and Setbacks</td>
<td>• to be determined at area plan level • protected through zoning</td>
<td>• promotes natural stream valleys • to be determined</td>
<td>N/A</td>
<td>Supported</td>
<td>Yes</td>
<td>Medium</td>
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<td>&gt; To be utilized where floodlines do not exist</td>
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<td>• Riparian vegetation contiguous to a designated watercourse</td>
<td>• protected through zoning</td>
<td>• protects terrestrial habitat and its related function to the stream corridor</td>
<td>N/A</td>
<td>Supported</td>
<td>Yes</td>
<td>High</td>
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<td></td>
<td></td>
<td>• land will be undevelopable • 107 ha of contiguous or floodplain woodlots identified</td>
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<td>Practices</td>
<td>Technical Considerations</td>
<td>Environmental Benefits</td>
<td>Land Requirements/Impacts</td>
<td>Costs</td>
<td>Agency Acceptance</td>
<td>Public Acceptance</td>
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<td><strong>Constraint Areas - Category 2</strong></td>
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<td>显著补给区/排放区</td>
<td>根据优选策略映射，但需要在准备EIS时进行详细检查</td>
<td>水文平衡</td>
<td>728公顷已识别</td>
<td>支持</td>
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<td>基流保存</td>
<td>潜在影响开发密度</td>
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<td>需要措施来增强渗滤</td>
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<tr>
<td>其他土地面积 &gt; 4公顷且不在Category 1</td>
<td>要在EIS编制过程中评估</td>
<td>水系美学</td>
<td>234公顷的其他土地面积</td>
<td>支持</td>
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<td>其他土地面积</td>
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<td><strong>Anti-Fragmentation Areas for Terrestrial Enhancement</strong></td>
<td>要在EIS中评估</td>
<td>扩大内部森林栖息地</td>
<td>138公顷已识别作为抗分割区域，需要在EIS中进一步精细</td>
<td>支持</td>
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<td>增加生物多样性</td>
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<td>提高野生动物移动</td>
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<td><strong>Terrestrial Corridors and Linkages</strong></td>
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<td>增加野生动物栖息地</td>
<td>414公顷的提出草/草</td>
<td>支持</td>
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<td>高</td>
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<td>提高野生动物栖息地</td>
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<td>草地/草</td>
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<td>Practices</td>
<td>Technical Considerations</td>
<td>Environmental Benefits</td>
<td>Land Requirements/Impacts</td>
<td>Costs</td>
<td>Agency Acceptance</td>
<td>Public Acceptance</td>
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<td>Development Criteria</td>
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</tr>
<tr>
<td>• Peak Flow Attenuation Storage for Development Areas</td>
<td>• detention ponds to be constructed as development proceeds</td>
<td>• flood control</td>
<td>• land must be set aside for SWM as development is planned</td>
<td>• $25/m³ of SWM storage volume (includes design and inspection)</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>&gt; 200 m³/ha for 35% impervious</td>
<td>• follow implementation guidelines for consolidation of SWM facilities</td>
<td>• preserves hydrologic function of floodplain lands</td>
<td>• attenuation facilities to be consolidated wherever possible</td>
<td></td>
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<tr>
<td>&gt; 300 m³/ha for 50% impervious</td>
<td></td>
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<tr>
<td>• Water Quality Storage Requirements for Development</td>
<td>• quality storage to be incorporated as development proceeds</td>
<td>• reduces suspended solids, metals and nutrient loadings</td>
<td>• land must be set aside for SWM as development is planned</td>
<td>• $25/m³ of SWM storage volume (proponents cost)</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>&gt; 140 m³/ha with a 100 m³/ha permanent pool</td>
<td>• SWMP guideline manual to be followed</td>
<td>• protects aquatic habitat</td>
<td></td>
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<tr>
<td>• Erosion/Stream Morphology Extended Detention Storage Requirements</td>
<td>• extended detention requirements as development proceeds</td>
<td>• minimizes stress on existing erosion sites</td>
<td>• land must be set aside for SWM as development is planned</td>
<td>• $25/m³ of SWM storage volume (proponents cost)</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>&gt; 70 m³/ha for 35% impervious</td>
<td></td>
<td>• prevents further excessive erosion</td>
<td></td>
<td></td>
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<tr>
<td>&gt; 130 m³/ha for 50% impervious</td>
<td></td>
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<tr>
<td>• Infiltration Facilities</td>
<td>• subject to detailed hydrogeologic study at area plan level</td>
<td>• maintains groundwater discharge to streams</td>
<td>• a lot level management strategy</td>
<td>• $400/lot where permeable soils exist</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>&gt; 20 mm of roof runoff where permeable soils exist</td>
<td>• applicable only in recharge areas</td>
<td>• minimizes impact to groundwater supply</td>
<td></td>
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<tr>
<td>• Erosion Control During Construction</td>
<td>• incorporation of soil-void-pits as development proceeds</td>
<td></td>
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<tr>
<td>• use of silt fencing, sedimentation basins and check dams during</td>
<td></td>
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</tr>
<tr>
<td>construction</td>
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<tr>
<td>• Construction Inspection</td>
<td>• ensures that management practices are constructed as per specification</td>
<td></td>
<td></td>
<td></td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>• staff will be required to inspect the appropriateness of erosion control</td>
<td></td>
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</tr>
<tr>
<td>• Environmentally Sensitive Site Planning Techniques</td>
<td>• minimizes grading</td>
<td>• maintains hydrologic balance</td>
<td>• N/A</td>
<td>• development dependent</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>• tree preservation</td>
<td></td>
<td>• provides community amenity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Innovative SWM techniques</td>
<td></td>
<td>• provides terrestrial habitat</td>
<td></td>
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<td>• reduces sediment and pollutant loading</td>
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<td>• reduces sediment and pollutant loading</td>
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<td>Practices</td>
<td>Technical Considerations</td>
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<tr>
<td><strong>Development Criteria</strong></td>
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<tr>
<td>Manure Management and Feedlot Runoff Controls</td>
<td>Need to enforce OMAF guidelines for manure spreading</td>
<td>Reduces bacterial and nutrient loadings</td>
<td>None</td>
<td>High</td>
<td>Supported</td>
<td>Variable owner support</td>
</tr>
<tr>
<td></td>
<td>General problems of over-spreading of manure, however no priority farms were identified</td>
<td></td>
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<tr>
<td></td>
<td>Feedlot operations will need to control storm water runoff</td>
<td></td>
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<tr>
<td></td>
<td>8 operations have potential for runoff occurrence</td>
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<tr>
<td><strong>Conservation and Management Practices</strong></td>
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</tr>
<tr>
<td>Milkhouse Waste Control</td>
<td>Milkhouse wastes can be collected and treated prior to discharge</td>
<td>Reduces nutrient, bacterial and BOD loadings</td>
<td>Nil</td>
<td>$4,000 to $8,000 Estimated: $24,000</td>
<td>Supported</td>
<td>Variable owner support</td>
</tr>
<tr>
<td></td>
<td>4 operations within 150 m of stream course, potentially discharging milkhouse wastes</td>
<td></td>
<td></td>
<td>6,000 on average/operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Septic System Effluent</td>
<td>Existing septic systems need to be surveyed to identify problem systems</td>
<td>Reduces bacterial and nutrient loading</td>
<td>Nil</td>
<td>$5,000 to $15,000 if replaced required</td>
<td>Supported</td>
<td>Variable owner support</td>
</tr>
<tr>
<td>Conservation Tillage</td>
<td>Farmers to modify tillage practices in high and medium erosion potential areas</td>
<td>Reduces soil loss, sediment and phosphorus loadings</td>
<td>Nil</td>
<td>$8,000 to upgrade/farm</td>
<td>Supported</td>
<td>Variable owner support</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$11,000 to $25,000 new/farm</td>
<td></td>
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<tr>
<td>Grassed Waterways</td>
<td>Streams in the upper reaches can be left grassed instead of ploughed</td>
<td>Reduces stream erosion, flow moderation</td>
<td>12 km of grassed waterways proposed</td>
<td>Site specific</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Loss of strip of land from crop production</td>
<td></td>
<td></td>
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<tr>
<td>Vegetated Buffer Strips</td>
<td>Buffer strip and setback requirement should be identified in rural areas</td>
<td>Reduces soil loss, sediment and phosphorus loading</td>
<td>8 km of vegetated buffer strips proposed</td>
<td>Dependent on existing adjacent land use</td>
<td>Supported</td>
<td>Varied</td>
</tr>
<tr>
<td>Practices</td>
<td>Technical Considerations</td>
<td>Environmental Benefits</td>
<td>Land Requirements/Impacts</td>
<td>Costs</td>
<td>Agency Acceptance</td>
<td>Public Acceptance</td>
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<td><strong>Conservation and Management Practices</strong></td>
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<tr>
<td>Municipal De-Icing Programs</td>
<td>de-icing compounds (salt) can be replaced with sand in areas adjacent to streams</td>
<td>reduces chloride load to stream</td>
<td>Nil</td>
<td>cost to replace salt with another de-icing agent</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>may require increased frequency of street sweeping and catchbasin cleanouts</td>
<td>reduces splash impact on vegetation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top Soil Preservation</td>
<td>enforcement as development proceeds applicable within City boundary</td>
<td>reduces soil loss and sediment loading</td>
<td>Nil</td>
<td>cost for administration of program</td>
<td>Supported</td>
<td>Varied</td>
</tr>
<tr>
<td></td>
<td></td>
<td>provides retention of soil moisture preserves organic soil structure secondary benefit of reduced phosphorus loading to surface water</td>
<td></td>
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<tr>
<td><strong>Specific Projects and Programs</strong></td>
<td></td>
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</tr>
<tr>
<td>Erosion Monitoring</td>
<td>instream monitoring program needs to be implemented under Conservation Authority jurisdiction</td>
<td>provides feedback on success of fluvial geomorphology enhancement and erosion control measures</td>
<td>None</td>
<td>program dependent</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>Disconnect Roof Leaders from Storm Sewers</td>
<td>program to be carried out by City in existing urban areas</td>
<td>augment infiltration flow moderation</td>
<td>Nil</td>
<td>$200/property</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>Plant Riparian Vegetation</td>
<td>program carried out by City Parks and Recreation Department and Interest groups promotes natural succession also applicable in rural areas to improve quantity and diversity of riparian vegetation</td>
<td>reduces stream erosion improves aquatic habitat filters runoff</td>
<td>2 km of riparian vegetation to be planted</td>
<td>15 m buffer - $4,500/km 30 m buffer - $9,000/km</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>Natural Channel Rehabilitation Techniques Including Pools and Riffles with Stone Weirs</td>
<td>improves aquatic habitat improves fluvial geomorphology</td>
<td>creates aquatic habitat</td>
<td>2 km of improvements proposed</td>
<td>$7,500/km</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>Practices</td>
<td>Technical Considerations</td>
<td>Environmental Benefits</td>
<td>Land Requirements/Impacts</td>
<td>Costs</td>
<td>Agency Acceptance</td>
<td>Public Acceptance</td>
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</tr>
<tr>
<td>Remediation of Significant Erosion Area</td>
<td>1.5 m bank, experiencing erosion over a distance of 150 m due to cattle access and lack of riparian vegetation</td>
<td>reduced sediment, nutrient and bacterial loading to stream</td>
<td>0.12 ha</td>
<td>$30,000 to $50,000</td>
<td>Supported</td>
<td>Potential Landowner Opposition</td>
</tr>
<tr>
<td>Remediation of Significant Erosion Area</td>
<td>Site 1: bank erosion over a distance of 100 m due to lack of vegetation and change in flow regime resulting from previous development</td>
<td>reduces sediment loading to watercourse, Improves aquatic habitat</td>
<td>Site 1: approximately 150 m²</td>
<td>$50,000 total</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>Remediation and Management Strategy for the North Park Reach (Fanachwe Park Road to 1/2 km upstream of Trassacks Avenue (See Plate 3))</td>
<td>erosion is occurring at drop structures in this channel reach based on observations by UTRCA staff, gabion structure requires eminent maintenance, drop structure is a barrier to fish movement</td>
<td>removes sediment loading to watercourses, Improves aquatic habitat, may result in naturalized concept for this reach</td>
<td>uncertain at this time</td>
<td>$50,000 for remediation/management plan</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>Public Awareness Program</td>
<td>general public, landowners and agricultural community to be the focus</td>
<td>builds support for ecosystem protection and enhancement</td>
<td>N/A</td>
<td>Program dependent</td>
<td>Supported</td>
<td>Yes</td>
</tr>
</tbody>
</table>

D.17
<table>
<thead>
<tr>
<th>Practices</th>
<th>Technical Considerations</th>
<th>Environmental Benefits</th>
<th>Land Requirements/Impacts</th>
<th>Costs</th>
<th>Agency Acceptance</th>
<th>Public Acceptance</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation and Management Practices</td>
<td>• de-icing compounds (salt) can be replaced with sand in areas adjacent to streams</td>
<td>• reduces chloride load to stream</td>
<td>• Nil</td>
<td>• cost to replace salt with another de-icing agent</td>
<td>Supported</td>
<td>Yes</td>
<td>Medium</td>
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<td></td>
<td>• may require increased frequency of street sweeping and catchbasin clean-outs</td>
<td>• reduces splash impact on vegetation</td>
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<td></td>
<td></td>
<td>• reduces soil loss and sediment loading</td>
<td>• Nil</td>
<td>• cost for administration of program</td>
<td>Supported</td>
<td>Varied</td>
<td>Medium</td>
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<td></td>
<td></td>
<td>• provides retention of soil moisture</td>
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<td></td>
<td></td>
<td>• preserves organic soil structure</td>
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<td>• secondary benefit of reduced phosphorus loading to surface water</td>
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<td></td>
<td>• Erosion Monitoring</td>
<td>• provides feedback on success of fluvial geomorphology enhancement and erosion control measures</td>
<td>• None</td>
<td>• program dependent</td>
<td>Supported</td>
<td>Yes</td>
<td>High</td>
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<tr>
<td></td>
<td>• Disconnect Roof Leaders from Storm Sewers</td>
<td>• augment infiltration</td>
<td>• Nil</td>
<td>• $200/property</td>
<td>Supported</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• flow moderation</td>
<td></td>
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<tr>
<td></td>
<td>• Plant Riparian Vegetation</td>
<td>• reduces stream erosion</td>
<td>• 2 km of riparian vegetation to be planted</td>
<td>• 15 m buffer - $4,500/km</td>
<td>Supported</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• improves aquatic habitat</td>
<td></td>
<td>• 30 m buffer - $9,000/km</td>
<td></td>
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<td></td>
<td></td>
<td>• filters runoff</td>
<td></td>
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<td></td>
<td>• Natural Channel Rehabilitation Techniques including Pools and Riffles with Stone Weirs</td>
<td>• improves aquatic habitat</td>
<td>• 2 km of improvements proposed</td>
<td>• $7,500/km</td>
<td>Supported</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• improves fluvial geomorphology</td>
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</table>
D3.1.2 Development Criteria

This group of management actions refers to the requirements and standards that new urban development and re-development will be expected to meet, as a condition of development approval. In general, the cost of these options is to be borne by the proponent. The actions seek to mitigate the impacts of land use change and in some cases to improve upon the degraded conditions which have resulted from past land use practices.

Examples of the management actions under this category include various storm water controls: for flood protection, erosion prevention, water quality treatment, flow augmentation; infiltration requirements, and additional studies such as extension of floodline mapping. In general, where specified in the Subwatershed Plan, these controls are a requirement for development to proceed and specific design criteria are provided.

In addition to these requirements, this category may include management options which are not mandatory but which may be in the best interests of both the proponent and the natural environment. Such options may include replacement and restoration of a degraded stream corridor or creation of a stable channel which will avoid future erosion problems. Where specific SWM volume requirements on a per hectare basis are provided, these are to be taken as cumulative volumes. In addition, erosion monitoring will be required and it should involve a program overseen by the Conservation Authority.

D3.1.3 Conservation and Management Practices

Conservation and management practices provide a means of preventing or mitigating the impacts of certain land uses or practices at-source. This category of management action seeks to prevent problems from occurring, or to reduce the impacts resulting from existing land use practices.

There are many sound environmental management practices which are generally applicable to urban environments. Recycling programs, household hazardous waste collection, industrial site management programs, public education and many other such programs are all important to an urban centre. These programs address the general needs of the community however, and are not specific to a particular subwatershed and so they are not discussed in detail in the Plan. Conservation and management programs which have a direct applicability to the subwatershed include:

- Flood and Fill Lines and Flood Policy;
- Agricultural Practices such as conservation tillage, stream buffers, virtually eliminating livestock access;
- Septic System Control Practices;
- Erosion and Sediment Control during construction;
- Use of De-icing Chemicals; and
- Public Awareness Programs.

Many of the conservation and management options involve both agency assistance and cooperation and participation by landowners. The relative success of many conservation and management programs is dependent upon agency staff resources to promote the program, as well as the level of financial assistance available to the landowner.
D3.1.4 Specific Projects and Programs

Specific projects and programs are recommended as part of the Subwatershed Plan in order to correct existing problems which have occurred as a result of past land use practices. Specific projects are targeted at individual stream reaches or flood damage centres. Examples of projects include reconstruction of a natural, stable channel in an area experiencing severe on-going erosion problems, or protective berming to prevent potential flood damage. Programs are more general in their application than projects and may include stream bank revegetation or stream habitat rehabilitation along fairly long reaches of watercourse. Plates 1, 2 and 3 are photographs of areas requiring specific projects in the Stoney Creek subwatershed.

Projects and programs are normally publicly funded, whether through Municipal or Conservation Authority resources, or through Provincial grants to public organizations. As such, their implementation is dependent upon approvals of budgets.

D3.2 Subwatershed Plan Components

The components of the Stoney Creek Subwatershed Plan are shown in Table D.3. The evaluation criteria are provided to substantiate the selection of the components. As well, a ranking is provided. Plan components are given a rank of high, medium or low, which is intended to prioritize the implementation of the components. Plan components with the ranking of high should be implemented as development proceeds or should be implemented as soon as possible, as these plan components will lead to a direct improvement in the ecological health of the Stoney Creek subwatershed system. Components with the ranking of medium should be implemented over time. Components with the rank of low will provide some ecological improvement, however, may be implemented as funds and programs become available.

Map D1 illustrates the recommended Subwatershed Plan and selected management actions for Stoney Creek. The map shows the various recommended constraint areas within the Stoney Creek system. It also identifies locations within the watercourse where either natural channel design projects are recommended.

D3.3 Fact Sheets

In an effort to clarify the goals and objectives, targets and overall management strategy for the Stoney Creek system, fact sheets have been prepared on a reach-by-reach basis that summarize pertinent information with respect to:

- Resources (including water resources, aquatic resources, stream morphology, and terrestrial resources);
- A proposed Best Management Practices (including SWM);
- Proposed studies; and
- Environmental targets (for flows, water quality, aquatic community and terrestrial).

The Facts Sheets and accompanying reference map are provided in Appendix I of this document and are also included in the Technical Appendix.
PLATE 1: STONEY CREEK WEST OF HIGHLAND AVENUE, NORTH OF FANSHAWE PARK ROAD

PLATE 2: NORTH OF WINDERMERE ROAD, UPSTREAM OF BRIDGE ON EAST BANK

PLATE 3: NORTH OF FANSHAWE PARK ROAD NEAR GABION STRUCTURE
D3.4  Greenspace Planning

D3.4.1  General

A Comprehensive Open Space Plan is a necessary element in the planning of any municipality, in order to meet current trends and objectives for the provision of open space, recreation and leisure planning, and healthy communities. At the subwatershed study level, the development of a greenspace plan identifies opportunities for the integration of environmental planning criteria with open space planning, as a first step toward the development of a city-wide network of linked green spaces.

The subwatershed greenspace plan identifies the broad structuring elements based on the natural systems and principles of sustainability. Further refinement of the open space plan should be undertaken at both the strategic city-wide level and through the secondary plan process, as land use change take place. Municipal parks, school sites, storm water management areas and other public open space lands should be planned and located with objectives of ecological protection and restoration, the establishment or re-establishment of linkages between the natural systems, in addition to enhancing the landscape quality and passive recreation opportunities throughout the city. The development and management of the municipal open space system represents one of the greatest opportunities for implementing ecological restoration proposals.

The following principles were used in the development of the conceptual greenspace plan:

- Identify a system of interconnected natural corridors and green spaces that will provide for the integration of passive recreation opportunities with the maintenance of ecosystem functions and protection of natural areas;

- Establish the broad greenspace framework that can be used to structure community open space planning;

- Provide the structure for a looped (where possible) system of trails for inter-regional, city-wide and local community uses;

- Integrate existing and potential recreation areas based on natural and cultural heritage features as special features or destinations within the greenspace system; and

- Encourage management practices within the greenspace system that will enhance recreation opportunities in addition to the restoration of the natural systems.

D3.4.2  Greenspace Plan

The subwatershed greenspace system comprises of the following components which are based on environmental planning criteria established within the earlier phases of the subwatershed study. The proposed greenspace plan for the Stoney Creek subwatershed is illustrated on Map D2 and includes potential connections into adjacent subwatersheds.
Corridors

The natural corridors are the structuring framework of the greenspace system. The following classifications have been developed to assist in the development of a city-wide plan, that can be implemented as new development takes place. A city-wide or community open space plan should consider other corridors which provide opportunities for linkages, not specifically identified at this level of study. These include hydro or other utility corridors, unopened road allowances or rights-of-way, and hedgerows.

Urban Greenways

The creek valleylands and tributaries of the subwatershed within the urban boundaries are the primary open space corridors and include all lands within the Regulatory floodlines or fill lines (See Figure D1). The greenways will establish connections between key recreation areas, natural environment areas or points of interest throughout the city or surrounding region, and would support a city-wide/regional trail system consisting of bikeways and/or hiking trails that link into the existing trail system. Trails through undeveloped areas may begin as hiking trails and be upgraded to bikeways as adjacent communities are developed.

Through the developed areas in the southern sector of the Stoney Creek subwatershed study, there are municipally owned and managed open space lands. This urban greenway should be expanded to the east along Stoney Creek and north along its tributaries as land uses change and development occurs. To facilitate an interconnected greenspace system, connections should be made south to the North Thames River system and east to Fanshawe Conservation Area, both considered to be the core recreational areas in this area of the City.

Secondary Community Corridors

These corridors establish connections between the urban greenways, natural environment areas, and community areas throughout the city. The most significant opportunities have been identified, based on lesser watercourses within the subwatershed which have been recommended for ecological restoration through such measures as vegetated buffers. Additional opportunities would include other designated stream corridors identified through the community plan or EIS process, as development occurs. The secondary community corridors would support local trails that create loops (where possible) within the broader city-wide trails system and could include bikeways and/or walking trails.

Future Potential Corridors

Enhancement of water quality in rural areas is proposed through such management practices as grassed waterways and vegetation buffer strips along existing stream courses (See Figure D2). If further expansion of the urban boundaries or land subdivision in rural areas were to take place, the natural stream corridors should form the potential framework for a future open space system. It is not intended at this time that the stream corridors through rural areas form part of the planned trail network. However, there may be future interest and opportunities for regional trail connections through rural areas, along these stream corridors. Any proposed public access over private lands would have to be conducted with the full support and permission of land owners.
Urban Corridor Cross - Section

Riparian Edge Planting
- indigenous riparian species
- deep, wide spreading root systems
- dense well balanced top growth
- high tolerance to flood and sediment inundations

Low Maintenance Area
- native shrubs and trees, grasses and wildflowers
- suited to soil, moisture and site conditions
- no intensive cutting, fertilizing, herbicide/pesticide treatments

FIGURE D1
**Rural Stream Channel Cross - Section**

- **Buffer Strip**
  - indigenous riparian species
  - deep, wide spreading root systems
  - dense well balanced top growth
  - high tolerance to flood and sediment inundations

*FIGURE D2*
Potential Recreation Amenity Areas

Existing Natural Areas

The designation of a system of natural areas within the subwatershed included the identification of Constraint Areas, with restrictions placed on development or land use change including candidate ESA’s and provincially significant wetlands. These areas may have potential as recreation areas for low impact uses, if sensitively handled. For Stoney Creek there are two such areas: the Fanshawe Wetlands and the significant woodlots along the Ballymote Tributary. Recreational opportunities may include walking trails, boardwalks and nature observation decks, interpretive signage, and fishing.

Numerous other natural vegetation areas within the subwatershed were also identified as Constraint Areas. Many are interconnected with the watercourses or may be connected through the EIS process proposed for designated anti-fragmentation areas. In addition to ecological benefits, the retention and/or re-establishment of connections between these woodlots will be integral to the development of a linked city-wide green space system, and could provide additional recreational opportunities at the local community level for walking trails and nature observation.

Aquatic habitat within Stoney Creek has been identified as relatively high quality. Proposed improvements through restoration and management practices will increase the fishing opportunities along the Stoney Creek.

Areas of Cultural/Natural Heritage Interest

This classification defines areas of interest from a cultural and natural heritage perspective, that have recreation potential and/or should be considered for special policies/ guidelines to ensure that land use change respects the heritage integrity.

One such area lies in association with the aggregate extraction areas in the southeastern portion of the Stoney Creek subwatershed. The area lies adjacent to Fanshawe Park Conservation Area, where the reservoir and pioneer village are a major regional recreation attraction, and the Fanshawe Wetland Complex. Due to its high recharge potential, the area is designated as a constraint area, and the proposed natural heritage strategy involves a restoration to the pre-settlement landscape of natural prairie and grasslands. Opportunities should be explored through both public and private sector initiatives, for creative land uses that are compatible with the environmental constraints and that would enhance the significant recreational value of the entire area.

At the west end of the subwatershed there is a ridge of land that likely represents the prehistoric shoreline of the glacial lake that once covered the area. The rolling topography, views, and relatively intact pattern of heritage farms along Sunningdale Road are unique within the subwatershed. Consideration should be given to the development of guidelines for the area to ensure that views are retained, and the natural and cultural features of the area, preserved.

Other rural areas of the Stoney Creek subwatershed, while lacking in the distinctive character of the Sunningdale area would nevertheless benefit from the encouragement of practices that would enrich the landscape character and restore some of the area’s heritage features, as land uses change. Examples of restoration would include street tree and roadway planting and re-establishment of hedgerows, as well as revegetation of watercourses.
PART E

CONCLUSIONS AND RECOMMENDATIONS
PART E  CONCLUSIONS AND RECOMMENDATIONS

Completion of the Stoney Creek Subwatershed Study involved undertaking detailed studies and analyses to develop an understanding of features, functions and linkages of the Stoney Creek ecosystem, and to identify a Plan to sustain, and where possible, enhance existing conditions in the subwatershed. Through this process a number of key conclusions and recommendations have been made, which are summarized in the following subsections. Additional recommendations regarding the implementation of this study’s recommended Subwatershed Plan are discussed in the Implementation Plan Report.

E1.1  Conclusions

The following conclusions have been organized with respect to the disciplines for which detailed studies have been undertaken, in addition to general conclusions on the Stoney Creek Subwatershed ecosystem.

E1.1.1  Land Use

1. The Vision ’96 report has identified 364 ha, or about 10 percent of the Stoney Creek subwatershed as a potential community growth area. Portions of the growth area are crossed by Stoney Creek and its tributaries, and includes Category 1 and Category 2 Constraint Areas. The ultimate developable portions of these lands would be subject to further clarification of the extent of natural features and constraints (to be defined in an EIS).

2. Approximately 14 percent of the subwatershed is designated “Aggregate Resources.” A significant portion of the aggregate resources is already licensed for extraction. Taking into account the projected demand and current licensed users, aggregate resources in the London market area will be exhausted by the year 2000. Proposed after uses of the extraction areas include grassland, savannah habitat.

E1.1.2  Geology/Hydrogeology

1. The hydrogeological regime in the Stoney Creek subwatershed can be divided into the regional and local groundwater flow systems. The regional system covers the northern Thames Basin with groundwater flow likely originating to the north and northwest of the Stoney Creek subwatershed, and flowing south-easterly to the Thames River and North Thames River. The local groundwater flow system is controlled by subwatershed topography and drainage. The local groundwater flow occurs at shallow depths within the overburden sediments. Approximately two-thirds of recharge flows through the local groundwater flow system to Stoney Creek, while the balance enters the regional system.

2. Recharge to the local groundwater flow system will be reduced by 2 percent (and discharge to Stoney Creek and its tributaries by the same amount) based on future development in the community expansion area.

E1.1.3  Fluvial Geomorphology

1. The fluvial geomorphology classification of Stoney Creek indicates that most channel reaches are stable, except for some headwater areas which are sensitive to disturbance.
2. Critical velocities for the movement of bed material were found to be lower than bankfull velocities at three locations in the subwatershed. Two of these locations are within the built-up area, which indicates that some reaches in the subwatershed could be particularly sensitive to increases in flow rates or runoff volumes (that could result from future development).

3. Most erosion sites in the subwatershed are the result of cattle access to the creek.

E1.1.4 Surface Water Hydrology

1. Flow measurements indicate that Stoney Creek is continuously flowing along the main channel, while some of its tributaries have intermittent flow.

2. Peak runoff conditions in the upstream, rural area of the subwatershed are greatest from a combination of runoff and snowmelt events, while peak flow conditions in the lower, developed areas of the subwatershed are greatest during extreme rainfall events.

3. Future development in the subwatershed could triple peak flow rates, if storm water management controls are not utilized.

E1.1.5 Rural Point and Non-Point Source Pollution

1. Current gross soil erosion rates are estimated to be 13,000 tonnes/year in agricultural areas of the subwatershed. Recent changes in cropping systems and in the area of land base which they are performed have resulted in an increased annual soil loss from the most highly susceptible areas.

2. Conservation tillage practices are currently in use at a number of areas in the subwatershed, but could be further extended to a number of key areas to realize a substantial reduction in actual sediment loading to surface waters.

3. Some headwater swales which are currently cultivated would benefit from the establishment of grassed waterways.

4. Livestock access contributes more than 90 percent of the raw fecal coliform input to the headwaters of Stoney Creek.

5. Milkhouse waste may contribute up to 95 percent of annual continuous phosphorus loading.

E1.1.6 Water Quality

1. The water quality monitoring program results indicated that median concentrations of the E. Coli Bacteria, total phosphorus and copper and iron (at 2 of 4 stations) exceeded provincial guidelines.

2. Median concentrations of suspended solids, ammonia, nitrate, potassium, lead, manganese, zinc and dissolved oxygen were within provincial guidelines.

3. Compared to other creeks in the London Subwatershed Studies, Stoney Creek consistently maintained a higher water quality with regard to clarity, BOD, DO, total solids, turbidity, TKN, nitrate, total phosphorus, calcium, calculated hardness, sodium, aluminium strontium and vanadium.
4. Stoney Creek, in general, had dissolved oxygen levels within the recommended guidelines for cold water fish species.

**E1.1.7 Aquatic Resources**

1. Water Quality Index ratings for reaches of Stoney Creek were generally found to be unstable or impaired, except for some locations in the central portion of the subwatershed which were found to have the healthiest benthic invertebrate communities in all of the City of London Subwatershed Studies.

2. Overall the quality of fish habitat in Stoney Creek is relatively high. In particular, higher order streams (3 and 4) are generally Type 1 and Type 2 habitat.

3. Two provincially significant fish species were documented in Stoney Creek: central stoneroller and greenside darter.

**E1.1.8 Terrestrial Resources**

1. The combined area of natural vegetation in the Stoney Creek subwatershed is approximately 449 ha, or about 12 percent of the total area. This makes it slightly less forested than Middlesex County (13.5%).

2. The existing natural areas in the Stoney Creek subwatershed are relatively well connected.

3. The majority of patches were found to be too small to support forest-interior species. Patches 2017 and 2030 have the potential to support some forest-interior and area-dependent species.

4. A provincially significant bird species, the short-eared owl, was found in Patch 2026 (part of Fanshawe Wetland Complex).

5. Two provincially significant and nationally rare plant species were found in the Stoney Creek subwatershed.

**E1.1.9 Archaeological Resources**

1. Fifteen registered and one unregistered archaeological sites were noted during this study.

2. Sixty-four locations of standing or extinct heritage buildings were noted in published and unpublished studies.

**E1.1.10 Infrastructure**

1. The developed area in the Stoney Creek subwatershed (in the City of London) is serviced by an existing sanitary sewer system.

2. The original development areas in Stoneybrook which were serviced by septic tank systems, had sanitary sewers installed in the 1970’s.
E1.1.11  Stoney Creek Subwatershed Ecosystem

1. Four distinct management areas in the subwatershed can be defined by physiographic, geologic, land use and environmental quality conditions. The management areas represent the rural upper reaches of Stoney Creek (Management Unit 1, or MU1), the eastern central reaches within the future development area (MU2), the west central reaches within the future development area (MU3), and the a lower reaches in the existing development area (MU4).

2. Streams in MU1 are all first and second order, and almost all are agricultural drains. Streams in MU1 are highly degraded or support no fish species. Low baseflows in these streams provides limited opportunities to enhance these streams.

3. Streams in MU2 are mostly third order streams which are predominantly natural and of good water quality. MU2 supports the healthiest aquatic communities in Stoney Creek, and is amongst the best in all of the subwatersheds in London. These reaches support a Type III fish community and Type II benthic invertebrate community. There is good potential to increase the quality of the streams in this unit by improving instream cover. However these streams are highly susceptible to increases in temperature due to loss of riparian vegetation or diminished groundwater discharge, and increased inputs of nutrients or sediments.

4. MU3 contains two tributaries that discharge into Stoney Creek which are severely degraded and support only Type IV and V aquatic communities. Watercourses in this area flow from channelized reaches in rural areas to storm sewers in urban areas. The low baseflow, poor water quality, limited riparian vegetation, channelization, bank hardening and drop structures provide little opportunity to enhance these watercourses. If they are further degraded, however, they may not be capable of supporting any aquatic community, and may impact downstream conditions.

5. MU4 is the main channel of Stoney Creek which flows through the built-up area in channelized reaches. The creek is a fourth order stream, that is of fairly high quality which supports a Type III aquatic community. This reach supports the greenside darter and central stoneroller, which are provincially significant. This reach can be improved by increasing riparian and instream cover and by naturalizing portions of the channel. It also has the potential to be degraded by changes in land use practices in other upstream management unit areas.
E2.0 RECOMMENDATIONS

The main recommendations resulting from the Stoney Creek Subwatershed Study are presented in the Implementation Plan and in Table D.3 of this report. The recommendations of the Subwatershed Plan fall within four categories: Constraint Areas, Development Criteria, Conservation and Management Practices and Special Projects and Programs.

E2.1 Constraint Areas

1. It is recommended that the following constraint areas be classified as Category 1, in which development is prohibited.

   i) Fanshawe Wetland Complex;  
   ii) Proposed ESA Complex;  
   iii) Lands within Regulatory Flood or Fill Lines;  
   iv) Designated streams and setbacks; and  
   v) Riparian Vegetation Contiguous to a Designated Watercourse.

2. It is recommended that the following constraint areas be classified as Category 2, in which the extent of development permissible must be the subject of an EIS:

   i) Significant recharge/discharge areas;  
   ii) Other terrestrial patches > 4 ha and not in Category 1;  
   iii) Anti-fragmentation areas for terrestrial enhancement; and  
   iv) Terrestrial corridors and linkages.

E2.2 Development Criteria

1. It is recommended that the following storm water management measures be required for urban development:

   i) Peak flow attenuation;  
   ii) Water quality control;  
   iii) Extended detention for erosion/stream morphology constraints; and  
   iv) Infiltration facilities where permeable soils exist.

2. It is recommended that environmentally sensitive site planning techniques be used in all developments to maintain the hydrologic balance, preserve trees and natural habitat areas and reduce impacts to water quality in the receiving watercourse.

3. It is recommended that erosion controls be required on all construction sites and that during the construction period, the measures are inspected and monitored.

E2.3 Conservation and Management Practices

1. It is recommended that the following practices be employed to control point-source pollution sources:

   i) Manure management and feedlot runoff controls;  
   ii) Control of livestock access to streams;  
   iii) Milkhouse waste controls; and  
   iv) Septic system effluent controls.
2. It is recommended that the following practices be employed to control non-point source pollution sources:

i) Conservation tillage;
ii) Grassed waterways;
iii) Natural channel succession;
iv) Municipal de-icing program optimization; and
v) Top soil preservation.

E2.4 Specific Projects and Programs

1. It is recommended that the following programs be initiated to improve current subwatershed conditions:

i) Disconnect roof leaders from storm sewers; and
ii) Initiate a public awareness program.

2. It is recommended that the following projects be initiated to improve current subwatershed conditions:

i) Plant riparian vegetation along stream corridor through built-up area;
ii) Rehabilitate urban channelized reaches using natural channel design techniques;
iii) Remediate significant erosion areas: west of Highbury Avenue, north of Fanshawe Park Road; and at two areas near Windermere Road; and
iv) Prepare a remediation and management strategy for the North Park reach.

All of which is respectfully submitted,

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JG/sc
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APPENDIX 1

Stoney Creek Fact Sheets
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 1

RESOURCES

Water Resources

- 678 ha drainage area
- permanently flowing and intermittently-flowing drainage ditches (Ballymote Tributary and Armitage Drain)
- tile drainage system

Aquatic Resources  (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- 900 m reach with Type III aquatic communities
- 3600 m reach with Type IV aquatic communities
- remainder supports Type V aquatic communities

Stream Morphology

- mostly agricultural drains

Terrestrial Resources

- Category 1:
  - Candidate ESA - 2030, intermediate-aged forest dominated by yellow birch and red maple, with forest-interior habitat.

- Category 2:
  - terrestrial patches 2044, 2045, 2046, 3059, 2037, 2036, 2033
  - significant recharge area
  - anti-fragmentation areas

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- 3000 m of stream maintained/established as grassed waterways

PROPOSED STUDIES

Water Resources

- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows

- N/A (rural area)
STONEY CREEK

Tributary and Catchment Area Factsheet

AREA 1 (continued)

**Water Quality** (instream targets)

- TP \( \leq 0.03 \text{ mg/l} \)
- SS \( \leq 50 \text{ mg/l} \)
- Nitrite \( < 0.03 \text{ mg/l} \)
- Nitrate \( < 1.0 \text{ mg/l} \)
- Fecal Coliform (counts per 100 ml < 50)

**Aquatic Community**

- maintain/establish grassed waterways
- WQI Score = 6-10, EPT Index = 2-5
- Maintain existing fisheries or restore/enhance to Type IV fishery

**Terrestrial**

- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 2

RESOURCES

Water Resources

- 1214 ha drainage area
- permanently flowing and intermittently-flowing drainage ditches (Ballymote East Drain, Harris Award Drain, Talbot Award Drain, Wonnacott Drain, Talbot Drain
- extensive tile drainage system

Aquatic Resources  (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- 2880 m reach with Type III aquatic communities
- 5400 m reach with Type IV aquatic communities
- remainder supports Type IV aquatic communities

Stream Morphology

- mostly agricultural drains

Terrestrial Resources

- Category 1:
  - 2038, 2028, woodlots contiguous to watercourse

- Category 2:
  - terrestrial patches 2047, 2048, 2050, 2039, 2040, 2041, 2042, 2043, 2029
  - anti-fragmentation areas

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- vegetated buffer strips to 6120 m watercourse
- 5400 m of stream maintained/established as grassed waterways

PROPOSED STUDIES

Water Resources

- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows

- N/A (rural area)
STONEY CREEK

Tributary and Catchment Area Factsheet

AREA 2 (continued)

**Water Quality (instream targets)**

- TP ≤ 0.03 mg/l
- SS ≤ 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate <1.0 mg/l
- Fecal Coliform (Counts per 100 ml) < 50

**Aquatic Community**

- maintain/establish grassed waterways
- WQI Score = 6-10, EPT Index = 2-5
- maintain existing fisheries or restore/enhance to Type IV fishery

**Terrestrial**

- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 3

RESOURCES

**Water Resources**
- 77 ha drainage area
- 1050 m watercourse
- provincially significant wetlands (Fanshawe wetland complex)

**Aquatic Resources** (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)
- Type IV aquatic community

**Stream Morphology**
- 1050 m of natural watercourses

**Terrestrial Resources**
- Category 1:
  - provincially significant wetland, 2025, 2026, 2024
- Category 2:
  - lands within fill lines
  - 120 m adjacent lands
  - significant recharge areas

KEY BEST MANAGEMENT PRACTICES
(refer to Table D.3 and Map D1 for details)

**Storm Water Management Practices**
- storm water management facilities designed to satisfy the subwatershed development criteria (250 m³/ha for peak flow attenuation, 100 m³/ha for extended detention, and 100 m³/ha at-source controls)
- distributed runoff control techniques for protection of stream morphology
- infiltration of 25 mm roof runoff where permeable soils exist

PROPOSED STUDIES

**Water Resources**
- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- regulatory floodlines to be defined
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 3 (continued)

ENVIRONMENTAL TARGETS

Flows

- match existing peak flows from the 2 through 100 year return period storms

Water Quality (instream targets)

- TP ≤ 0.03 mg/l
- SS ≤ 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- protect provincial significant wetlands
- WQI Score >12, EPT Index >10
- Type II fishery in the main branch, Type V fishery in tributaries

Terrestrial

- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
- revegetate non-vegetated areas in Category I
- use indigenous species
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 4

RESOURCES

Water Resources
- 194 ha drainage area
- 2400 m natural watercourse with permanent streamflow

Aquatic Resources (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)
- 2400 m watercourse supports tolerant warmwater fishery (Type III)

Stream Morphology
- 2400 m natural watercourses

Terrestrial Resources
- Category 1:
  - provincially significant wetland, 2021, 2023, Fanshawe Wetland Complex
  - 120 m adjacent lands (adjacent to the wetland complex)
  - regulatory flood plains
  - lands within fill lines
- Category 2:
  - significant recharge areas
  - woodlots with high recharge potential areas, 2022

KEY BEST MANAGEMENT PRACTICES
(refer to Table D.3 and Map D1 for details)

Storm Water Management Facilities
- storm water management facilities designed to satisfy the subwatershed development criteria (250 m³/ha for peak flow attenuation, 100 m³/ha for extended detention, and 100 m³/ha at-source controls)
- infiltration facilities designed to infiltrate 25 mm of runoff from contributing roof areas where permeable soils exist

PROPOSED STUDIES

Water Quality
- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 area
ENVIRONMENTAL TARGETS

Flows

• match existing peak flows from the 2 through 100 year return period storms

Water Quality (instream targets)

• TP ≤ 0.03 mg/l
• SS ≤ 50 mg/l
• Nitrite < 0.03 mg/l
• Nitrate < 1.0 mg/l
• Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

• protect provincial significant wetlands
• WQI Score >12, EPT Index >10
• Type II fishery is the main branch, Type V fishery in tributaries

Terrestrial

• protect all Category 1 Areas
• protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
• revegetate non-vegetated areas in Category I
• use indigenous species
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 5

RESOURCES

Water Resources

- 253 ha drainage area
- 1950 m of natural watercourse with permanent streamflow
- 1890 m of agricultural drains (Shoebottom Award Drain)

Aquatic Resources (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- 1890 m watercourse supports Type V aquatic communities
- 1950 m watercourse with tolerant warmater fishery (Type III)

Stream Morphology

- 1950 m of natural watercourses
- 1890 m of agricultural drains

Terrestrial Resources

- Category 1:
  - Candidate ESA - Part of 2030, 2020
  - woodlots contiguous to watercourses (part of 2028)
- Category 2:
  - significant recharge areas
  - anti-fragmentation areas
  - Type 3 terrestrial patches (2051)

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management facilities designed to satisfy the subwatershed development criteria (250 m³/ha for peak flow attenuation, 100 m³/ha for extended detention, and 100 m³/ha at-source controls)
- maintain/establish grassed swales for agricultural drains
- infiltrations of 25 mm roof runoff where permeable soils exist
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 5 (continued)

PROPOSED STUDIES

Water Resources
- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- regulatory floodlines to be defined
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows
- match existing peak flows from the 2 through 100 year return period storms

Water Quality (instream targets)
- TP < 0.03 mg/l
- SS ≤ 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community
- 1890 m agricultural drains maintained/established as grassed swales
- WQI Score >12, EPT Index >10
- Type II fishery in the main branch, Type V in tributaries

Terrestrial
- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
- revegetate non-vegetated areas in Category 1 (e.g. within fill lines)
- use indigenous species
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 6

RESOURCES

Water Resources
- 150 ha drainage area
- 1300 m of natural watercourse with permanent streamflow

Aquatic Resources  (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)
- 1500 m of watercourse with warmwater fishery (Type II)
- 1050 m of watercourse with Type V aquatic community

Stream Morphology
- 1300 of natural watercourses
- 200 m of altered watercourses
- 1050 m of agricultural drain (Hodgins Award Drain)
- one significant erosion area and one minor erosion area

Terrestrial Resources
- Category 1:
  - Candidate ESA - 2018, part of 2019
  - lands within the regulatory floodlines
  - lands within the fill lines
- Category 2:
  - none

KEY BEST MANAGEMENT PRACTICES
(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices
- storm water management facilities designed to satisfy the subwatershed development criteria (250 m$^3$/ha for peak flow attenuation, 100 m$^3$/ha for extended detention, and 100 m$^3$/ha at-source controls)
- bank regrading, watercourse widening, rip-rap placement and revegetation for 150 m of watercourse (significant erosion area)
- remediation of minor erosion areas
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 6 (continued)

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- scoped EIS for areas within 50-100 m of Category 1 Areas

ENVIRONMENTAL TARGETS

Flows

- match existing peak flows from the 2 through 100 year return period storms

Water Quality (instream targets)

- TP ≤ 0.03 mg/l
- SS < 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- riparian vegetation planting for 300 m reach
- create pools and riffles with stone weirs in 300 m reach
- WQI Score >12, EPT Index >10
- Type II fishery in the main branch, Type V in tributaries

Terrestrial

- protect all Category 1 Areas
- revegetate non-vegetated areas in Category 1 (e.g. within fill lines)
- use indigenous species
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 7

RESOURCES

Water Resources

- 182 ha drainage area
- 3450 m agricultural drains (Worral Award Drain and Foran Gough Drain)
- random tile drainage systems

Aquatic Resources

(refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- 1500 m watercourses with Type IV aquatic communities
- remainder with Type V communities

Stream Morphology

- all are natural watercourses

Terrestrial Resources

- Category 1:
  - woodlots within high recharge potential areas (part of 2017)
- Category 2:
  - significant recharge areas
  - terrestrial patches, part of 3044, 2031, 2032, 2016
  - anti-fragmentation areas

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management facilities designed to satisfy the subwatershed development criteria (250 m³/ha for peak flow attenuation, 100 m³/ha for extended detention, and 100 m³/ha at-source controls)
- infiltration facilities to infiltrate 20 mm of roof runoff where permeable soils exist

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 7 (continued)

ENVIRONMENTAL TARGETS

Flows

- match existing peak flows from the 2 through 100 year return period storms

Water Quality (instream targets)

- TP ≤ 0.03 mg/l
- SS ≤ 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- WQI Score = 6-10, EPT Index = 3-5
- Type IV fishery in the main branch, Type V in tributaries

Terrestrial

- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
- re-vegetate non-vegetated areas in Category 1 (e.g. within fill lines)
- use indigenous species
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 8

RESOURCES

Water Resources
- 207 ha drainage area
- random tile drainage system
- agricultural drain (Powell Drain)

Aquatic Resources  (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)
- 2400 m watercourses with Type IV aquatic communities
- 750 m watercourses with Type V aquatic communities

Stream Morphology
- 300 m of altered watercourses
- remainder are natural drainage features

Terrestrial Resources
- Category 1:
  - woodlots contiguous to watercourse or within regulatory flood plain, 2052, 2014, 2015
- Category 2:
  - terrestrial patches, part of 3042, part of 3043, part of 3044
  - significant recharge areas

KEY BEST MANAGEMENT PRACTICES
(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices
- storm water management facilities designed to satisfy the subwatershed development criteria (250 m³/ha for peak flow attenuation, 100 m³/ha for extended detention, and 100 m³/ha at-source controls)
- Infiltration facilities to infiltrate 20 mm of roof runoff where permeable soils exist

PROPOSED STUDIES

Water Resources
- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 8 (continued)

ENVIRONMENTAL TARGETS

- match existing peak flows from the 2 through 100 year return period storms

Water Quality (instream targets)

- TP < 0.03 mg/l
- SS < 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- WQI Score = 6-10, EPT Index = 3-5
- Type IV fishery in the main branch, Type V in tributaries

Terrestrial

- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
- revegetate non-vegetated areas in Category 1
- use indigenous species
RESOURCES

Water Resources
- 60 ha drainage area
- 280 m drainage ditch

Aquatic Resources (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)
- 280 m ditch with Type V aquatic community

Stream Morphology
- 280 m of natural drainage ditch

Terrestrial Resources
- Category 2:
  - Type 3 terrestrial patches, 2013, part of 2100

KEY BEST MANAGEMENT PRACTICES
(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices
- storm water management facilities designed to satisfy the subwatershed development criteria (250 m$^3$/ha for peak flow attenuation, 100 m$^3$/ha for extended detention, and 100 m$^3$/ha at-source controls)

PROPOSED STUDIES

Water Resources
- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- scoped EIS for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows
- match existing peak flows from the 2 through 100 year return period storms
STONEY CREEK

Tributary and Catchment Area Factsheet

AREA 9 (continued)

Water Quality (instream targets)

- TP < 0.03 mg/l
- SS < 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- WQI Score = 6-10, EPT Index = 3-5
- Type V fishery

Terrestrial

- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
STONEY CREEK
Tributary and Catchment Area Factsheet

AREA 10

RESOURCES

Water Resources
  • 431 ha drainage area
  • permanent streamflow

Aquatic Resources (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)
  • main branch of Stoney Creek with warmwater fishery (Type II) or tolerant warmwater fishery (Type III)
  • minor tributaries of the main branch support Type IV or Type V aquatic communities

Stream Morphology
  • 1800 m main branch is natural watercourses
  • 1800 m main branch is altered watercourses
  • 300 m tributaries are altered watercourses

Terrestrial Resources
  • Category 1:
    • lands within regulatory floodlines
    • woodlots contiguous to watercourse or within regulatory flood plain, 2003, 2006, 2005, 2004, part of 2001
  • Category 2:
    • significant recharge areas

KEY BEST MANAGEMENT PRACTICES
(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices
  • storm water management facilities designed to satisfy the subwatershed development criteria (250 m$^3$/ha for peak flow attenuation, 100 m$^3$/ha for extended detention, and 100 m$^3$/ha at-source controls)
  • infiltration facilities to infiltrate 20 mm of roof runoff where permeable soils exist
  • remediation of bank erosion over a distance of 100 m due to lack of vegetation and change in flow regime resulting from previous development (near Windemere Road)
  • meander is approaching residential area and parking lot, remediation is required over a distance of 30 m (near Windemere Road)
  • disconnect roof leaders from storm sewers
STONEY CREEK

Tributary and Catchment Area Factsheet

AREA 10 (continued)

PROPOSED STUDIES

Water Resources

• storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
• scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows

• N/A (existing developed area)

Water Quality (instream targets)

• TP < 0.03 mg/l
• SS < 50 mg/l
• Nitrite < 0.03 mg/l
• Nitrate < 1.0 mg/l
• Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

• 1560 m streambanks of the main branch vegetated
• stone weirs placed in 1560 reach of the main branch to create pools and riffles
• WQI Score >12, EPT Inces >10
• Type II fishery in the main branch, Type IV in tributaries

Terrestrial

• protect all Category 1 Areas
• protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
• re-vegetate non-vegetated areas in Category 1
• use indigenous species