Eastern Ontario
WATER RESOURCES MANAGEMENT STUDY

Final Report

Prepared for

United Counties of Prescott and Russell
United Counties of Stormont,
Dundas and Glengarry
City of Ottawa

Prepared by

CH2MHILL

March 2001

"Working with Eastern Ontarians to develop a common understanding of regional water resources issues and a strategy to use comprehensive information and analysis to manage these resources for sustainable development."

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EOWRMS Steering Committees and Technical Advisory Group

Subject: Final Report
Phases 1B, 2, and 3
Eastern Ontario Water Resources Management Study

Dear Committee Members:

On behalf of our Consultant Team, it is with pleasure that we submit the final report for Phases 1B, 2, and 3 of the Eastern Ontario Water Resources Management Study (EOWRMS). The report presents the characterization of regional water resources, land resources, and servicing infrastructure, which is a significant milestone for the long-term management of these resources. Comprehensive data has been compiled, analyzed, and presented to highlight the significance of this information relative to the EOWRMS objectives.

Assimilating the results of such diverse and thorough analyses into a comprehensive report that outlines regional water resources management action plans has been a challenging but valuable undertaking. The action plans will help communities make sound decisions on where growth and settlement can be supported by safe water resources and what infrastructure may be needed to resolve concerns with water quality and quantity.

The next major step will be the implementation of these action plans through an Eastern Ontario Water Resources Management Strategy. We believe that the future prosperity of Eastern Ontario will in part depend on the timely and successful implementation of this strategy.

It has been our pleasure to work with each of you on this exciting and challenging study. Your guidance and leadership have contributed significantly to the study's success.

Sincerely,

CH2M HILL Canada Limited

William D. Banks, P.Eng.
Project Manager

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Enclosure

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Executive Summary

The Eastern Ontario Water Resources Management Study (EOWRMS) has encompassed an extensive compilation and evaluation of regional water resources and servicing infrastructure information. The United Counties of Prescott and Russell (P&R) and the United Counties of Stormont, Dundas and Glengarry (SD&G) initiated this study in recognition of the need to develop a regional water resources information system on a watershed basis. The study area includes the South Nation River and Raisin Region watersheds and other minor adjacent watersheds (Figure 1-1[1]) and covers approximately 6,800 square kilometers. The City of Ottawa (Ottawa), facing similar issues, recognized that participation in the study would also benefit that part of Ottawa that falls within the South Nation watershed. It has become widely acknowledged that, to make informed decisions related to changes in land use and infrastructure, the physical features of a watershed must be clearly defined in terms of functions, attributes, and linkages. Each of the five counties in the study area is faced with decisions related to land development for residential, commercial, and industrial purposes. In considering these potential land-use changes, the relationship of the specific site to the watershed must be understood from an ecological perspective.

It is clear that Ontario does not have a comprehensive and integrated water resources management strategy. Water management in Ontario is characterized as fragmented and uncoordinated. The EOWRMS municipalities and conservation authorities have shown foresight, leadership, and understanding of the important relationship between water resources and healthy, sustainable communities.

Objectives

The principal study objectives are summarized as follows:

- **Objective 1**: Develop a database and geographic information system (GIS) on the state of water resources and servicing infrastructure within the study area.
- **Objective 2**: Develop data management protocols to ensure the database is properly maintained and updated.
- **Objective 3**: Assess the capability of key areas to potentially support development on private services.
- **Objective 4**: Identify potential cost-effective servicing alternatives on a regional basis.
- **Objective 5**: Develop community demonstration projects that provide integrated solutions to water resource issues on a local / regional basis.
- **Objective 6**: Develop and promote tools and action plans to protect the quality and quantity of regional water and related land resources.

[1] All figures are located in a separate volume.

Study Process

The study has been completed in several phases. An initial phase (Phase 1A) focussed on public consultation approaches, information needs, existing information, literature review, and information gaps. Separate reports were completed for this phase.

This report presents a summary of the approaches and the results of Phases 1B, 2, and 3. Phase 1B included assembling the required information and filling the information gaps where possible and feasible to address characteristics of groundwater and surface water resources. Information was also compiled and assessed to establish the state of servicing infrastructure in the study area. Relevant data will continue to be collected following the study. Therefore, protocols for maintaining and updating the database will ensure that ongoing analytical processes, such as water quality trends, will be made possible.

The data analysis completed in Phase 2 focussed on two principal areas: the capability of key areas to potentially support development and potential cost-effective servicing alternatives on a regional basis. To make informed decisions related to development, areas with favourable quantity and quality of water supply were identified. Areas that have limited supply or that require protection to maintain an adequate supply were also identified.

In recent years, the local municipal governments have collectively spent over $100-million to upgrade water supply and sewage treatment systems. Although there have been specific environmental and infrastructure issues in some of the municipalities, the relationship of these issues to the region has not been addressed. In some cases, cost-effective servicing alternatives have been successfully implemented in Eastern Ontario. Elsewhere in the province, site-specific solutions have been commissioned. During Phase 2 of the study, numerous practical, innovative, efficient, and cost-effective alternatives that are applicable to Eastern Ontario were identified. On the basis of the Phase 2 analyses, a list of potential community demonstration projects was compiled that could provide integrated solutions to water resources issues on a local and/or regional basis.

Management of regional water resources recognizes the shared nature of the resources. The responsibility and cost for water resources management should be shared by society-at-large. A comprehensive regional water resources management strategy is required to ensure that both the quality and quantity of groundwater and surface water are maintained and possibly improved. Environmentally sustainable development of urban areas would be guided by such a strategy. Monitoring programs would be implemented, ultimately providing evidence of the strategy's success. In areas identified as being particularly sensitive, monitoring of potential point and non-point contamination sources would be included in the programs to provide opportunities for corrective actions. During Phase 3, the key elements of this strategy were developed and presented as several potential action plans. Recommendations related to the implementation of the strategy were made.

Overview of Study Results

An overview from each principal section of the report is presented below.

Database Compilation (Section 2)

A primary goal of the study was to develop a comprehensive digital database suitable for incorporation into a Geographic Information System (GIS). Data compiled for the purpose of completing the analyses of regional water resources and servicing infrastructure were obtained from existing data sources. The majority of the data collected was obtained from secondary sources. Agriculture and Agri-Food Canada (AAFC) coordinated the collection of information from AAFC, Ontario Ministry of Natural Resources (MNR), Ontario Ministry of the Environment (MOE), and federal and provincial geological surveys. The type of information reflects the information needs identified in Phase 1A. The consultant team identified possible sources of additional data required for the study and approached the custodians of the data directly.

The consultant team also collected some primary data through a water resources survey and a servicing infrastructure survey. As a result of these surveys, most of the data gaps identified in Phase 1A were filled. During the course of the data analyses, additional information requirements were identified.

Metadata is the background information that describes the source, quality, location, and other important characteristics of the data. A metadata table was completed to accompany the compiled information base.

The geographic data used to evaluate the regional water budget, land use, and groundwater characteristics were managed using a GIS. AAFC and the consultants compiled the geographic databases used in the analysis. As data were acquired, they were combined with other geographic data in a common database.

The analysis of the GIS database has resulted in numerous interim or derivative data layers that represent the water budget, groundwater, and land use activities in the study area. The water budget analysis was undertaken using source data from the satellite land classification, topographic data, soil data, tile drainage mapping, surficial geology, ecodistrict data, and digital elevation model. From this data, a regional water balance model was developed and calibrated against actual stream flow measurements from 11 subwatersheds in the study area. The components of this model were presented in maps at the public open houses and in this report. Moreover, the results of the water balance were used for further analysis of the land use and groundwater characteristics.

The groundwater analysis was conducted using data derived from the water budget analysis and water well records. Aquifer extents and connectivity were mapped by interpreted aquifer thickness and locations from the water well records. Aquifer properties and recharge to the deeper aquifers were derived from the aquifer extents mapping, the water budget analysis, and the water well records. Aquifer capability and vulnerability were derived from a number of intermediate groundwater analyses.

The land use analysis was conducted using data derived from the water budget analysis and agriculture census survey results. The subwatershed zones calculated from the elevation model were used to represent much of the land use analysis. The agricultural land areas derived from the satellite imagery provided a measure of the agricultural land within the surface and groundwater subwatersheds. The census data was aggregated at the subwatershed level and combined with the agriculture lands and drainage network data to provide a characterization of agriculture intensity within the study area. The results of this analysis have been summarized at both the surface water and groundwater subwatershed levels. The GIS data consists of numerous tables calculated from the mentioned data sources.

The digital databases, including relevant GIS layers, are a deliverable of this study. These data products will be delivered to AAFC at the completion of the study. AAFC has the responsibility for ensuring timely transfer of the data files to the EOWRMS project partners.

Regional Water Budget (Section 3)

The water (hydrological) cycle, shown in Figure 3-1, illustrates how water is continuously recycled. Water falls as precipitation, commonly referred to as rain or snow. Precipitation replenishes our lakes and rivers, which are called surface water. Part of the precipitation infiltrates the ground to become groundwater. Much of the precipitation is returned to the atmosphere through evaporation and transpiration (the combined term is evapotranspiration) to form clouds and precipitate once again.

The EOWRMS study carried out a detailed analysis of individual components of the hydrological cycle as they affect the quantity and quality of the water resources across the region (described later in this report). To set the stage for the detailed analysis a regional water budget (a general model of the complete hydrological cycle) was used to estimate the maximum amounts of water available for development and use. The first stage of this analysis is an estimate of the quantity of water available annually to replenish surface and groundwater resources. This **Net Available Water Quantity** is the difference between the quantity of precipitation and the amount of water returned to the atmosphere through evaporation and transpiration. In the second stage of the regional water budget analysis a **Partition Model** was developed to estimate the allocation of water between surface and groundwater resources.

The regional water budget provides general estimates of:

- The quantity of water cycling through the study area (average annual precipitation)
- The quantity of water returned to the atmosphere by evapotranspiration (Figure 3-2)
- The quantity of water contributed annually to surface water resources (Figure 3-3)
- The quantity of water that contributes to groundwater resources (Figure 3-4)

These estimates show the upper limits of the quantities of water available for human use and consumption. In many cases water will be used and returned to the water resources (most frequently it will be returned to the surface water resource whether or not it has been drawn from surface or groundwater). Water, particularly surface water, may be used several times between the time it falls as rain and the time it evaporates or transpires back into the atmosphere. Frequently, factors other than water quantity limit its use or reuse. These factors include water quality, seasonality of flow and rate of flow through bedrock and geological deposits.

The EOWRMS study area (South Nation River and Raisin Region watersheds and subwatersheds and associated peripheral watersheds [see Figure 3-5]) covers an area of approximately 6,800 square kilometers. It receives an average of about 930 mm of precipitation annually. Based on the calculations of the regional water budget model, the fate of precipitation across the study area is as follows:

- Approximately 420 mm is returned to the atmosphere through evaporation and transpiration
- 510 mm of water is partitioned between the surface water drainage network (94 percent) and the deep groundwater reserves (6 percent)

In practical terms, these measurements indicate that every hectare of land in the study area contributes on average 5,100,000 litres of water annually to the water resources or the equivalent of 455,000 gal / acre.

Across the EOWRMS area, the average annual contribution to the water resource (both surface and groundwater) amounts to almost 35 billion cubic meters (1,220 billion cubic feet). The current demand for domestic, industrial, and institutional uses is only a small fraction of the total annual contribution. It is anticipated that the minimum base flow requirements to sustain aquatic and terrestrial habitat are also a small fraction of the total annual contribution.

Surface Water Analysis (Section 4)

Data and statistics on streamflow were compiled for the analysis of surface water including water budget analysis, assessment of water supply potential, and evaluation of the capacity of watercourses to assimilate wastewater.

An assessment of the available streamflow data and an interpretation of the data was needed to assist with various analyses such as water budget analyses for the study area and individual watersheds, and assessment of wastewater assimilation capacity.

During the earlier phases of the EOWRMS work, surface water quality data sources had been identified. Subsequent efforts were made, as part of the study, to collect the available information. The collected data has been analyzed to characterize surface water as a regional resource from a number of perspectives.

Water quality is an important aspect of the resource characterization because the quality of the existing surface waters dictates, to some degree, the availability of surface waters for potable water supplies and the degree of treatment that may be required to use these surface waters as potable water supplies. The quality of surface waters also impacts the ability of surface waters to act as receiving streams for wastewater discharges from agricultural, industrial and municipal wastewater sources. Surface water quality is also a principal factor in the determination of the quality and viability of aquatic habitat that exists in various parts of the region.

Groundwater Analysis (Section 5)

One of Eastern Ontario's primary sources of water is groundwater. Groundwater is obtained from dug or drilled wells, which extract water from an aquifer. An aquifer is any geologic material such as sand, gravel, or limestone that is permeable enough to yield a significant amount of water to a well or spring. Water quality within aquifers can vary significantly depending on the natural setting or human induced impacts.

In the exploration for new groundwater sources, or aquifers with additional capability, it is necessary to identify the locations of aquifers, determine the long-term capability of the aquifer to yield water, and to determine the quality of the water the aquifer yields. In general, a groundwater source is less vulnerable to contamination than a surface water source because of the protection afforded by the overlying geologic units. However, dug and shallow drilled wells may have little geologic protection, making them vulnerable to contamination. Therefore, in evaluating the supply potential (capability) of an aquifer, it is important to consider its geologic (intrinsic) protection from potential contamination.

With these considerations in mind, the groundwater analysis component of the EOWRMS was undertaken to:

- Define and map aquifer extents and connectivity
- Quantify groundwater recharge
- Characterize aquifer natural water quality
- Characterize current and additional aquifer capability
- Characterize the intrinsic aquifer vulnerability to contamination

The groundwater analysis presented in the report was completed on a regional scale to provide an overall characterization of the groundwater systems in Eastern Ontario. The analysis was completed by first developing a relational database of all available information, which was managed and interpreted within a Geographic Information System (GIS).

Land Use Analysis – Agriculture (Section 6)

As stated in the water budget summary, an area of approximately 6,800 km^2 across the South Nation River and the Raisin Region watersheds and the associated peripheral watersheds receives on average about 930 mm of precipitation annually, of which approximately 420 mm is lost through evapotranspiration. The remaining 510 mm of water is partitioned between the surface water drainage network and the deep groundwater reserves. In areas close to the surface drainage network, a larger proportion of water moves either by overland flow or lateral flow through the upper overburden to the surface reserves. Even higher amounts will move in areas that slope to the drainage network or where tile drains shunt the excess water directly to the surface network. Areas farther away from the surface drainage pathways are more likely to contribute water to the deep groundwater reserves, particularly where the soil and geological materials are relatively porous. The mix of land uses in these water resource “contributing areas” determines to some extent the quantity of water moving into the water resource and directly influences the quality of water replenishing the resources. Figure 6-1 illustrates the regional distribution of different land uses, as defined by land cover classification from Landsat satellite imagery.

Approximately 55 percent of the EOWRMS project area is in agricultural use, which involves active land management. Forest is the next major category; however, the level of management carried out on forested areas is much lower than on agricultural land and therefore there are few options available to modify forest land use to impact on the water resource contribution. Various water resource management aspects of urban areas were considered under the servicing infrastructure assessment.

Agricultural activities impact more than half of the annual contribution from precipitation to the surface water and groundwater resources of the region. The kinds and intensities of agricultural activities in the study area have been assessed. For this analysis, the intensity of agricultural activities across the study area was compared with intensities in other parts of the province or to levels that are within Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) recommendations for environmental sustainability. The results are expressed as a fraction showing the degree to which the specific agricultural activities under consideration approach, match, or exceed the average or recommended level.

The report presents a characterization of the location, nature, and extent of agricultural land use within subwatersheds related to surface water resources in the project area. The sub-watersheds represent land units that contribute to the surface water within a defined area of the surface drainage network, but they also include areas where the partitioning of excess water is primarily to deep groundwater resources.

Analysis was done to show the relationship between agricultural activities and major aquifers, areas of recharge and discharge. The combined analysis allows for the identification of sensitive areas and areas with development potential or constraints.

In the development of a regional water strategy, it is important to recognize that managed land areas tend to have a greater impact on water quality than most natural areas. Schnoor (1996) presents data compiled by the United States Environmental Protection Agency showing mean total phosphorus and nitrogen concentrations in surface waters by land use type and region of the United States. These summaries suggest that the concentrations for agricultural land uses are 2.5 times the levels found in land that is mostly forest and that urban land uses are slightly lower but generally about double. These findings suggest that the quality of surface water in a subwatershed is directly influenced by the proportion of the subwatershed area in agricultural or urban use.

Servicing Infrastructure (Section 7)

Infrastructure, including water, wastewater, and stormwater services has a direct impact on the maintenance of our high health standards, productivity, and our environment. As health and environmental standards increase, water and wastewater servicing standards need to keep pace.

Approval standards for treatment plants and conveyance systems moved from being almost non-existent in the 1930s and 1940s to the departments of health setting modest standards in the 1950s and 1960s. The 1970s saw the development of detailed “design guidelines” by provincial ministries of environment. These guidelines prescribed minimal acceptable standards to all municipalities. Still, in the 1970s stormwater management meant preventing flooding; no consideration was given to environmental impacts.

Many municipalities constructed their first water treatment plants between 1930 and 1960. Most of the early wastewater treatment plants were constructed after 1950. However, as urbanization increased and treatment technology advanced, the number of treatment plants increased significantly. The early plants also needed upgrading to improve their performance to meet new standards.

Recently, some provinces have started to give more of the responsibility to the design engineer and the municipality for developing area-specific standards and ensuring that these standards are met. This transfer of responsibility provides some opportunity to customize the approach to the development to account for variables including:

- Raw water quality: river, lake, groundwater
- Wastewater composition: strong, weak
- Distribution system, topography
- Sewage collection system: combined, separated, mixture
- Seasonal variations in water demand and wastewater flow
- Leakage from water mains, unaccounted-for losses
- Infiltration / inflow into the sewer system
- Receiving stream requirements, nitrification, phosphorus limits
- Age of the system

Current water, wastewater, and stormwater servicing in each community has been shaped by many different factors, and it is critical to understand these factors before determining how needs can best be met from a regional perspective.

Servicing infrastructure was evaluated based on the existing conditions within the EOWRMS area, the relevancy of policies and guidelines and the available alternatives for upgrading the existing systems or developing new infrastructure. The objective of this evaluation is to provide relevant discussion on the opportunities to manage water resources more effectively and more efficiently on a regional basis.

The relevant infrastructure components assessed include:

- Wastewater treatment infrastructure
- Water treatment infrastructure
- Stormwater management infrastructure
- Water efficiency alternatives

In addition, a regional analysis of water demand was conducted. No evaluation of industrial point sources was undertaken.

Public Consultation (Section 8)

A major component of the EOWRMS was the program for public consultation. A variety of consultation techniques were used to interact with the public. The intent of the public consultations was to raise the awareness of water resources management issues and to encourage dialogue. In order to encourage public involvement, over 64,000 households and businesses in the study area were sent a survey and a newsletter that described the EOWRMS study and objectives. Therefore, everyone affected by the study was given an opportunity to participate and to learn about this study, the activities and programs of other agencies, and the importance of wise management of water resources. The public consultation also provided an opportunity to obtain information and input from the public. The public's input served to confirm observations or findings made by the consultant team. It also brought forth new information and new perspectives on study issues.

The consultation program provided an opportunity for agencies to participate including municipalities, agricultural and rural organizations, and public service organizations. The EOWRMS steering committee members provided important contributions to the consultation process, materials and interpretation of some of the findings. Overall, the consultation program fulfilled the objective of appealing to a wide audience of concerned / interested parties throughout the period of the study.

Demonstration Projects (Section 9)

The EOWRMS is founded in principles of collaborate participation and pragmatic approaches to water resources management. Demonstration projects provide one means of delivering information and experiences on water resources planning and best management practices.

The theory behind using demonstration projects is based largely on people's predisposition towards trying or avoiding new things. Traditionally, demonstration projects provided a means of showcasing a technology or practice under conditions familiar to people with an interest in "adopting" the technology or practice. Simple examples would be the "test-drive" of a new farm implement (e.g. a chisel plough) or looking at a new model home. Increasingly, demonstration projects are being applied to programs and behaviours (e.g. water conservation, recycling, or energy efficiency). Regardless of the focus, the primary aim of demonstration projects generally involves increasing the adoption rate of new methods by demonstrating their effects and benefits.

The EOWRMS Terms of Reference asked the consultant team to "develop community demonstration projects that provide integrated solutions to water resource issues on a local and / or regional basis" and to "develop and promote tools and action plans to protect the quality and quantity of regional water and related land resources". Given such direction, a broad definition of demonstration projects has been adopted, one that combines practices, technologies, and programs.

The approach is also strategic in that recognition is given to past, ongoing, and planned initiatives and projects within the study area that promote and demonstrate different methods and technology to help protect and enhance water resources. The Provincial Water Protection Fund is a major contributor to the study; other current initiatives in the study area include[2]:

- Rural Clean Water Program: City of Ottawa
- Clean Water Program: South Nation Conservation
- Tributary Restoration Project: Raisin Region Conservation Authority
- Baseline Water Well Testing Program: Ontario Federation of Agriculture
- Livestock Manure Prevention Program
- Regional Environmental Information System (REIS): Agriculture and Agri-Food Canada
- Nutrient Management Planning: Ontario Ministry of Agriculture, Food and Rural Affairs
- Water Efficiency Campaign: City of Ottawa
- Waterlinks: City of Ottawa
- Agricultural Environmental Stewardship Initiative (forthcoming)
- Subwatershed Studies
- Ongoing public education and awareness

[2] This list is not meant to be exhaustive, but rather illustrative of some current initiatives within the study area.

Action Plans and Implementation

Study Highlights (Section 10)

The policy and regulatory framework for water resources management in Eastern Ontario is highly fragmented. The existing database could be characterized as incomplete, inconsistent, and divided amongst a variety of agencies. No comprehensive inventory or assessment has ever been undertaken to determine what information exists and how that information could be used effectively in making decisions on water resources management.

A key accomplishment of this study, therefore, was to identify, assemble, and produce a regional-scale digital water resource database. This database has brought together information on climate, water quality, water quantity, servicing infrastructure, land use, and public opinion from diverse sources. This information has been reformatted digitally to produce a comprehensive tool for managing the single most important natural resource in the area. This tool will become an invaluable resource within the study area for community planning; managing water and sewage infrastructure; and empowering municipalities, conservation agencies, rural organizations, and the public to take action, monitor change, and take charge of managing their water resources.

The database has been used in the study to analyze groundwater and surface water resources and to develop models for the management of land and water resources. These activities have consolidated the different data sets to provide a broad and detailed account of water resources in the study area. Some of these are described below.

A regional water budget was developed to model, in detail, the various components of the hydrologic cycle as they affect the quantity and quality of water across the study area. This approach provided the net amount of groundwater and surface water available for use and development on an annual basis. The use of geographic information system (GIS) and digital data allowed this analysis to be undertaken on a 30-m grid basis, which provides a a high level of resolution for a regional study. This information system is essential for water resources planning and the allocation of water resources for various users.

Surface water analysis was undertaken for both the quantity and quality of water. A key component of this work was the assembly and manipulation of an incredibly large volume of raw data into a useable and interpretable form. This activity was essential for the identification and analysis of long-term trends in stream flows and surface water quality on a watershed and subwatershed basis.

Groundwater was also a key component of the study, as over two-thirds of the population depend on groundwater for their water supply. The groundwater analysis developed a detailed characterization of groundwater resources across the region. Data from approximately 40,000 water well records were used to aid in the characterization. A groundwater system characterization at this level of detail was previously unavailable in the study area. The analysis identified aquifers with good potential for water supplies, identified critical recharge and discharge areas, identified the vulnerability to contamination of different aquifers, and highlighted the risks associated with water supplies from shallow overburden aquifers. The groundwater analysis provides a strong basis for development of land use and other policies for effective groundwater resources management on a local and regional basis.

The operation and maintenance of municipal water and sewage works is a responsibility of local municipalities. A major undertaking of the study was the development of a comprehensive database of all servicing infrastructure in the study area. This information had not been previously available in an aggregated form. Case study analysis revealed that, for municipalities facing critical capacity challenges, significant infrastructure expenditures will not be avoidable in the short-term. A detailed list of different technology alternatives for meeting some of the challenges identified by the infrastructure characterization was developed. The possible longer-term benefits of water conservation and demand management were also identified.

The characteristics of water demand were developed on a regional basis. The overall level of water demand from municipal and private sources was allocated between surface and groundwater sources. This information had not been previously available and is critical in planning for water resource management. This analysis identified significant gaps in the data on water use and demand and, consequently, the need to gain a better understanding of rural domestic water uses.

There was a strong emphasis on engaging the public in this study. A significant accomplishment was the universal mailing of two newsletters and a water resources survey to over 64,000 households and businesses in the study area. This survey provided important information for all aspects of the study in the areas of water quality and domestic treatment, types of water sources, and public attitudes towards water conservation and water resources management strategies.

Study Recommendations and Regional Water Resources Management Action Plans (Sections 10 and 11)

Most of the recommendations developed on the basis of the EOWRMS analyses can be summarized under the following three categories:

- Those that acknowledge the need for policies and guidelines
- Those that identify areas requiring additional data collection and monitoring
- Those that specify more detailed analysis requirements

Action plans provide a framework for implementation of the study recommendations.

The results of the characterization of regional water resources, land resources, and servicing infrastructure reinforce the need to develop and promote action plans to ensure that the quality and quantity of regional water and related land resources are maintained and possibly improved. A Regional Water Resources Management Strategy would comprise specific short-term and long-term action plans and must incorporate conservation, preservation, protection, development, and long-term stewardship if the strategy is to be successful.

The MOE is responsible for the management of water resources under the administration of the Ontario Water Resources Act. Other provincial ministries with interests in water management include (MNR), Agriculture, Food, and Rural Affairs (OMAFRA), and Municipal Affairs and Housing (MMAH). There are also numerous federal, provincial, and municipal policies, bylaws, Acts, and regulations related to our water resources (Environmental Commissioner of Ontario, 2000). The effectiveness of this shared responsibility has been questioned, and perhaps the need to complete a study such as the Eastern Ontario Water Resources Management Study demonstrates the lack of coordination and leadership in managing water resources across the province. As a result of the divided responsibility for the management of water resources, the responsibility for implementation of the action plans outlined in this report may be questioned. However, as it has been widely acknowledged that management of water resources must be on a watershed basis, consideration should be given to delegating the responsibility for leading the implementation of the action plans to a single agency. Such an organization would need to be supported by all levels of government, both financially and technically. A proposed program to initiate the implementation is presented following the recommended action plans.

On the basis of the characterization of regional water resources, land resources, and servicing infrastructure presented in the report, it is recommended that a Regional Water Resources Management Strategy for Eastern Ontario comprise preparation of the following principal action plans:

- Groundwater Resources Management Plan
- Surface Water Management Plan
- Water Efficiency Plan
- Wetland and Forest Preservation Plan
- Information Management and Distribution Plan
- Public Education and Awareness Plan

The report provides a detailed summary of the key tasks that would need to be completed in order to implement these action plans.

Program for Implementation (Section 10)

Implementation of the recommendations of this report will be carried out in a variety of ways. In some respects, implementation is already underway through the well and septic tank maintenance initiatives of the City of Ottawa and through the land use planning activities of the United Counties of SD&G. These initiatives, however, are only a start. The program for implementation needs a concerted effort by government, rural and other organizations, and the public in developing the tools to use water resources more wisely.

The following summarizes a proposed program for implementation of the study recommendations and action plans:

1. ***Adoption of the report***: This signifies both an acknowledgement as well as a commitment towards water resources management by community leaders. It may be advisable to seek the tacit approval or acceptance of the report by other key stakeholders (i.e. conservation agencies, area municipalities, provincial ministries).

2. ***Who does what:*** The various project partners have taken an active role in directing this study. The ongoing support of these individuals and organizations will be critical to the successful implementation of the study recommendations and action plans. Therefore, an initial implementation committee should be formed under the continued direction of the project partners. Such a committee would then be responsible for identifying and

recommending how the Regional Water Resources Management Strategy should be implemented, particularly what agency or organization should assume a leadership role in this long-term activity.

3. ***Prioritization***: Once a leadership role is assigned to an agency or organization, the activities of implementation should be prioritized in greater detail than is described in this report (i.e. determine which activities should be carried out immediately or in the short-term and which may be left until later). Invariably, there will be certain activities that will be carried out at the same time. Priorities will emerge and change as funding opportunities and strategic partnerships are explored and developed.

4. ***Scheduling and Resources***: Effective implementation implies the commitment of resources and establishing a timetable or schedule to carry out activities. The lead agency / organization would be responsible for developing a timetable and assembling the resources for implementation. The shared resources of the project partners could augment the technical capabilities of the lead agency.

5. ***Monitoring and Review***: The lead agency / organization should monitor the progress of implementation and review the results. This may lead to adjustments in the timing or measures being undertaken. An implementation committee may choose to meet at regular intervals (e.g. quarterly) to monitor progress. A review may be an annual activity by the project partners.

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Acknowledgements

A study as in-depth and complex as the EOWRMS requires the cooperative efforts of many individuals. The Consultant Team wishes to acknowledge the commitment of the members of the Steering Committees from the United Counties of Prescott and Russell; the United Counties of Stormont, Dundas and Glengarry; and the City of Ottawa; and the members of the Technical Advisory Group. The direction, advice, and support provided by the committees have been instrumental in the successful completion of the study tasks. The members of each committee are listed below.

United Counties of Prescott and Russell EOWRMS Steering Committee

- Chair, Michel Lalonde, Township of East Hawkesbury
- Carl Dubé, Project Manager, MHPM Project Managers
- Richard Lalonde, Prescott Federation of Agriculture
- Gérald Poupart, Russell Federation of Agriculture
- Pierre Glaude, Union des Cultivateurs franco-ontariens
- Claude Lafrance, South Nation Conservation
- Gaston Patenaude, Township of Russell and Warden (1999)
- Jean-Claude Trottier, Township of Alfred and Plantagenet
- Lucien Berniquez, Town of Hawkesbury and Warden (2000)
- Jean-Pierre Pierre, City of Clarence-Rockland and Warden (2001)
- Marc Clermont, P&R County Engineer
- Pierre Mercier, P&R County Planner
- Josée Thériault, P&R Staff
- Gary MacTavish, Ontario Ministry of Agriculture, Food and Rural Affairs
- Luc Brunet, Ontario Ministry of Agriculture, Food and Rural Affairs

United Counties of Stormont, Dundas and Glengarry EOWRMS Steering Committee

- Chair, Cameron Martel, SD&G County Council
- John Meek, Project Manager, Raisin Region Conservation Authority
- Bob Younger, Dundas Pork Producers
- Glenn Smirle, Dundas Dairy Producers
- Bill VanLoon Sr., Stormont Dairy Producers
- Tom Pasco, Glengarry Dairy Producers
- William Rutley, Stormont Cattlemen’s Association
- Ron MacDonell, Glengarry Cattlemen’s Association
- Keith Seguin, Stormont Soil and Crop Improvement Association
- John Roosendaal, Dundas Soil and Crop Improvement Association
- Lyall MacLachlan, Glengarry Soil and Crop Improvement Association
- Tom Anderegg, Stormont Federation of Agriculture
- Leo Loughlin, Dundas Federation of Agriculture

– William Hagen, Glengarry Federation of Agriculture
– Brian Vandenburg, Christian Farmers Federation of Ontario
– Johnny Whitteker, South Nation Conservation
– Andy Code, Raisin Region Conservation Authority
– Gary McTavish, Ontario Ministry of Agriculture, Food and Rural Affairs
– Elaine Kennedy, Resource Stewardship S.D.&G.
– Floyd Dingwall, Township of North Stormont
– Randy Moke, Township of South Stormont
– Roger Cole, Township of North Dundas
– Ramon Casselman, Township of South Dundas
– Bill Franklin, Township of North Glengarry
– Marcel Lapierre, Township of South Glengarry

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– Brian Stratton *, Project Manager / Chair, Region of Ottawa-Carleton
– Sue Murphy *, Region of Ottawa-Carleton
– Moira Winch, Township of Osgoode
– Gord Pratt *, Township of Osgoode
– Steven Boyle *, City of Cumberland
– Larry Morrison *, City of Gloucester
– Philip Huntley *, City of Gloucester
– Ian Jarvis, Agriculture and Agi-Food Canada
– Mezmure Haile-Meskale, Rideau Valley Conservation Authority
– Mary-Ann Wilson, South Nation Conservation
– Dennis O'Grady, South Nation Conservation
– Gerald Van Der Linden, Ottawa-Carleton Region Federation of Agriculture
– Carl Dubé, MHPM Project Managers

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– Pierre Mercier, P&R County Planner
– Kay Stone, SD&G County Planner
– Brian Stratton, City of Ottawa
– Mary-Ann Wilson, South Nation Conservation
– Dennis O’Grady, South Nation Conservation
– Andy Code, Raisin Region Conservation Authority
– John Meek, Raisin Region Conservation Authority
– Gary McTavish, Ontario Ministry of Agriculture, Food and Rural Affairs

- Clyde Hammond, Ministry of Environment
- Bob Holland, Ministry of Environment
- Anne Bendig, Ministry of Natural Resources
- Sandy Hay, Leeds & Grenville County Planner
- Carl Dubé, MHPM Project Managers
- Michel Robin, University of Ottawa

Consultant Team

The Consultant Team for the Eastern Ontario Water Resources Management Study comprised a number of talented individuals, encompassing a wide variety of technical expertise. The consulting firms and task leaders are listed below.

Prime Consultant

- **CH2M HILL Canada Limited**
  Ottawa, ON
  Bill Banks, Project Manager and Groundwater Analysis
  Scott Duff, Rural Land Use Planning and Demonstration Projects
  Tom Mahood, Surface Water Quality Analysis and Servicing Alternatives

Subconsultants (listed in alphabetical order)

- **Fortin Environmental Economics**
  Guelph, ON
  Mike Fortin, Servicing Infrastructure Economics

- **GeoSolutions Consulting Inc.**
  Ottawa, ON
  Dave Branson, Geographic Information System

- **K. Bruce MacDonald Consulting**
  Teeswater, ON
  Bruce MacDonald, Soils and Agricultural Land Use

- **Neil A. Levac Engineering Ltd.**
  Rockland, ON
  Neil Levac, Servicing Infrastructure Survey

- **Paula Neice & Associates**
  Waterloo, ON
  Paula Neice, Focus Group Facilitator

- **Tunnock Consulting Ltd.**
  North Bay, ON
  Glenn Tunnock, Public Consultation

- **Waterloo Hydrogeologic, Inc.**
  Waterloo, ON
  Paul Martin, Groundwater Analysis
  Daron Abbey, Geographic Information System

- **XCG Consultants Ltd.**
  Kingston, ON
  Harold Chard, Surface Water Quantity Analysis

Public Participation

The Consultant Team appreciates the time and input citizens provided throughout the public consultation activities (e.g. water resources survey, open houses, focus groups, organization meetings, and public meetings). Their contributions helped develop the proposed action plans that are expected to form the basis for the implementation of an Eastern Ontario Water Resources Management Strategy.

1. Introduction

Every drop of water is precious. "Humans can live for a month without food, but will die in less than a week without water" (de Villiers, 1999). Our water resources are finite and are irreplaceable. If we contaminate our water supply, the consequences will be costly. Within the South Nation River and Raisin Region watersheds, the principal study area for the Eastern Ontario Water Resources Management Study (EOWRMS) (Figure 1-1), the quantity of water is the same today as it was centuries ago. However, the quality of surface water, in particular, has significantly decreased. And while the quantity of precipitation currently continues to be sufficient to replenish the surface water and groundwater resources of Eastern Ontario and to meet current demands, vast quantities of water are not readily available in all areas at all times of the year. The future prosperity of Eastern Ontario will therefore depend on the prudent management of these water resources.

Many communities in Ontario are taking precautions to provide their residents with a safe water supply. In fact, the province has introduced a new regulation to ensure that Ontarians will have safe drinking water[1]. In Eastern Ontario, a study was initiated in the fall of 1999 to develop a database and prepare action plans to manage the quality and quantity of the water resources in the South Nation and the Raisin Region watersheds. The action plans will help communities to make decisions on where growth and settlement can be supported by safe water resources and what infrastructure may be needed to resolve concerns with water quality and quantity. This report provides the methodology, detailed findings, and recommendations from the EOWRMS.

The study partners are indicative of the broad interest in this study. They include the federal, provincial, and municipal levels of government; the agricultural community; rural organizations; and other agencies. At the municipal level, the key partners are the United Counties of Prescott and Russell (P&R); the United Counties of Stormont, Dundas, and Glengarry (SD&G); and the City of Ottawa.[2] The Ministry of the Environment (MOE) is the project's major funding organization and provincial partner. The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) is the other key provincial partner. The Raisin Region Conservation Authority (RRCA) and South Nation Conservation (SNC) are also major partners to the study and have provided funding and in-kind contributions of technical staff and project management resources. Agriculture and Agri-Food Canada is the principal federal partner and repository for the geographic information base that was used and expanded as part of the study.

Steering committees were appointed to represent each of the two county governments and the City of Ottawa. A Technical Advisory Group (TAG) assisted these committees. Members of the committees and TAG included government as well as many other study partners including:

- Beef Producers

[1] Drinking Water Protection Regulation 459/00 was enacted in August 2000.

[2] The Region of Ottawa-Carleton was restructured as the City of Ottawa effective January 1, 2001.

- Christian Farmers Federation of Ontario
- Dairy Producers
- Ontario Federation of Agriculture
- Ontario Soil and Crop Improvement Association
- Pork Producers
- Resource Stewardship SD&G
- South Nation Conservation
- Raisin Region Conservation Authority

Members of these committees are listed in the acknowledgements.

Community representatives were also participants on the committees and provided a linkage to the largest interest of all, approximately 66,000 homeowners and businesses that reside in the study area.

Early in the study, a mission statement was drafted. This statement embodies the goal of this study as well as sets the tone for what the partners of the study would like to achieve:

Our Mission

"Working with Eastern Ontarians to develop a common understanding of regional resource issues and a strategy to use comprehensive information and analysis to manage these resources for sustainable development."

The objectives of the EOWRMS stem from the mission statement:

- **Objective 1**: Develop a database and geographic information system (GIS) on the state of water resources and servicing infrastructure within the study area.
- **Objective 2**: Develop data management protocols to ensure the database is properly maintained and updated.
- **Objective 3**: Assess the capability of key areas to potentially support development on private services.
- **Objective 4**: Identify potential cost-effective servicing alternatives on a regional basis.
- **Objective 5**: Develop community demonstration projects that provide integrated solutions to water resource issues on a local/regional basis.
- **Objective 6**: Develop and promote tools and action plans to protect the quality and quantity of regional water and related land resources.

Implicit to the first objective is the fact that a large body of information already exists. Many of the potential solutions to the stewardship of the water resources in the study area will evolve from use of this information. The vision of the study partners was to collect and organize available information into a digital format that communities could use as a tool in making decisions on infrastructure and community planning. All of the other objectives of the study are based on this primary objective. The database is a building block that must not only be maintained, hence the need for data management protocols, but must be added to as new information becomes available.

1.2 Interpretation

The question of level of detail (scale) is an important consideration in interpreting the information, and particularly the report maps.

The EOWRMS is a regional-level study based largely on the collection, manipulation, and updating of existing information and data. As such, the data were available at different scales (level of detail). The scale at which data is collected helps describe and determine the accuracy that can be associated with a given piece of information.

A map is a representation of the real world. Table 1.1 illustrates the effect of map scale on defining the accuracy of a line or an area.

TABLE 1.1
SCALE VERSUS ACTUAL MEASUREMENTS

Map Scale	Real World Width of a 1-mm Line on the Map	Map Scale	Real World Size of a 1-cm Square on the Map
1:10,000	10 m	1:10,000	1 ha
1:50,000	50 m	1:50,000	25 ha
1:250,000	250 m	1:250,000	625 ha
1:500,000	500 m	1:500,000	2,500 ha

The report maps are presented at a scale of 1:500,000. Therefore, at a minimum, a 1-mm line is accurate to within 0.5 km and a 1-cm square is accurate to within 2,500 ha. This level of detail is not appropriate for site-specific interpretation, but provides a reasonable scale for regional-level analysis.

The map scale is relevant to data displayed as a single thematic layer. As multiple layers are combined for interpretation or modelling, uncertainty introduced by different scales associated with additional data layers increases.

1.3 Report Organization

The purpose of this report is to, firstly, summarize the scope of information that exists and limitations to the database. This is organized by topic (i.e. surface water, groundwater, land use, etc.). From this point, the major task was to interpret and analyze the information to determine the state of water resources in the study area. With this understanding, the report then sets out the key findings and their relevance to water resources management on a regional basis. Finally, the report provides a comprehensive series of recommendations and proposed action plans. These are intended to provide guidance to the users of the report in developing a regional water resources management strategy. The report also incorporates the results of the public consultation process and the significance of this process to the findings and recommendations. Supporting material for individual sections are found in appendixes. All figures have been assembled in a separate document

1.4 Audience

Because everyone in a community has a responsibility for the wise use of our water resources, such as individual property owners and the municipal government, this report may have many users. Primary users are the county governments and the City of Ottawa. They are expected to use the report and information base in the preparation of Official Plan policies for water resources management and in planning for new, or improvements to, existing communal water and sewer systems. The province will be a user in its advisory or regulatory role, such as in the issuing of water-taking permits, managing the resource, or approving and funding infrastructure. The private sector will be a user in the application of information to development proposals or by homeowners and businesses in the maintenance of private wells and sewage disposal systems. The agricultural community can use the information in modifying or improving farm practices, such as placing manure storage facilities. Conservation agencies can use the information in the management of the watershed. The information base may also be used in the preparation of educational materials for a wide audience (e.g. students, homeowners, elected officials) or as a basis for demonstration programs such as well abandonment, flow monitoring, etc. Whoever the user, an objective of the report is to raise the awareness of agencies and the public on the needs for, and benefits of, managing the quality and quantity of water resources in Eastern Ontario.

2. Database Compilation

This section of the report specifically addresses data compilation and metadata standards. The compilation of a comprehensive database relevant to water resources in Eastern Ontario is a major product of this study and forms the basis for the water resources analysis that is presented in Sections 3 to 7.

2.1 Overview

Phase 1 of the Eastern Ontario Water Resources Management Study (EOWRMS) dealt with information development to provide a regional context and information base on water resources. Guiding principles for the assembly of the information base were:

- It was based on existing information (there was no provision within the study to collect new data).
- The information should be available consistently for the entire region.
- The information should be sufficiently detailed to support analysis and interpretation at a notional scale of 1:50,000.

In support of the information base, database compilation has proceeded in two phases:

- Phase 1A, which focussed on defining information needs, identifying existing information and sources, reviewing literature, and defining information gaps (CH2M Gore & Storrie Limited, 1999 and M.S. Thompson & Associates Limited, 1999).
- Phase 1B, which deals with obtaining copies of the information, assembling the various layers of information into a consistent region-wide coverage, identifying sources of information to fill essential gaps, and obtaining these data.

This section documents activities carried out to meet the requirements of Phase 1B and describes the information collected for analysis, the gaps filled, the metadata updated, and the state of the geographic information system (GIS). The other Phase 1B deliverable – public consultation results – is discussed in Section 8.

2.2 Information Collected

Agriculture and Agri-Food Canada (AAFC) coordinated the collection of information from AAFC [including soils and Census of Agriculture (CoA) data, Landsat imagery digital air photos], Ontario Ministry of Natural Resources (MNR) (layers from the Natural Resource Values Information System (NRVIS)[1] database), and federal and provincial geological surveys. The types of information collected and assembled for the region from these sources are summarized in Table 2.1. The type of information reflects the information needs as identified in Phase 1A and in several cases, a layer of information contains more than one type of information.

[1] NRVIS has replaced the former Ontario Base Map (OBM) database

TABLE 2.1
AAFC DATA COLLECTION AND COMPILATION

Type of Information	Data Manipulation by Consultant Team	Comments
NRVIS: selected layers		
Forest type		As classified by MNR from NRVIS
Topography		Contours from NRVIS
Surface water bodies		NRVIS drainage layer
County road system		Centrelines from NRVIS – not classified
Municipal road system		Centrelines from OBM – not classified
Digital elevation data		Layer in NRVIS
Soils: separate datasets received for P&R, SD&G, Ottawa, Gloucester, and Grenville	A combined coverage was prepared for P&R, SD&G, and Ottawa. Gloucester and Grenville were not included (data not consistent)	
Soil characteristics	Required linkage to soil map covers	Gaps in Ontario soil names and layer files
Canada Land Inventory: Capability for agriculture		Part of soils map database
Nature and extent of subsurface drainage	Separate maps were combined for study area	
Physiography		Supplied in hard copy
Quaternary geology maps	Combined coverage prepared	Correlation between map sheets required
Bedrock geology maps		Remain as individual maps
Floodline mapping of existing modelled streams and public information maps		Separate cover for each client
Land cover/agricultural land use		Classified Landsat grid
Aerial photography (digital)		Gap in N. Prescott
CoA 1996, EA group level	Polygon map was gridded to combine with other data layers	
Cropping practices/rotations		Layer in CoA
Tillage practices		Layer in CoA
Herbicide/pesticide use		Layer in CoA
Fertilizer use		Layer in CoA
Livestock information		Layer in CoA
Number and extent of environmental farm plans		Number by county obtained in hard copy
Subdivision approval hydrogeology data		Report form only

Notes:

NRVIS = Natural Resource Values Information System
P&R = Prescott and Russell
SD&G = Stormont, Dundas and Glengarry
EA = Enumeration Area

2.2.1 Information Gaps Filled

For study data not identified and supplied by AAFC, the consultant team identified possible sources for the outstanding data layers identified as "needs" and approached the custodians of the data directly. As a result, most of the gaps identified in Phase 1A were filled. During the course of the information application and analysis phases, the consultant team identified additional information requirements. Table 2.2 summarizes data layers obtained both to satisfy the information needs as defined in Phase 1A and also the additional information needs identified by the consultant team during the regional water resources management analysis.

TABLE 2.2
CONSULTANT TEAM DATA COLLECTION AND COMPILATION TO COMPLETE INFORMATION NEEDS AND CONDUCT ANALYSIS

Type of Information	Action Required by Consultant Team	Comment
Aggregate Resource Mapping	Data obtained from MNDM	
Climate Records		Data purchased from EC
Watershed and subwatershed physical characteristics	Register to base map	Requested from SNC and RRCA
Stream flow data	Link to base map	From Water Survey of Canada
Surface water quality	Station locations required and linked to base map	Data from Drinking Water Surveillance Program (DWSP), the Clean Up Rural Beaches Program (CURB), the Provincial Water Quality Monitoring Network (PWQMN), and the South Nation River Conservation Authority
Groundwater quality		Groundwater quality from EC
Stream assimilative capacity	Relevant water quality data linked to base map	
Water well records	Quality assessment; locations estimated from legal location	Data from MOE: • Primary source of regional geologic and hydrogeologic information. • Location and elevation of all registered water wells. • Lithology information over the depth of the well (i.e. 5 m of gravel, and 3 m of clay). Used to develop regional geologic/hydrogeologic maps. • Static water levels for groundwater flow mapping. • Well details including depth of water-bearing zones. • Well construction details such as depth of casing and recommended pumping rate
Permits to Take Water		MOE
Groundwater level monitoring		MOE water well database
Location of potential point and non-point sources of contamination	Locations required to register to base	Waste inventory data from MOE as a spreadsheet
Communal groundwater drinking water systems	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team
Communal surface water drinking water systems	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team

TABLE 2.2
CONSULTANT TEAM DATA COLLECTION AND COMPILATION TO COMPLETE INFORMATION NEEDS AND CONDUCT ANALYSIS

Type of Information	Action Required by Consultant Team	Comment
Regional drinking water systems	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team
Industrial water usage	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team
Storm sewer systems	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team
Storm water management facilities	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team
Subsurface sewage disposal systems	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team
Communal sanitary sewer collection systems	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team
Communal sanitary sewer treatment systems	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team
Sewage and water treatment plant uncommitted capacity	Analyzed results from 26 municipalities	Infrastructure survey conducted by EOWRMS consultant team
Official plans		
1996 population census	Purchased by consultant team	Urban and rural population estimates by EA
Water Resources Survey	Prepared by consultant team and sent to more than 64,000 addresses; more than 5,000 responses received, which were collated and analyzed.	Nature and extent of water supply and septic systems Perceptions and attitudes of citizens

Notes:

MNDM = Ministry of Northern Development and Mines
EC = Environment Canada
SNC = South Nation Conservation
RRCA = Raisin Region Conservation Authority

The majority of the data collected was obtained from secondary sources as existing information. The consultant team also collected some primary data: the water resources survey and the servicing infrastructure survey. These data are discussed in more detail below.

2.3 Water Resources Survey

2.3.1 Information Collected

In April 2000, a water resources survey was sent to more than 64,000 mailing addresses across the EOWRMS study area. The purpose of the survey was to collect and analyze:

- Data on the nature, extent, and use of water supply and septic systems in the area
- Baseline perceptions and attitudes of citizens' concerns and experiences with local water quality and quantity
- Citizens' opinions regarding a range of measures for water conservation and water quality / quantity improvement.
- Citizens' preferences for future contact and consultation during the remainder of the study

2.3.2 Potential Limitations or Biases

The potential limitations and biases of this data are common to most data obtained from mail-back questionnaires and can include non-representation of returned questionnaires associated with bulk-mail delivery, inaccuracies / incompleteness of the mailing address database, and the differences between the views of respondents and non-respondents. For example, the nature of the bulk-mailing process resulted in a portion of residents on the fringe of Cornwall not receiving questionnaires. A pre-paid return envelope was enclosed with the questionnaire to minimize non-response bias.

2.3.3 Assumptions

The water resources survey was not conducted on a sampling basis. It was designed to survey the entire population of households and business in the study area as defined by mailing addresses. More than 5,000 responses were received (eight percent). For the purposes of this regional study, the responses are assumed to be adequately representative of the population.

2.3.4 Information Gaps Filled

Historically, water resource planning has been done locally, or in some cases, on a watershed basis coordinated through conservation authorities. The water resources survey provides regional:

- Data on the nature and extent of water supply and septic system in the area
- Baseline perceptions and attitudes of citizens' concerns and experiences with local water quality and quantity
- Citizens' opinions regarding a range of measures for water conservation and water quality / quantity improvement.

This data, which has not been available previously, has been used to characterize the nature and extent of water resource issues and water use in the study. It will also be valuable as a baseline to measure the effect of measures and practices recommended of this study as they are implemented over time. Results of this survey are outlined throughout this report. A copy of the questionnaire is located in Appendix A.

2.4 Servicing Infrastructure Survey

2.4.1 Information Collected

In January 2000, a servicing infrastructure survey was sent to all municipalities or authorities in the study area responsible for water and wastewater infrastructure.

The purpose of the survey was to collect detailed information to characterize existing servicing infrastructure for surface and groundwater supply and distribution systems; wastewater collection, treatment, and discharge systems; and private systems. Information was collected for the following categories of infrastructure:

- Water Supply
- Distribution System
    - General Information
    - Water Mains
    - Booster Stations
  - Communal Groundwater Systems
  - Communal Surface Water Systems
  - Private Wells
  - Other Water Supply Systems

- Wastewater
  - Collection System
    - General Information
    - Sewers
    - Pumping Stations
    - Force Mains
  - Wastewater Treatment Plants
  - Lagoons
  - Recirculating Sand Filters
  - Communal Septic Systems
  - Private Septic Systems
  - No Treatment
  - Other Waste Treatment System

Types of data collected include age, construction, capacity, flows, serviced population, maintenance, etc. This level of data has not been previously available on a regional basis in a single database. The information is available in a digital database (Access format) and spreadsheet format. Complete versions of the questionnaires are located in Appendix A.

Data was collected for the following locations:

Prescott and Russell		
Rockland	Township of West Hawkesbury	Village of L'Original
Forest Park	Ste. Anne-de-Prescott	St. Eugene
Embrun	Clarence Point	St. Isidore
Town of Hawkesbury	Limoges	Lefaivre
Vancleek Hill	Township of Longueil	Alfred
Chute-a-Blondeau	Hammond	Wendover
Casselman	Bourget	Longueuil
Clarence Creek	Fournier	Cheney
St. Albert	Curran	St.-Pascal-Baylon
Russell		

Stormont, Dundas and Glengarry		
Moose Creek	Summerstown	Newington
Glen Walter	St. Raphael	Dalkeith
Winchester	Martintown	Osnabruck Centre
Alexandria	Williamstown	Lunenburg
Williamsburg	Morrisburg	Glen Valley
Long Sault	Ingleside	Bainesville,
Crysler	Lancaster	Redwood Estates
Green Valley	Apple Hill	Curry Hill
Chesterville	Iroquois	Glen Robertson
Maxville	Rosedale Terrace	Finch
Greenfield	St. Andrews West	
City of Ottawa		
Gloucester	Vars	Greely
Orleans	Marionville	Notre-Dame des Champs
Osgoode	Sarsfield	South Gloucester
Vernon	Navan	Carlsbad Springs
Cumberland	Metcalfe	

2.4.2 Potential Limitations or Biases

Returned surveys were verified for internal consistency. In cases where entries did not match or incorrect units or erroneous information appeared to have been provided, verification was sought from the respondents. Verification was not received in all cases. Despite the possible limitation, we have assumed that all data is accurate and reflective of conditions when the survey was completed. It is likely that conditions in any particular municipality may have changed since the data was collected.

Although the EOWRMS team's goal was to obtain all data layers identified in the information needs section of Phase 1A, some data were not available (Table 2.3).

TABLE 2.3
INFORMATION GAPS

Information Type	Comment
Classified wetlands and provincially significant wetlands	These data have recently become available. The data can now be used to delineate areas of wetland within the context of other land uses in the study area. They would not be expected to have significant effect on the regional water budget because groundwater analysis has defined areas of discharge and surficial geology has indicated areas of restricted recharge.
Riparian habitat cover	Not available – under revision by NMR
Nature and extent of conservation practices and BMPs	No existing data source identified – problems with confidentiality

Note:

BMPs = Best Management Practices

2.5 Metadata Updated

Metadata is the background information that describes the source, quality, location, and other important characteristics of the data. In Phase 1A of EOWRMS, metadata reports were prepared by consultants and submitted to the United County clients (P&R and SD&G). During Phase 1B, 2, and 3, various activities have altered the metadata reports submitted in Phase 1A. Consequently, a revised metadata table is required to accompany the compiled information base.

As with the metadata table for Phase 1A, the revised metadata table were submitted in digital form and were compiled in accordance with the “Content Standards for Digital Geospatial Metadata” provided by AAFC. In addition to the standard items identified by AAFC as required for metadata documentation, the EOWRMS metadata contain a record number for cross-reference to Tables 2.1 and 2.2 as well as a description of the type of the metadata record. There are four possible classes for this item:

The metadata record is unaltered from Phase 1A. The associated dataset was adequately described in the Phase 1A assessment. Data layers not used for any specific analysis generally receive this designation. Designated as “Phase 1A.”

The basic content of the dataset is unchanged; however, the format and/or coverage area has been updated to account for the work done by the consultant team (e.g. tile drainage coverage for P&R, SD&G, and City of Ottawa were supplied as separate datasets but have been merged to provide a single seamless layer for the study area). Designated as “Basic EOWRMS data.”

Layers have been added through the initiative of the consultant team. In most cases, the accompanying metadata will not be available from the agency supplying the data and the metadata record was compiled by the consultant team; therefore, there is caution in relying on the accuracy of the metadata information. Designated as “prepared by consultants.”

In a limited number of cases, data layers, representing interim data derived from interpretations of one or more of the basic data layers, are stored in the GIS. These layers are retained for convenience because they are likely to be used for additional analysis. The metadata associated with these layers has been compiled by the consultant team and consists of the basic information on format and area covered. The content is described by indicating the layers from which it was derived and the interpretation used to derive the layer. Designated as “Interim Data Layer.”

Table 2.4 provides a sample of the items of information documented in the metadata records. Field code definitions in this table can be found at http://sis.agr.gc.ca/cansis/nsdb/detailed/on/webpages/eowrms/N_metadata_descriptions.htm

TABLE 2.4
SAMPLE METADATA RECORD

Record #	1
Type	Basic EOWRMS data
Metadata layer entered by	AAFC
Origin	AAFC
Pubdate	19990101
Title	Tiledrain_1
Edition	1
Geoform	map
Pubplace	Ottawa, ON and Guelph, ON
Publish	AAFC
Onlink	None
abstract	This cover shows the location of tile drains in the counties of P&R, SD&G, and Ottawa. Tile drains are matched to lot and concession.
purpose	Show the location of systematic and random tile drainage. Tile drains affect the hydrologic cycle and tend to shunt water to streams quickly, without the natural filtering and ameliorating action of the soil. By removing excess water, they also permit farmers to grow crops on otherwise poorly drained fields.
supplinfo	The tile drains were digitized from 1:25,000 blueprints. These blueprint maps were created from an assortment of tile drainage information, and their quality and accuracy is somewhat suspect. Comparison of tile drain with geo-referenced air photos showed that the drains often extend beyond the edge of fields into woodlots or other non-agricultural areas. This highlights the inaccuracy and poor data quality of this coverage. AAFC and OMAFRA are currently discussing an upgrade of the tile drain data using the 1:10,000 OBM mapping and geo-referenced 1:50,000 air photos. The two counties were digitized separately and then map-joined, which required some adjustment of the .pat files; however, no change was made to the attributes or topology.
scale	1:50,000
begdate	199712??
enddate	19990101
current	Ground condition
progress	In progress
update	Unknown
westbc	421494
eastbc	551438
northbc	5053926
southbc	4940551
themekey	Hydrology, soils, land use, or land cover
themeky2	Tile drain, tile drainage, soils, hydrology
themekt	None
placekey	P&R, SD&G, Ottawa, Grenville
placekt	None
accconst	None
useconst	None
browsen	n/a
browsed	n/a
browset	

TABLE 2.4
SAMPLE METADATA RECORD

native	ARC/INFO v7 for HP UNIX. On the hp260 at /home/guelph/gis-data/drains/tiledrain_1
logic	Checks on the original cover or the original data are unknown. However the accuracy of the data itself is suspect (as noted in supplemental information). This coverage has been built, checked for node errors and label errors, and visually inspected. Twenty-two polygons have no labels, while two polygons have multiple labels. Updates of this coverage are planned so no corrections were made.
complete	None
horizpar	Unknown, but the tile drain locations are known to be inaccurate or somewhat vague.
horizpav	Unknown
horizpae	Unknown
vertaccr	n/a
vertaccv	n/a
vertacce	n/a
procdesc	Original tolerances are unknown; however, this coverage was clipped and built with no adjustment of the originals.
procdate	19990201
direct	Point
latres	
longres	
geogunit	
system	Planar
gridsysn	Universal Transverse Mercator
utmzone	18
spcszone	
horizdn	North American Datum of 1927á
dcntorg	AAFC
dcntpos	Ian Jarvis
daddrtype	Mailing and physical address
daddress	Neatby Building, 960 Carling Ave.
dcity	Ottawa
dstate	ON
dpostal	K1A 0C6
dcountry	Canada
dcntvoice	613-759-1477
dcntfax	613-759-1924
dcntemail	Jarvisi@em.agr.ca
resdesc	Tiledrain_1
distliab	None
digform	ARC/INFO Export File (.e00)á
networkr	n/a
fees	None
metd	19990305

Note:
OMAFRA = Ontario Ministry of Agriculture, Food and Rural Affairs

2.6 GIS/Database Status

The geographic data used to evaluate the regional water budget, land use, and groundwater characteristics were managed using a Geographic Information System (GIS). AAFC and the consultants compiled the geographic databases used in the analysis. As data were acquired, they were combined with other geographic data in a common database.

The analysis of the GIS database has resulted in numerous interim or derivative data layers that represent the water budget, groundwater, and land use activities in the study area. The water budget analysis was undertaken using source data from the satellite land classification, topographic data, soil data, tile drainage mapping, surficial geology, ecodistrict data, and digital elevation model. From this data, a regional water balance model was developed and calibrated against actual stream flow measurements from 11 subwatersheds in the study area. The components of this model have been presented in maps at the public open houses and in this report. Moreover, the results of the water balance were used for further analysis of the land use and groundwater characteristics.

The groundwater analysis was conducted using data derived from the water budget analysis and the MOE water well records. Aquifer extents and connectivity were mapped by interpreted aquifer thicknesses and locations from the MOE water well records. Aquifer properties and recharge to the Contact Zone Aquifer were derived from the aquifer extents mapping, the water budget analysis, and the water well records. Aquifer capability and vulnerability were derived from a number of intermediate groundwater analyses. All of this data, excluding the aquifer capability, is mapped using a 25- to 50-m grid cell size and were prepared as Vertical Mapper grid files. The capability mapping and interim line and point data was prepared as MapInfo tables.

The land use analysis was conducted using data derived from the water budget analysis and agriculture census survey results. The subwatershed zones calculated from the elevation model were used to represent much of the land use analysis. The agricultural land areas derived from the satellite imagery provided a measure of the agricultural land within the surface and groundwater subwatersheds. The census data was aggregated at the subwatershed level and combined with the agriculture lands and drainage network data to provide a characterization of agriculture intensity within the study area. The results of this analysis have been summarized at both the surface and groundwater subwatershed levels. The GIS data consists of numerous tables calculated from the mentioned data sources. The results have been prepared as ESRI shape files.

The spatial modelling was completed using ESRI Spatial Analyst and Northwood Vertical Mapper (late exchange protocols were developed to ensure error-free transfer between GIS applications). Both of these software products represent geographic data in grid formats and the grids are transferable from one product to the other. The data that has been aggregated to the subwatershed level (surface and groundwater) is represented in a polygonal vector format (i.e. ESRI shape files). All of the data, except for the MOE water well records, have been stored in latitude/longitude geographic coordinates and projected to the Universal Transverse Mercator projection (Zone 18, NAD27). The MOE water well records are stored in Universal Transverse Mercator projection (Zone 18, NAD27). ArcExport format has been used to transfer data between AAFC and the consultants.

The digital databases, including relevant GIS layers, are a deliverable under this contract. These data products were delivered to AAFC at the completion of the study. AAFC had the responsibility for ensuring transfer of the data files to the EOWRMS project partners.

3. Regional Water Budget

This section of the report specifically addresses the development of a regional water budget model for Eastern Ontario. Specific analyses of surface water, groundwater, land use and servicing infrastructure are addressed in Sections 4, 5, 6, and 7, respectively.

3.1 Overview

The water (hydrological) cycle, shown in Figure 3-1[1], illustrates how water is continuously recycled. Water falls as precipitation, commonly referred to as rain or snow. Precipitation replenishes our lakes and rivers, which are called surface water. Part of the precipitation infiltrates the ground to become groundwater. Much of the precipitation is returned to the atmosphere through evaporation and transpiration (the combined term is evapotranspiration) to form clouds and precipitate once again.

The EOWRMS study carried out a detailed analysis of individual components of the hydrological cycle as they affect the quantity and quality of the water resources across the region (described later in this report). To set the stage for the detailed analysis a regional water budget (a general model of the complete hydrological cycle) was used to estimate the maximum amounts of water available for development and use. The first stage of this analysis is an estimate of the quantity of water available annually to replenish surface and groundwater resources. This Net Available Water quantity is the difference between the quantity of precipitation and the amount of water returned to the atmosphere through evaporation and transpiration. In the second stage of the regional water budget analysis a Partition Model was developed to estimate the allocation of water between surface and groundwater resources.

The regional water budget provides general estimates of:

- The quantity of water cycling through the study area (average annual precipitation)
- The quantity of water returned to the atmosphere by evapotranspiration (Figure 3-2)
- The quantity of water contributed annually to surface water resources (Figure 3-3)
- The quantity of water that contributes to groundwater resources (Figure 3-4)

These estimates show the upper limits of the quantities of water available for human use and consumption. In many cases water will be used and returned to the water resources (most frequently it will be returned to the surface water resource whether or not it has been drawn from surface or groundwater). Water, particularly surface water, may be used several times between the time it falls as rain and the time it evaporates or transpires back into the atmosphere. Frequently, factors other than water quantity limit its use or reuse. These factors include water quality, seasonality of flow and rate of flow through bedrock and geological deposits.

[1] All figures are located in the separate figures document.

The EOWRMS study area (South Nation River and Raisin River watersheds and subwatersheds and associated peripheral watersheds [see Figure 3-5]) covers an area of approximately 6,800 square kilometres. It receives an average of about 930 mm of precipitation annually. Based on the calculations of the regional water budget model, the fate of precipitation across the study area is as follows:

- Approximately 420 mm is returned to the atmosphere through evaporation and transpiration
- 510 mm of water is partitioned between the surface water drainage network (94 percent) and the deep groundwater reserves (6 percent)

In practical terms, these measurements indicate that every hectare of land in the study area contributes on average 5,100,000 litres of water annually to the water resources or the equivalent of 455,000 gal/acre.

Across the EOWRMS study area, the average annual contribution to the water resource (both surface and groundwater) amounts to almost 35 billion cubic meters (1,220 billion cubic feet). The current demand for domestic, industrial, and institutional uses is only a small fraction of the total annual contribution. These demands are discussed in more detail in Section 7. It is anticipated that the minimum base flow requirements to sustain aquatic and terrestrial habitat are also a small fraction of the total annual contribution.

3.2 Data Sources and Limitations

Precipitation data was obtained from AAFC at the URL:
http://res.agr.ca/CANSIS/NSDB/ECOSTRAT/DISTRICT/climate.html

The data provide consistent broad regional coverage but do not show any of the local or micro level variability. These measurements are available on a monthly basis, however, they were not appropriate to this level of analysis.

Evapotranspiration data were developed from:

- Land cover data was derived from landsat imagery interpreted by Agriculture and Agri-Food Canada (AAFC) and Ministry of Natural Resources (MNR) forestry data. The interpretation is based on 30 m pixels, while the classification was supervised it was not checked extensively in the field. The MNR data is from a different date than the imagery.
- Evapotranspiration estimates for agricultural land are based on the results of a computer model and are derived from a limited range of soil textures.
- Evapotranspiration estimates for non-agricultural land are based on published estimates of actual evapotranspiration rates (AET) for major biomes, vegetation subgroups and climatic zones. Research did not reveal the availability of AET values for the study area. Natural Resources Canada is involved in a project that will be developing AET estimates on a grid basis; however, data were not currently available for the study area (D. Mckenne, personal communication).
- The Ontario Soil Layer File and soil survey reports were used as a source for soil surface texture. The Ontario Soil Layer File does not contain records for all the soils identified in

the area. In some cases (e.g. Gloucester) the data linkages have not been provided to relate the soil map symbol to the soil layer information. Generally the texture is given in ranges and in cases where no reliable source for surface texture was available an average value was used.

- Net Water Available is derived by taking the difference between precipitation and evapotranspiration. It is based on data compiled over the EOWRMS area on a 30 m grid.

Data used to develop the partition model was derived from:

- The tile drainage data were mapped by Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and digitized by AAFC. They represent the information available at the time the manuscript maps were prepared and may not reflect more recent tile installations. In addition, the data may not reflect some areas that were tiled but not reported to OMAFRA.
- Surface drainage network data was obtained from MNR at a detailed level (1:10,000) and should provide a good representation of the actual network.
- Surficial geology data was taken from the published maps that cover the area. There are some discrepancies between the maps that were resolved by experts on the project to the highest degree of accuracy possible.
- The best available data on digital elevation was obtained from the MNR's Natural Resource Values Information System (NRVIS); however, the vertical resolution is not sufficient to be absolutely confident of either the slopes or the direction associated with the surface water system.
- Data concerning groundwater discharge areas was derived from the EOWRMS groundwater analysis (see Section 5).

3.3 Assumptions

The major assumption in the regional water budget is that, at a regional level, the components of the hydrologic cycle can be estimated from broad categories of data with sufficient accuracy to provide reasonable estimates of the net available quantity of water. For a long-term average, this assumption is probably fairly reasonable. It was also assumed that the expert decision rules can provide a reasonable procedure to partition the net available water between surface and groundwater resources. The regional water budget has been adjusted so that the overall quantities of water contributing to surface and groundwater resources are close to the best measurements or estimates. As such, it should provide realistic background information for the more detailed studies of specific components of the hydrologic cycle.

3.4 Approach and Methods

3.4.1 The Hydrologic Cycle

At the broadest level of generality, the hydrologic cycle (Figure 3-1) consists of four main components:

- Precipitation
- Evapotranspiration

- Surface water resources
- Groundwater resources

The regional water budget provides estimates of the quantity of water coming into the study area from precipitation (the main source), surface water and groundwater flow. These estimates were compared to actual measurements. The measurements used for comparison were stream gauge measurements obtained at subwatersheds across the study area and groundwater measurements based on well-log records.

The general equation describing water partitioning in the environment can be specified as follows:

$$P = ET + SW + GW + Loss$$

Where: P = Precipitation
ET = Evapotranspiration (a combined estimate of evaporation and actual transpiration)
SW = Runoff to surface water resources (includes overland flow, tile flow and base flow)
GW = Groundwater recharge (less base flow)
Loss = Unaccounted losses (includes errors and water consumption by human uses)

With the exception of ‘Loss’, each item in the above equation is estimated in the Regional Water Budget model. In the first stage of the analysis, estimates of ‘P’ and ‘ET’ are developed and used to estimate the quantity of water available to replenish surface and groundwater resources (Net Available Water Quantity). In the second stage of the regional water budget analysis, the net available water quantity is divided between surface and groundwater resources (Partition Model). Human use is discussed in detail in Section 7.

3.4.2 Net Available Water Quantity

There are many factors that influence precipitation, runoff, recharge and evapotranspiration; therefore, establishing a water budget for the study area is a complex process. The layers of information used to assess the regional water budget include: soils, geology, topography, distance from water courses, tile drainage, urban drainage, forest cover, wetlands, crops, water well records. The following sections describe the way these various kinds of information have been combined to form the regional water budget.

Precipitation was estimated from climate normals information. The climate information originated from point-based weather station data obtained from Environment Canada (1994). The 1961-1990 data for temperature and precipitation included only stations with averages based on more than 19 years of data. These point-based estimates have been generalized over the study region as part of a national study (Marshall et al., 1996). The national Eco-stratification study developed a series of nested levels of ecological generalization with linkages to existing federal and provincial databases. The Ecodistrict represents the third level of detail within this system and identifies areas within a physiographic region characterized by distinctive assemblages of relief, geology, landforms and soils, vegetation, water, fauna, and land use. For broad regional studies such as EOWRMS, the most detailed climatic data available is compiled at the Ecodistrict level. The database provides regional estimates of precipitation but does not describe local and micro-climatic variability.

Evapotranspiration refers to water moving back into the atmosphere through evaporation from the moist soil or the surface of water bodies and transpiration from plants. It is estimated directly by assigning average values to the various land cover classes across the study area. These land cover classes are determined primarily from the interpreted Landsat image that shows areas of agricultural land (corn, soybeans, cereals, hay, and pasture), bare soil, urban, water, and forest. The nature of the forest has been refined by combining the satellite imagery with forest cover data obtained from the MNR. The areas identified as forest on the satellite imagery have been subdivided into conifer, deciduous, mixed, open / sparse, and unclassed.

Evapotranspiration estimates for agricultural land have been calculated by Dr. R. de Jong, (personal communication, 1998). Dr. de Jong used the SWATRE model to estimate moisture use by four agricultural crop rotations (corn, soybeans, winter wheat; Grass – perennial forage, continuous corn, and potatoes and barley (as a representative short seasoned crop rotation). These rotations were modeled over 30 years of climate records for climate stations for coarse, medium, and fine textured soils. There were three stations relevant to the EOWRMS study (Ottawa CDA, Cornwall and Brockville PCC). The results showed that soil texture was the main factor determining evapotranspiration from agricultural crop rotaions. Evapotranspiration from agricultural crops shows considerable variation with soil texture (e.g. on average, 354 mm for Newburg loam, 287 mm for Brandon clay, and 217 mm for Fox sandy loam). Discussions with Dr. R. de Jong (personal communication, 2000) suggest that these variations with texture would be expected because of the differences in plant available water holding capacity with the various soil textures.

Surface textures for agricultural soils of Ontario were determined from the Ontario soil layer file and soil survey reports. These textures were compared to estimated available water holding capacity and the following textural groupings are suggested in order to provide estimates for evapotranspiration from agricultural land uses in the EOWRMS study area (Table 3.1).

TABLE 3.1
LAND COVER CLASSES AND CORRESPONDING EVAPOTRANSPIRATION VALUES

Land Cover Class	Evapotranspiration (mm/year)
Urban	150
Agricultural (coarse textured)	270
Agricultural (unclassed texture)	330, 334*
Open/Sparse forest	335
Agricultural (fine textured)	340
Agricultural (medium textured)	390
Forest –conifer	445
Forest – mixed	541
Forest – unclassed	577
Forest – deciduous	638
Water	640

Note: Where soil surface texture was not reliably available, an average value of 334 was used for soils in Gloucester and 330 for the rest of the study area.

Evapotranspiration values for the other land cover classes were estimated from published ranges of values (Rockström, et al., 1999) (Table 3.1). These values were verified against published data of potential evapotranspiration and were also modified during the calibration of the regional model to use values towards the high end of the published ranges.

Figure 3-2 shows the estimated evapotranspiration values across the EOWRMS area.

The net quantity of water required to replenish surface and groundwater resources was estimated as the difference between the values of precipitation and evapotranspiration.

3.4.3 Partition Model

The previous section describes the procedure used to estimate the quantity of water available annually on average to replenish surface and groundwater resources. A series of decision rules were developed by the consultant team and used to apportion the net available water between surface and groundwater resources. These rules are based on the proximity and degree of connection between the water resource and the source of the water and were also guided by previous work in the region (Ontario Ministry of the Environment, 1980). They provide approximate estimates only as the actual pathways and movement of water to surface and groundwater resources would require a much more complicated and detailed model than is possible at the level of the EOWRMS area and within the limitations of this project.

Excess water in tile-drained agricultural areas and urban areas will move directly into the surface drainage network. These areas were assigned the highest class for surface water contribution (98 percent). In most cases, excess water from land areas close to the surface drainage network will contribute to the surface water resource. The areas of relative proximity were defined using the analytical capability of the Geographic Information System (GIS) to 'buffer' land areas various distances away the surface drainage network. The distances chosen were 50 m, 50 – 200 m, 200 – 400 m, and greater than 400 m from the surface water system. The location and extent of the surface drainage network was provided at a high level of detail that showed not only the rivers, tributaries and streams but also the small creeks and ditches that would carry excess surface water only during peak periods.

The distance of 50 m was selected because, in the expert opinion of the consultant team hydrogeologists, most of the excess water would move to the surface water system. The distance of 200 m was selected because it represents the dimension of agricultural fields as traditionally surveyed. In recent times field size has tended to become larger; however, the 200 m distance was chosen to indicate the approximate distance where land management practices would likely be consistent and there was a good likelihood that excess water could move to the surface drainage system without encountering a physical barrier such as a fencerow. The distance of 400 m was selected as an approximation of the longest distance that surface water would likely flow directly from the land into the surface drainage system. Excess water at distances beyond 400 m from the surface drainage network would most likely infiltrate the soil. While there would be some contribution to base flow from water beyond 400 m, it is also likely to contribute to groundwater recharge. In the final version of the decision rules, the 400 m distance was not used; the effects of recharge potential estimated from surficial geology replaced rules associated with this distance.

In addition to the physical distance separating the land from the surface water system, two other surface properties were considered. These were slope of the land, which was estimated from the digital elevation model, and the nature of the upper overburden deposit, as indicated on the surficial geology maps. The surficial deposits were classed as ‘low’, ‘medium’ or ‘high’ with respect to groundwater recharge potential. Appendix B provides details of the groundwater recharge potential interpretation of surficial geology classes.

The rules derived for these data were as follows:

- Land within 50 m of the surface water system is assigned the partition class where 95 percent of the excess water contributes to the surface system
- Land with high recharge potential at a distance of greater than 50 m of the surface water system is assigned to the class where 80 percent of the excess water goes to the surface system
- Land with a low recharge potential at a distance of greater than 50 m of the surface water system is assigned to the partition class where 95 percent of the excess water contributes to the surface resource
- Land with a medium recharge potential within the distance 50-200 m of the surface water and a slope of greater than 2 percent is assigned to the class were 90 percent of the excess water goes to the surface system
- Land with a medium recharge potential in the 50-200 m distance with a slope of 2 percent or less is assigned to the 85 percent partition class
- Land with a medium recharge potential at a distance of 200 m or greater from the surface water system is assigned a to the class where 85 percent of the excess water contributes to the surface water resources

Based on the decision rules, the land base of the study area was divided into 5 classes based on an estimate of the destination of water in excess of evaporation and transpiration, which contributes to groundwater and surface water resources. Previous studies of water resources in the region have shown that surface water receives the largest portion of the net available water resource contribution. Consequently, the class values were heavily biased towards surface water contributions. The class designations range from 98, 95, 90, 85, and 80 percent of the water contributing to surface water resources; the remainder going to replenish groundwater resources. The use of five classes was deemed by the consultant team to be more than sufficient to characterize the partitioning given the range of values (80 to 98 percent) and the generality of the regional model.

An intermediate map was developed to define areas by partition class across the EOWRMS area. It was combined with the map showing net available water quantity to produce two maps; one showing estimated annual surface water contribution and the other showing estimated annual groundwater contribution.

A final modification was applied to these maps to account for groundwater discharge areas. In the course of the well-log analysis to characterize existing groundwater conditions, localized discharge areas were defined. These areas represent conditions of groundwater pressures and flows not directly related to conditions at the surface. This information was used to develop a map to show reduction in groundwater as a result of deep conditions that suggested groundwater discharge. The EOWRMS area was classified into five classes of recharge reduction (0, 25, 50, 75, and 100 percent). This map was used to modify the partition classes that had been developed based on decision rules related to surface characteristics.

The resultant maps for annual surface water contribution (Figure 3-3) and estimated annual groundwater contribution (Figure 3-4) are shown.

3.5 Characterization

The results of the regional water budget were checked against recorded data for stream flow at various subwatersheds across the region. Data were available for only a limited number of subwatersheds across the region and for these, the data were averaged for the same years as the budget model (1961-90). Table 3.2 shows a comparison between the modelled and measured. The agreement between the modelled estimates and actual measurements ranges from a 20 percent underestimation to an overestimation of 33 percent at Berwick. While this range is quite high it should be noted that there are many possible sources of error in both the modelled and measured values. For example, the modelled estimates are based on broad classes of land use and very generalized estimates of the amount of water, which infiltrates and moves to groundwater. The measured values are based limited numbers of stream guage measurements that may have missed some periods of extreme flow conditions. For several watersheds the length of time for actual estimates is limited and may provide a biased estimate compared to the average conditions. Small errors in the depth measured or in the shape of the stream channel can result in large errors in total flow estimates. In addition, the stream flow measurements are generally taken only during the period when the watercourse is thawed while the model is providing an annual estimate.

TABLE 3.2
COMPARISON BETWEEN MODELLED AND MEASURED SURFACE WATER FLOW FOR SELECTED EOWRMS SUBWATERSHEDS

Subwatershed	Code	Area (km^2)	Model Estimate of Mean (mm)	Total Contribution from Model (m^3/year)	Revised Average Total Annual Streamflow Observed (m^3/year) (1961-90)	No. of Years of Data	Model Compared to Observed Percent Difference
Spencerville	02LB007	212	381.2	7.25E+07	9.078E+07	30 years (1961–1990 incl.)	-20.1 percent
Heckston	02LB017	93	337.0	3.04E+07	2.699E+07	13 years (1978–1990 incl.)	12.6 percent
Chesterville	02LB009	1,133	420.3	4.79E+08	5.230E+08	3 years (1972–1974)	-8.3 percent
Russell	02LB006	428	437.2	1.98E+08	1.719E+08	23 years (1968–1990 incl.)	15.4 percent
Casselman	02LB013	2,352	447.4	1.09E+09	9.259E+08	12 years (1974, 1976 – 1986 incl.)	17.3 percent
Bourget	02LB008	354	426.4	1.70E+08	1.871E+08	14 years (1977–1990 incl.)	-9.2 percent
Plantagenet	02LB005	3,769	446.7	1.76E+09	1.369E+09	30 years (1961–1990 incl.)	28.6 percent
Berwick	02LB022	149	451.7	7.13E+07	5.344E+07	13 years (1977, 78, 1980 – 1990)	33.4 percent
Williamstown	02MC001	365	414.8	1.68E+08	1.605E+08	30 years (1961–1990 incl.)	4.9 percent
Glen Nevis	02MC026	134	423.7	6.23E+07	5.339E+07	7 years (1984–1990 incl.)	16.7 percent
Alexandria	02MC028	85	405.9	3.90E+07	3.068E+07	5 years (1986–1990 incl.)	27.0 percent
MEAN			**417.5**				

Note:
Watershed areas in this table do not necessarily match those provided by the Water Survey of Canada (WSC) as listed in Table 4.1 because they were calculated based on GIS data for the purposes of modelling components of the watershed and not necessarily the entire watershed area as represented in the WSC database.

In addition, the groundwater contribution had been previously modelled in regional studies. The calculated values from these studies were used to adjust the partition coefficients to provide realistic values.

3.6 Key Findings

The regional water budget provides estimates of the theoretical upper limits of water available for use and development. For the EOWRMS area the results of the regional water budget are summarized in Table 3.3.

TABLE 3.3
EOWRMS REGIONAL ESTIMATES OF THE FOUR MAIN COMPONENTS OF THE HYDROLOGIC CYCLE

Component	Mean (mm/yr)	Standard Deviation (mm/yr)	Minimum (mm/yr)	Maximum (mm/yr)	Range (mm/yr)
Precipitation	932.4	31.4	856.0	960.0	104.0
AET	422.6	144.5	150.0	640.0	490.0
Surface	478.8	146.6	172.8	810.0	637.2
Groundwater	31.4	28.5	0.0	160.0	160.0

Model Area: 6,800 km^2

The quantity of water available to replenish surface and groundwater resources is quite large, particularly when compared with the results of the water demand/consumption survey (Section 7). The regional water budget provides annual estimates of the quantities of water in the main components of the hydrologic cycle. However, a major constraint on the quantities of water available for use and development relate to the fact that much of the precipitation falls in the spring and early summer period, while most of the evapotranspiration occurs in summer. Therefore, the quantities of water available on a monthly or weekly basis will vary widely from the simple estimate obtained by distributing the water availability evenly over the year (see Section 4). This variation is particularly true of surface water resources that respond quickly and directly to patterns of rainfall and evapotranspiration. In addition, the difficulties introduced by seasonal flow variability, water quality, transmissivity, etc. will limit the quantities of water available reliably for use and development.

Most of the net available water contributes to the surface water resources, which suggests that water use and development based on groundwater resources is limited in the region. In the development of a regional water strategy, particular care should be taken to ensure the conservation and sustainability of groundwater resources and the protection of significant recharge areas.

The regional water budget provides a broad-scale estimate of the spatial distribution of the water resources. The maps of surface and groundwater contributions provide two layers of data for use in a multi-layer analysis to identify areas with development potential and to highlight areas of particular importance in sustaining the regional water resources.

Mapping of classified wetlands became available at the conclusion of this study. The data can now be used to delineate areas of wetland within the context of other land uses in the study area. The wetlands would not be expected to have significant impact on the regional water budget because the groundwater analysis has defined areas of discharge and recharge (refer to Section 5). The wetlands mapping is particularly useful in identifying areas of importance in sustaining the regional water resources. The regional map of wetlands is presented in Figure 3-6.

3.7 Relevance to Regional Water Strategy

The regional water budget provides estimates of the theoretical upper limits of water available for use and development. The more detailed analyses described in subsequent chapters identify factors that reduce the total quantity of an estimate that reflects amounts that are reliably available for use. The challenge of developing a water management strategy for this area, as with any region, is to identify water use and development activities that promote the sustainable use of a larger portion of the theoretical upper limit of supply. This strategy may involve the use of flow regulation to stabilize the surface flow variability. It will certainly involve the protection of significant groundwater recharge areas to ensure a continued supply of quality water. The regional water budget also provides a clear indication that water resources for the region (both surface and groundwater) are finite. While options for increased development can be based on using greater quantities of the potential water resources, much of the development will rely on more efficient use of the water currently available. Practices such as increased conservation and water use efficiency and the reduction of human and natural practices that impair water quality will contribute to the available water supply.

The regional water budget approach highlights the universal nature of the water resource. Just as in the ‘tragedy of the commons’ discussions, where the common pasture can support the production of livestock for a village up to the point at which the carrying capacity is exceeded, water resources (both surface and groundwater) belong to everyone in the region as a shared common resource. Each individual or community will normally use the resource within its capacity, but collectively the resource may be endangered when the level of use exceeds either the supply capacity or the ability for the water resource to assimilate contaminants. The spatial distribution of the annual contributions to surface and groundwater resources provides two layers in a multi-layer analysis to show areas where extra care is needed to preserve the quantity of the water resources. These layers primarily show areas that are important from the standpoint of water quantity, but when combined with other analysis, in particular, land use they also identify areas where water quality may be susceptible to impairment. The water budget model can also be used in an evaluation of minimum base flow requirements to support aquatic and terrestrial habitat once they are established.

3.8 Recommendations

While it is recognized that most elements of a regional water strategy involve more specific and detailed analysis, it is recommended that the regional water budget be used to:

1. Target areas within the EOWRMS region where additional care in development planning is needed and also where additional data collection and information may be required to support development. For example, the areas that show larger contributions to groundwater should have land use policies that protect groundwater quality, while

areas where contribution is primarily to surface water would benefit from programs that protect streambanks and buffer surface water from adjacent land uses.

2. Evaluate the kinds of programs, actions and costs that will best achieve the objectives of quantity and quality for water resources and identify who will benefit from improvements in the water resources. There will be cases where the major costs occur in one sector of society while the major benefits will accrue to another; for example, improving agricultural practices to maintain surface water quality by taking land out of production for stream buffers would prolong the functional life of a municipal water treatment facility. Planning activities, such as the Rural Water Quality Program in the Regional Municipality of Waterloo, provide examples of how the benefits and costs of maintaining the water resource can be equitably shared across all sectors of society.

3. Provide a context for analysis for more localized municipalities and areas by providing an estimate of surface and groundwater resources and showing how they depend on ‘upstream’ communities and can impact on ‘downstream’ communities. The analysis is most relevant at a broad regional level; on more localized scales, the approximations used in the model may cause serious deviations from the actual situation.

4. Show the limitations for resource development based on the limited groundwater resources in the area by highlighting the limited areas of significant recharge and how these and the underlying aquifers are shared between communities.

5. Indicate the potential to increase development based on increased management of the water resources to achieve better consistency of flow throughout the year. (Please see Section 4 for more detailed discussion.)

In addition to these recommendations designed to guide sustainable development, the regional water budget study showed a large variability between modelled and measured annual water quantities. This variability suggests that the components of the hydrologic cycle are not well quantified and that:

1. Additional care and effort should be devoted to gathering complete data on surface and groundwater quantities across the region.

2. Individual development proposals should be analyzed in greater detail at a more localized scale to provide a better model for the water budget as a tool to confirm the feasibility and desirability of the proposed development.

3. The current regional water budget can and should be used to target areas within the region which are important to surface and groundwater resources and that these areas should be analyzed in greater detail to ensure the reliability and sustainability of the water resource.

4. Surface Water Analysis

This section presents an analysis of surface water quantity and quality within the Eastern Ontario Water Resources Management Study (EOWRMS) area. Combined recommendations are presented at the end of the section. The discussion and recommendations provided in this section need to be interpreted in the context of a regional strategy and in the context of watershed management. The recommendations made in a regional context are meant to be interpreted and implemented as a coordination effort that will make better and more efficient use of the resources and information available to the region. The recommendations made in a watershed context are meant to be interpreted and implemented as a management effort that will provide the most effective strategy based on watershed requirements. Simply put, regional recommendations involve inter-basin planning and coordination of programs undertaken on a watershed basis.

4.1 Surface Water Quantity Assessment

4.1.1 Overview

Data and statistics on streamflow are needed to assist with various tasks in the analysis of surface water including water budget analysis, assessment of water supply potential and evaluation of the capacity of watercourses to assimilate wastewater.

This section summarizes the available streamflow data and provides interpretation of the data as needed to assist with various analyses such as water budget analyses for the study area and individual watersheds, and assessment of wastewater assimilation capacity.

4.1.2 Data Sources

All streamflow data known or believed to be available for streamflow gauging stations in the study area has been acquired. The data acquired are those identified by the metadata records created during Phase 1A of EOWRMS.

The Water Survey of Canada (WSC), a division of Environment Canada, has provided data for all WSC gauges in the study area. The data was collected by the WSC office located in Guelph, Ontario.

WSC provided all the historical data for 26 stations. These data include monthly mean flows, daily mean flows, as well as daily mean and instantaneous extreme flows for the entire historical record. In addition, at some stations, water level data has been provided.

Table 4.1 shows a summary of the streamflow gauging stations and the data provided by WSC. The locations of these stations are shown on Figure 4-1 (map).

TABLE 4.1
SUMMARY OF ACQUIRED STREAMFLOW DATA FOR THE EOWRMS AREA

Data provided by Water Survey of Canada, Guelph office, February 2000

Station ID	Description	Drainage Area (km^2)	Period of Record	Monthly and/or Daily Data	Years with 12 Months of Daily Flow Data
02LB005	South Nation River near Plantagenet Springs	3,810	1915-98	M/D	1916-33, 1949-98
02LB006	Castor River at Russell	433	1948-98	M/D	1968-98
02LB007	South Nation River at Spencerville	246	1948-98	M/D	1950-98
02LB008	Bear Brook near Bourget	440	1949-98	M/D	1977-95
02LB009	South Nation River at Chesterville	1,050	1949-94	M/D	1972-74
02LB012	East Branch of Scotch River at St. Isidore	77	1970-94	M/D	1970-78
02LB013	South Nation River at Casselman	2,410	1974-95	M/D	1974, 1976-86
02LB014W	South Nation River below Casselman	2,410	1972-94	M/D	None
02LB015W	South Nation River at Lemieux		1972-94	M/D	1973-76
02LB016	Little Castor River near Embrun	76.1	1978-83	M/D	1978-83
02LB017Q	North Branch South Nation River near Heckston	69.2	1977-97	M/D	1978-96
02LB017W	North Branch South Nation River near Heckston	69.2	1997-98	M/D	1997-98
02LB018	West Branch of Scotch River at St. Isidore	99.5	1979-98	M/D	1979-83
02LB019	South Indian Creek near Limoges	72.3	1978-83	M/D	1979-83
02LB020	South Castor at Kenmore	189	1978-97	M/D	1979-96
02LB022	Payne River near Berwick	152	1976-97	M/D	1977-78, 1980-96
02LB027	Black Creek near Bourget	17.7	1993-94	M/D	None
02LB029W	South Nation River at Sequin Bridge		1993-94	D	None
02LB030	South Nation River at Pendleton Bridge		1994-95	D	None
02LB101	Bear Brook at Carlsbad Springs	65	1976-78	M/D	1976-77
02MC001	Raisin River near Williamstown	404	1960-98	M/D	1961-98
02MC009	South Raisin River Diversion at Long Sault		1972-96	M/D	None
02MC026	Riviere Beaudette near Glen Nevis	124	1983-98	M/D	1984-98
02MC027	Raisin River at Black River	129	1986-92	M/D	None
02MC028	Riviere Delisle near Alexandria	85.4	1985-98	M/D	1986-97
02MC030	South Raisin River near Cornwall	25.8	1986-98	D	None

4.1.3 Data Adequacy, Limitations, and Assumptions

Data Adequacy for Estimating Average Annual Streamflow Volume

An annual water budget was constructed for the study area. The required information included average annual streamflow volume at as many gauged watershed locations as possible.

Of the 26 gauging stations, seven do not contain one single year of complete daily or monthly data. Eight more of the stations have less than 10 years of data. A total of 11 stations have 10 or more years of data. Ten years of data was considered the minimum needed to compute what could be considered a reasonable estimate of average annual streamflow. Therefore, the data have been judged adequate to provide an average annual streamflow value for 11 subwatersheds; these are listed in Table 4.2.

TABLE 4.2
STREAMFLOW STATIONS WITH 10 OR MORE YEARS OF COMPLETE DAILY OR MONTHLY DATA

Station ID	Description	Drainage Area (km^2)	Average Annual Flow Volume ($x\ 10^6\ m^3$)	Number of Years of Data
02LB005	South Nation River near Plantagenet Springs	3,810	1,354.9	68
02LB006	Castor River at Russell	433	172.0	31
02LB007	South Nation River at Spencerville	246	95.1	49
02LB008	Bear Brook near Bourget	440	187.9	19
02LB013	South Nation River at Casselman	2410	925.9	12
02LB017Q	North Branch South Nation River near Heckston	69.2	27.2	19
02LB020	South Castor at Kenmore	189	67.3	18
02LB022	Payne River near Berwick	152	55.0	19
02MC001	Raisin River near Williamstown	404	161.9	38
02MC026	Riviere Beaudette near Glen Nevis	124	57.5	15
02MC028	Riviere Delisle near Alexandria	85.4	33.3	12

Data Adequacy for Developing Low-flow and Flood-flow Statistics

Low-flow statistics are needed to assist with assessing the capacity of watercourses to assimilate waste loadings, such as those from municipal sewage lagoons or wastewater treatment plants.

Historically, permitting of wastewater discharges by the Ontario Ministry of the Environment (MOE) under the Ontario Water Resources Act has been based on technical evaluations that typically consider the 1-in-20-years 7-day low flow, the so-called 7Q20. Typically, fifteen or more years of historical streamflow data are needed to perform statistical analyses to derive the 7Q20.

Similarly, to develop flood flow estimates for return periods of 2 years to 100 years, at least 15 years of daily flow data are required to support statistical analyses. A substantially longer period (e.g. 30 years or more) is desirable and arguably required, since the longer record will provide a significantly higher level of confidence in the statistical results.

Of the 26 stations provided by the WSC, nine stations have 15 or more years with complete daily streamflow data. These stations are listed in Table 4.3.

TABLE 4.3
STATIONS WITH 15 OR MORE YEARS OF COMPLETE DAILY STREAMFLOW RECORD

Station ID	Description	Drainage Area (km^2)	Number of Years of Data
02LB005	South Nation River near Plantagenet Springs	3,810	50
02LB006	Castor River at Russell	433	31
02LB007	South Nation River at Spencerville	246	49
02LB008	Bear Brook near Bourget	440	19
02LB017Q	North Branch South Nation River near Heckston	69.2	19
02LB020	South Castor at Kenmore	189	18
02LB022	Payne River near Berwick	152	19
02MC001	Raisin River near Williamstown	404	38
02MC026	Riviere Beaudette near Glen Nevis	124	15

4.1.4 Approach and Methods

Various flow statistics were calculated for the stations with sufficient recorded data. The flow statistics include:

- Average annual streamflow volume as needed for regional water budget analysis
- Average monthly streamflow volume as needed to characterize seasonal variation in watershed water yield
- Flow duration curves to characterize the entire streamflow regime
- Low-flow statistics as needed to assess waste assimilative capacities
- High-flow statistics to characterize flood conditions and flood frequency

Average Annual Streamflow Volume

Average annual streamflow volume has been computed for all gauging stations with at least 10 complete calendar years of daily streamflow measurements. Average monthly stream-flow volumes were also computed for the same stations. Streamflow volume units have been converted to an average water depth over the watershed (mm), which are the same units used in the water budget.

Flow Duration Curves

Flow duration curves were developed for gauging stations with a least 10 complete calendar years of daily streamflow record. Flow duration curves show the percentage of time that specified flowrates were met or exceeded during the period of record. These curves are useful for summarizing the entire streamflow regime at a given gauging station. The shape or form of the curve can indicate the relative amount of surface water storage within a watershed (as reflected in attenuation of higher flows) and the extent to which groundwater discharge is sustaining baseflow (as indicated by magnitude of flows with highest fre-quency / duration).

Low-Flow Statistics

A minimum of 15 years of data is needed to support statistical analyses to derive 7Q20 estimates. 7Q20 values have been derived for the nine stations that have sufficient data. Monthly low-flow analysis was completed to provide statistics that depict seasonal flow variability.

Frequency analysis was done using the method of moments and the method of lowest observed flow (Pilon et al., 1988). For each station analyzed, the method of lowest observed flow resulted in the lowest estimation error and was selected as the preferred approach. Comparisons were made between the MOE calculations of 7Q20 and the method of lowest observed flows used in this study.

High-Flow Statistics

Statistics on high flows or flood flows are used for various purposes. Flows with return periods of 2 years to 100 years are used in the design of bridges, culverts and other hydraulic structures. The 100-year flood flow has been historically used in Eastern Ontario to delineate the Regulatory floodline, which is used by Conservation Authorities and municipalities for regulation of buildings and land use in accordance with Planning Act policy regarding floodplains.

Frequency analysis of historical flow data is a widely accepted approach for estimating flows for return periods of 2 years to 100 years or even longer. Pilon et al. (1985) provides details on accepted methods of statistical analysis.

Environment Canada’s Consolidated Frequency Analysis Package (CFA) has been used to derive flood flow estimates for those stations with adequate daily flow data. CFA screens the data for independence, trend, homogeneity and randomness, and then performs the flow frequency analysis to develop estimates of flows with return periods of 2 years to 500 years.

All gauging stations with 15 years or more of data have been analyzed with the CFA program.

4.1.5 Characterization and Key Findings

Average Annual Streamflow Volumes

Table 4.4 presents the average annual streamflow volume statistics as computed for gauging stations with 10 or more years of data.

The average annual streamflow values have been used in determining the regional water budget on a subwatershed basis, as described in the previous section of this report.

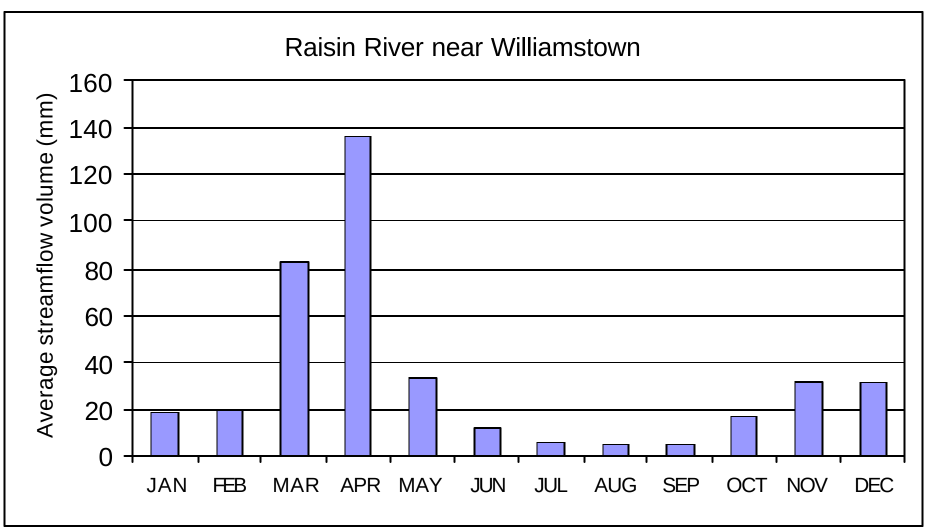
TABLE 4.4
AVERAGE ANNUAL STREAMFLOW VOLUME AS DEPTH OVER DRAINAGE AREA

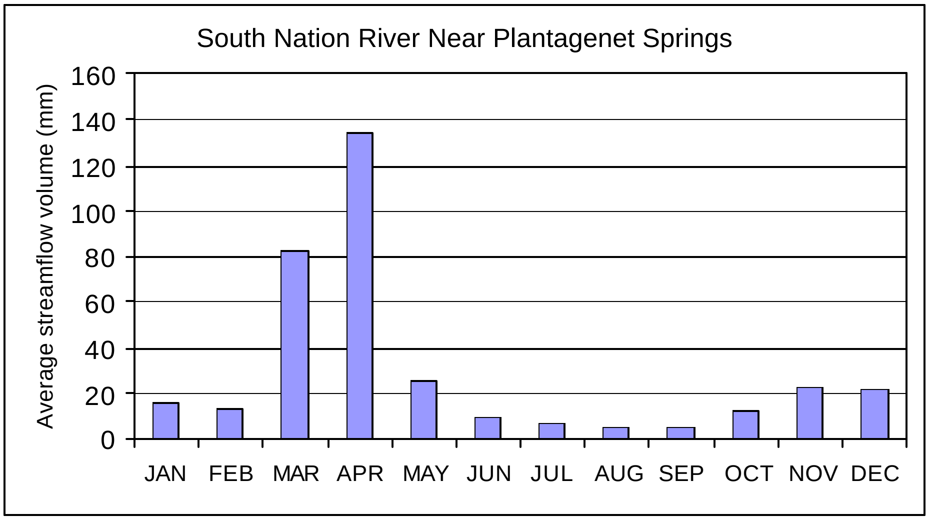
Station ID	Description	Drainage Area (km^2)	Number of Years of Data	Average Annual Streamflow Volume as Water Depth over the Watershed (mm)
02LB005	South Nation River near Plantagenet Springs	3,810	68	356
02LB006	Castor River at Russell	433	31	397
02LB007	South Nation River at Spencerville	246	49	386
02LB008	Bear Brook near Bourget	440	19	427
02LB013	South Nation River at Casselman	2,410	12	384
02LB017Q	North Branch South Nation River near Heckston	69.2	19	392
02LB020	South Castor at Kenmore	189	18	356
02LB022	Payne River near Berwick	152	19	362
02MC001	Raisin River near Williamstown	404	38	401
02MC026	Riviere Beaudette near Glen Nevis	124	15	464
02MC028	Riviere Delisle near Alexandria	85.4	12	389

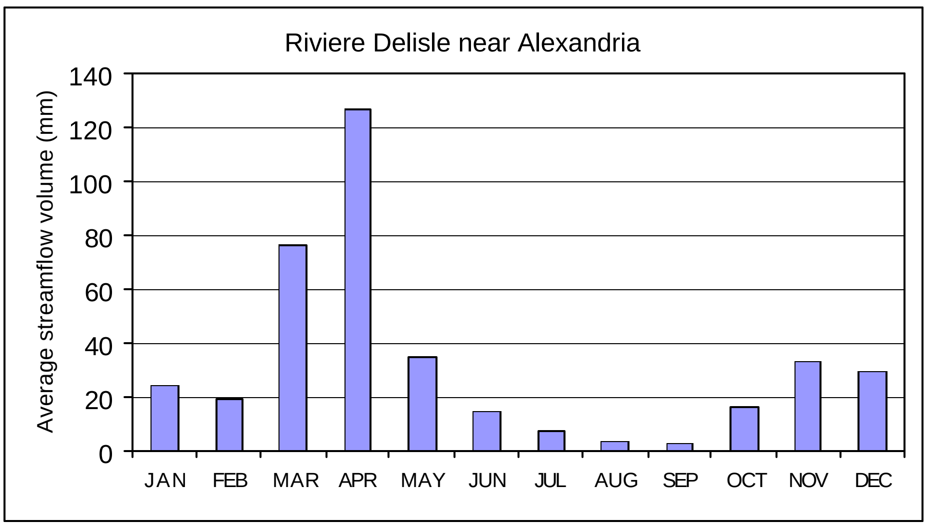
Monthly Variation in Streamflow

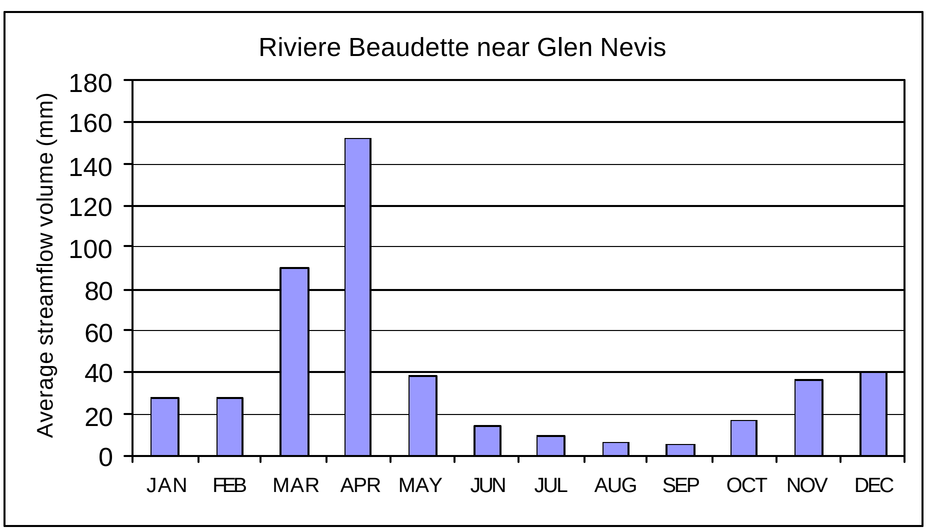
An important aspect of the streamflow regime is the seasonal variation in flow. Seasonal variation will affect strategies for dealing with wastewater, and will also affect the feasibility of using surface water sources for water supply purposes.

Appendix C contains a tabulation of average monthly streamflow volumes for all stations with 10 or more years of data. The monthly and seasonal variations can best be examined graphically, and Appendix C therefore contains plots of the monthly volumes. Selected plots are shown in this section.





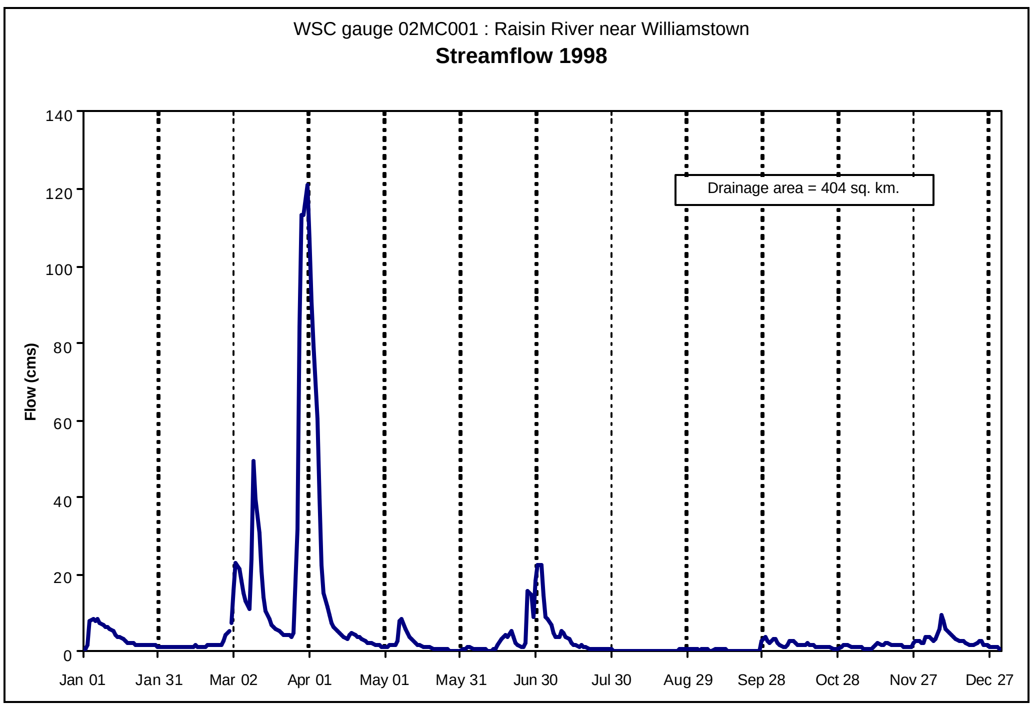


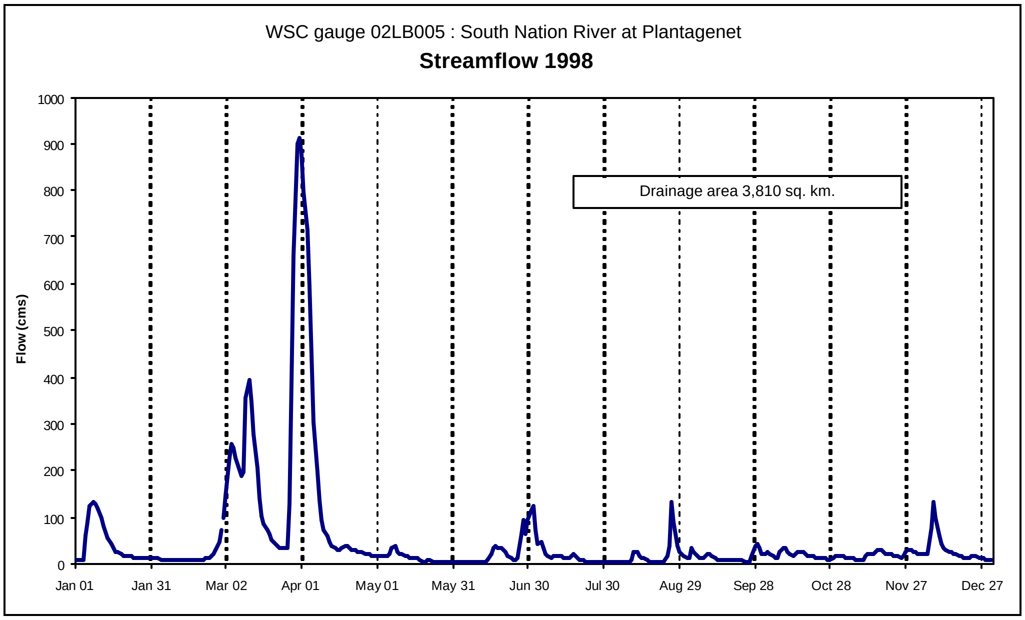


These plots clearly show the highly seasonal nature of streamflow throughout the study area. On average, 52 percent to 62 percent of annual streamflow volume is delivered from local watersheds during the months of March and April. The spring high-flow period is followed by relatively rapid recession of streamflow during May, followed then by a period of low flow during the late spring and summer growing season.

While this pattern is not uncommon of southern Ontario streams, its implications are significant for the EOWRMS area. First of all, as will be discussed in more detail in the context of surface water quality, wastewater discharges from municipal sewage treatment systems, such as lagoon systems, need to be managed such that discharge occurs when in-stream dilution capacity is high (i.e. when streamflow is high), in order to protect water quality and aquatic life. This requirement is reflected in the fact that most existing systems are designed and operated using seasonal discharge (i.e. spring and fall discharge, or spring only). Some options for improving the quality of existing lagoon discharge are noted in Section 7 and in Appendix E.

Secondly, the extent of the low-flow period means that careful management of all surface water withdrawals (e.g. irrigation supplies, municipal water supplies) is needed to ensure that aquatic habitat is protected and to ensure that downstream water users have adequate supply.





The importance of managing surface water withdrawals can be seen by considering average streamflow volume during the June to September low-flow period. Table 4.5 expresses average June-September flow volume per unit watershed area per day.

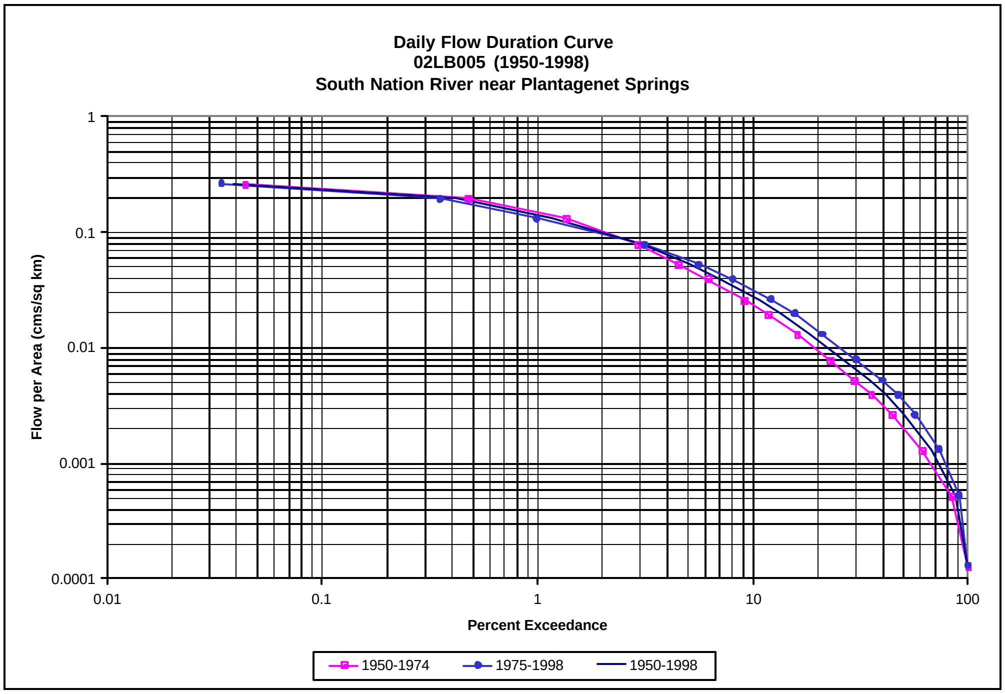
As Table 4.5 shows, the daily summer flow volume is on the order of 2,000 to 3,000 litres per hectare throughout the study area. When existing and potential population densities, live-stock watering requirements and potential irrigation needs are considered, it becomes apparent that the summer low-flow period may present a significant constraint if surface water sources are to managed in a way that meets demand while also protecting aquatic habitat during the critical summer months. Furthermore, any reduction of streamflow during the summer period could serve to aggravate water quality problems.

TABLE 4.5
AVERAGE STREAMFLOW AT SELECTED STATIONS, FOR JUNE 1 TO SEPT. 30, EXPRESSED AS A VOLUME PER AREA OVER THE WATERSHED AREA

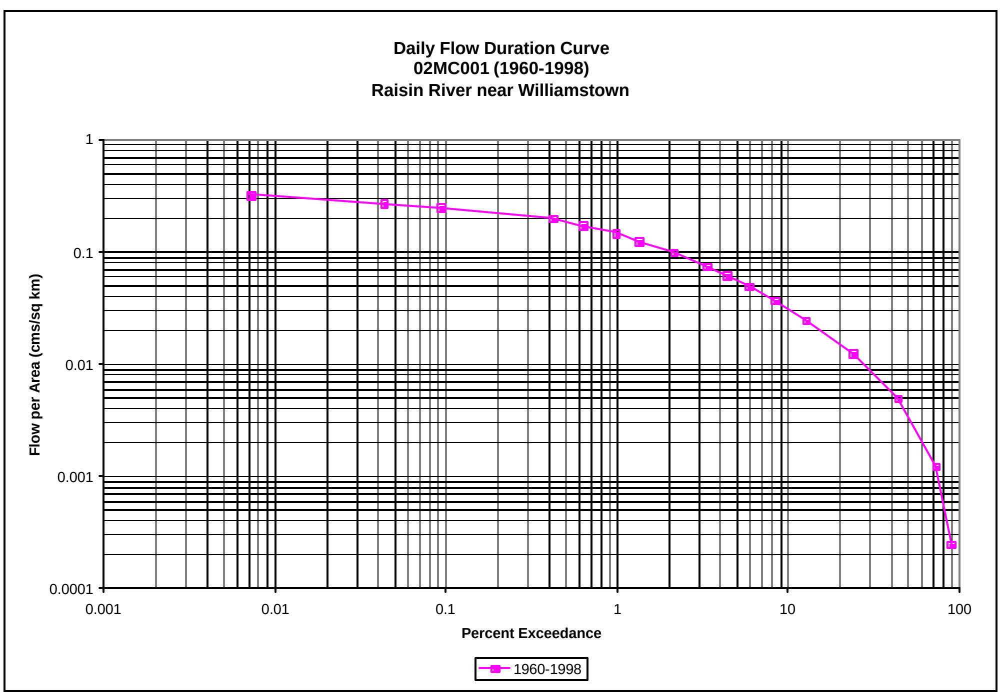
	Litres/hectare/day	Imp gals/acre/day
South Nation River at Plantagenet	2,081	186
Castor River at Russell	2,715	242
South Nation River at Casselman	2,068	184
South Nation River at Spencerville	2,083	186
Raisin River near Williamstown	2,294	204
Riviere Beaudette near Glen Nevis	2,944	262
Riviere Delisle near Alexandria	2,378	212

Flow Duration Curves

Flow duration curves were developed for stations with 10 or more complete calendar years of data. Example curves for the South Nation River and the Raisin River as shown below. The complete set of curves are in Appendix C.



The 1980 MOE report *Water Resources of the South Nation River Basin*, presents flow duration curves for stations in the South Nation watershed, based on data for the interval 1950 to 1974. To allow comparison with the earlier work, the figure above shows curves developed using data for years since 1974, alongside the curve for the 1950-1974 period, as well as the curve developed using all available data for the station. The differences in these curves do not indicate any significant change in the overall streamflow regime between the 1950-1974 period and the 1975-1998 period.



Flow duration curves can be used to develop an estimate of watercourse “baseflow”, this being an indication of the flow that is sustained during relatively dry periods. Although various definitions of “baseflow” are used, it is sometimes estimated as the flowrate that is met or exceeded at least 60 percent of the time.

Using this definition, the flow duration curves presented in Appendix C show that baseflow across the study area is in the range of 1 to 2 litres / per second per square kilometre of drainage area (which equates to approximately 900 to 1,800 litres per day per hectare). This particular statistic again indicates that available streamflow may present significant constraints to increased surface water withdrawals if baseflow is to be maintained to meet environmental protection and enhancement objectives.

Low-Flow Statistics

The annual and monthly 7-day low-flow frequency statistics are presented in Appendix C.

MOE (1980) presents 7-day mean flows for selected stations, based on data for the years 1950 to 1974. Table 4.6 compares the 7Q20 flows from the 1980 MOE report and the 7Q20 flows calculated using the method of lowest observed flow from 1950 to 1998, for the gauging station on the South Nation at Plantagenet.

TABLE 4.6
SOUTH NATION RIVER AT PLANTAGENET SPRINGS (STATION 02LB005) 7Q20 FLOWS (M^3/S)

Month	From MOE (1980) Based on Streamflow Data for 1950 – 1974	Results from Updated Analysis Using Streamflow Data for 1950 – 1998
January	1.08	0.92
February	1.08	0.91
March	1.98	1.60
April	11.32	10.01
May	3.11	2.77
June	1.08	0.68
July	0.85	0.59
August	0.91	0.51
September	0.85	0.48
October	0.91	0.61
November	1.08	1.30
December	1.42	1.13

These results indicate a possible trend towards more extreme low flows, as indicated by the fact that 1950-1998 7Q20 values are consistently lower than those for the 1950-1974 period. This apparent change appears to be most significant in the critical summer months and is likely indicative of general climatic conditions, as evidenced by low Great Lakes water levels, over the last several years.

Flood flow statistics

Table 4.7 presents the computed estimates of flows with return period of 2 to 500 years.

TABLE 4.7
FLOOD FLOW ESTIMATES

Derived from Flow Frequency Analysis for Stations with 15 or More Years of Streamflow Data

Station		Years of Record	Flood Flow Estimates (m^3/sec) for Various Return Periods							
			2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years
02LB005	South Nation at Plantagenet	68	713	905	996	1060	1130	1170	1200	1230
02LB006	Castor R. at Russell	31	104	137	153	165	177	185	191	197
02LB007	South Nation at Spencerville	49	43.4	60.3	70.9	80.6	92.7	101	110	121
02LB008	Bear Brook near Bourget	19	101	149	183	216	260	293	327	374
02LB017	North Branch South Nation near Heckston	19	11.3	13.8	15.3	16.7	18.5	19.8	21.1	22.7
02LB020	South Castor near Kenmore	18	38.6	45.7	48.5	50.2	51.7	52.3	52.7	53.1
02LB022	Payne River Near Berwick	19	29.3	44.6	59	77.2	109	140	180	250
02MC001	Raisin River near Williamstown	38	74.3	95.9	107	115	124	129	134	139
02MC026	Riviere Beaudette near Glen Nevis	15	20.1	25.7	28.7	31.1	33.7	35.4	37	38.7

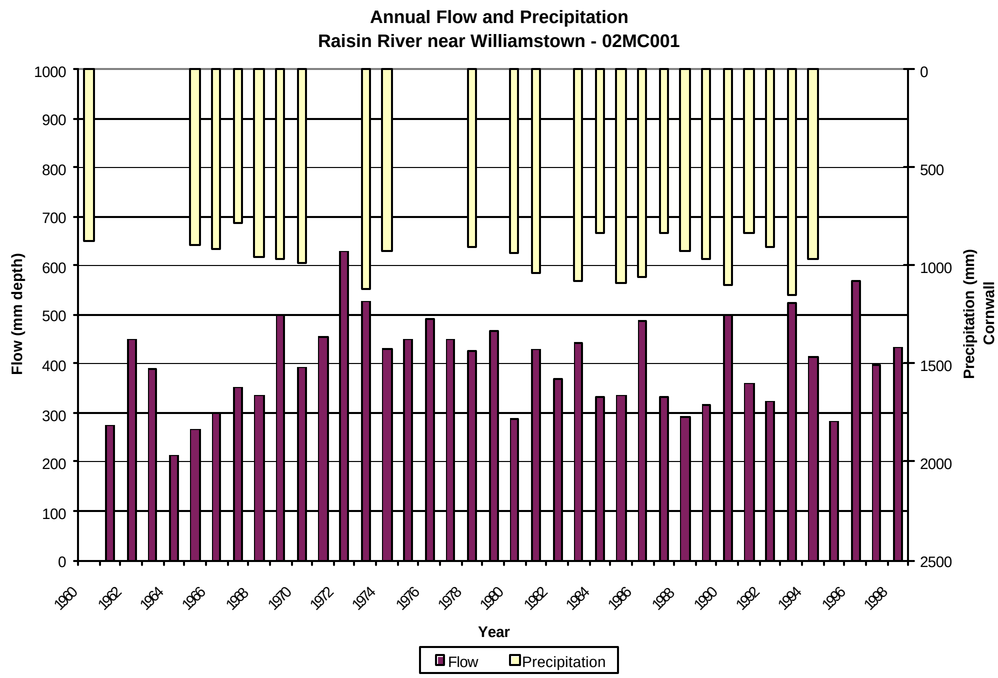
Streamflow versus Precipitation

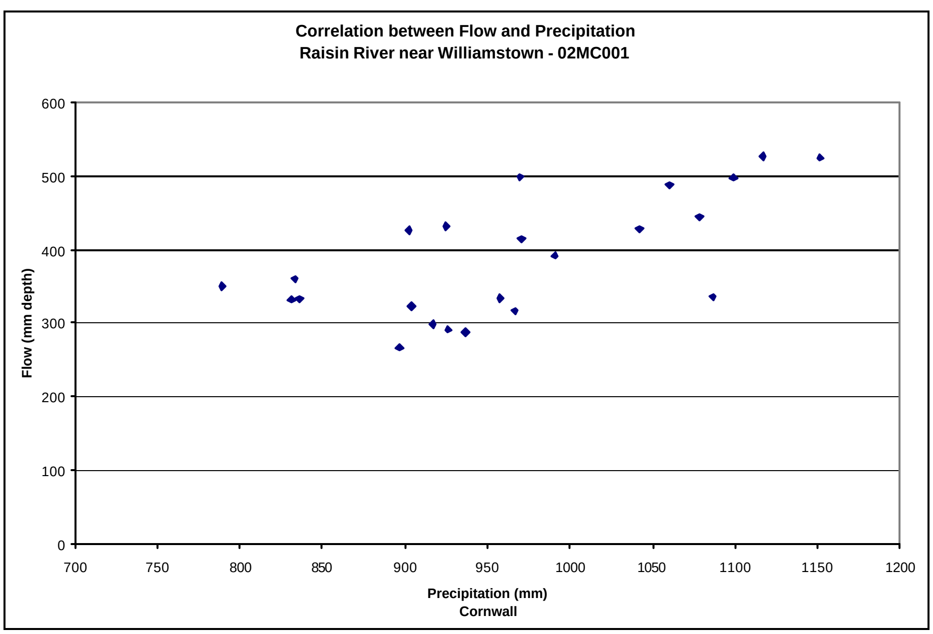
Environment Canada's Atmospheric Environment Service (AES), now called the Meteorological Service of Canada, records climatological information for all regions of Canada. Historical data for AES stations within the EOWRMS study area have been acquired, along with data for selected stations that are close to the study area limits. The stations for which data have been acquired are listed in Table 4.8 with the period of record and average annual precipitation.

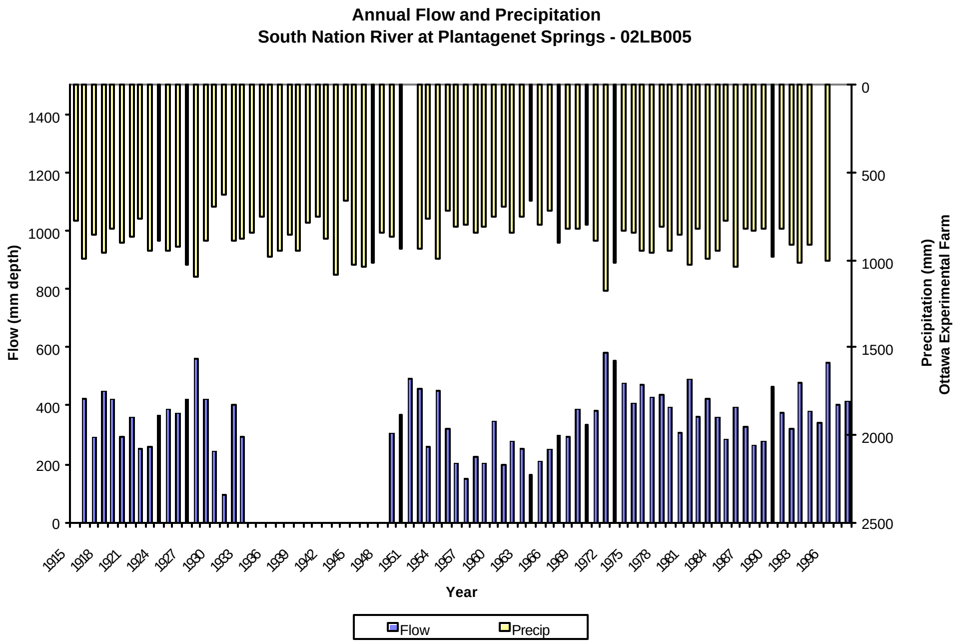
TABLE 4.8
ENVIRONMENT CANADA CLIMATOLOGICAL STATIONS: SUMMARY OF DATA ACQUIRED AND AVERAGE ANNUAL PRECIPITATION STATISTICS

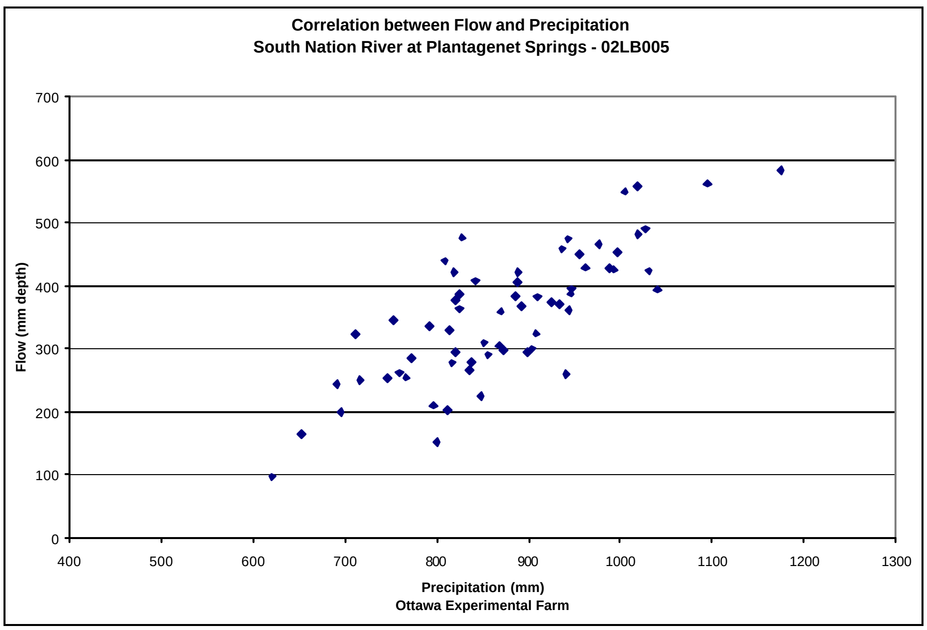
Station ID	Location	Period of Record	Overview of Data Acquired	Average Annual Precipitation (mm)
6100971	Brockville	1965-1999	Daily and monthly precip., monthly air temp.	979.5
6101502	Chesterville	1965-1997	Daily and monthly precip., monthly air temp.	959.5
6101901	Cornwall	1955-1995	Daily and monthly precip., monthly air temp.	944.9
6104025	Kemptville	1928-1997	Daily and monthly precip., monthly air temp., and daily pan evaporation	860.7
6105976	Ottawa Experimental Farm	1889-1999	Daily and monthly precip., daily and monthly air temp., and daily pan evaporation	875.5
6106000	Ottawa International Airport	1938-1999	Daily and monthly precip., monthly air temp.	891.5
7025250	Montreal/Dorval International Airport	1961-1990	Climate normals only (for precip., air temp., humidity)	939.7

Year-to-year variations in annual streamflow volumes have been assessed by plotting annual streamflow volumes alongside annual precipitation at the AES station closest to the respective streamflow gauge. As well, scatter plots of annual streamflow volume versus annual precipitation have been created to allow for some initial examination of correlation between the amount of rainfall and the volume of flow measured in the streams. From the correlation, it is possible to determine how dependent the stream flow volumes are on the variations in rainfall annual events. Example plots are presented here for the South Nation at Plantagenet and the Raisin River near Williamstown. These plots illustrate a reasonable correlation as they approach a straight line relationship. Further comparisons are presented in Appendix C.









4.2 Surface Water Quality Assessment

4.2.1 Overview

During the earlier phases of the EOWRMS work, surface water quality data sources had been identified. Subsequent efforts were made, as part of the study, to collect the available information. As part of this current phase of EOWRMS, the collected data has been analyzed to characterize surface water as a regional resource from a number of perspectives.

Water quality is an important aspect of the resource characterization because the quality of the existing surface waters dictates, to some degree, the availability of surface waters for potable water supplies and the degree of treatment that may be required to use these surface waters as potable water supplies. The quality of surface waters also impacts the ability of surface waters to act as receiving streams for wastewater discharges from agricultural, industrial and municipal wastewater sources. Surface water quality is also a principal factor in the determination of the quality and viability of aquatic habitat that exists in various parts of the region.

4.2.2 Data Sources and Limitations

The consultant team obtained data from various government agencies for this study. These included data from the Clean Up Rural Beaches (CURB) Program, the Provincial Water Quality Monitoring Network, the City of Ottawa and the South Nation River Conservation Authority. The MOE provided surface water quality data collected in rivers and streams in the United Counties of Stormont, Dundas and Glengarry (SD&G) as part of the Provincial Water Quality Monitoring Network. The network of data collection has been ongoing since the 1960s. The information received from the South Nation River Conservation Authority was from all the available water quality and flow data for the streams in the watershed, generally from the period of 1987 to 1995. The City of Ottawa provided data for stations it is monitoring in the South Nation River watershed. Some of these stations were previously monitored by the SNC. Data from the City of Ottawa is generally for the period 1994 to 1999.

The locations of streamflow data stations used in the water quality assessments are shown in Figure 4-2. Under theSouth Nation River Conservation Authority Area there are a total of eight watersheds covered. These include:

- South Nation River at Spencerville
- North Branch South Nation at Heckston
- South Nation at Chesterville
- Castor River near Russell
- South Nation River near Casselman
- Bear Brook at Bourget
- South Nation at Plantagenet
- Payne River near Berwick

Three watersheds are covered under the Raisin Region Conservation Authority Area. They are:

- Raisin River near Williamstown
- Beaudette River near Glen Nevis
- Delisle River near Alexandria

Figure 4-2 shows acceptable data coverage of the northern region of the EOWRMS area. The watersheds with the most information include the South Nation at Plantagenet and Casselman, the Castor River, the Payne River, and the Raisin River region. There were several sample locations for the remaining watersheds, with the exception of North Branch South Nation at Heckston, where no data was available.

4.2.3 Approach and Methods

The data collected from the various sources was first screened to select only that data relevant to the geography within the study area. The selected data was then tabled to provide a digital database of all parameters relative to available water quality standards such as the MOE's Provincial Water Quality Objectives or the Canadian Water Quality Guidelines.

At this point in the analysis, discussions were undertaken with the MOE to determine what the principal water quality parameters of concern were (from the MOE's perspective) on regulatory matters of stream assimilation. From the discussions and the consultant team's experience in the development of discharge requirements for municipal treatment facilities it was decided that the most relevant parameters to assess using a more detailed approach were total phosphorus and ammonia.

Other parameters are often used in various types of water quality analysis. Suspended and total solids can be correlated against levels of a number of other parameters such as metals and are, therefore, sometimes used as indicators of potential contamination from point sources. This method of analysis was not used here because the characteristics of the in-stream sample locations varied too much to make any useful correlations. Parameters such as bacteria are very transient in nature and are better suited to an assessment of changes in contaminant levels at particular sites (e.g. used for contact recreation, rather than for regional analysis).

In addition, from a drinking water supply perspective, the quantity of water was determined to be the overriding factor in the assessment. If there were adequate supplies available from a quantity perspective, the question of water quality becomes simply one of treatment requirements and costs.

Our analysis, therefore, focused on two parameters of concern. These parameters, total phosphorus and total ammonia, best represent the assimilative capacity of the surface waters within the study area watersheds and they are also the parameters most often assessed by the MOE in regard to available assimilative capacity. Data from the digital summaries was screened for total phosphorus and ammonia results and these were compared to applicable water quality guidelines. The guidelines used for comparison were 0.03 mg/L for total phosphorus from the Ontario Provincial Water Quality Objectives (February 1999) and 1.37 mg/L for total ammonia from the Canadian Environmental Quality Guidelines for Freshwater Aquatic Life (1999).

The total ammonia levels derived from the Canadian Guidelines provide a range of acceptable levels of total ammonia, which are dependent on water temperature and pH. There was insufficient data collected on water temperature and pH to determine the actual cases where the ammonia levels exceeded the acceptable Canadian Water Quality Guidelines. The level of 1.37 was selected for reference in the tabulated data but does not necessarily represent a direct comparison of water quality conditions to acceptable levels of ammonia. Table 4.9 provides the full range of acceptable total ammonia levels at the range of potential water temperatures and pH values.

TABLE 4.9
RECOMMENDED CANADIAN WATER QUALITY GUIDELINES FOR TOTAL AMMONIA CONCENTRATIONS (MG /L) AT THE FOLLOWING TEMPERATURES

pH	0	5	10	15	20	25	30
6.50	2.5	2.4	2.2	2.2	2.2	1.04	.73
6.75	2.5	2.4	2.2	2.2	2.2	1.04	.73
7.00	2.5	2.4	2.2	2.2	2.2	1.04	.74
7.25	2.5	2.4	2.2	2.2	2.2	1.04	.74
7.50	2.5	2.4	2.2	2.2	2.2	1.05	.74
7.75	2.3	2.2	2.1	2.0	1.40	0.99	0.71
8.00	1.53	1.44	1.37	1.33	0.93	0.66	0.47
8.25	0.87	0.82	0.78	0.76	0.54	0.39	0.28
8.50	0.49	0.47	0.45	0.44	0.32	0.23	0.17
8.75	0.28	0.27	0.26	0.27	0.19	0.16	0.11
9.00	0.16	0.16	0.16	0.16	0.13	0.10	0.08

4.2.4 Assumptions

Assumptions made in the analysis of surface water quality include the selection of the parameters of concern. The other parameters including metals and other organic parameters, although relevant in many aspects of water quality analysis, were not deemed to be the contaminants of most concern to the discussion of waste assimilation by surface water receiving bodies.

It was also assumed that the water quality data presented to us by the various agencies in its raw form had received sufficient quality assurance and quality control and that the numbers were representative of water quality in the study area.

In the analysis of the water quality results, a general assumption was made that data acquired from the sample locations over the period from 1990 to 1999 was more representative of current conditions. Efforts to analyze trends in water quality data acquired from stations between 1990 and 1999 was used when available. Data acquired from stations before 1990 was used if and only sufficient data was not available for the station between 1990 and 1999.

It was also assumed that the data acquired was representative of average water quality conditions and not representative of stream conditions at point source discharges. Concentrations of certain parameters such as phosphorus and ammonia may be higher than represented in the summarized data, in the dilution zones of point source discharges.

4.2.5 Characterization and Key Findings

Although water quality in the EOWRMS area has been improving, phosphorus levels have consistently remained above the Provincial Water Quality Objectives (PWQO). The levels of total phosphorus and total ammonia at each of the water quality stations used in the assessment are shown in Figures 4-3 and 4-4, respectively. A total phosphorus and total ammonia water quality summary for each station is shown in Table 4.10.

The summary tables consist of Station ID and description and the yearly averages of phosphorus and ammonia from 1990 to 1999 for each location. Many of the stations did not have recent data from the last ten years available. As such, the average values for the data representing the most recent 10 years of record and the total averages for all available data were provided in the summaries. The tables also include the total number of samples taken and the number of samples exceeding the applicable water quality guidelines.

The results indicate that although the levels of phosphorus and ammonia have generally decreased at a number of the stations during the ten-year period from 1990 to 1999, other water quality stations have increased. The average levels of phosphorus have consistently remained above the limits set by the Provincial Water Quality Objectives.

Phosphorus levels exceeded the provincial guidelines at every station; in fact, total phosphorus levels increased over the five-year period from 1990 to 1995.

The findings for ammonia reveal a general improvement on a watershed basis. While ammonia levels were generally trending downwards, there were several cases that demonstrated increasing levels of ammonia, such as at South Nation River near Plantagenet, Casselman, and Chesterville. A few sample locations in the Payne River region also reported high levels of ammonia contamination. The levels of ammonia did not exceed the selected guideline level of 1.37 mg/L in the summarized data.

Generally, the watersheds with the highest levels of phosphorus and ammonia are along the South Nation River at Plantagenet, Casselman, and Chesterville. The Raisin River region also tends to show high levels of exceedance, as did the Bear Brook watershed.

There are several explanations for the results obtained, and the contrast in levels of phosphorus and ammonia. First, it should be stressed that it was impossible to determine a direct comparison of total ammonia to Canadian or Provincial water quality guidelines because of the lack of temperature and pH data. The Canadian guidelines are provided in this report because they represent total ammonia and provide some relative comparison with the water quality data available. It should also be noted that recent data from the last ten years was often not available, and the number of exceedances was calculated from the total number of samples for each station. These exceedances were often from data collected in the 1960s and 70s, and are less relevant to the present situation. In addition, there were more sample locations in the regions where most of the exceedances occur. Since there was more data available for the upper regions of the EOWRMS area, there is a possibility that the phosphorus and ammonia levels in the lower regions, such as the Raisin River region, are not as representative of current or recent conditions.

Other Parameters

The data obtained for the assessment of surface water quality in the EOWRMS study area contains a number of parameters other than total phosphorus and ammonia that can also be indicative of surface water quality. Most of this data consists of various nutrient parameters such as forms of nitrogen, and field measurements such as pH, conductivity, dissolved oxygen and temperature. These parameters provide fairly transient results in that they are not persistent in the environment and it is, therefore, difficult to develop more than a site-specific assessment of the impacts these parameters may be having on water quality. This digital database has been provided to the project partners as part of the data product deliverables.

Table 4.10
Total Phosphorus and Total Ammonia Water Quality Summary

Watershed Name	Subwatershed Number	Station ID	Station Name	Sample Point Description: Description	Distance, Upstream	Township	Lot	Concession	LATD	LONGD	Parameter Data: Parameter	Period		Guideline	Units	1990 Average	1991 Average	1992 Average	1993 Average	1994 Average	1995 Average	1996 Average	1997 Average	1998 Average	1999 Average	2000 Average	Total Average	Units	# of Samples Collected	# of Exceedances	% of Time Exceeded
Bear Brook at Bourget	23	06023001		North Indian Creek		Clarence	19	7	45.436	-75.209	*TP	1992	1993	0.03	mg/L	N/A	N/A	0.08225	0.062	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0782	mg/L	15	15	100%
											*TA	1992	1993	1.37	mg/L	N/A	N/A	0.001828878	0.001537033	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001787185	mg/L	14	0	0%
	32																														
	33	06033001		Bear Brook upstream of N. Indian Creek		Clarence	21	7	45.420	-75.192	TP	1992	1993	0.03	mg/L	N/A	N/A	0.117833333	0.104666667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.1152	mg/L	15	14	93%
											TA	1992	1993	1.37	mg/L	N/A	N/A	0.001959226	0.001260416	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001819464	mg/L	15	0	0%
	36																														
	37																														
	50																														
	54	18207012002	Bear Brook	At Hwy 417 South of Carlsbad Spring	87.868				45.366	-75.489	TP	1974-07-30	1974-11-20	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.092	mg/L	5	5	100%
	*	18207013002	Bear Brook	At Carlsbad Spring	83.362				45.375	-75.475	No data																				
	208	06208001		3 way Junction of County Rd 37, 2, 26		Cumberland	20	2	45.426	-75.153	TP	1990	1994	0.03	mg/L	0.083925	0.05166	0.070571429	0.143518182	0.101925	N/A	N/A	N/A	N/A	N/A	N/A	0.093905263	mg/L	38	36	95%
											TA	1990	1994	1.37	mg/L	0.10975	0.0388	0.047857143	0.116454545	0.156	N/A	N/A	N/A	N/A	N/A	N/A	0.080444444	mg/L	36	0	0%
		CK31-01		Bearbrook Creek at Russell Rd, near Samure Rd		City of Ottawa			45.3993965	-75.282480	TP	1995	2000	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	0.800	0.148	0.107	0.092	0.191	0.097	0.177	mg/L	52	52	100%
											TA	1995	2000	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	0.106	0.044	0.067	0.069	0.139	0.070	0.083	mg/L	52	0	0%
		CK31-04		Bearbrook Creek at Boundary Rd		City of Ottawa			45.3750374	-75.459164	TP	1998	2000	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.066	0.098	0.087	0.085	mg/L	25	25	100%
											TA	1998	2000	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.014	0.083	0.072	0.060	mg/L	25	0	0%
Beaudette River Near Glen Nevis	77	12008000102	Beaudette River	West of Glen Nevis					45.273	-74.482	TP	07/05/1988	11/16/1999	0.03	mg/L	0.051333333	0.07375	0.050083333	0.07924	0.069666667	0.057428571	N/A	0.045333333	0.057	0.05	N/A	0.061103297	mg/L	91	77	85%
											TA	09/27/1994	11/16/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.072	0.056571429	N/A	0.039333333	0.006	0.016444444	N/A	0.033909091	mg/L	22	0	0%
	93	12008000202	Beaudette River	Near Apple Hill					45.214	-74.731	TP	07/05/1988	05/03/1993	0.03	mg/L	0.086272727	0.143916667	0.0745	0.0485	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.112433962	mg/L	53	50	94%
	201																														
	210																														
South Nation River at Chesterville	125	18207011002	South Nation River	At Dam Chesterville	93.339				45.101	-75.227	TP	09/30/1965	11/24/1999	0.03	mg/L	0.055375	0.066285714	0.072142857	0.07	0.0585	0.044666667	0.07575	0.048666667	0.0635	0.055	N/A	0.107485849	mg/L	212	198	93%
											TA	10/11/1994	11/24/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.053	0.084666667	0.08825	0.029333333	0.03975	0.027	N/A	0.050277778	mg/L	36	0	0%
	138	03138001		S. Branch at Oak Valley Rd		Mountain	13	2	45.010	-75.347	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.153666667	0.12925	0.092	N/A	N/A	N/A	N/A	0.127157895	mg/L	19	18	95%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.002542127	0.003007246	0.003934493	N/A	N/A	N/A	N/A	0.003061262	mg/L	17	0	0%
	167	03167001		S. Branch on Taylor Rd		Matilda	25	6	44.937	-75.393	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.094	0.106571429	0.086	N/A	N/A	N/A	N/A	0.096666667	mg/L	18	17	94%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.000578487	0.001581103	0.007032258	N/A	N/A	N/A	N/A	0.002189207	mg/L	17	0	0%
		03167002		Black Creek at County Rd 18			22	5	44.909	-75.370	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.176333333	0.325142857	0.118	N/A	N/A	N/A	N/A	0.218	mg/L	18	18	100%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.000992219	0.001892042	0.00256311	N/A	N/A	N/A	N/A	0.001638492	mg/L	16	0	0
		3167003		S. Branch at County Rd 18			29	06-May	44.896	-75.412	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.099666667	0.140857143	0.102	N/A	N/A	N/A	N/A	0.116333333	mg/L	18	16	89%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.001442089	0.000884845	0.002424821	N/A	N/A	N/A	N/A	0.001286308	mg/L	16	0	0%
South Nation River Near Casselman	71	18207014002	Castor River	At Conc Rd. No. 5 Russell Twp.	82.396			4	45.266	-75.309	TP	06/26/1980	11/24/1999	0.03	mg/L	0.069	0.062833333	0.058166667	0.062	0.082	0.086571429	0.095333333	0.075142857	0.11425	0.055	N/A	0.079514706	mg/L	136	123	90%
											TA	12/06/1994	11/24/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.056	0.072571429	0.043777778	0.059142857	0.086	0.039333333	N/A	0.060421053	mg/L	38	0	0%
		05071001		Castor R. County Rd 3 Russell/Osgoode Twp.		Osgoode	24	11	-75.280	45.272	TP	1995	1995	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	0.047666667	N/A	N/A	N/A	N/A	N/A	0.047666667	mg/L	12	8	67%
											TA	1995	1995	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	0.001510131	N/A	N/A	N/A	N/A	N/A	0.001510131	mg/L	10	0	0%
		05071002		Middle Castor R., County Rd 29		Osgoode	24	9	45.276	-75.331	TP	1994	1995	0.03	mg/L	N/A	N/A	N/A	N/A	0.036111111	0.031888889	N/A	N/A	N/A	N/A	N/A	0.034	mg/L	18	8	44%
											TA	1994	1995	1.37	mg/L	N/A	N/A	N/A	N/A	0.001638575	0.00173307	N/A	N/A	N/A	N/A	N/A	0.001682673	mg/L	15	0	0%
		05071003		Castor River Downstream of Embrun		Russell	10	7	45.266	-75.307	TP	1992	1995	0.03	mg/L	N/A	N/A	0.103583333	0.097363636	0.092153846	0.099333333	N/A	N/A	N/A	N/A	N/A	0.098	mg/L	48	48	100%
	81	05081001		Butternut Creek at Mouth		Cambridge	13	7	45.295	-75.085	TP	1992	1995	0.03	mg/L	N/A	N/A	0.126166667	0.122090909	0.150230769	0.224833333	N/A	N/A	N/A	N/A	N/A	0.156416667	mg/L	48	48	100%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.004849257	0.006938289	0.007489534	0.009106608	N/A	N/A	N/A	N/A	N/A	0.00706487	mg/L	47	0	0%
	83	5083001		Little Castor River		Cambridge	16	7	45.242	-75.190	TP	1992	1995	0.03	mg/L	N/A	N/A	0.211625	0.147888889	0.143333333	0.140545455	N/A	N/A	N/A	N/A	N/A	0.15725	mg/L	40	40	100%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.002035059	0.001308345	0.002790492	0.001932028	N/A	N/A	N/A	N/A	N/A	0.002057386	mg/L	39	0	0%
	92	05092001		East Castor River		Russell	6	3	45.202	-75.323	TP	1992	1995	0.03	mg/L	N/A	N/A	0.113583333	0.122444444	0.146307692	0.089583333	N/A	N/A	N/A	N/A	N/A	0.118304348	mg/L	46	44	96%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.001489531	0.001668385	0.005065831	0.004365074	N/A	N/A	N/A	N/A	N/A	0.00321003	mg/L	43	0	0%
	94	05094001		South Nation at Crysler		Finch	12	10	45.220	-75.153	TP	1992	1995	0.03	mg/L	N/A	N/A	0.053	0.068363636	0.046153846	0.050222222	N/A	N/A	N/A	N/A	N/A	0.054222222	mg/L	45	41	91%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.007336119	0.004619888	0.006400992	0.006664663	N/A	N/A	N/A	N/A	N/A	0.006276342	mg/L	46	0	0%
	109	05109001		Payne River near Mouth		Finch	16	9	45.238	-75.130	TP	1992	1995	0.03	mg/L	N/A	N/A	0.075833333	0.127090909	0.059692308	0.057	N/A	N/A	N/A	N/A	N/A	0.082780488	mg/L	48	44	92%
	209	18207010002	South Nation River	At Dam Downstream of Casselman	62.763				45.319	-75.093	TP	09/30/1965	11/23/1999	0.03	mg/L	0.089142857	0.104833333	0.066333333	0.12	0.094	0.0536	0.07225	0.06325	0.0555	0.054	N/A	0.56128629	mg/L	248	244	98%
											TA	12/06/1994	11/23/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.09	0.1072	0.069777778	0.09925	0.074	0.025666667	N/A	0.075513514	mg/L	37	0	0%
		05209001		South Nation at Casselman		Cambridge	10	6	45.320	-75.093	TP	1992	1995	0.03	mg/L	N/A	N/A	0.087333333	0.107454545	0.078769231	0.124090909	N/A	N/A	N/A	N/A	N/A	0.098276596	mg/L	47	47	100%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.006047704	0.00545618	0.006734408	0.004485492	N/A	N/A	N/A	N/A	N/A	0.005733578	mg/L	47	0	0%
		05209002		South Nation River Upstream of Casselman		Cambridge	16	7	45.325	-75.099	TP	1992	1995	0.03	mg/L	N/A	N/A	0.08525	0.122090909	0.059692308	0.0504	N/A	N/A	N/A	N/A	N/A	0.082780488	mg/L	41	41	100%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.00609149	0.00528559	0.002169436	0.012544099	N/A	N/A	N/A	N/A	N/A	0.005418598	mg/L	41	0	0%
South Nation at Spencerville	173	18207015002	South Nation River	County Rd. 18, Augusta TP. 3 km S. of Roebuck	0				No Data	No Data	TP	05/23/1995	11/24/1999	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	0.038315789	0.033333333	0.03525	0.049	0.034	N/A	0.038315789	mg/L	38	24	63%
											TA	05/23/1995	11/24/1999	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	0.064571429	0.020444444	0.02475	0.0405	0.025	N/A	0.034421053	mg/L	38	0	0%
Castor River Near Russell	70	04070001		N. Castor at Pana Rd.		Osgoode	17	10	45.261	-75.414	TP	1994	1995	0.03	mg/L	N/A	N/A	N/A	N/A	0.051428571	0.063625	N/A	N/A	N/A	N/A	N/A	0.057933333	mg/L	15	6	40%
											TA	1994	1995	1.37	mg/L	N/A	N/A	N/A	N/A	0.00381058	0.003330221	N/A	N/A	N/A	N/A	N/A	0.003570401	mg/L	14	0	0%
		CK63-002		Middle Castor River at Yorks Corners Rd, south of RR #6		City of Ottawa			45.2434558	-75.423715	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.036	0.032	0.031727273	N/A	N/A	N/A	N/A	0.033	mg/L	33	16	48%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.018	0.016	0.023181818	N/A	N/A	N/A	N/A	0.019	mg/L	32	0	0%
		04070002		North Castor River		Osgoode	15	10	45.273	-75.431	TP	1992	1995	0.03	mg/L	N/A	N/A	0.064666667	0.065636364	0.075923077	0.122833333	N/A	N/A	N/A	N/A	N/A	0.082479167	mg/L	48	45	94%
											TA	1994	1995	1.37	mg/L	N/A	N/A	0.001519097	0.002456239	0.003186866	0.003083085	N/A	N/A	N/A	N/A	N/A	0.002554519	mg/L	46	0	0%
		04070003		N. Castor at 8th Line Rd.		Osgoode	3	7	45.295	-75.506	TP	1994	1995	0.03	mg/L	N/A	N/A	N/A	N/A	0.037444444	0.039	N/A	N/A	N/A	N/A	N/A	0.038222222	mg/L	18	14	78%
											TA	1994	1995	1.37	mg/L	N/A	N/A	N/A	N/A	0.000813245	0.002991882	N/A	N/A	N/A	N/A	N/A	0.001829942	mg/L	15	0	0%
		CK63-206		North Castor River at 8th Line Rd, 1km South of Mitch Owens Rd		City of Ottawa			45.2955694	-75.505467	TP	1994	2000	0.03	mg/L	N/A	N/A	N/A	N/A	0.037	0.039	0.045272727	N/A	0.042	0.053	0.037	0.042	mg/L	63	49	78%
											TA	1994	2000	1.37	mg/L	N/A	N/A	N/A	N/A	0.011	0.030	0.028909091	N/A	0.035	0.052	0.053	0.036	mg/L	62	0	0%
		04070004		N. Castor at Hwy 31		Gloucester	23	4	45.327	-75.598	TP	1994	1995	0.03	mg/L	N/A	N/A	N/A	N/A	0.034777778	0.047222222	N/A	N/A	N/A	N/A	N/A	0.041	mg/L	18	11	61%
											TA	1993	1995	1.37	mg/L	N/A	N/A	N/A	N/A	0.031111111	0.048375	N/A	N/A	N/A	N/A	N/A	0.039235294	mg/L	17	0	0%
		CK63-254		North Castor River at Bank St. North of Blais Rd		City of Ottawa			45.3173365	-75.592682	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.035	0.059	0.0272	N/A	N/A	N/A	N/A	0.042	mg/L	32	15	47%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.031	0.109	0.0169	N/A	N/A	N/A	N/A	0.057	mg/L	31	0	0%
		04070005		N. Castor River at Greely at Hwy 31		Osgoode	5	5	45.265	-75.559	TP	1993	1993	0.03	mg/L	N/A	N/A	N/A	0.03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03	mg/L	6	1	17%
											TA	1993	1993	1.37	mg/L	N/A	N/A	N/A	0.000764628	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.000764628	mg/L	6	0	0%
		04070006		N. Castor at Hwy 31		Osgoode	5	5	45.259	-75.544	TP	1994	1995	0.03	mg/L	N/A	N/A	N/A	N/A	0.0195	0.017111111	N/A	N/A	N/A	N/A	N/A	0.018235294	mg/L	12	1	8%
											TA	1993	1995	1.37	mg/L	N/A	N/A	N/A	N/A	0.01325	0.016375	N/A	N/A	N/A	N/A	N/A	0.0148125	mg/L	16	0	0%
		CK63-262		North Castor River at Bank St. North of Parkway Rd		City of Ottawa			45.2639705	-75.558923	TP	1994	1997	0.03	mg/L	N/A	N/A	N/A	N/A	0.020	0.018	0.015545455	0.021	N/A	N/A	N/A	0.018	mg/L	33	1	3%
											TA	1994	1997	1.37	mg/L	N/A	N/A	N/A	N/A	0.013	0.014	0.017272727	0.022	N/A	N/A	N/A	0.015	mg/L	32	0	0%
	91	04091001		Middle Castor River		Osgoode	24	9	45.214	-75.493	TP	1992	1995	0.03	mg/L	N/A	N/A	0.03375	0.109727273	0.050769231	0.036181818	N/A	N/A	N/A	N/A	N/A	0.056808511	mg/L	47	35	74%
											TA	1994	1995	1.37	mg/L	N/A	N/A	0.001037605	0.001368396	0.002144796	0.001508021	N/A	N/A	N/A	N/A	N/A	0.001531366	mg/L	47	0	0%
		04091002		Middle Castor River at Herbert Corners		Osgoode	17	3	45.206	-75.569	TP	1993	1993	0.03	mg/L	N/A	N/A	N/A	0.032666667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.032666667	mg/L	82	1	1%
											TA	1993	1993	1.37	mg/L	N/A	N/A	N/A	0.00052505	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00052505	mg/L	6	0	0%
		04091003		N. Castor at Parkway Rd.		Osgoode	6	6	45.240	-75.568	TP	1994	1995	0.03	mg/L	N/A	N/A	N/A	N/A	0.044777778	0.043333333	N/A	N/A	N/A	N/A	N/A	0.044055556	mg/L	18	13	72%
											TA	1993	1995	1.37	mg/L	N/A	N/A	N/A	N/A	0.036111111	0.017875	N/A	N/A	N/A	N/A	N/A	0.027529412	mg/L	17	0	0%
		CK63-208		North Castor River Branch at Parkway Rd West of 7th Line Rd		City of Ottawa			45.2759711	-75.529436	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.045	0.039	0.037	N/A	N/A	N/A	N/A	0.040	mg/L	32	23	72%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.036	0.019	0.032	N/A	N/A	N/A	N/A	0.029	mg/L	31	0	0%
		04091004		Middle Castor at County Rd 25		Osgoode	17	3	No Data	No Data	TP	1994	1995	0.03	mg/L	N/A	N/A	N/A	N/A	0.015	0.018555556	N/A	N/A	N/A	N/A	N/A	0.016882353	mg/L	17	3	18%
											TA	1994	1995	1.37	mg/L	N/A	N/A	N/A	N/A	0.00058722	0.01175	N/A	N/A	N/A	N/A	N/A	0.006540703	mg/L	15	0	0%
		CK63-007		Middle Castor River at Stagecoach Rd (RR #25)		City of Ottawa			45.2061346	-75.569883	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.016	0.019	0.019	N/A	N/A	N/A	N/A	0.018	mg/L	33	6	18%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.017	0.012	0.037	N/A	N/A	N/A	N/A	0.022	mg/L	31	0	0%

*TP = Total Phosphorus
TA = Total Ammonia

Table 4.10
Total Phosphorus and Total Ammonia Water Quality Summary

Watershed Name	Subwatershed Number	Station ID	Station Name	Sample Point Description: Description	Distance, Upstream	Township	Lot	Concession	LATD	LONGD	Parameter Data: Parameter	Period		Guideline	Units	1990 Average	1991 Average	1992 Average	1993 Average	1994 Average	1995 Average	1996 Average	1997 Average	1998 Average	1999 Average	2000 Average	Total Average	Units	# of Samples Collected	# of Exceedances	% of Time Exceeded
Castor River Near Russell (cont'd)	108	04108001		South Castor at Ray Wilson Rd		Russell	26	10	-75.394	45.252	TP	1994	1995	0.03	mg/L	N/A	N/A	N/A	N/A	0.050666667	0.053222222	N/A	N/A	N/A	N/A	N/A	0.051944444	mg/L	18	18	100%
											TA	1994	1995	1.37	mg/L	N/A	N/A	N/A	N/A	0.004553957	0.002656997	N/A	N/A	N/A	N/A	N/A	0.003605477	mg/L	14	0	0%
		CK63-102		South Castor River at Roy Wilson Rd West of Boundary Rd		City of Ottawa			45.2427414	-75.407245	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.051	0.052	0.044	N/A	N/A	N/A	N/A	0.049	mg/L	33	31	94%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.043	0.026	0.039	N/A	N/A	N/A	N/A	0.035	mg/L	31	0	0%
		04108002		South Castor River		Osgoode	26	10	-75.410	45.238	TP	1992	1995	0.03	mg/L	N/A	N/A	0.05725	0.065636364	0.064583333	0.0665	N/A	N/A	N/A	N/A	N/A	0.063446809	mg/L	47	44	94%
											TA	1994	1995	1.37	mg/L	N/A	N/A	0.001766494	0.001430223	0.003650653	0.002364174	N/A	N/A	N/A	N/A	N/A	0.002320525	mg/L	46	0	0%
		04108003		S. Castor at Hwy 31		Osgoode		7	-75.450	45.151	TP	1994	1995	0.03	mg/L	N/A	N/A	N/A	N/A	0.067444444	0.069666667	N/A	N/A	N/A	N/A	N/A	0.068555556	mg/L	18	9	50%
											TA	1994	1995	1.37	mg/L	N/A	N/A	N/A	N/A	0.002600787	0.004169297	N/A	N/A	N/A	N/A	N/A	0.003332758	mg/L	15	0	0%
		04108004		S. Castor at Vernon at Hwy 31		Osgoode	43	7	-75.453	45.155	TP	1993	1993	0.03	mg/L	N/A	N/A	N/A	0.058	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.058	mg/L	5	5	100%
											TA	1993	1993	1.37	mg/L	N/A	N/A	N/A	0.000953027	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.000953027	mg/L	5	0	0%
	117	No Data																													
	130	No Data																													
	202	18207014502	Castor River	At Conc. Rd. No. 3 Russell Twp.	85.615				45.262	-75.356	TP	06/26/1980	11/24/1999	0.03	mg/L	0.055285714	0.155666667	0.045166667	0.042	0.083	0.062333333	0.062666667	0.052	0.0415	0.042666667	N/A	0.072881119	mg/L	143	119	83%
											TA	12/06/1994	11/24/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.044	0.034666667	0.023333333	0.025	0.01825	0.023333333	N/A	0.024947368	mg/L	38	0	0%
		04202001		Castor River at Russell		Russell	11	3	No Data	No Data	TP	1992	1995	0.03	mg/L	N/A	N/A	0.061833333	0.068	0.061615385	0.059666667	N/A	N/A	N/A	N/A	N/A	0.062645833	mg/L	48	42	88%
											TA	1994	1995	1.37	mg/L	N/A	N/A	0.002674805	0.002258601	0.004486345	0.003395405	N/A	N/A	N/A	N/A	N/A	0.00324052	mg/L	45	0	0%
		CK63-001		South Castor River at Gregoire Rd, 250m South of Victoria Rd		City of Ottawa			45.2524132	-75.395159	TP	1995	2000	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	0.047	0.052	0.053	0.085	0.067	0.048	0.058	mg/L	76	65	86%
											TA	1995	2000	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	0.016	0.023	0.037	0.040	0.058	0.054	0.036	mg/L	75	0	0%
		CK63-002		Middle Castor River at Yorks Corners Rd, South of RR #6		City of Ottawa			45.243	-75.423715	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.036	0.032	0.032	N/A	N/A	N/A	N/A	0.033	mg/L	33	16	48%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.018	0.016	0.023	N/A	N/A	N/A	N/A	0.019	mg/L	32	0	0%
		CK63-264		North Castor River at Old Prescott Rd South of Parkway Rd		City of Ottawa			45.2570096	-75.567116	TP	1996	1997	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	0.045	0.043	N/A	N/A	N/A	0.045	mg/L	13	10	77%
											TA	1996	1997	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	0.041	0.003	N/A	N/A	N/A	0.038	mg/L	13	0	0%
		CK63-265		Middle Castor River at Hwy 31, 0.5 km South of Victoria Rd		City of Ottawa			45.2221634	-75.493060	TP	1998	2000	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.023	0.055	0.031	0.037	mg/L	29	12	41%
											TA	1998	2000	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.011	0.056	0.035	0.036	mg/L	29	0	0%
		CK63-266		Middle Castor/North Castor Rivers at Gregorie Rd and Victoria Rd		City of Ottawa			45.2547333	-75.396759	TP	1998	2000	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.024	0.053	0.041	0.041	mg/L	29	16	55%
											TA	1998	2000	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.009	0.057	0.040	0.038	mg/L	29	0	0%
		CK63-108		South Castor River at Bank St. North of Kennedy Rd					45.1505323	-75.449743	TP	1994	1996	0.03	mg/L	N/A	N/A	N/A	N/A	0.067	0.069	0.051	N/A	N/A	N/A	N/A	0.063	mg/L	33	30	91%
											TA	1994	1996	1.37	mg/L	N/A	N/A	N/A	N/A	0.035	0.044	0.039	N/A	N/A	N/A	N/A	0.040	mg/L	32	0	0%
Delisle River Near Alexandria	72	12008600302	Garry River	At CNR Tressle Alexandris					45.316	-74.627	TP	1980-03-10	1999-11-16	0.03	mg/L	0.118	0.06575	0.03975	0.0483	0.063571429	0.024	N/A	0.024	0.014666667	0.018666667	0.053972222	0.097869318	mg/L	176	99	56%
											TA	1994-09-27	1999-11-16	1.37	mg/L	N/A	N/A	N/A	N/A	0.055	0.0268	N/A	0.018	0.003333333	0.042222222	0.031272727	0.031272727	mg/L	22	0	0%
		12008600402	Garry River	At First Bridge Upstream of Alexandria					45.302	-74.638	TP	1980-03-10	1999-11-16	0.03	mg/L	0.035636364	0.01475	0.026333333	0.0152	0.016857143	0.031142857	N/A	0.019333333	0.014	0.017333333	0.022123288	0.035571429	mg/L	175	40	23%
											TA	1994-09-27	1999-11-16	1.37	mg/L	N/A	N/A	N/A	N/A	0.035	0.016857143	N/A	0.02	0.005	0.032444444	0.023913043	0.023913043	mg/L	23	0	0%
		12008600102	Delisle River	At CNR Trestle Downstream of Alexandria					45.323	-74.603	TP	1980-03-10	1999-11-16	0.03	mg/L	0.106416667	0.102916667	0.064090909	0.080555556	0.076571429	0.075714286	N/A	0.076666667	0.064	0.107111111	0.086851351	0.215638418	mg/L	177	173	98%
											TA	1994-09-27	1999-11-16	1.37	mg/L	N/A	N/A	N/A	N/A	0.272	0.113714286	N/A	0.346666667	0.199333333	0.248	0.217083333	0.217083333	mg/L	24	0	0%
		12008600602	Garry River	Catherine Street, Alexandria					45.308	-74.638	TP	1997-06-11	1998-10-26	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0185	0.0195	N/A	0.01575	0.01575	mg/L	8	0	0%
											TA	1997-07-03	1998-10-26	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.036	0.0195	N/A	0.026571429	0.026571429	mg/L	7	0	0%
	79	12008600902	Garry River	Fillions Landing, Loch Garry Lake					45.262	-74.710	TP	1997-06-11	1998-10-26	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0205	0.0228	N/A	0.021777778	0.021777778	mg/L	9	0	0%
											TA	1997-07-03	1998-10-26	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.124	0.0312	N/A	0.066	0.066	mg/L	8	0	0%
		12008601002	Garry River	Girl Guide Camp, Loch Garry Lake					45.243	-74.733	TP	1997-07-03	1998-10-26	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.023333333	0.031	N/A	0.0264	0.0264	mg/L	5	1	20%
											TA	1997-07-03	1998-10-26	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.655333333	0.053	N/A	0.4144	0.4144	mg/L	5	0	0%
	200	12008600202	Delisle River	At First Bridge Upstream of Alexandria					45.329	-74.618	TP	1980-03-10	1999-11-16	0.03	mg/L	0.035	0.045	0.037166667	0.05139	0.051714286	0.044285714	N/A	0.044666667	0.032	0.041111111	0.042701351	0.055192614	mg/L	176	123	70%
											TA	1994-09-27	1999-11-16	1.37	mg/L	N/A	N/A	N/A	N/A	0.041	0.018285714	N/A	0.022666667	0.005	0.021333333	0.020869565	0.020869565	mg/L	23	0	0%
Payne River at Berwick	204	08204001		No Description		Finch	16	9	45.224	-75.124	TP	1987	1990	0.03	mg/L	0.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.04	0.048777778	mg/L	18	11	61%
											TA	1987	1990	1.37	mg/L	0.028	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.028	0.036666667	mg/L	18	1	6%
		08204002		No Description		Finch	17	8	45.213	-75.107	TP	1987	1989	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.054923077	mg/L	13	8	62%
											TA	1987	1989	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.055384615	mg/L	13	1	8%
		08204003		No Description		Finch	17	7	45.203	-75.103	TP	1987	1989	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.052307692	mg/L	13	10	77%
											TA	1987	1989	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.051428571	mg/L	14	10	71%
		08204004		No Description		Finch	15	6	45.186	-75.108	TP	1987	1991	0.03	mg/L	0.3225	0.07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.272	0.114333333	mg/L	18	12	67%
											TA	1987	1991	1.37	mg/L	0.0175	0.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.024	0.042222222	mg/L	18	1	6%
		08204005		No Description		Finch	17	5	45.180	-75.086	TP	1987	1989	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.047076923	mg/L	13	7	54%
											TA	1987	1989	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.048461538	mg/L	13	1	8%
		08204006		No Description		Finch	14	4	45.160	-75.093	TP	1987	1989	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.049769231	mg/L	13	8	62%
											TA	1987	1989	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.047692308	mg/L	13	1	8%
		08204007		No Description		Finch	14	3	45.151	-75.090	TP	1987	1989	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.044769231	mg/L	13	7	54%
											TA	1987	1989	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.052857143	mg/L	131	0	0%
		08204008		No Description		Finch	14	2	45.142	-75.082	TP	1987	1991	0.03	mg/L	0.05625	0.09	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.063	0.053294118	mg/L	17	11	65%
											TA	1987	1991	1.37	mg/L	0.0275	0.07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.036	0.045	mg/L	18	1	6%
		08204009		No Description		Finch	19	2	45.155	-75.043	TP	1987	1989	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.053666667	mg/L	12	7	58%
											TA	1987	1989	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.036923077	mg/L	13	1	8%
		08204010		No Description		Finch	21	1	45.143	-75.018	TP	1987	1989	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.055166667	mg/L	12	9	75%
											TA	1987	1989	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.040714286	mg/L	14	0	0%
		08204011		No Description		Finch	14	1	45.126	-75.060	TP	1987	1991	0.03	mg/L	0.126	0.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.1108	0.124222222	mg/L	18	14	78%
											TA	1987	1991	1.37	mg/L	0.085	0.02	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.072	0.142222222	mg/L	18	2	11%
		08204012		No Description		Roxborough	27	3	45.180	-74.953	TP	1987	1989	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.133384615	mg/L	13	9	69%
											TA	1987	1989	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.797692308	mg/L	13	2	15%
		08204013		No Description		Roxborough	18	4	45.206	-74.924	TP	1987	1989	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.439416667	mg/L	12	6	50%
											TA	1987	1989	1.37	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.153333333	mg/L	12	1	8%
		08204014		No Description		Roxborough	12	4	45.220	-74.900	TP	1987	1991	0.03	mg/L	0.0505	0.02	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0444	0.093277778	mg/L	18	12	67%
											TA	1987	1991	1.37	mg/L	0.02	0.02	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02	0.117368421	mg/L	19	0	0%
		08204015		No Description		Finch	12	10	45.219	-75.149	TP	1990	1991	0.03	mg/L	0.06825	0.032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.061	0.061	mg/L	6	5	83%
											TA	1990	1991	1.37	mg/L	0.0625	0.03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.056	0.056	mg/L	5	0	0%
		08204016		No Description		Cambridge	21	10	45.242	-75.131	TP	1990	1991	0.03	mg/L	0.09325	0.044	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0834	0.0834	mg/L	5	5	100%
Raisin River Near Williamstown	101	12007300202	Raisin River	Br. Between Williamstown and Lancaster					45.133	-74.543	TP	11/17/1976	11/26/1984	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.058878788	mg/L	33	29	88%
	104	12007300602	Raisin River	1.4 Miles Downstream from Martintown					45.144	-74.696	TP	11/17/1976	12/17/1979	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.060333333	mg/L	30	24	80%
		12007300702	Raisin River	At First Bridge Upstream of Martintown					45.143	-74.730	TP	11/17/1976	12/17/1979	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.043875	mg/L	32	23	72%
		12007301302	North Raisin River	At Hwy 43 Monckland					45.199	-74.868	TP	11/18/1976	11/11/1984	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.050272727	mg/L	33	20	61%
	105	12007300302	Raisin River	First Bend Downstream from Williamstown					45.143	-74.576	TP	11/17/1976	11/16/1999	0.03	mg/L	0.06	0.048416667	0.039727273	0.0455	0.058333333	0.041333333	N/A	0.044666667	0.036	0.045777778	N/A	0.060360976	mg/L	205	169	82%
											TA	09/27/1994	11/16/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.044	0.044333333	N/A	0.036	0.008	0.022444444	N/A	0.030285714	mg/L	21	0	0%
		12007300402	Raisin River	At CPR Bridge Upstream of Williamstown					45.147	-74.589	TP	11/17/1976	12/17/1979	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0474375	mg/L	32	27	84%
	115	12007300102	Raisin River	Hwy 401, Lancaster					45.132	-74.506	TP	08/21/1972	10/23/1979	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.061851064	mg/L	47	43	91%
	129	12007300802	Raisin River	First Bridge Downstream from St. Andrews					45.110	-74.773	TP	11/18/1976	11/16/1999	0.03	mg/L	0.043333333	0.039833333	0.027666667	0.039333333	0.049333333	0.032666667	N/A	0.042666667	0.023	0.035111111	N/A	0.047405797	mg/L	207	131	63%
											TA	09/27/1994	11/16/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.014	0.010333333	N/A	0.014666667	0.002	0.013111111	N/A	0.01152381	mg/L	21	0	0%
		12007300902	Raisin River	At First Bridge Upstream of St. Andrews					45.091	-74.836	TP	11/18/1976	12/18/1979	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.049451613	mg/L	31	21	68%
	132	12007301602	South Raisin River	At Bridge on McConnel Ave. (Cornwall)					45.056	-74.742	TP	11/17/1976	12/17/1979	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.092333333	mg/L	30	26	87%

*TP = Total Phosphorus
TA = Total Ammonia

Table 4.10
Total Phosphorus and Total Ammonia Water Quality Summary

Watershed Name	Subwatershed Number	Station ID	Station Name	Sample Point Description					LATD	LONGD	Parameter Data																				
				Description	Distance, Upstream	Township	Lot	Concession			Parameter	Period		Guideline	Units	1990 Average	1991 Average	1992 Average	1993 Average	1994 Average	1995 Average	1996 Average	1997 Average	1998 Average	1999 Average	2000 Average	Total Average	Units	# of Samples Collected	# of Exceedances	% of Time Exceeded
South Nation																															
	8	18207003002	South Nation River	At CPR Bridge Plantagenet Spring	12.874				45.519	-74.978	TP	01/13/1970	11/25/1971	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.142947368	mg/L	19	19	100%
	19	07019001		South Nation at Seguin bridge (County Rd 9)		S. Plantagenet	6	11	45.456	-74.942	TP	1993	1995	0.03	mg/L	N/A	N/A	N/A	0.506857143	0.148333333	0.126416667	N/A	N/A	N/A	N/A	N/A	0.220806452	mg/L	31	31	100%
											TA	1993	1995	1.37	mg/L	N/A	N/A	N/A	0.007417187	0.004500366	0.004791621	N/A	N/A	N/A	N/A	N/A	0.005271747	mg/L	31	0	0%
	25	07025001		Mouth of Scotch River		S. Plantagenet	11	11	45.454	-74.990	TP	1992	1995	0.03	mg/L	N/A	N/A	0.198333333	0.235363636	0.251769231	0.126166667	N/A	N/A	N/A	N/A	N/A	0.20325	mg/L	48	46	96%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.005078512	0.004750227	0.005715702	0.003787626	N/A	N/A	N/A	N/A	N/A	0.004853131	mg/L	48	0	0%
		07025002		Cobb's Lake Creek at Mouth		S. Plantagenet	21	10	45.444	-75.051	TP	1992	1995	0.03	mg/L	N/A	N/A	0.22325	0.491222222	0.259538462	0.2498	N/A	N/A	N/A	N/A	N/A	0.301975	mg/L	40	40	100%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.002188673	0.001328801	0.002057128	0.001863676	N/A	N/A	N/A	N/A	N/A	0.004669883	mg/L	40	0	0%
	27	07027001		Bear Brook at Mouth		Clarence	26	1	45.419	-75.071	TP	1992	1995	0.03	mg/L	N/A	N/A	0.137083333	0.146727273	0.1465	0.1435	N/A	N/A	N/A	N/A	N/A	0.143382979	mg/L	47	47	100%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.001264287	0.001224897	0.001660768	0.001174029	N/A	N/A	N/A	N/A	N/A	0.001343609	mg/L	47	0	0%
	28	07028001		South Nation River at Pendleton		S. Plantagenet	20	11	45.426	-75.050	TP	1992	1995	0.03	mg/L	N/A	N/A	0.122416667	0.214	0.151692308	0.126333333	N/A	N/A	N/A	N/A	N/A	0.1523125	mg/L	48	47	98%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.006795375	0.005601328	0.006737702	0.15	N/A	N/A	N/A	N/A	N/A	0.042307276	mg/L	48	0	0%
	34	18207009502	Scotch River	At County Rd South of St. Isidore	51.980				45.370	-74.899	TP	10/21/1965	04/10/1967	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.623266667	mg/L	12	9	75%
		18207004002	Scotch River East	At Conc. 17 Downstream from St. Isidore	48.601				45.383	-74.925	TP	09/16/1965	11/23/1999	0.03	mg/L	0.158428571	0.0914	0.2048	0.21	0.237	0.136333333	1.153111111	0.11725	0.08025	0.097428571	N/A	0.388847458	mg/L	236	233	99%
											TA	12/06/1994	11/23/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.086	0.150666667	0.258	0.09375	0.03875	0.033714286	N/A	0.118153846	mg/L	39	1	3%
	35	07035001	Black Creek	Wouth of Bourget, County Rd 8		Cambridge	5	1	-75.102	45.405	TP	1990	1994	0.03	mg/L	0.032875	0.04114	0.033421429	0.039158333	0.056575	N/A	N/A	N/A	N/A	N/A	N/A	0.038494872	mg/L	39	27	69%
											TA	1992	1994	1.37	mg/L	0.04625	0.0422	0.031714286	0.113	0.268	N/A	N/A	N/A	N/A	N/A	N/A	0.073837838	mg/L	37	0	0%
	38	18207005002	Scotch River East	Upstream from Dunvegan Creek	50.21				45.376	-74.910	TP	09/18/1967	10/19/1971	0.03	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.146967742	mg/L	31	29	94%
		07038001		West Branch of Scotch River at County Rd 3		S. Plantagenet	11	3	45.379	-74.914	TP	1992	1993	0.03	mg/L	N/A	N/A	0.128	0.13	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.128588235	mg/L	17	0	0%
											TA	1992	1993	1.37	mg/L	N/A	N/A	0.002062764	0.001099369	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001761703	mg/L	16	0	0%
	39	No Data																													
	41	07041001		Mouth of Moose Creek		S. Plantagenet	22	14	45.389	-75.061	TP	1992	1995	0.03	mg/L	N/A	N/A	0.232333333	0.3064	0.415384615	0.455833333	N/A	N/A	N/A	N/A	N/A	0.355787234	mg/L	47	47	100%
											TA	06/14/1905	06/17/1905	1.37	mg/L	N/A	N/A	0.002983962	0.003916459	0.006119577	0.002771731	N/A	N/A	N/A	N/A	N/A	0.00402208	mg/L	46	0	0%
	44	7044001		South Nation at Lemieux		S. Plantagenet	23	14	45.396	-75.064	TP	06/14/1905	06/17/1905	0.03	mg/L	N/A	N/A	0.137083333	0.146727273	0.1465	0.1435	N/A	N/A	N/A	N/A	N/A	0.124777778	mg/L	45	45	100%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.008369742	0.007527643	0.010796654	0.005916827	N/A	N/A	N/A	N/A	N/A	0.008267033	mg/L	45	0	0%
	48	No Data									TA	12/06/1994	11/24/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.044	0.034666667	0.023333333	0.025	0.01825	0.023333333	N/A	0.024947368	mg/L	38	0	0%
	51	No Data																													
	52	No Data																													
	53	No Data																													
	55	18207006002	Scotch River East	At Conc. 19 Upstream from St. Isidore	51.015				45.374	-74.908	TP	09/18/1967	11/23/1999	0.03	mg/L	0.095666667	0.167	0.087	N/A	0.183	0.086666667	0.04675	0.132	0.069428571	0.084571429	N/A	0.164960591	mg/L	203	192	95%
											TA	12/06/1994	11/23/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.06	0.047	0.018	0.075	0.041714286	0.139714286	N/A	0.062473684	mg/L	38	0	0%
		7055001		East Branch of Scotch River at County Rd 3		S. Plantagenet	8	3	45.354	-74.889	TP	1992	1993	0.03	mg/L	N/A	N/A	0.230833333	0.2668	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.241411765	mg/L	17	0	0%
											TA	1992	1993	1.37	mg/L	N/A	N/A	0.003168179	0.004028452	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.003421201	mg/L	17	0	0%
	56	No Data																													
	75	No Data																													
	90	No Data																													
	211	7211001		South Nation at Hwy 17		N. Plantagenet	20	2	45.559	-75.066	TP	1992	1995	0.03	mg/L	N/A	N/A	0.1585	0.137363636	0.215692308	0.137666667	N/A	N/A	N/A	N/A	N/A	0.1639375	mg/L	48	48	100%
											TA	1992	1995	1.37	mg/L	N/A	N/A	0.027333171	0.008964477	0.008086988	0.004320355	0.049777778	0.13425	0.06425	0.084857143	N/A	0.012324724	mg/L	36	0	0%
		7211002		South Nation at Plantagenet (County Rd 26)		N. Plantagenet	7	4	45.549	-75.042	TP	1993	1995	0.03	mg/L	N/A	N/A	N/A	0.102333333	0.241846154	0.1121	N/A	N/A	N/A	N/A	N/A	0.168241379	mg/L	29	28	97%
											TA	1993	1995	1.37	mg/L	N/A	N/A	N/A	0.005691348	0.003570827	0.003275392	N/A	N/A	N/A	N/A	N/A	0.003930263	mg/L	28	0	0%
		18207002002	South Nation River	Hwy 17 Plantagenet	10.3				-75.064	45.559	TP	10/26/1966	11/23/1999	0.03	mg/L	0.1449	0.1015	0.117818182	0.112416667	0.1612	0.093666667	0.170888889	0.10275	0.09075	0.075428571	N/A	0.133833935	mg/L	277	273	99%
											TA	09/27/1994	11/23/1999	1.37	mg/L	N/A	N/A	N/A	N/A	0.1315	0.038666667	0.049777778	0.13425	0.06425	0.084857143	N/A	0.083897436	mg/L	39	0	0%

*TP = Total Phosphorus
TA = Total Ammonia

The other principal parameters that are available for some of the sample locations are metals such a copper, iron, cadmium, chromium, and zinc. On a subwatershed or watershed basis, these numbers can be useful in developing an understanding of the current contaminant conditions.

From our analysis of the data available for the study area it is evident that a number of the metals parameters exceed the available provincial guidelines for the protection of aquatic life. Within the study area, the data indicates that the following selected parameters exceeded guidelines with the most regularity:

Iron – Provincial water quality objective is 0.3 mg/L. This level is defined to provide protection to fish and invertebrates. Iron exceeded this guideline in samples from most watersheds. The toxicity of iron is, however, quite variable to different species of invertebrates and fish.

Copper – Provincial water quality objective is 0.5 mg/L. The toxicity of copper increases as the hardness of water and the level of dissolved oxygen goes down. Copper is also bioaccumulated in some organisms. The objective for copper was exceeded in the majority of watersheds in the study area.

Cadmium – Provincial water quality objective is 0.2 mg/L. The toxicity of cadmium increases as the hardness of water and the level of dissolved organic matter goes down. Cadmium is also bioaccumulated in some organisms. The objective for cadmium was exceeded in the majority of watersheds in the study area.

Mercury – Provincial water quality objective is 0.0002 mg/L. The level recommended for protection of marketability of freshwater fish is 0.0001 mg/L. Methylmercury is the most toxic form of mercury. The mercury as it is measured in the study area is comprised of only small amounts of methylmercury. Mercury exceeded the 0.0002 mg/L guideline on occasion in the Black Creek and South Nation watersheds. Mercury is bioaccumulated in some organisms.

Nickel – Provincial water quality objective is 0.025 mg/L. Nickel is more toxic at lower hardness levels. It is removed from solution by high levels of suspended solids. Nickel is more acutely toxic to juvenile fish than adults. It is also more toxic in the presence of copper. Nickel is not biomagnified but can be bioaccumulated in some organisms.

Zinc – Provincial water quality objective is 0.03 mg/L. Acute toxicity of zinc is lowered by higher water hardness and low pH. It is exceeded on occasion in the South Nation River watershed. Zinc bioaccumulates but is not suspected of biomagnifying.

Cobalt – Provincial water quality objective is 0.0009 mg/L. Cobalt guidelines are exceeded in a number of areas in the South Nation watershed.

The assessment of the metal parameters exceedences were carried out on a regional basis to provide some indication of the relative significance of the other parameters available in the database. The concentrations and distribution of the metal parameters in the study area suggests that there is significant contamination from a variety of sources. However, no statistical analysis of the significance of these parameters has been carried out.

Road Salt

During the study, members of the steering committees and the public expressed some concern over potential environmental impacts of road salt. This concern was particularly heightened following the release of a draft report by the federal government recommending that road salt be considered "toxic" as defined by Section 64 of the Canadian Environmental Assessment Act (Environment Canada and Health Canada, 2000). Substances that are assessed as toxic may be placed on Schedule I of the Act and considered for possible risk management measures, such as regulations, guidelines, pollution prevention plans or codes of practice to control any aspect of their life cycle, from the research and development stage through manufacture, use, storage, transport and ultimate disposal.

Road salts enter the Canadian environment through their storage and use and through disposal of waste snow. Road salts are used for de-icing and anti-icing winter road maintenance, with some use as summer dust suppressants. Inorganic chloride salts considered in the Environment Canada report include sodium chloride, calcium chloride, potassium chloride, and magnesium chloride. In the environment, these chloride salts dissociate into the chloride anion and the corresponding cation. In addition, ferrocyanide salts, which are added as anti-caking agents in road salts formulations, were assessed. These compounds enter surface water, soil and groundwater after snowmelts, and are dispersed by splash and spray through the air. Approximately five million tons of road salts used across the country every winter contaminate groundwater and surface water, poison wildlife, and harm vegetation.

Management of road salt impact should focus on key source areas including patrol yards, road application and snow disposal. Environment Canada recommends that patrol yards implement better storage of salt and abrasives to reduce losses through weathering. Management practices to reduce losses during transfers, and management of stormwater and equipment washwater to minimize releases should be started. When handling disposal of snow, measures should be considered to minimize percolation into soil and groundwater and direct release into water. In cases of release into surface water via storm sewer systems, the salted snow should be diluted before release. The selection of alternative products or of appropriate technology or practices to reduce salt use should be considered while ensuring maintenance of roadway safety.

Relative Source Contributions for Parameters of Concern

As noted above, the primary surface water quality issue within the study area is nutrient enrichment in the form of high levels of phosphorus. This conclusion is based on the representative database, the emphasis placed on enrichment problems and toxicity from these two parameters of concern and the regulatory issues determined to be most predominant by the MOE. The MOE has the regulatory mandate within the Province of Ontario to set guidelines for the levels of surface water contaminants that will allow for an acceptable level of aquatic habitat protection and the limits of contaminants allowed to be discharged from point sources including municipal wastewater treatment plants and industrial treatment facilities. The MOE also regulates the discharge of surface waters through their Municipal and Industrial strategies for abatement.

Ammonia can also pose a problem with respect to being toxic to aquatic life, depending on water temperature and water alkalinity. The net effect of nutrient enrichment, primarily in the form of phosphorus, is excessive weed and algae growth within creeks and rivers, which can, in turn, result in high water turbidity and wide fluctuations in dissolved oxygen levels, making watercourses unsuitable for certain species of aquatic life. As well, algae growth and high turbidity can cause problems at water treatment facilities that draw their water from surface supplies. Phosphorus and ammonia are often derived from non-point sources from a variety of land uses. Phosphorus and ammonia can also be directly discharged from point source municipal wastewater treatment facilities. These point sources can represent zones of ammonia toxicity in the discharge plume.

Earlier studies have examined this issue in some detail within the South Nation River watershed, in order to determine the source of the problem and provide guidance on what management measures would provide the most benefit. The South Nation River Basin Management Study (Water Resources Component, Maclaren Plansearch, 1982) concluded that wastewater discharges from regulated point sources such as municipal and industrial sewage treatment systems accounted for approximately 5 percent of the total phosphorus load and 1 percent of the total nitrogen load carried by the River. An updated analysis was presented in the South Nation River Wastewater Allocation Study (Gore & Storrie Limited, 1992), and this analysis showed that regulated point sources accounted for 3 to 7 percent of the total phosphorus load, about 1 percent of the total nitrogen load and approximately 5 percent of the ammonia load. The 1992 study therefore concluded that no significant change had occurred over the 10 years. In the Raisin River watershed, there are no municipal point sources, which would suggest that non-point sources of contaminants could represent an even greater percentage (than that of the South Nation) of contaminant loads to the river system.

While EOWRMS has not included a detailed update of the loading analysis, it is reasonable to presume that since the 1992 analysis, the relative contribution of regulated point discharges has not changed significantly and very likely remains at less than 10 percent of the total load entering the river system. As concluded in the 1992 study, the bulk of the nutrient loading originates from so-called “non-point sources” (NPS). Non-point sources include a wide range of possible sources including soil erosion and runoff from agricultural land, leakage from domestic septic systems, livestock access to watercourses, and background levels from watercourse erosion.

From a management perspective, the dominant role of NPS needs to be recognized. Many forms of NPS are not subject to any form of direct regulation. What is therefore needed are watershed-based programs that identify areas and land parcels that are mostly likely to contribute to NPS, and which are then based on working with land owners to find practical and economical ways of reducing such processes as direct surface runoff and associated soil erosion (see Section 6). The project partners have recognized this need and have in place a number of programs and projects designed to address this issue. These programs include the Clean Water Program (SNC), the Rural Clean Water Program (City of Ottawa), and the Tributary Restoration Program (RRCA). In addition the SNC is currently using the AGNPS model to characterise and target high potential NPS source areas within the watershed.

4.3 Relevance to Regional Water Strategy

Surface Water Quantity

The review of streamflow data has resulted in the following findings that are particularly relevant to the development of a long-term regional water resources management strategy:

- Streamflow regime throughout the study area has high seasonal variability. Roughly 60 percent of surface water yield is delivered during the spring freshet (March and April). A low-flow period then extends through the summer growing season and into early autumn. The magnitude and duration of low-flows likely presents constraints on the expanded use of surface waters as sources for water supply for purposes such as irrigation, livestock watering or communal water supply systems.
- The magnitude and duration of low-flows also presents constraints on development by virtue of the resulting limits on the ability of watercourses to assimilate contaminant loadings. As discussed below, the low summer flow period means that waste discharges and overall contaminant loadings must be carefully managed if water quality is to be protected and enhanced to meet environmental objectives such as those related to protection of aquatic habitat and ecosystems.

In terms of surface water quantity, these findings point to the need for careful management of water resources to ensure that sources of streamflow such as groundwater discharge zones and wetlands are protected through appropriate land-use planning, and that surface water withdrawals are managed and allocated in a way that recognizes the limits of the available resource.

A fundamental requirement for managing surface water quantity is a set of clear targets with respect to the amount of streamflow that should be maintained through critical periods (especially the summer low-flow period) for the purposes of meeting overall objectives for ecosystem and aquatic habitat protection. The total amount of acceptable surface water withdrawal during critical period can only be determined once such ecosystem-based management targets are set. The need for such management is iterated in the recommendations below.

Surface Water Quality

In the context of the Regional Water Strategy, the findings of high levels of total phosphorus in most surface waters, as indicated by the analyzed data, shows that there is very little opportunity for surface waters to assimilate additional waste loads. In fact, the data indicates that surface waters are generally deteriorated below what is considered to be a level (of total phosphorus) sufficient to protect aquatic life in many areas. Effectively, there is no capacity for watercourses to assimilate increased phosphorus loadings.

The current state of the receiving waters indicates that habitat conditions are deteriorated and measures need to be taken to improve the quality of surface waters. Therefore, a number of strategies must be employed that will manage wastes discharged to receiving streams in a manner that promotes the improvement of water quality across the region.

4.4 Recommendations

Protection of Streamflow Sources

As noted above, an important management objective is the protection of sources of streamflow, particularly those that sustain streamflow during dry periods. It is recommended that land-use planning policies and regulations be put in place to protect identified sources of stream baseflow. This could include protection of specific areas where groundwater discharge is occurring, possibly including wetland areas that are known to be supplied by groundwater upwelling. Protection of such discharge areas or zones should be considered as part of an overall strategy to protect groundwater resources in a way that protects the annual amount of water recharge to groundwater aquifers.

Identification and mapping of groundwater discharge zones and other sources of stream baseflow is needed to assist with long-term protection of streamflow sources through land development planning and land-use regulation. It is recommended that the location of these sources of streamflow be identified through a watercourse baseflow source investigation. Such an investigation would involve a program of systematic measurement of baseflow at a number of locations within each subwatershed, to determine where flow is originating in dry-weather periods. The program should consist of spot measurements of volumetric streamflow rate during dry periods in the summer. The program should be structured such that investigations proceed in an upstream direction along the major watercourses and then upstream along various tributaries. The initial program could consist of baseflow measurements at all roadway crossings. The program might need to extend over a number of weeks or months depending on resources available. As the flow readings are made, they must be recorded in a consistent format and collated in a central data record. Once sufficient readings are made, data can be mapped. When observed baseflow rates are considered, along with information on estimated upstream surface drainage area, flow sources and probable groundwater discharge locations should reveal themselves. Additional flow measurements would then be required to home in on discharge zones.

Later sections of this report provide information on the groundwater conditions across the study area, including generalized mapping of probable groundwater discharge zones, as determined through the water budget analyses carried out during this project. This information can be used to help guide the flow measurement program.

Management of Surface Water Withdrawals

The seasonal variation in streamflow and the magnitude and duration of low-flow periods that characterizes the streamflow regime throughout the study area means that surface water withdrawals need to be carefully managed.

At present, there are generally two types of withdrawals: those that are subject to regulation (Permit to Take Water for withdrawal of more than 50,000 L per day) under the Ontario Water Resources Act, such as communal water supply systems and industrial/commercial operations, and those that do not require a formal permit to take water, such as livestock watering.

The number of water takers and total water usage associated with unregulated withdrawals is largely unknown or unconfirmed and must be estimated (see Section 7). This presents a water management difficulty insofar as it limits the ability to make decisions on how much increase in regulated withdrawals can be permitted.

It is therefore recommended that an inventory of all surface water users and their estimated water withdrawal amounts be created and maintained, for the purpose of allowing better management of regulated water takers. It is recommended that this inventory be a watershed-based activity that is best lead by the MOE and could carried out with the assistance of Conservation Authorities in cooperation with member municipalities and local agricultural groups. This information is critical for the MOE to fulfill its responsibilities as outlined in the Water Taking and Transfer Regulation (O. Reg. 285/95).

It is recommended that applications for new Permits to Take Water or renewal of existing Permits to Take Water be based on a watershed-based surface water allocation strategy. It is recommended that this strategy be based on the data and statistics on streamflow and regional water budget presented in this report, along with the information that would result from the recommended inventory of all surface water withdrawals. It is recommended that the allocation strategy be based on targets for the total allowable streamflow withdrawal at various locations within each watershed. These targets or limits should be based on statistics on streamflow presented in this report and the level of streamflow that should be maintained to protect aquatic habitat and other water-related environmental features.

Surface Wastewater Discharge Management

As explained above, nutrient enrichment of watercourses is the dominant concern for surface water quality. A significant challenge is to address the acknowledged importance of non-point sources (NPS), which include soil erosion and direct runoff from agricultural land, watercourse channel erosion and leakage from faulty septic systems.

From a practical management perspective, it needs to be recognized that there are various forms of NPS distributed throughout each watershed, some of which may be active only at certain times of the year. Dealing with all of these potential sources in an efficient and economical manner will require time, and will also require the cooperative effort of landowners and various regulatory agencies that have a mandate to deal with water quality and land-use regulation.

A number of programs exist in the study area that are helping to improve surface water quality and habitat by targeting and reducing NPS contributions. These programs include the Clean Water Program (SNC), the Rural Clean Water Program (City of Ottawa), and the Tributary Restoration Program (RRCA). Funding and support for these programs should be at least maintained or expanded.

Part of the solution is to continue to work towards higher levels of sewage treatment at municipal treatment facilities; this is being pursued on case-by-case basis by municipalities in cooperation with the regulatory agency, the MOE. However, because of the dominant effect of NPS, it needs to be recognized that improved nutrient removal at municipal sewage treatment facilities will not have any substantial effect unless NPS is also dealt with, as stated in the 1992 South Nation River Wastewater Allocation Study.

The need to manage NPS has been recognized through the development of the “Total Phosphorus Management” pilot program for the South Nation River watershed. This program is a cooperative effort of the MOE, South Nation Conservation, and local farm operators and landowners.

In a regional context, the opportunities presented by the MOE’s Total Phosphorus Management (TPM) program for the South Nation River watershed should be explored and incorporated into other watersheds in the study area. When there is a recognized need to expand a municipal or industrial waste treatment system, this program allows for two options: provide higher levels of phosphorus treatment and removal or put resources toward non-point source control measures. The NPS control measures option, as a method of improving receiving stream conditions and allow for additional waste discharge from a municipal or industrial source, currently requires a number of conditions to be met. These conditions include:

- Analysis that clearly shows environmental benefit
- Assurance of investment
- A 4:1 offset ratio for phosphorus reduction such that the estimated TP load reduction caused by the NPS controls would be 4 times that of the proposed discharge from the regulated point source

Opportunities for a regional strategy, coordinated on a watershed basis, for seasonal discharge from municipal lagoons should be examined. Currently, there are a variety of strategies exercised in the region for the seasonal (spring) discharge from municipal treatment lagoons. A program for discharge from the lagoons, coordinated on a regional basis, may provide additional stream water quality benefit. Such a program might also ease some seasonal capacity issues at municipal facilities.

There may also be additional opportunities for effluent polishing from municipal lagoons that could provide significant reductions in total phosphorus loading to receiving streams. Effluent polishing technologies such as treatment wetlands, which provide additional habitat and ecological benefit, should be examined. In addition to the conventional methods now employed across the region, other waste management technologies, such as communal wastewater treatment systems, should be examined for new developments.

The stream water quality sampling programs of the various agencies should be incorporated into a regional program to ensure that adequate data is collected over the next 20 years in the most effective and efficient manner possible.

The impact of additional development should be a component of all Official Plans in the region, both from a rural and an urban perspective. Additional development opportunities would be required to provide sufficient evidence of proper waste management to ensure that additional receiving water deterioration is not a factor.

Southern Ontario uses particularly high volumes of road salt. Municipalities and road maintenance contractors in Eastern Ontario should be made aware of the potential and persistent effects to the environment from road salt as described in the Environment Canada, Health Canada 2000 assessment report. They should also be encouraged to voluntarily adopt the suggested mitigation strategies and actions in advance of likely future federal requirements.

St. Lawrence River Remedial Action Plan (RAP) Recommendations

There are a number of recommendations that were put forward in the St. Lawrence River RAP (Dreier et al., 1997) that are relevant to the finding and recommendations of EOWRMS. The consultant team generally concurs with the recommendations. The RAP recommendations pertaining to regional surface water management are listed here along with their RAP recommendation number. RAP recommendations specific to particular industrial sources or particular site specific contaminant sources have been omitted from the list presented here because they are not regional in nature.

TABLE 4.11
ST. LAWRENCE RIVER REMEDIAL ACTION PLAN RECOMMENDATIONS

Number	Recommendation
1.	Ask the federal and provincial governments to show more tangible evidence of their commitment to the goal of virtual elimination of persistent toxic contaminants by using their legislative authorities to ban the use of mercury and production of persistent toxic compounds like dioxins and dibenzofurans.
5.	Establish federal and provincial regulations banning the manufacture and sale of all detergents containing phosphates.
6.	Recommend that OMAFRA vigorously pursue its pesticides reduction goal in the Great Lakes-St. Lawrence River Basin by encouraging improved chemical herbicide/pesticide application practices, integrated pest management and other alternative farming practices that reduce the environmental impact of pest and weed control.
7.	Recommend that all authorities involved in managing public lands, transportation routes and transmission corridors in the Great Lakes-St. Lawrence River Basin do the following: • Provide an inventory of their herbicide and pesticide use • Develop and implement strategies that will reduce their use of these chemicals in the Basin by 50 percent by the year 2002
31.	Control stormwater discharges from municipalities other than Cornwall, particularly roads and communities along the Raisin and St. Lawrence Rivers, by collecting and treating stormwater.
32.	Install proper septic systems on private shoreline properties where land is sufficient and can meet existing regulations; carry out inspections to ensure compliance.
34.	As a long-term plan, install sewage treatment plants for river communities, including Summerstown, South Lancaster, Pilon Island, Cornwall Island and Bainsville.
35.	Inspect park and campground sewage disposal systems and correct deficient systems.
37.	Eliminate livestock access to surface waters by providing education and financial incentives to farmers and by enforcing existing regulations.
38.	Inspect manure piles and milkhouse waste disposal systems which have the potential to be sources of surface water contamination, and correct by: • Providing education to farmers on how to correct the problem • Providing financial incentives to farmers • Enforcing existing regulations • Incorporating into municipal zoning by-laws, the Agricultural Code of Practice regarding manure/milkhouse wastes • Establishing a bioconversion facility for production of fertilizer from manure and other organic sludges pending feasibility study (to determine available manure supply, interest in participation etc.)
39.	Endorse the Farm Environmental Plan program described in *Our Farm Environmental Agenda* as part of the development of an agricultural land stewardship program.
48.	Encourage municipalities to continue to implement the Provincial Natural Heritage Policy (1996) which requires all planning agencies to have regard for provincially significant wetlands in their planning decisions. The Policy calls for no development in provincially significant wetlands and no development on adjacent lands if the wetland will be affected. This policy is to be interpreted as part of all the new Planning Act policies by municipalities and agencies.
49.	Encourage municipalities to protect wetlands that are not designated provincially significant by requesting that they include development constraints and buffer zones around these areas.

TABLE 4.11
ST. LAWRENCE RIVER REMEDIAL ACTION PLAN RECOMMENDATIONS

Number	Recommendation
51.	Continue to use existing legislation (including the federal Fisheries Act, Public Lands Act, Lakes and Rivers Improvement Act, Conservation Authorities Act and Environmental Protection Act) to protect aquatic habitats (including fish habitat and wetlands) where this legislation applies. Continue to require a minimum compensation of 1:1 (new habitat created: habitat altered) for fish habitat harmfully altered by development activities. Minimum compensation should be 1:1 for like habitat onsite; 1:2 for like habitat offsite or replacement habitat onsite; and 1:4 for replacement habitat offsite.
58.	Encourage the enhancement of the protection, number, size, quality, and distribution (i.e. reduce fragmentation) of certain terrestrial habitats (i.e. mature and over-mature forests, riparian habitats) and their dependent species.
60.	For specific problem areas, design the appropriate stabilization technique and implement the work as a government initiative either with public funding only or on a cost-shared basis with the landowner.

5. Groundwater Analysis

This section of the report specifically addresses the analysis groundwater resources in the study area. Surface water was addressed in Section 4. Land use and servicing infrastructure are addressed in Sections 6 and 7, respectively.

5.1 Overview

One of Eastern Ontario's primary sources of water is groundwater. Groundwater is obtained from dug or drilled wells, which extract water from an aquifer. An aquifer is any geologic material such as sand, gravel, or limestone that is permeable enough to yield a significant amount of water to a well or spring. Water quality within aquifers can vary significantly depending on the natural setting or human induced impacts.

In the exploration for new groundwater sources, or aquifers with additional capability, it is necessary to identify the locations of aquifers, determine the long-term capability of the aquifer to yield water, and to determine the quality of the water the aquifer yields. In general, a groundwater source is less vulnerable to contamination than a surface water source because of the protection afforded by the overlying geologic units. However, dug and shallow drilled wells may have little geologic protection, making them vulnerable to contamination. Therefore, in evaluating the supply potential (capability) of an aquifer, it is important to consider its geologic (intrinsic) protection from potential contamination.

With these considerations in mind, the groundwater analysis component of the Eastern Ontario Water Resources Management Study (EOWRMS) was undertaken to:

- Define and map aquifer extents and connectivity
- Quantify groundwater recharge
- Characterize aquifer natural water quality
- Characterize current and additional aquifer capability
- Characterize the intrinsic aquifer vulnerability to contamination

The groundwater analysis presented in this section was completed on a regional scale to provide an overall characterization of the groundwater systems in Eastern Ontario. The analysis was completed by first developing a relational database of all available information, which was managed and interpreted within a Geographic Information System (GIS).

An overview of the groundwater analysis and data sources is presented in Figure 5-1.

5.2 Data Sources and Limitations

5.2.1 Data Sources

A number of data sources were used to meet the objectives of the groundwater analysis. Data and reports on water wells, geology, topography, climate, land cover, cadastre (lot and concession locations), and groundwater use were compiled and analyzed within a relational database and GIS system.

The following is a list of the specific data sources used and the primary information these sources provided:

- Ministry of the Environment (MOE) Water Well Records
  - Primary source of geologic and hydrogeologic information
  - Location and elevation of all registered water wells
  - Lithology information along the depth of the well (i.e. 5 m of gravel and 3 m of clay). Used to develop regional geologic/hydrogeologic maps
  - Static water levels for groundwater head (pressure) and flow mapping
  - Well details including depth of water bearing zones
  - Well construction details such as depth of casing and recommended pumping rate
- Reports and Maps
  - Geology and structure reports fill gaps in mapping and provide a check of maps created from water well records
  - Physiography provides additional geologic data on landforms to aid in the interpretation of recharge and discharge
  - Hydrogeology reports provide regional interpretations that often include field confirmation of smaller databases. These reports are used as a check of the large database used in this study
- Permits to Take Water
  - Permits from the MOE for large groundwater withdrawals provide the location of potentially significant aquifers and an estimate of the current groundwater demand of that particular aquifer
- GIS Maps and Databases Created in Other Components of EOWRMS
  - Digital Elevation Model. Ground surface elevation for developing hydrogeologic maps
  - Cadastre (lot and concessions) used for verification of well locations
  - Land cover maps used to determine type of likely groundwater use
  - Water budget model used to partition precipitation, runoff, evapotranspiration, and groundwater recharge input
  - Groundwater demand within each township from all sources (e.g. agriculture, private domestic, communal domestic)
  - Miscellaneous maps showing roads, town names, county boundaries, and surface water features

5.2.2 Limitations of the Data

MOE Water Well Records

For any particular water well, the quality of the reported data may be suspect in terms of:

- Overall data reporting quality
- Reported location and elevation of the well
- Consistency of terms used to describe geology

- Consistency and completeness of the water quality reporting (no formal testing completed)
- Static water level, which, being measured after a well-yield pumping test, may not have fully recovered to a static level. In addition, static water levels may be affected by year-to-year variations in water levels and longer-term trends since the database contains records from 1930 to 2000.

The water well records database documents very few dug wells; however, the responses to the Water Resources Survey and discussions at the EOWRMS open houses indicate a number of dug wells may be in use. Because this data is not reported to the MOE and therefore not available in the MOE database for most of these wells, our analysis lacks water level data in the upper portion of overburden geologic deposits. However, deeper drilled wells penetrate these deposits and provide adequate geologic and hydrogeologic information. It may be possible to obtain records of some dug wells from the Eastern Ontario Health Unit as records are often included in septic system applications. The water well record database could then be updated with this information.

An additional limitation of the MOE water well record data is that it is point data, which must be spatially related to other points using professional judgement. The interpolation is accurate at a regional scale given the data being used but will have some error at a site scale.

Reports and Maps

A total of 52 hydrogeology reports completed in support of applications for proposed residential/commercial/industrial developments are on file with the MOE in Kingston. These reports provide site-specific groundwater data and there are no complementary reports for all areas. This incomplete coverage often limits the use of existing reports and maps. In addition, other reports and maps must be used with caution after ensuring that the methods used to create these documents are comparable with the database and methods used in EOWRMS.

Permits to Take Water

The data provided in the Permits to Take Water (PTTW) are often limited by the fact that some of the permits are expired and the quantity of water actually being extracted is not reported – only the maximum permitted amount is reported. In addition, only lot and concession information is provided for these permits rather than map coordinates, leading to inaccuracies in their locations.

GIS Maps and Databases Created in Other Components of EOWRMS

The limitations of these data sources were discussed in the Sections 3 and 4 where they were first created or added to the database.

5.3 Assumptions

The most important assumption made in the groundwater analysis is that a two-dimensional interpolation of point data can be used to represent and model a three-dimensional hydrogeologic system. This assumption is valid at regional scale where the components of the flow system can be balanced. However, any interpretations of groundwater flow directions and recharge are based on the two-dimensional mapping of the systems. In reality, these processes are controlled by the three-dimensional hydrogeologic system and the regional analysis represents a reasonable approximation of this system.

The use of the MOE water well records, in consideration of the data limitations, requires that a number of assumptions be made with respect to the quality of data reported for any particular well. It is assumed that all wells are of acceptable quality and can be used in the analysis following a process of data verification and interpretation that involves:

- Verifying the location of a well using the reported lot and concession and the reported x and y coordinates
- Verifying the ground surface elevation of the well using the Digital Elevation Model (DEM)
- Interpreting the geologic descriptors used in the original well logs using a standard set of rules to reclassify the geologic description into one of 29 standard descriptions developed for Eastern Ontario
- Estimating the depth of the water-bearing zone in each well using information from well construction in conjunction with professional judgement where the water-bearing zone is not reported

5.4 Approach and Methods

The groundwater analysis approach is GIS-based and based on interpretation using professional judgement. The GIS approach incorporates the interpolation of point data to produce maps of components or properties of the groundwater flow system. Two or more maps can be combined within the GIS to produce a new map for interpretation of a property or parameter. For example, a map of the elevation of the bedrock surface can be numerically subtracted from a map of the ground surface elevation to produce a new map of the depth to the bedrock surface. More complex map operations can be completed to calculate hydro-geologic properties such as aquifer capability.

The process of modelling / mapping the groundwater system in Eastern Ontario is summarized in Figure 5-2. The first step in the analysis is to develop a conceptual model of the spatial relationships between aquifers and geologic layers. Once the conceptual model is developed, additional mapping can be completed. The mapping process uses all data sources, which have been verified and incorporated into the relational database to produce all of the component maps, needed to map and determine:

- Conceptual model development
- Aquifer locations
- Aquifer properties
- Groundwater quality
- Groundwater recharge
- Aquifer capability
- Aquifer vulnerability

The following sections describe the methodology and results of each component of the groundwater analysis.

5.5 Characterization

5.5.1 Conceptual Model

A conceptual model of groundwater flow was developed to understand what aquifers are present in Eastern Ontario, where they occur within the vertical geologic sequence, and how the units that comprise the aquifers were deposited or formed. The conceptual model was developed through the interpretation of a number of regional geologic cross-sections constructed from the MOE water well records and descriptions of the geology of Eastern Ontario (Wilson, 1964; Bélanger and Harrison, 1980; Charron, 1978; Chapman and Putnam, 1983; Brandon, 1960). Table 5.1 summarizes the distribution of wells throughout the study area and Figure 5-3 shows the spatial distribution of the wells.

TABLE 5.1
SUMMARY OF MOE WATER WELL RECORDS IN EASTERN ONTARIO

Area	Total Number of Wells	Number of Located Wells	Upper Overburden Wells*	Lower Overburden Wells**	Bedrock Wells
P&R	6058	6040	0.8%	18.4%	80.8%
SD&G	11718	11341	0.1%	10.4%	89.5%
Ottawa	9856	9430	0.2%	10.3%	89.5%

Notes: P&R = Prescott and Russell
SD&G = Stormont, Dundas and Glengarry
Ottawa = City of Ottawa
*Upper Overburden Wells: Wells completed in the upper, shallow portion of the overburden (i.e. dug wells)
**Lower Overburden Wells: Wells completed in the lower, deep portion of the overburden

The development of the conceptual model is outlined in Figure 5-4 and identifies the major aquifers in Eastern Ontario. Two regional cross-sections and the interpretation of bedrock surface are presented in Figures 5-5 and 5-6.

The geologic history of Eastern Ontario can be summarized by the following succession of occurrences (Wilson, 1964):

- Formation of Precambrian deposits, followed by a period of erosion
- Deposition of Paleozoic deposits, which were later exposed to faulting and a long period of erosion
- Glaciation and withdrawal of the Champlain Sea (Quaternary deposits), and subsequent erosion

Pleistocene and recent deposits overlie the Paleozoic bedrock. These deposits are referred to as overburden or unconsolidated deposits and include pre-glacial sands, till and moraine, post-glacial sands and Champlain Sea deposits. Pockets of quaternary sand and gravel deposits directly overlie the Paleozoic bedrock throughout much of the area. Throughout most of Eastern Ontario, clays of the Champlain Sea overlie the bedrock and glacial till deposits. In some areas, sand and gravel deposits are essentially continuous from the soil horizon to the bedrock.

Water may be obtained from fractures in the bedded Paleozoic sandstone, dolomite, and shale in the upper portion of these deposits. Faulting and fracturing within these units controls the amount of water that can be extracted and conducted through these units. Where fracturing is intensive, large quantities of water suitable to supply communal systems may be extracted.

The primary aquifer in Eastern Ontario consists of the upper portion of the fractured Paleozoic bedrock and sand and gravel deposits, which directly overlie the bedrock in the lower portion of the overburden. This aquifer system is referred to as the Contact Zone Aquifer. The clay and fine-grained deposits in the region act as a confining layer for the Contact Zone Aquifer. The low conductivity of the confining layer is instrumental in preserving the quality of water in the fractured bedrock and sand and gravel aquifer as it significantly decreases the downward migration of recharge from the surface to the aquifer. In regions where the glacial till is absent, the aquifer is more exposed to contamination (Brandon, 1960).

5.5.2 Aquifer Extents and Connectivity

Characterization of spatial aquifer extents and connectivity was completed to map the locations of all sand and gravel and bedrock aquifers in Eastern Ontario and any vertical connection that exists between the sand and gravel units. Figure 5-7 outlines the mapping process used to map aquifer locations. Table 5.2 summarizes the data used and the purpose of each map.

TABLE 5.2
AQUIFER EXTENTS AND CONNECTIVITY MAPPING

Map	Purpose	Source	Methodology	Comment
Bedrock Surface Elevation (Figure 5-8)	Define bedrock surface variability	Water well records	Interpreted from well log lithologies	Reported continuous “bedrock” lithologies
Overburden Thickness (Figure 5-9)	Define thickness of non-bedrock deposits	Water well records	Topography – bedrock surface	
Upper Overburden Aquifer Thickness (Figure 5-10)	Define shallow sand and gravel aquifers	Water well records	Interpreted from well log lithologies	Represents shallow deposits
Lower Overburden Aquifer Thickness (Figure 5-11)	Define deep sand and gravel aquifers	Water well records	Interpreted from well log lithologies	Represents deep deposits in contact with bedrock
Connection with Ground Surface (Figure 5-12)	Define connectivity of aquifers vertically	Water well records	Interpreted from well log lithologies	Represents vulnerable areas
Histogram of Productive Bedrock Zones (Figure 5-13)	Evaluate distribution of productive zones vertically within bedrock	Water well records	Interpreted from lowest permeable zones	
Aquifer Location Map (Figure 5-14)	Define areas where lower overburden or bedrock aquifers are found	Water well records	Summary of above mapping	Bedrock found to be productive throughout the study area, at some depth

Figures 5-8 and 5-9 show the bedrock surface elevations and the calculated overburden thickness, respectively. These maps show the variation in overburden thickness and the bedrock surface within Eastern Ontario. Generally, areas with a large thickness of overburden are more likely to have large quantities of sand and gravel that can act as aquifers.

Figures 5-10 and 5-11 show the location and thicknesses of sand and gravel in the upper and lower portions of the overburden, respectively. Areas with a sand and gravel thickness of greater than 2 m are considered to be possible aquifers that could supply groundwater to a well. The larger the area, the greater the potential for the aquifer to supply water. In the context of the conceptual model, the lower overburden aquifers have the greatest potential for development when combined with the upper portion of the bedrock (discussed below).

The degree of geologic protection from contamination varies throughout the study area. In general, the lower overburden aquifers have a lesser potential for contamination than the upper overburden. However, in many cases, the two aquifers may be connected such that the lower overburden aquifer may be as vulnerable as the upper overburden aquifer. Figure 5-12 shows areas where the lower overburden and bedrock aquifers are near to the ground surface, where there is little protection from the overlying geologic material.

Bedrock aquifer locations are more difficult to map with the available data sources. The fracturing or porosity of bedrock units intersected by a well is reported inconsistently in the MOE water well records. Therefore an interpretation of fracturing using point data does not reflect the spatial distribution of wells extracting water from the bedrock. Anecdotal information and reports by Charron (1978), Bélanger and Harrison (1980), and Brandon (1960) support the interpretation that the first few metres of the bedrock is generally fractured from weathering and can provide a source of groundwater to a well at least for domestic use. This interpretation is supported by the distribution of bedrock wells throughout Eastern Ontario that provide groundwater from areas that are not reported as being fractured. Additional porous or fractured zones may exist within the bedrock and provide adequate amounts of groundwater.

Figure 5-13 presents a histogram showing the number of wells that obtain groundwater at each depth interval below the bedrock surface. The histogram indicates that most wells are completed within the first 10 m of the bedrock surface, which suggests that the rock is sufficiently fractured to supply groundwater. A number of wells are completed below this 10-m depth, but the number decreases with the increasing depth. No depth interval appears to stand out from another below the 10-metre depth, which might indicate a more permeable zone. Because of the bedded nature of the bedrock, it was further subdivided for analysis purposes into 10 to 20 m in depth and 20 m and greater in depth. All subsequent analysis is focussed on the upper 10 m of bedrock, because it has the greatest potential to yield groundwater.

The aquifer extents and connectivity mapping indicate that the lower overburden sand and gravel aquifers and the upper 10 m of bedrock have the greatest groundwater supply potential. Figure 5-14 combines the aquifer mapping of both of these units into a single map. Areas that have both lower overburden and bedrock aquifers have the greatest potential to supply groundwater.

5.5.3 Aquifer Properties

An evaluation of groundwater potential must also include an estimate of the ability of an aquifer to conduct water to a well. Transmissivity is a measurable property of an aquifer that indicates its ability to transmit groundwater. Transmissivity is the product of the hydraulic conductivity of the aquifer material and the thickness of the aquifer.

The protection afforded an aquifer from contamination is a function of the thickness and the vertical hydraulic conductivity of the geologic material overlying the aquifer. Figure 5-15 presents the methodology used to determine the vertical hydraulic conductivity of the geologic material that overlies the bedrock. Figure 5-16 shows the vertical hydraulic conductivity of the geologic material overlying the aquifer. The red colours indicate the areas with the greatest vertical hydraulic conductivity and the blue indicates areas of lower hydraulic conductivity. Areas of low vertical hydraulic conductivity such as the Champlain Sea clays in Prescott and Russell (P&R) and the City of Ottawa, and tills of the Glengarry Till Plain restrict the vertical flow of groundwater and associated contaminants. The weighted harmonic mean underestimates the vertical hydraulic conductivity at a regional-scale, which results in lower (conservative) estimates of recharge to the Contact Zone Aquifer.

Transmissivity is usually measured with a pumping test of a well, but it can be estimated using regional estimates of hydraulic conductivity and the aquifer thickness. Figure 5-15 describes the process for estimating transmissivity, using GIS. Representative hydraulic conductivities (K) were estimated for each geologic unit using professional judgement and typical values presented by Freeze and Cherry (1979). The transmissivity estimate should only be considered an approximation to allow for comparison between aquifers. The arithmetic average used to calculate a bulk K for each aquifer may overestimate the value at a regional scale. Figure 5-17 shows the relative transmissivity of the lower overburden aquifer. The red colours indicate the aquifers with the greatest transmissivity and the blue indicates areas of lower transmissivity.

Table 5.3 summarizes the purpose, data source, and methodology used to develop these maps.

TABLE 5.3
AQUIFER PROPERTY MAPPING

Map	Purpose	Source	Methodology	Comment
Vertical Overburden Hydraulic Conductivity (Figure 5-16)	Define areas where recharge can readily flow to the Contact Zone Aquifer	Water well records	Conductivity calculated from well log lithologies	Harmonic average of conductivities used
Lower Overburden Aquifer Transmissivity (Figure 5-17)	Define highest yield aquifer zones	Water well records	Conductivity calculated from well log lithologies	Arithmetic average of conductivities used

5.5.4 Groundwater Recharge and Flow Directions

Groundwater recharge refers to the portion of precipitation flow downward to the saturated portion of an aquifer. Recharge of an aquifer is important to quantify as it limits the maximum (theoretical) amount of groundwater that can be sustainably extracted from the aquifer. The process of estimating groundwater recharge to the Contact Zone Aquifer is summarized in Figure 5-18.

Groundwater flow can be summarized as a process whereby water flows from areas of high potential (elevation) to areas of low potential (elevation). The high potential areas represent recharge areas where groundwater flow is generally downwards into an aquifer, such as topographic highs. Areas of low potential are discharge zones where groundwater flow is generally upwards towards surface water features such as streams. Aquifers lose water by discharge to surface water features.

Figures 5-19 and 5-20 show the elevation of the piezometric surfaces (static water levels) of the Contact Zone Aquifer and the deep bedrock. The higher potential areas are shown in red, while the low potential areas are shown in blue. The direction of groundwater flow from recharge zones to discharge zones is from the red areas to the blue areas. Ground watersheds are presented in Figure 5-19 for the Contact Zone Aquifer. These maps can be used to develop groundwater water budgets in a similar manner to surface watersheds whereby recharge to a ground watershed should equal discharge, at a regional scale.

The distribution of recharge and discharge to/from the Contact Zone Aquifer is controlled by the ability of the overlying materials to transmit water (hydraulic conductivity) and the vertical hydraulic gradient (driving force). The vertical hydraulic gradient can be approximated by subtracting the piezometric surface of the Contact Zone Aquifer from the ground surface elevation and dividing by the depth to the aquifer.

A better approximation of the gradient would be calculated using the static water levels in the upper overburden rather than ground surface; however, there is not enough static water level information available for the upper overburden to map the water table. The approximation of the water table with the ground surface may overestimate the magnitude of the recharge/discharge, but this error is negligible in comparison to the error in the calculation of vertical hydraulic conductivity.

Groundwater recharge is quantified using the Darcy Flux Equation (Figure 5-18), which incorporates the vertical hydraulic conductivity of the material overlying the aquifer and the downward vertical gradient. Figure 5-21 presents the Darcy Flux values for the recharge zones as a Recharge Flux Potential. Red areas on the map have the greatest potential for water to move downwards. White areas represent discharge zones.

Although a potential for recharge may exist as presented above, the flow system still requires water to be supplied through precipitation partitioning for recharge to the Contact Aquifer Zone to occur. In Section 3, the regional water budget map indicates the amount of water available for groundwater. This map, when combined with the recharge flux potential map (Figure 5-21), can be used to compute the recharge the Contact Zone Aquifer. The process of combining these two maps is described in Figure 5-18.

Figure 5-22 presents the estimated groundwater recharge to the Contact Zone Aquifer. Red areas represent the highest recharge while white areas have zero recharge and represent discharge zones. The Champlain Sea deposits in P&R and the City of Ottawa have the least amount of recharge to the Contact Zone Aquifer, while more permeable deposits throughout Eastern Ontario have moderate to high values of recharge. The highest values of recharge occur on topographic highs where the largest downward gradients exist and in areas of thinner and/or permeable overburden such as in southwest Stormont, Dundas, and Glengarry (SD&G) and near Maxville.

Table 5.4 summarizes the purpose, data source, and methodology used to develop these groundwater recharge and flow maps.

TABLE 5.4
GROUNDWATER RECHARGE AND FLOW MAPPING

Map	Purpose	Source	Methodology	Comment
Contact Zone Aquifer Piezometric Surface (Figure 5-19)	Define water levels within the Contact Zone Aquifer	Water well records	Static water levels from well records	Assumed no regional temporal trend
Deep Bedrock Piezometric Surface (Figure 5-20)	Define water levels within the lower bedrock	Water well records	Static water levels from well records	Assumed no regional temporal trend
Recharge Flux Potential (Figure 5-21)	Evaluate potential for groundwater to recharge through overburden	Water well records	Compute Darcy Flux vertically from estimated conductivity values and hydraulic gradient	Vertical hydraulic conductivity is the most uncertain parameter. Gradient assumed from ground surface.
Estimated Groundwater Recharge (Figure 5-22)	Recharge = max. possible water extraction	Water well records/ Water budget model	Lesser of recharge potential and available recharge controls	

5.5.5 Natural Groundwater Quality

Groundwater quality is also an important consideration when selecting a water supply source. The quality of the water supply will determine the treatment technologies necessary and the associated costs of using that water supply.

The MOE water well records and a report by Charron (1978) represent the major sources of water quality data in Eastern Ontario. All observations of water quality noted in the water well records are based on visual, taste, and smell observations and do not reflect any water testing results. Charron (1978) provides some chemical analysis, but this data is sparse and only reports concentrations for a few substances. The majority of this water quality data is for the deep aquifer systems and may not be representative of shallow groundwater quality. Some of the hydrogeology reports on file with the MOE that were completed for developments, include groundwater quality data. It is expected that other reports filed with the MOE also provide groundwater quality data. However, these reports represent somewhat limited localized data that has not been compiled in a common database. Therefore, a large data gap currently exists in the understanding of groundwater quality in Eastern Ontario. The compilation of groundwater quality data from a variety of sources into a database would significantly improve this understanding and would assist in developing watershed-based monitoring programs.

Figure 5-23 summarizes the groundwater quality information that was incorporated into the EOWRMS database. Despite the shortcomings of the data, some generalizations can be made about groundwater quality. Figure 5-24 presents a map of water quality in Eastern Ontario as reported in the MOE water well records. Water quality issues associated with the Contact Zone Aquifer are primarily focussed on iron or other minerals that cause staining of fixtures or precipitate build-ups. In localized areas, particularly in SD&G, natural sulphur deposits generate hydrogen sulphide gas (rotten egg smell). Champlain Sea deposits, which underlie P&R, contain natural salts that are remnants of the seawater in which they were deposited. These water quality issues are aesthetic concerns, which are treatable with readily available technology (see City of Ottawa's *How Well is Your Well: Homeowner's Guide to Safe Wells and Septic Systems*).

Table 5.5 summarizes the available groundwater quality data and mapping.

TABLE 5.5
NATURAL GROUNDWATER QUALITY

Map	Purpose	Source	Methodology	Comment
Natural Water Quality (Figure 5-24)	Present available water quality data	Water Well Records	Water kind from well records	Based on rudimentary taste and smell tests when well is drilled

5.5.6 Aquifer Capability

Aquifer capability refers to quantity of water that is theoretically available for extraction from an aquifer beyond the current extraction amount. By convention and to incorporate a factor of safety, the total amount of groundwater available for extraction should not exceed 50 percent of the recharge to that aquifer. The groundwatersheds presented in Figure 5-19 were used in conjunction with the groundwater recharge to the Contact Zone Aquifer (Figure 5-22), and current groundwater demand values (see Section 3) were individually summed for each groundwatershed to compute aquifer capability.

The methodology used to estimate the capability of the Contact Zone Aquifer is presented in Figure 5-25 and the maps used in the analysis are presented in Table 5.6. The map of capability is presented in Figure 5-26. Throughout Eastern Ontario, the Contact Zone Aquifer has excess capability. The majority of wells intersect this Contact Zone Aquifer and yield enough water to support a domestic supply.

The results presented should be used as a guide to local water supply development since they represent a regional average estimate of excess capability and do not reflect the spatial variability of the aquifer. Localized mass balance efforts will be needed to confirm / refine available water supplies.

The simple water balance approach only accounts for the vertical flow of water within the ground watersheds. The two-dimensional representation of the flow system does not represent the three-dimensional nature of the system, including interaction between the bedrock and overburden aquifers. The construction and calibration of a three-dimensional groundwater flow model would better reflect this complex flow system.

Monitoring of current and future withdrawals should be undertaken to ensure that demand does not exceed 50 percent of the recharge within a groundwatershed. The capability methodology presented here could be used as a tool to predict the capability within a ground watershed under projected future groundwater demand and / or the predicted effect of water conservation initiatives.

TABLE 5.6
AQUIFER CAPABILITY

Map	Purpose	Source	Methodology	Comment
Aquifer Capability (Figure 5-26)	Define sustainable water quantity available for extraction	Evaluated from above mapping and available demand data	Aquifer Capability = 50% of Recharge – current Demand	50% is a rule of thumb to ensure flow to downstream users is maintained

5.5.7 Intrinsic Aquifer Vulnerability

Intrinsic aquifer vulnerability refers to the geologic protection an aquifer has to potential contaminant sources. Potential contaminant sources include inorganic and organic chemicals, which may be released into the groundwater system through common agricultural, industrial, and domestic activities. In this section, the analysis identifies areas that are more vulnerable to contamination than another based solely on the geologic protection overlying the Contact Zone Aquifer. This type of analysis does not account for the specific vulnerability to contamination, or actual risk of a contaminant entering the aquifer. That aspect of vulnerability can be addressed through a land use analysis to identify potential contaminants in each area. A regional land use analysis is presented in Section 6.

The geologic protection afforded an aquifer is primarily a function of the thickness (D), vertical hydraulic conductivity of geologic material overlying the aquifer (K_z) as well as the direction and magnitude of the hydraulic gradient (i). As described earlier, the vertical hydraulic conductivity and the gradient determine the recharge to the aquifer (see Section 5.5.4). Other factors, such as attenuation ability of the overlying soil, may also provide a degree of protection to an aquifer. The analysis presented here does not account for the attenuation ability of the soil as it is expected to be less important than the other factors. Figure 5-27 presents the methodology used to determine the intrinsic vulnerability of the Contact Zone Aquifer in Eastern Ontario.

The vulnerability analysis uses the thickness of the material overlying the aquifer divided by the recharge flux potential to determine a vertical travel time to the aquifer. The vertical travel time is an estimate of how long it would take for a dissolved and non-interacting contaminant to reach the aquifer.

The estimated intrinsic vulnerability of the Contact Zone Aquifer is presented as a map in Figure 5-28. The dark green colour represents the highest aquifer vulnerability while the white areas represent discharge zones that have the least aquifer vulnerability because of the existence of upward hydraulic gradients. Table 5.7 lists the five classes of intrinsic vulnerability shown on the map, which are based on travel times.

TABLE 5.7
AQUIFER VULNERABILITY CLASSES

Intrinsic Vulnerability Class	Travel Time	Implication
Class 1	<5 years	Water recharges the aquifer very quickly through high hydraulic conductivity materials (sand/gravel)
Class 2	5 to 10 years	Water recharges the aquifer moderately quickly; materials and distance to aquifer control rate of recharge
Class 3	10 to 100 years	Water recharges the aquifer slowly; materials and distance to aquifer control rate of recharge
Class 4	100 + years	Water recharges the aquifer very slowly through low hydraulic conductivity materials (silt/clay)
Class 5	Discharge Zone	Not vulnerable because water flow is upward from the aquifer

The classes are based on typical values used in wellhead protection studies, such as those conducted by the Regional Municipality of Waterloo (WHI, 1995; WHI, 2000). The following limitations must be considered:

- The travel time estimate may not be representative of contaminants that are more or less dense than water, those that interact with the soil, or those that are naturally degraded since the travel time assumes the contaminant has the mobility of water.
- Contaminant transport considerations such as concentration, sorption, and degradation are not accounted for, because these are contaminant specific and should be evaluated at a local scale or in a specific vulnerability analysis.
- The travel time estimate is presented in years. This estimate is subject to the previously presented error in vertical hydraulic conductivity and hydraulic gradients. The travel time is an approximation that allows classification of relative aquifer vulnerability.

Vulnerability Classes 1 and 2 are the most important classes to consider. Interpretation of the vulnerability map indicates that the Contact Zone Aquifer is least vulnerable where it is overlain by Champlain Sea Deposits in P&R and Ottawa. Outside these areas, particularly in the northern portion of SD&G and Osgoode Township, the aquifer vulnerability is dominated by Classes 1 and 2. The thin and permeable nature of the glacial deposits in these areas is reflected in their higher vulnerability classification. Where the Contact Zone Aquifer is overlain by glacial till (i.e. Glengarry Till Plain), the aquifer vulnerability is lower.

In consideration of the high vulnerability of many areas in Eastern Ontario, land use policies and guidelines should be created to manage development in these sensitive areas. Such policies and guidelines should include a requirement that the proponent of a development must perform a site-scale investigation of aquifer vulnerability and demonstrate that the proposed development will not contaminate the aquifer. This investigation would involve local characterization of the aquitard overlying the Contact Zone Aquifer and estimation of the travel time to the aquifer. At a minimum, this type of policy or guideline should be applied in areas identified as vulnerability classes 1 or 2, but would represent a good practice in all areas.

Table 5.8 summarizes the purpose, data source, and methodology used to develop these aquifer vulnerability maps.

TABLE 5.8
AQUIFER VULNERABILITY MAPPING

Map	Purpose	Source	Methodology	Comment
Aquifer Vulnerability (Figure 5-28)	Define areas where Contact Zone Aquifer is vulnerable to surface contamination	Based on maps presented above	Modified AVI method – uses recharge flux potential estimates	Sensitive to hydraulic conductivity estimates

5.6 Key Findings

The key study findings related to the groundwater analysis follow:

- Over 90 percent of water wells obtain water from the bedrock in Eastern Ontario.
- Groundwater can be found within the bedrock throughout Eastern Ontario in a quantity suitable for a domestic supply.
- Sand and gravel deposits in the lower portion of the overburden combined with the fractured upper portion of the bedrock comprise the Contact Zone Aquifer. The Contact

Zone Aquifer is the aquifer with the greatest potential for supply and is generally the least vulnerable to contamination. Glacial esker features that comprise local portions of the Contact Zone Aquifer (like the Morewood esker) provide excellent sources of water.

- Recharge to the Contact Zone Aquifer varies throughout Eastern Ontario. Areas that have the largest contribution to shallow groundwater determined in the water budget model may not represent areas of high recharge to the Contact Zone Aquifer unless a downward flux gradient exists and the hydraulic conductivity of the overlying materials is sufficient.
- The analysis of groundwater capability indicates that within each ground watershed there is potential for additional extraction of groundwater from the Contact Zone Aquifer.
- There is a lack of detailed groundwater quality information for health-related drinking water parameters throughout Eastern Ontario.
- Water quality concerns reported throughout Eastern Ontario are primarily focussed on inorganic compounds that are derived from the geologic material through which the water flows. These compounds, such as sulphur, chloride, and iron, are aesthetic parameters (non-health-related drinking water objectives), which are treatable with readily available technology (see the City of Ottawa's *How Well is Your Well: Homeowner's Guide to Safe Wells and Septic Systems*).
- Shallow aquifers are more susceptible to contamination due to the lack of geologic protection; therefore, deeper aquifers are more preferred from the perspective of contamination susceptibility. It is recognized that shallow drilled and dug wells are used in areas where the natural quality of deeper aquifers is characterized by elevated levels of chloride, hydrogen sulphide, iron, or manganese. However, modern and relatively inexpensive water treatment systems should be considered when deeper wells yield water quality of this type. Owners of shallow wells must be made aware of the susceptibility to contamination, what they can do to reduce the susceptibility (see Section 9), and the need to frequently monitor water quality.
- Areas within the Contact Zone Aquifer that are the most vulnerable to contamination have thin and permeable geologic protection and a strong downward flow gradient such that the vertical travel time for a contaminant released at the ground surface will reach the aquifer in less than 5 years.

5.7 Relevance to Regional Water Strategy

Groundwater represents one of the safest forms of water supply when compared with surface water. The groundwater analysis of Eastern Ontario indicates that a quantity of groundwater can be extracted from the bedrock that will supply domestic needs. A number of large aquifers that have good potential to meet the future supply needs of Eastern Ontario have been mapped.

The geologic deposits from which the water is derived control the water quality found throughout Eastern Ontario. Groundwater extraction throughout SD&G and Ottawa are primarily derived from the underlying limestone bedrock aquifers. Water quality issues associated with this aquifer are primarily focussed on iron or other minerals that cause staining of fixtures or precipitate build-ups. In localized areas, natural sulphur deposits generate hydrogen sulphide gas (rotten egg smell). Champlain Sea deposits, which underlie P&R, contain natural salts that are remnants of the seawater in which they were deposited. These water quality issues are aesthetic concerns, which are treatable with readily available technology. Such treatment does, however, raise the installation and operation and maintenance costs for each individual water supply.

The vulnerability of the groundwater supply aquifer(s) is controlled by the degree of geologic protection provided by the aquitard material overlying the aquifers. Throughout P&R, many of the aquifers exhibit a large degree of geologic protection from groundwater contamination due to the thick silt and clay Champlain Sea deposits; however, these aquifers also contain the natural salts. Lower overburden aquifers within SD&G that are overlain by till aquitard materials (such as portions of the Morewood aquifer) represent the greatest potential for new or expanded groundwater supply in SD&G. Throughout the City of Ottawa, there are few protected overburden deposits for use as water supply aquifers: bedrock is the predominant aquifer. The exception is near Osgoode, where lower overburden aquifer material is protected by overlying aquitard deposits, representing a good potential for additional water supply.

Areas mapped as vulnerability classes 1 or 2 should be considered areas where the drinking water supply is sensitive to surficial activity. In accordance, these areas should have:

- Tighter constraints and more stringent requirements for proposed land developments
- More stringent chemical storage and handling procedures for existing businesses and residences
- Focussed education programs to raise awareness of the potential effects of surficial activities on local water quality

In addition, action plans should be developed to deal with spill events within these sensitive areas. These planning efforts should be most rigorous within vulnerability class 1 areas.

While the protection of a groundwater supply is primarily controlled by the geologic deposits overlying the aquifer, the safety of the supply can be improved with the implementation of best management practices for potential contaminants. In addition, proactive protection initiatives such as standard well construction and abandonment procedures and long-term monitoring of water quality trends near municipal/communal production wells will help to avoid water quality problems.

Many of the aquifers exhibit a large degree of geologic protection from groundwater contamination. These areas have the greatest potential for new or expanded groundwater supply. The safety of a groundwater supply can be improved with the implementation of a number of standard well construction and abandonment procedures. Long-term monitoring of water levels and water quality will provide baseline information that can be used to monitor the integrity of the groundwater system. Areas with higher vulnerability should have a greater emphasis on best management activities to minimize contamination risks and tighter constraints on development requests.

The groundwater analysis as presented in this report provides a regional summary of the groundwater in Eastern Ontario. The analysis is applicable at the regional scale but requires additional site-scale investigations to refine the results when any new water supply or protection effort is undertaken on a site-specific basis.

5.8 Recommendations

The groundwater analysis provides an excellent two-dimensional model of the regional groundwater systems in Eastern Ontario. This analysis has highlighted the Contact Zone Aquifer as having the greatest supply potential but has also identified areas that are vulnerable to contamination. The results of this regional-scale analysis should be used as a guide for water supply and protection efforts and should be augmented with local-scale studies for site-specific decision-making.

5.8.1 Additional Data

The following are recommendations for additional data regarding the groundwater system (listed in no particular order):

- The vulnerability analysis should be expanded to incorporate municipal/communal well capture zones, where available. Well capture zones will outline the surficial areas where recharge eventually reaches the existing supply well(s). Overlaying the well capture zones with the vulnerability classes will highlight the most sensitive areas for the current water supply wells, and protection and education efforts can be focussed in those essential areas.
- An inventory of abandoned wells should be carried out to evaluate their potential as conduits for surficial contamination to reach otherwise protected aquifers. Improperly abandoned wells can be a significant problem even in vulnerability classes 3 and 4 areas.
- A contaminated sites inventory should be completed to highlight areas of concern within the mapped vulnerable areas and evaluate the risk of aquifer contamination. This information can be used to identify areas that should have development restrictions because of the vulnerability of the aquifer.
- Water quality data is sparse and outdated, and represents the greatest data gap in the groundwater analysis. Prior to developing a local groundwater supply, additional local-scale investigations should be designed to better characterize the local water quality, both from natural geologic and surficial contaminant sources. Once this data is available, potential groundwater supplies can be better evaluated considering the operational treatment costs of the water supply.
- A large data gap currently exists in the understanding of groundwater quality in Eastern Ontario. The compilation of groundwater quality data from a variety of sources (e.g. bacteriological testing reports, hydrogeology reports, engineering reports) into a database would significantly improve this understanding and would assist in developing watershed-based monitoring programs.
- Well location accuracy checks should be undertaken locally in areas of potential additional groundwater supply to verify the water well data used to generate the maps in this study.
- Additional local-scale investigations are needed in the vicinity of fault zones to characterize groundwater flow conditions along faults. These fault zones are potentially higher yield aquifer zones and thus may warrant additional study.
- Additional local-scale investigations are needed along the suspected esker (or moraine) features to more accurately map and characterize local groundwater flow conditions.

These permeable overburden features are potentially higher-yield aquifer zones that are typically an excellent supply of fresh water and may warrant additional study.

- Long-term monitoring programs, such as those currently being implemented by MOE (in cooperation with SNC and RRCA) and OFA, of water levels and water quality must be implemented to develop baseline data. This baseline data can be used to assess a change in conditions over time. The ability to detect changes in quantity or quality of water will allow for planning to mitigate the effects of deterioration, and to measure the effects of water conservation initiatives and / or aquifer protection strategies.

5.8.2 Application of Groundwater Analysis Results for Groundwater Management Initiatives

The groundwater analysis developed in this study provides a strong basis for developing groundwater management plans and undertaking further management initiatives. Groundwater management plans will undoubtedly have the following components:

- Water Supply: planned development to ensure the existing groundwater supply is not over-extracted; recharge to the Contact Zone Aquifer is maintained; and discharge to streams, lakes, and wetlands is sufficient to continue to support the existing local ecology
- Water Quality: planned water supply treatment initiatives to ensure that the water supply is aesthetically pleasing even under additional pumping conditions
- Source Vulnerability: planned development of supplies in low vulnerability areas (ensuring proper sealing of any abandoned wells) to avoid the likelihood of contamination events impacting water supply wells. Additionally, an inventory of potential contaminant sources and plans to minimize high-risk surficial activities should be implemented, particularly in vulnerable areas that might impact water supply wells, as described above.

Local-scale analyses (well capture zone scale) should be undertaken to confirm / refine this regional analysis. The local-scale analysis should include a series of standard tests to refine the delineation of aquifer extents and determine the specific characteristics of the aquifer and overlying aquitard material.

In consideration of the high vulnerability of many areas in Eastern Ontario, land use policies and guidelines should be created to manage development in these sensitive areas. Such policies and guidelines should include a requirement that the proponent of a development must perform a site-scale investigation of aquifer vulnerability and demonstrate that the proposed development will not contaminate the aquifer. This investigation would involve local characterization of the aquitard overlying the Contact Zone Aquifer and estimation of the travel time to the aquifer. At a minimum, this type of policy or guideline should be applied in areas that are identified as vulnerability classes 1 or 2, but would represent a good practice in all areas.

Areas mapped as vulnerability classes 1 or 2 should be considered areas where the drinking water supply is sensitive to surficial activity. In accordance, these areas should have:

- Tighter constraints and more stringent requirements for proposed land developments
- More stringent chemical storage and handling procedures for existing businesses and residences

- Focussed education programs to raise awareness of the potential effects of surficial activities on local water quality

In addition, action plans should be developed to deal with spill events within these sensitive areas. These planning efforts should be most rigorous within vulnerability class 1 areas.

As part of the public education plans, individuals relying on shallow groundwater supplies, either through dug or shallow drilled wells, should be made aware of the vulnerability of their water supply to surface contamination. These individuals should be advised to have their wells tested regularly for common bacterial contamination, as a minimum. They should also be aware of alternative water sources and the potential costs associated with developing an alternative (i.e. deep groundwater) source and applying appropriate treatment technologies, as needed.

The principal components of a proposed groundwater resources protection plan are summarized in Section 10.

5.8.3 Further Groundwater Analysis

The limitations of the two-dimensional model of the groundwater systems should be addressed by three-dimensional flow modelling. A three-dimensional groundwater flow model would provide a more reliable estimation of the groundwater flow budget and the supply capability of aquifer units. In addition, a groundwater model could be used to evaluate future water quantity and quality conditions, such as the impacts of best management practices, water conservation, climate change, etc. The groundwater mapping developed in this study provides the basis for constructing the three-dimensional groundwater model. The model can provide a useful tool to guide additional data collection efforts based on the most uncertain parameters, which will enhance understanding of groundwater quantity and quality predictions.

Local-scale groundwater modelling should be used to define capture zones of municipal/ communal well fields and evaluate their vulnerability.

6. Land Use Analysis (Agriculture)

This section of the report specifically addresses land use and focuses on agriculture as the major land use in the study area. Surface water and groundwater resources were addressed in Sections 4 and 5, respectively. Servicing infrastructure is addressed in Section 7.

6.1 Overview

An area of approximately 6,800 km^2 across the South Nation River and the Raisin River watershed and the associated peripheral watersheds receives on average about 930 mm of precipitation annually, of which approximately 420 mm is lost through evaporation and transpiration. The remaining 510 mm of water is partitioned between the surface water drainage network and the deep groundwater reserves. In areas close to the surface drainage network, a larger proportion of water moves either by overland flow or lateral flow through the upper overburden to the surface reserves. Even higher amounts will move in areas that slope to the drainage network or where tile drains shunt the excess water directly to the surface network. Areas farther away from the surface drainage pathways are more likely to contribute water to the deep groundwater reserves, particularly where the soil and geological materials are relatively porous. The mix of land uses in these water resource "contributing areas" determines to some extent the quantity of water moving into the water resource and directly influences the quality of water replenishing the resources. Figure 6-1 illustrates the regional distribution of different land uses, as defined by land cover classification from Landsat satellite imagery. The relative distribution of the different land cover classes is shown in Table 6.1.

TABLE 6.1
LAND COVER*

County	Prescott and Russell		Stormont, Dundas and Glengarry		City of Ottawa		EOWRMS Study Area	
	ha	%	ha	%	ha	%	Ha	%
Corn	23,919	11.9%	40,963	12.6%	8,734	8.7%	73,616	11.7%
Soybean	10,757	5.3%	19,283	5.9%	3,978	4.0%	34,018	5.4%
Grain	7,975	4.0%	10,186	3.1%	3,612	3.6%	21,773	3.5%
Hay	67,243	33.4%	101,631	31.2%	32,191	32.1%	201,066	32.1%
Bare	14,874	7.4%	16,353	5.0%	6,963	6.9%	38,190	6.1%
Coniferous Forest	6,325	3.1%	19,180	5.9%	943	0.9%	26,447	4.2%
Deciduous Forest	38,050	18.9%	61,666	18.9%	20,401	20.4%	120,118	19.2%
Mixed Forest	10,709	5.3%	19,383	5.9%	5,781	5.8%	35,874	5.7%
Open/Sparse Forest	2,520	1.3%	7278	2.2%	3,439	3.4%	13,237	2.1%
Unclassified Forest	15,345	7.6%	25,081	7.7%	7,316	7.3%	47,742	7.6%
Urban Areas	2,516	1.3%	1,958	0.6%	6,698	6.7%	11,172	1.8%
Water	875	0.4%	2,891	0.9%	138	0.1%	3,905	0.6%
Total (ha)	**201,108**	**100%**	**325,854**	**100%**	**100,195**	**100%**	**627,158**	**100%**

*Land cover is based on satellite imagery enhanced with forest data from MNR. Wetland information from various sources including NRVIS and soil survey was evaluated but not used in anticipation of the revised wetland classification prepared by MNR. Unfortunately, the revised wetland data was not available in time for inclusion in this analysis. It is now available and would enhance this table by providing specific data on wetland area across the project. These data can be incorporated into the project database for use by the project partners in the future.

Approximately 55 percent of the Eastern Ontario Water Resources Management Study (EOWRMS) project area is in agricultural use, which involves active land management. Forest is the next major category. Various water resource management aspects of urban areas are considered in the next chapter, which discusses servicing infrastructure.

Consequently, agricultural activities impact more than half of the annual contribution from precipitation to the surface water and groundwater resources of the region. The kinds and intensities of agricultural activities in the study area have been assessed. For this analysis, the intensity of agricultural activities across the study area was compared with intensities in other parts of the province or to levels that are within Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) recommendations for environmental sustainability. The results are expressed as a fraction showing the degree to which the specific agricultural activities under consideration approach, match, or exceed the average or recommended level.

This section presents a characterization of the location, nature, and extent of agricultural land use within subwatersheds related to surface water resources in the project area. The subwatersheds represent land units that contribute to the surface water within a defined area of the surface drainage network, but they also include areas where the partitioning of excess water is primarily to deep groundwater resources.

Analysis was done to show the relationship between agricultural activities and major aquifers, areas of recharge and discharge. The combined analysis allows for the identification of sensitive areas and areas with development potential or constraints.

In the development of a regional water strategy, it is important to recognize that managed land areas tend to have a greater impact on water quality than most natural areas. Schnoor (1996) presents data compiled by the United States Environmental Protection Agency showing mean total phosphorus and nitrogen concentrations in surface waters by land use type and region of the United States. These summaries suggest that the concentrations for agricultural land uses are 2.5 times the levels found in land that is mostly forest and that urban land uses are slightly lower but generally about double. These findings suggest that the quality of surface water in a subwatershed is directly influenced by the proportion of the subwatershed area in agricultural or urban use.

6.2 Data Sources and Limitations

The data sources used for the land use analysis and limitations of these sources are summarized below:

- Satellite imagery with supervised classification for agriculture (beans, corn, small grains, hay, and pasture, and bare soil) and non-agricultural land (forest, urban, and water). These results are limited to one year of analysis, so it has been assumed that the agricultural uses will occur within a crop rotation. Furthermore, it is not possible to determine whether the bare soil represents land in agricultural use or others, such as aggregate extraction or development. A multi-year analysis would resolve this.
- Soil inventory maps for the City of Ottawa Gloucester, Prescott and Russell (P&R), and Stormont, Dundas and Glengarry (SD&G). These maps are of variable quality and scale such that the analysis is not completely comparable across the study area.

- Tile drainage maps digitized by Agriculture and Agri-Food Canada (AAFC) from manuscript copy provided by OMAFRA. These maps are the most recent and complete available but they may miss some areas that are tile drained and not yet reported or incorporated into the manuscript.
- Census of Agriculture (CoA) data by enumeration grouping provided by AAFC. While this is the most detailed information possible, it is still relatively general in nature in order to preserve confidentiality. The results are reported based on the location of the farm headquarters, which may not accurately represent the actual area where the farming operations take place.
- Surface drainage network data from the Ontario Ministry of Natural Resources (MNR).
- Subwatershed delineations calculated by the consultant team from digital elevation data. There may be slight discrepancies between these boundaries and the actual sub-watershed boundaries and also from boundaries used by other agencies.
- Groundwater watersheds and groundwater vulnerability classes were delineated by the consultant team.

While there are a number of data limitations noted, the data appear to be of reasonable quality for the regional level of analysis carried out within this project.

6.3 Assumptions

The land use analysis is based on the following assumptions:

- Tile-drained areas are adequately represented by the OMAFRA maps.
- Good agricultural management practices are followed – nutrient management, manure management, stream buffers, etc. The analysis addresses the potential impacts of the agriculture industry, not risks associated with known problematic practices. Some specific implications are described in the next two assumptions.
- Environmentally sound manure management practices will be followed. There is no attempt to distinguish manure management technology. It would be possible to estimate the manure handling systems based on livestock type. There is a strong correlation between livestock type and type of manure management system (e.g. the Farm Inputs Management Survey [FIMS] [Koroluk et al, 1995] provides information for the Mixedwood plain, which suggests that manure is managed in liquid form on 25 percent of the dairy, 5 percent of the beef, 77 percent of the hog, and 36 percent of the poultry and egg farms). Since that time, the proportion of manure handled in liquid form has increased.
- Livestock and manure handling systems are environmentally sustainable (neglecting practices such as grazing livestock, which may interact with the surface drainage network as well as deposit some manure directly on pasture; manure storage systems, which may be susceptible to losses and direct leakage to surface and groundwater resources and wells).
- The CoA provides a good characterization of agricultural activities and problems, such as reporting based on farm headquarters, do not introduce serious errors.
- Agricultural activities are uniform across an enumeration area (EA) grouping.

- Agricultural activities are uniform across a subwatershed and are adequately represented by a weighted average.
- The dominant soil provides a reasonable assessment of potential soil loss from bare soil.
- The satellite image classes of beans, corn, small grains, and forage for 1998 provide a reasonable determination of the extent and location of agricultural land use within the study area.
- The distribution of livestock within a commodity group (e.g. dairy, beef, hogs, or poultry) is adequately represented by the Ontario 1997 data presented by Barnett (1996).

6.4 Approach and Methods

6.4.1 Introduction

At a regional level, there are two major water resource management components:

- Surface water resources (from rivers, streams, creeks, ditches, ponds, lakes, and wetlands)
- Groundwater resources (from aquifers found in overburden [shallow and deep] and bedrock)

The characteristics (quality and quantity) of water resources in each component reflect the mix of land uses in the contributing area as well as the inflow of water.

The land use categories include:

- Urban residential, industrial, commercial, institutional
- Rural residential, industrial, commercial, institutional
- Agricultural
- Transportation corridors – roads, railways, powerlines
- Forest and wetlands
- Watercourses and water bodies

Of these, the major managed land use activities include agricultural, residential/industrial/commercial, and institutional. This section deals primarily with the potential impact of agriculture on regional water resources. The impact of other managed land uses is addressed in other sections.

The impact of agriculture on water quality can be evaluated at a variety of scales ranging from individual land parcels through farms up to larger spatial units such as watersheds or municipalities. Approximately 200 subwatersheds were identified across the study region as defined by digital elevation data. The analysis was done for each subwatershed in the project area.

This section describes the four major steps used to assess the impact of agricultural on surface water quality and quantity.

6.4.2 Step 1: Recognizes that Agriculture is Only One of the Land Uses Influencing Water Resource Quantity and Quality within a Subwatershed

Land use was determined using classified satellite imagery for 1998 (Figure 6-1). The results were gridded (with each pixel representing a 30-m square) and combined with subwatershed boundaries. Agricultural pixels are those classified as beans, corn, forage, small grains, or bare soil. Non-agricultural pixels are those classified as forest, urban, or water. The proportion of agricultural land was determined as the percent of land within each subwatershed classified as agricultural (Figure 6-2). This analysis determined the **extent** of agriculture within each subwatershed for the project area and provided an indication of the quantity of water moving from land in agricultural or non-agricultural uses (represented by Equation 1 below). A similar analysis could be carried out for boundaries other than subwatershed (e.g. major recharge areas, municipal or urban regions, etc.).

$$\text{Extent}^{a} = \text{Watershed Boundaries} + \text{Land Cover} \qquad (1)$$

[a] Column 1 of Table 6.2; i.e. how much of the watershed is occupied by agriculture

6.4.3 Step 2: Recognizes that the Location of Agriculture within a Subwatershed can Influence the Impact on the Quality and Quantity of Water Resources

In addition to considering the simple quantities of water from agricultural and non-agricultural lands, it is also relevant to consider whether or not there is a direct pathway for transport of potential contaminants or whether conditions are such that potential contaminants will likely be filtered out by natural processes before the water reaches the surface drainage network. The data are not sufficiently detailed to show where best management practices such as stream buffers, or the distance provisions of nutrient management plans, have been adopted.

The impact of a particular land use on a water resource (surface or ground) depends on the directness of the pathway between water moving from the land to the water resource. For the surface water resources, this can be estimated by characterizing the mix of land uses close to streams, ditches, etc. Traditional field sizes for agriculture have been about 10 acres or 4 ha. More recently, field sizes have increased substantially. However, recognizing that a square field of 10 acres would have dimensions of 40 x 40 rods or 200 m on the side, a distance of 200 m was chosen for this project to represent agricultural activities with a potential to influence surface water resources directly. This distance was also used in the partition model component of the regional water budget to define the proportion of water moving to surface water resources compared to that moving to groundwater resources.

Subsurface tiles at less than 1 m below the soil surface provide a direct shunt for potential contaminants with only minimal natural filtering capability. Cracking soils may be a direct channel from the soil surface, through soil macropores directly to the tile line and through it to the surface watercourse. Irrigation can also alter the natural water balance by drawing water from deep groundwater reserves and using it for crop production while a portion of it is diverted to surface water resources. However, irrigation appears to be only a minor water use in the study area.

Areas of direct influence to surface water resources were determined by buffering the surface drainage network to delineate all areas within 200 m and adding additional areas mapped as tile drained. This area was gridded (30 m x 30 m) and intersected with the satellite imagery of land use to determine areas in proximity to the surface drainage network for which the land use was agriculture for each subwatershed. This area was expressed as a percent of the total agricultural area in the subwatershed. (Figure 6-3)

This analysis determines the **proximity** of agriculture to the surface drainage system (e.g. streams, rivers, municipal drains) for each subwatershed (represented by Equation 2).

Proximity[a] = Watershed Boundaries + Land Cover + Sensitive Areas (2)

[a] Column 2 of Table 6.2; i.e. the amount of agricultural land in the watershed that is within a sensitive area

6.4.4 Step 3: Recognizes that Different Agricultural Activities may have Different Kinds and Degrees of Impact on Water Resources

The potential impacts of agricultural activities on water resource quality include contamination from excessive levels of nutrients, pathogenic organisms, sediment, pesticides and organics that affect colour, smell, and taste of the water resource. Data collected for the 1996 CoA were used to characterize agricultural activities. The data, obtained from AAFC, were compiled on the basis of groupings of enumeration areas (referred to as EA groupings). EAs represent the smallest area for which Statistics Canada compiles information. The actual processing of the census data into EA groupings was directed by AAFC personnel. It was done to minimize the amount of data suppressed due to confidentiality regulations.

The nature and intensity of agricultural activities is characterized for each EA grouping. For this analysis, the intensity of agricultural activities across the study area was compared with intensities in other parts of the province or to intensities that fall within OMAFRA recommendations for environmental sustainability. The results are expressed as a fraction showing the degree to which the specific agricultural activities approach, match, or exceed the average or recommended level.

These data were then used to estimate the levels of agricultural activities for each subwatershed. The estimate relies on the assumption that agricultural activities are uniform across the entire area of the EA grouping. The procedure used was to convert the EA grouping theme to a grid (30 x 30 m) and to tag the grid cells classified as agricultural from the satellite imagery with the agricultural characteristics of the EA grouping. A weighted average of agricultural activities was then calculated for each subwatershed. A similar approach was used to estimate soil loss. The potential loss from bare soil was calculated for each soil unit in the study area. The result was converted to a grid (30 x 30 m) to tag the grid cells classified as agricultural from satellite imagery with a potential soil loss, which was modified by the crop factor obtained from the CoA data.

The evaluation of nature and intensity are represented by Equation 3.

Nature & Intensity[a] = Watershed Boundaries + Characteristics of Agriculture[b] (3)

[a] Incorporates comparative levels of agricultural intensity
[b] Column 2 of Table 6.2; i.e. current land use as a percent of comparative standards for each watershed

In general, there are two major types of agricultural production activities: those related to crop production and those related to livestock production.

Crop Production

Crop production management practices are designed to enhance the quality and quantity (yield) of a selected suite of crops through such practices as:

- Seedbed preparation and residue management (tillage)
- Plant nutrition through nutrient amendments (organic and inorganic)
- Disease, weed, and insect control (pesticides, crop rotations, tillage)
- Water management (tile drainage, irrigation)

As well as enhancing crop production, these practices affect the health of the agro-ecosystem. For example, good residue management will reduce the impact of raindrops and mitigate compaction of bare soil and detachment of soil particles and subsequent erosion; tillage generally loosens the soil surface to enhance infiltration but also potentially to make the soil more susceptible to soil erosion. Similarly, amendments of nutrients of crop protection products (pesticides) introduce new materials (pesticides) or higher levels of naturally occurring chemicals (nutrients) into the environment. When these are transported into surface or groundwater resources, water quality is reduced.

For crop production, the risks to water quality were determined by estimating the intensity of cropping activities and by estimating the level of soil loss due to erosion by water. This approach provides a broad regional scale characterization. More detailed models such as Agricultural Non-point Source (AGNPS) (being developed for the South Nation River watershed) are appropriate for more specific, localized analysis.

Crop Intensity Factor (Figure 6-4). Cropping practices across the EOWRMS area were compared with those in other parts of the province. This was done by defining an intensive crop rotation that provides maximum economic productivity in an environmentally sustainable fashion as a three-year cash crop rotation of corn, soybeans, and cereals. This rotation was used as an example of an optimal intensive rotation and the actual cropping practices across the study area were compared with it. The comparison was based on area of cropland including the forage component of the rotation and annual cropping with relatively large quantities of supplemental nutrients, a mix of pesticides, and substantial tillage operations. The current crop intensity was approximated by calculating the quantity of supplemental nitrogen required for annual crop production as reported in the CoA (based on OMAFRA recommendations in publication 296) and expressing this nitrogen level as a fraction of the nitrogen required for the optimal intensive rotation. When this calculation was done for Ontario, the average intensity level was 60 percent.

For much of Ontario, a three-year rotation consisting of corn, soybeans, and winter wheat would constitute an optimal intensive crop rotation. However, very little winter wheat is grown in Eastern Ontario due to problems with winterkill. Data in the 1996 CoA reported an area of 36,710 ha of spring grains and 2,122 ha of winter wheat. An area-weighted calculation was done to estimate that the average nitrogen requirement for the cereal portion of the crop rotation was 47 kg/ha (using a recommendation of 75 kg/ha for winter wheat and 45 kg/ha for spring grains). For corn, the nitrogen recommendation was estimated based on the yield levels as reported at the county level. This resulted in a nitrogen recommendation for corn of 115 kg/ha. The nitrogen recommendation for a three-year rotation was estimated to be 55 kg/ha. The ratio of current crop intensity to the optimal intensive rotation exceeded one for some of the EA groupings in the study area. This reflects areas where corn in the census year occupied greater than a third of the cropland. This does not necessarily reflect an environmental risk but more likely is an indication of current market conditions.

Soil Sediment and Bound Phosphorus Loss. The risks to surface water resources from agricultural activities include runoff and leaching of nutrients and pesticides as well as the transport of sediment (and associated bound phosphorus) to streams as a result of water erosion. Phosphorus transport with sediment is considered to be a major source of phosphorus from agricultural land. This factor was estimated using the RUSLEFAC (Revised Universal Soil Loss Equation for Application in Canada) model to estimate soil loss from agricultural lands (Figure 6-5). Details of the procedures are described in Appendix D. In interpreting the results of this model it should be noted that:

- The model output is a theoretical estimate that attempts to present the results of the sporadic episodes of erosion in terms of an annual average
- The estimate of soil loss is an indication of soil displacement and only a small fraction (normally less than 15 percent [G. Wall, personal communication, see also Wall et al, 1982 or Snell, 1985]) will be deposited as sediment in surface water
- Loss levels of 6 tonnes / ha / year (or less) are considered tolerable from the standpoint of sustained production. This amount corresponds to a thickness of soil of less than half a mm / year.

Areas susceptible to erosion are more likely to have an accumulation of sediment in the surface watercourses, which will gradually release phosphorus and other contaminants over time regardless of whether or not current practices result in additional erosion and sediment accumulation.

Livestock Production

Livestock production represents the other major agricultural activity. It is related to crop production since a portion of the crop production is determined by the needs of livestock and animal manure is a major byproduct of livestock production. It is normally managed by application to cropland so that the nutrients can be used for crop production and the organic matter improves soil tilth. It is the manure management component of livestock production that is predominantly related to the environmental aspects of the water resource. Some specific aspects follow.

Livestock Intensity Factor (Figure 6-6). A density of livestock that is no greater than the capacity for the agricultural crops to take up and use the available nutrients from the manure produced. [For EOWRMS, the guideline from the 1976 Agricultural Code of Practice (one livestock unit per cropped acre)] was used as an example. Areas with high livestock densities may indicate locations where water resources may be degraded in colour, odour, taste, and bacterial content if precautions are not taken to ensure proper storage, handling, and application of manure. The procedures used to estimate livestock units from the 1996 CoA are described in Appendix D.

Livestock type determines to some extent the quantity of nutrients that will be excreted on an annualized base (the quantity of nutrients and particularly phosphorus should be in balance with the quantity harvested in the course of crop production to avoid undesirable accumulation in the environment).

Phosphorus Balance (Figure 6-7). Nutrient management planning provides a more comprehensive and explicit way of matching the quantity of nutrients from manure sources to crop requirements. It involves an accounting of nutrients from all sources including soil reserves, chemical fertilizers, crop residues, manure, and biosolids (municipal and industrial sludges). While it was not possible to do a complete nutrient management plan at the level of the EOWRMS, the phosphorus balance calculation shows the quantity of phosphorus excreted in livestock manure as a fraction of the total quantity harvested in crops. The intent of the calculation is to show whether or not there is a sufficient demand for phosphorus in the crops grown and harvested to use the annual addition of phosphorus from manure. When the amount of manure phosphorus is only a small portion of the crop uptake, it should be relatively easy to manage this manure nutrient. As the amount of manure phosphorus approaches the amount taken up in the crops and harvested, greater attention to nutrient management is required to ensure that the conditions of balance are met across the cropped area. Details of the calculation are provided in Appendix D.

6.4.5 Step 4: Recognizes that the Net Impact of Agricultural Activities is the Result of a Combination of the Previous Three Steps to Identify Sensitive Areas

The following discussion presents a procedure to identify sensitive areas based on three aspects of the agro-ecosystem:

- **Extent** of agriculture within an area defined either by agricultural area as a fraction of the total area.
- **Proximity** indicates the directness of the connection pathway agricultural activities and the water resource under consideration. For example, crop production on tile-drained land or adjacent to streams or drainage ditches is more likely to result in contamination of surface water than crop production on land that is at a distance from the surface drainage network.
- **Intensity** of the agricultural activities as indicated by the levels of management (tillage, nutrient amendments and pesticides) normally used for production

Each of these components is expressed in relative terms on a continuous scale. The presence of sensitive areas is indicated by the product of the three components. Therefore, only those areas that have a significant amount of each component will be identified. The presence of a sensitive area does not directly indicate a problem but simply an area where greater care and good management will likely be required to sustain environmental (water) quality.

$$\text{Sensitivity} = \text{Extent*Intensity*Proximity} \qquad (4)$$

A series of maps was produced to illustrate the various aspects of agricultural practices across the study area. Maps based on satellite imagery of land cover show the relative concentration (extent) of agriculture in the surface water subwatersheds and the groundwater watersheds. The location of agriculture within the watersheds or subwatersheds was mapped to show the proximity of agricultural activities to vulnerable groundwater zones or surface water resources. Maps were also generated to show the intensity of agricultural activities across the region. Finally, combined maps were produced to show sensitivity of surface water and groundwater resources to impact from agriculture. Table 6.2 summarizes the series of maps produced and indicates how the maps have been combined (based on Equation 4) to illustrate sensitive areas.

TABLE 6.2
LAND USE ANALYSIS MAPS SHOWING EXTENT, PROXIMITY, AND INTENSITY OF AGRICULTURE IN EOWRMS

Extent Proportion of Total Area in Agriculture (%)	Proximity Proportion of Agricultural Lands Close to Sensitive Water Resource (%)	Nature and Intensity of Agricultural Activity Relative to other areas of Ontario	Sensitivity of Water Resource to Agricultural Impacts (Combined Extent, Proximity, and Intensity)	Interpretation or Potential Impacts from Agriculture
Extent of agriculture in surface subwatersheds (**Figure 6-2**)	Proportion of agriculture close to surface subwater sheds (**Figure 6-3**)	Relative crop intensity within surface subwatersheds (**Figure 6-4**)	Sensitivity of surface subwatersheds to cropping impact (**Figure 6-8**)	Transport of soluble contaminants (e.g. nitrate, soluble pesticides)
Extent of agriculture in surface subwatersheds (**Figure 6-2**)	Proportion of agriculture close to surface subwatersheds (**Figure 6-3**)	Erosion risk as estimated by RUSLE (**Figure 6-5**)	Soil Erosion and sediment sensitivity to surface subwatersheds (map not shown)	Risks for insoluble contaminants (e.g. bound P)
Extent of agriculture in surface subwatersheds (**Figure 6-2**)	Proportion of agriculture close to surface subwatersheds (**Figure 6-3**)	Estimated P excreted in manure/estimated P harvested in crops (**Figure 6-7**)	Livestock excreted sensitivity to surface subwatersheds (map not shown)	Risk of phosphorus contamination in surface waters from livestock manure causing a P buildup
Extent of agriculture in surface subwatersheds (**Figure 6-2**)	Proportion of agriculture close to surface subwatersheds (**Figure 6-3**)	Estimated number of livestock units/ha of cultivated land compared with guideline of 1 LU/acre (**Figure 6-6**)	Livestock surface subwatershed sensitivity (**Figure 6-9**)	General risk from all aspects of livestock (N, P, bacteria, viruses, odour, taste, smell, etc.)
Extent of agricultural land in groundwater watersheds (**Figure 6-10**)	Proportion of agricultural land within groundwater watersheds and within vulnerability classes 1 and 2 (**Figure 6-11**)	Relative crop intensity within groundwater subwatersheds (map not shown)	Sensitivity of groundwater watersheds to cropping impact (**Figure 6-12**)	Risk from soluble contaminants (e.g. nitrate, soluble pesticides)
Extent of agricultural land in groundwater watersheds (**Figure 6-10**)	Proportion of agricultural land within groundwater watersheds and within vulnerability classes 1 and 2 (**Figure 6-11**)	Estimated number of livestock units/ha of cultivated land compared with guideline of 1 LU/acre (map not shown)	Livestock groundwater watershed sensitivity (**Figure 6-13**)	General risk from all aspects of livestock (N, P, bacteria, viruses, odour, taste, smell, etc.)

Notes: N = nitrogen
P = phosphorus
The analysis completed for Figures 6-10 to 6-13 is preliminary and is under review.

6.5 Characterization

The extent of agriculture across the study area is characterized at the subwatershed level in Figure 6-2 – a map of project area showing surface subwatersheds and indicating the proportion of the area in agriculture (%).

The relationship between agricultural activities and the surface drainage network is shown in Figure 6-3 – a map of the proximity of agriculture to surface water resources. The map shows percent of watershed in agricultural activities AND close to surface water network (within 200 m of drainage network and / or tile drained).

Figure 6-4 and 6-6 provide an indication of the potential for agricultural development of crop-based and livestock-based agriculture respectively. Clearly, the actual potential is contingent on many more factors including the risk of erosion (Figure 6-5) and a full nutrient balance (Figure 6-7 represents only one component of this balance).

Figures 6-8 and 6-9 show the results of combining the analysis of extent (Figure 6-2) with proximity (Figure 6-3) and agricultural intensity. Figure 6-8 provides a relative assessment of the sensitivity of surface water resources to cropping activities. Areas where the rating is moderately high to high occur throughout much of the South Nation River watershed and also in the south eastern region of the study area. The use of best management practices, such as buffer stripalong the drainage network and tillage and residue management to minimize erosion, will be particularly important in these areas. Figure 6-9 provides a similar relative assessment of the sensitivity of surface water resources to livestock based activities. Clearly there are similarities between the area of cropping and livestock activities but also some substantial areas of difference. Throughout the area where livestock based activities are rated moderately high to high the use of best management practices, such as fencing or water courses and good manure management, will be most useful to minimize the reduction in surface water quality due to agricultural activities.

The potential impact of agriculture on groundwater is assessed in Figures 6-10 to 6-13. This analysis shows the information comparable to the surface water analysis for the extent of agriculture relative to groundwater watersheds (Figure 6-10); the proximity of agriculture to groundwater vulnerability classes within the watersheds (Figure 6-11); and the integrated sensitivity to groundwater from crop activities (Figure 6-12) and livestock production (Figure 6-13).

6.6 Key Findings

The maps showing the distribution of agriculture across the study area clearly identify areas where agriculture is the predominant land use and areas where agriculture makes up smaller proportions of the total land use classes. In addition, the maps of proximity show areas where surface or groundwater resources may be most sensitive to impacts from agricultural activities.

The analysis of agricultural intensity tends to show areas of greatest intensity are also areas where agriculture is the predominant land use. An important finding of the intensity analysis was that, in general, the agricultural activities in the study region were not excessively intensive. In fact, they were generally lower than the level used as recommended or average for the province.

A series of maps was prepared showing the results of the combined analysis incorporating the extent of agriculture, proximity to the surface drainage network, and the agricultural intensity. These maps are referred to as EPI maps. These maps provide the sharpest focus of potential agricultural impact on the water resources.

- Figure 6-8 shows the EPI map of crop intensity relative to surface water subwatersheds
- Figure 6-9 shows the EPI map of livestock intensity relative to surface water subwatersheds
- Figure 6-12 shows the EPI map of crop intensity relative to groundwater watersheds
- Figure 6-13 shows the EPI map of livestock intensity relative to groundwater watersheds

Throughout most of the study area a high proportion of agricultural activities take place close to the surface drainage network (Figure 6-3). However, the proportion of agriculture that occurs within vulnerability classes 1 and 2 is much lower (Figure 6-11). This is reflected in the lower relative sensitivities of groundwater to agricultural activities as shown in Figures 6-12 and 6-13. To a large extent this result occurs because the actual areas of vulnerability classes 1 and 2 are relatively small. However, for most of the South Nation River watershed as well as the eastern region of the study area, vulnerability classes 1 and 2 are 50 percent or more in agricultural uses. Consequently, while the area may be small, the potential impact of agriculture on groundwater quality can be significant if appropriate best management practices are not followed.

6.7 Relevance to Regional Water Strategy

This analysis shows the importance of agriculture across the entire study area. Consequently, it will be important to consider the impact of any proposed (non-agricultural) development on the adjacent agriculture.

The maps showing distribution of agriculture and proximity of agriculture to surface and groundwater resources clearly show areas where agriculture is concentrated. The analysis of the kind and intensity of agriculture provide additional detail of the agricultural activity. These factors are most clearly shown in the combined maps showing extent, proximity, and intensity. The spatial distribution of agriculture becomes important when further agricultural development is being considered. Based on the current analysis, agricultural development can occur throughout the region, provided the land resource base is appropriate and it is consistent with planning guidelines. However, this analysis shows areas where agriculture is currently relatively concentrated and intensive and suggests that additional development in these areas should proceed with careful attention to best management practices. Possibly, there may be a requirement for additional environmental safeguards (e.g. wider stream buffer strips or limitations to crop management practices on vulnerable zones).

Similarly, for non-agricultural development that requires access to surface water and / or groundwater resources, the agricultural land use analysis shows the current levels of agriculture and potential sensitivity of the water resources. The analysis provides a background to the complete development analysis and indicates areas where the agricultural activities need to be analyzed in greater detail to ensure a reliable and safe water supply to the proposed development.

In general, this analysis provides additional layers of information to be used in conjunction with other data to respond to proposed or desired developments. In terms of the regional water strategy, this analysis primarily provides:

- Indications of areas where agriculture may impact water quality
- Preliminary identification of areas to target for further study and management
- Identification of possible areas where incentives and conservation programs would play an important role in ensuring water quality
- The nature of agricultural activities in various areas will suggest a possible suite of best management practices, which can be confirmed by gathering information at greater detail

For example, the estimated groundwater vulnerability map (Figure 5-28) shows a greater proportion of areas where vulnerability is high in SD&G and a lower proportion in P&R. When these data are combined with the land use analysis (Figures 6-10 to 6-13), they show that while the area is greater in SD&G, the proportion of crop-based agriculture within the vulnerability classes 1 and 2 is higher in P&R. The vulnerability classes 1 and 2 represent areas to target for analysis of land use and its potential impacts. This analysis highlights the agricultural component of the land use and points out the need to look at multiple layers of information in developing a regional water strategy.

6.8 Recommendations

The land use analysis results in the following recommendations:

- It is recommended that the agricultural land use analysis be used to provide general guidelines and interpretations and identification of target areas at a regional level. For example:
  - From the standpoint of surface water quality, the central area of the South Nation River watershed has a high proportion of the land in agriculture and a substantial proportion of that agricultural land is close to the surface drainage network. Annual crops are an important part of agricultural practice in this area and the estimated soil loss from erosion is moderate. It would be appropriate to target this area for best management practices, which buffer streams from nutrients and sediment. These practices would deal with cropped area and would relate to both overland flow and tile flow.
  - Similarly, the land in the southeastern part of the study area appears to be significant from the standpoint of crop production and potential for soil erosion. It should also be targeted for more detailed study
  - From the standpoint of livestock production, areas around Casselman through to St. Isidore appear to be most intense. These areas would be appropriate to target for best management practices related to livestock rearing and manure management, such as fencing to restrict livestock access to streams and manure management practices consistent with nutrient management guidelines.
  - In many cases these target areas and the nature of agricultural activities have already been recognized locally and programs such as RAPs, Environmental Farm Plans, Total Phosphorus Management, Clean Water Programs and Tributary Restoration are already in progress. The regional analysis can be used to ensure that local programs target the most appropriate areas and also it can be used to track changes over time as agricultural development proceeds.
- It is recommended that additional more detailed analysis be conducted to support any local water management strategy or development. The application of AGNPS within the South Nation River watershed is an example of such analysis.
- Because the areas defined as groundwater watersheds are substantially larger than the surface subwatersheds, this analysis does not provide the same level of resolution and is subject to a higher degree of uncertainty. This uncertainty results from the transfer of information about the nature and intensity of agricultural activities from EA groupings

to these relatively large watershed areas. Similarly, the averaging process used to transfer information from satellite imagery to these areas increases the level of uncertainty. It is recommended that more localized areas of interest for groundwater be defined and the analysis repeated for use in assessing development potential.

- In light of the limitations noted above, it is not appropriate to make recommendations related to specific kinds of agricultural activities within vulnerability classes 1 and 2. However, it should be noted that while the proportion of agriculture within these zones is relatively small the land use within vulnerability classes 1 and 2 is generally greater than 50 percent agricultural over much of the project area. It is therefore recommended that the kinds of agricultural activities within vulnerability classes 1 and 2 be characterized and that programs promoting management practices that protect groundwater resources be implemented. These include careful nutrient and pesticide management in areas where the connection between the land surface and the aquifer is most direct.

- Several of these recommendations have identified the need for nutrient management plans (NMPs). These plans are an equally important part of minimizing the impact of agricultural activities on both surface and groundwater. Currently they are promoted as most important for livestock based activities where the farmer must manage nutrients from both organic and inorganic sources. With increasing urbanization and industry, there is an increasing need for land on which to manage nutrients from biosolids (sewage sludges, industrial sludges, composts etc). In recognition of the need for land to receive biosolids, it is recommended that, in addition to the MOE requirements for a Certificate of Approval, an NMP be developed and adhered to for all areas receiving these materials. The application of biosolids in accordance with a valid NMP will ensure the appropriate rate of nutrient application for crop requirements, regulate time of application and incorporation to minimize loss to the environment and establish appropriate buffer areas around sensitive water resources.

7. Servicing Infrastructure

This section of the report specifically addresses servicing infrastructure and focuses on municipal water and wastewater facilities and private services. Surface water, groundwater, and land use were addressed in Sections 4, 5, and 6, respectively.

7.1 Overview

Infrastructure, including water, wastewater, and stormwater services has a direct impact on the maintenance of our high health standards, productivity, and our environment. As health and environmental standards increase, water and wastewater servicing standards need to keep pace.

Approval standards for treatment plants and conveyance systems moved from being almost non-existent in the 1930s and 1940s to the departments of health setting modest standards in the 1950s and 1960s. The 1970s saw the development of detailed “design guidelines” by provincial ministries of environment. These guidelines prescribed minimal acceptable standards to all municipalities. Still, in the 1970’s stormwater management meant preventing flooding; no consideration was given to environmental impacts.

Many municipalities constructed their first water treatment plants between 1930 and 1960. Most of the early wastewater treatment plants were constructed after 1950. However, as urbanization increased and treatment technology advanced, the number of treatment plants increased significantly. The early plants also needed upgrading to improve their performance to meet new standards.

Recently, some provinces have started to give more of the responsibility to the design engineer and the municipality for developing area-specific standards and ensuring that these standards are met. This transfer of responsibility provides some opportunity to customize the approach to the development to account for variables including:

- Raw water quality: river, lake, groundwater
- Wastewater composition: strong, weak
- Distribution system, topography
- Sewage collection system: combined, separated, mixture
- Seasonal variations in water demand and wastewater flow
- Leakage from water mains, unaccounted-for losses
- Infiltration / inflow into the sewer system
- Receiving stream requirements, nitrification, phosphorus limits
- Age of the system

Current water, wastewater, and stormwater servicing in each community has been shaped by many different factors, and it is critical to understand these factors before determining how needs can best be met from a regional perspective.

Servicing infrastructure was evaluated based on the existing conditions within the Eastern Ontario Water Resource Management Study (EOWRMS) study area, the relevancy of policies and guidelines and the available alternatives for upgrading the existing systems or developing new infrastructure. The objective of this evaluation is to provide relevant discussion on the opportunities to manage water resources more effectively and more efficiently on a regional basis.

The relevant infrastructure components assessed include:

- Wastewater treatment infrastructure
- Water treatment infrastructure
- Stormwater management infrastructure
- Water efficiency alternatives

In addition, a regional analysis of water demand was conducted. No evaluation of industrial point sources was undertaken.

7.2 Data Sources and Limitations

Existing infrastructure characterizations were based on the responses to the infrastructure survey carried out as part of the study. This survey has been described in greater detail in Section 2. Copies of the questionnaire are located in Appendix A. The information obtained from the survey is fairly comprehensive. The data collected through the survey and assessed as part of the infrastructure analysis included information on:

- Wastewater
  - Types and conditions of municipal wastewater treatment infrastructure
  - Areas serviced by single unit septic systems
  - Areas serviced by and the condition of communal septic systems
- Water
  - Types of and conditions of municipal surface water treatment infrastructure
  - Types of and conditions of municipal groundwater treatment infrastructure
  - Indications of municipal water supply shortages
  - Indications of municipal water supply quality
  - Concerns from the public in regard to water supply shortages
  - Concerns from the public in regard to water supply quality
  - Concerns of the public in regard to changes in water supply availability and quality
- Stormwater
  - No survey data available
- Water Efficiency
  - Indications of municipal water supply shortages
  - Concerns from the public in regard to water supply shortages
  - Concerns of the public in regard to changes in water supply availability and quality
  - Opinion of residents in regard to implementation of water efficiency measures

Data collected from this questionnaire represents a snapshot of one point in time. It is very likely that infrastructure characteristics of any one municipality have changed since the data was collected.

Limited data was available on the existence of and/or implementation of water efficiency programs in either Prescott and Russell (P&R) or Stormont, Dundas and Glengarry (SD&G) from the survey results. The City of Ottawa (Ottawa) has an aggressive water efficiency program. However, this program is focused more on water infrastructure as there are virtually no municipal water services in the City of Ottawaportion of the EOWRMS area. This limits our characterization of the study area in regard to measures that may have already been put in place and the nature of those measures, if any. The referenced information source *Regional Municipality of Ottawa Carleton, Water Efficiency Strategy,* April 1992 report from EOWRMS Phase 1A, contains information from the City of Ottawa that describes their own Water Efficiency Program.

Data on stormwater management programs and practices implemented in Eastern Ontario was requested through the municipal infrastructure survey. Although there are many municipal stormwater management programs in place, no data was provided to the consultant team on stormwater management in P&R, SD&G, and Ottawa from the survey results. This lack of survey data limited our ability to complete a regional characterization of current stormwater management practices that have been put in place in the study area.

In regard to the biological components of stream corridors and habitats that require enhancement or protection from surface water runoff, no data was available to the consultant team.

The referenced sources of information from the Phase 1A report were reviewed for content related to regional servicing infrastructure. Information from these sources was compiled and summarized in a variety of formats for inclusion in the analysis of servicing infrastructure and infrastructure alternatives. The referenced documentation from the Phase 1A report was very comprehensive and provided sufficient information to complete the infrastructure servicing alternatives and regulations components of Phase 2.

Information related to private water supply and septic systems and information on public concerns, attitudes and experiences with water quality and quantity were collected through the EOWRMS Water Resources Survey. This survey is described in more detail in Section 2 and a copy is found in Appendix A.

7.3 Assumptions

In developing the infrastructure assessment, there were a number of assumptions made in regard to the quality of data and information and the requirements for servicing.

The data from the surveys were assumed to be the most current information available on existing characterization of servicing infrastructure. The information from the referenced documentation from Phase 1A was regarded as comprehensive and it was assumed that the most current and available information on infrastructure alternatives was accessible through the documentation.

In developing an assessment of stormwater management options it was assumed that the focus of the assessment would be on new rural developments or the upgrading of urban systems to conform with more stringent requirements for water quality management, as put forth by the Ministry of the Environment (MOE) and included in some Official Plans. The assessment, therefore, combines three important components of an integrated stormwater management plan; stormwater quantity and quality control, stream protection and enhancement, and erosion control.

Because no information was available on the existing stormwater management practices in the region, it was assumed that most stormwater management infrastructure components that may already be in place are primarily designed to water quantity criteria.

7.4 Approach and Methods

During Phase 1A of EOWRMS, the information sources relevant to the analysis of the regional infrastructure components were collected and included in the Phase 1A report. This information was reviewed and the relevant alternatives for the various infrastructure components were assessed for their applicability to the study.

The infrastructure survey conducted as part of the study was used to gather information on the existing infrastructure components.

Stormwater was addressed through the development of an integrated plan that looked at stormwater quality enhancement, stormwater quantity control, stream protection and enhancement, and erosion control. The presence of significant stormwater facilities in the study area is limited.

7.5 Wastewater Infrastructure Assessment

7.5.1 Overview

The intent of this phase of work is to expand upon the information presented in Phase 1A of the EOWRMS and to evaluate the alternatives in regard to their ability to resolve issues related to water resources management including water quality impairment. Water quality impairment of water resources through the application of existing treatment technologies has been a factor in constraining development and will continue to be a factor. The use of alternative treatment methods that cost effectively reduce these constraints and will potentially allow development to proceed without the need for new capital investments will be the focus of this discussion on treatment alternatives.

The existing infrastructure information from the EOWRMS survey data is used characterize the current wastewater infrastructure and to assist in the determination of additional treatment alternatives that may be used within the EOWRMS area to augment or upgrade existing systems or to allow development to proceed in currently undeveloped areas in the most effective way possible. A digital database of this data is available to the project partners as part of this study.

7.5.2 Characterization and Key Findings

The survey information from the servicing jurisdictions in the EOWRMS area indicates that the management of domestic wastewater is generally accomplished through individual septic systems, communal septic systems, conventional wastewater treatment plants (WWTPs), or lagoon systems. The following is a short summary of wastewater infrastructure within the study area:

Septic Systems

Responses to the survey distributed to area residents indicated that 61 percent of the respondents from P&R were on a private septic system while 65 percent of the SD&G respondents indicated the same. The responses from survey participants in the City of Ottawa indicated that 98 percent of the people that responded to the survey were on individual septic systems.

A summary of responses to the infrastructure survey that indicated the use of private septic systems are listed below:

Casselman	Only residents on the North side of the South Nation and the residents on the South side of 417 highway are on private septic systems.
Township of West Hawkesbury	Several homes connected to Vankleek Hill indicated the use of a private septic system.
Township of East Hawkesbury	The entire township is on private septic systems, except for portions of Ste. Anne, Ste. Eugene, and Chute-a-Blondeau.
Cumberland	A study is in progress to determine the cause of contamination in ditches in this area.
Gloucester	Approximately 500 ha designated urban is to receive central sewer service in 2002/2003.
Osgoode	The Village of Metcalfe is undergoing Phases 1 and 2 of an environmental assessment for water and wastewater services.
Township of South Stormont	The population throughout the Township of South Stormond, except the hamlets of long Sault and Ingleside, are served by private septic systems.

The municipal respondents indicated that there were a number of communal septic systems. The locations of these systems were described as:

Fournier	Constructed communal septic systems are not yet in operation. Life expectancy is anticipated to be more than 20 years.
St. Eugene	Services 20.5 residential units and 1.5 recreational units. Life expectancy is more than 20 years.
Ste. Anne-de-Prescott Village	Life expectancy is over 20 years.

Wastewater Treatment

Table 7.1 provides a summary of the flows and capacity of wastewater treatment plants (WWTP) and lagoons as reported by municipalities in the infrastructure. Additional information is provided below. Conditions in any particular municipality may have changed since the data was collected.

TABLE 7.1
FLOW AND CAPACITY OF REPORTED WASTEWATER TREATMENT PLANTS AND LAGOONS

Area Name	WWTP	LAGOON	Tot Pop Served	Avg. Inflow (m^3/day)	Capacity (m^3/day)	Capacity Utilization	Per cap Inflow (m3/d)
Prescott and Russell							
Rockland	v		8,100	3,120	6,800	45.90%	0.39
Limoges		v	1,300		1,073		
St. Albert		v		166	720	23.10%	
St. Isidore		v		394	655	60.20%	
Embrun		v	3,717	1,287	1,798	71.60%	0.35
Russell		v	2,422	714	1,000	71.40%	0.29
Casselman		v	2,382	1082	1,364	79.30%	0.45
Hawkesbury	v		10,266	9,649	12,274	78.60%	0.94
Alfred		v	1,231	1072	713	150.40%	0.87
Plantagenet		v	980	665	561	118.50%	0.68
Wendover	v		984	355	511	69.50%	0.36
L'Orignal	v		1,700	786	955	82.30%	0.46
Vankleek Hill	v		1,753	801	1,534	52.20%	0.46
Chute a Blondeau	v			68	109	62.40%	
Stormont, Dundas and Glengarry							
Alexandria		v	3,500				
Maxville		v	800		450		
Glen Walter	v		600	525	525	100.00%	0.88
Green Valley		v	325		300		
Lancaster		v	750		1,000		
Chesterville		v	1,563	646	1,046	61.8	0.41
Winchester		v	2,600	1,424	1,725	82.60%	0.55
Crysler		v		194	810	24.00%	
Moose Creek		v		118	302	39.10%	
Iroquois	v		1,368	2,700	45,000	6.00%	1.97
Morrisburg	v		5,140	4,561	2,273	200.70%	0.89
Williamsburg		v	350				
Ingleside	v		1,500	3,392	4,045	83.9	2.26
Long Sault	v		1,683	1,487	8,000	18.6	0.88

Note: Includes only municipalities where data was reported in the survey.

Wastewater Treatment Plants

Rockland	Constructed new secondary plant, which is an SBR plant in 1997 and is operating at 46 percent of capacity. Current need is for a biosolids management plan.
Hawkesbury	Has a 22-year-old secondary plant which is a modified activated sludge plant operating at 79 percent of capacity. Biosolids are aerobically treated and land applied.
Wendover	Has a 22-year-old secondary RBC plant operating at 69 percent of capacity. Biosolids are aerobically treated and land applied.
L'Original	Has a 27-year-old secondary plant which is an extended aeration system operating at 82 percent of capacity. Biosolids are aerobically treated and land applied.
Vankleek Hill	Has a 3-year-old secondary plant which is an RBC system with polishing ponds operating at 52 percent of capacity. Biosolids are treated anaerobically.

Chute a Blondeau	Has a 16-year-old secondary plant which is an extended aeration package plant operating at 62 percent capacity. Biosolids are aerobically treated and land applied.
Glen Walter	Has an 11-year-old secondary plant which is an aeration system operating at 100 percent of capacity.
Iroquois	Has a 45-year-old secondary plant classed as an anaerobic digester with land applied sludge. The plant currently operates at 6 percent of capacity.
Ingleside	Has a 3-year-old secondary plant which is an extended aeration system operating at 84 percent 0f capacity. Biosolids are treated aerobically.
Long Sault	Has a secondary system which is an SBR operating at 19 percent of capacity. Sludge is anaerobically treated.
Limoges	Has a secondary plant that is currently under construction.

Lagoons

Morrisburg	Has a 45-year-old primary system which is a lagoon operating at 201 percent of capacity.
St. Albert	Has a 6-year-old waste stabilization pond (lagoon) with P (Phosphorous) removal operating at 23 percent of capacity.
St. Isidore	Has a 24-year-old waste stabilization pond (lagoon) with P removal operating at 60 percent of capacity.
Embrun	Has a 14-year-old waste stabilization pond (lagoon) with P removal operating at 72 percent of capacity.
Russell	Has a 23-year-old waste stabilization pond (lagoon) with P removal operating at 71 percent of capacity.
Casselman	Has a 30-year-old secondary lagoon system operating at 79 percent of capacity
Alfred	Has a 5 -year -old waste stabilization pond (lagoon) with P removal operating at 150 percent of capacity, followed with wetland treatment pilot project
Plantagenet	Has a 27-year-old waste stabilization pond (lagoon) with P removal operating at 71 percent of capacity.
Alexandria	Has a 40-year secondary old lagoon system.
Maxville	Has a 10-year secondary old lagoon system.
Green Valley	Has a 9-year secondary old lagoon system.
Chesterville	Has a 35-year secondary old lagoon system.
Winchester	Has a 35-year secondary old lagoon system.
Crysler	Has a 5-year secondary old lagoon system.
Moose Creek	Has a 5-year secondary old lagoon system.
Morrisburg	Has a 50-year old primary lagoon system.
Williamsburg	Has an 11-year-old primary lagoon system.

7.5.3 Wastewater Treatment Alternatives

Types of Systems

Sewage disposal and treatment systems range from small single unit applications to communal systems and finally to large municipal treatment plants. There is a range of technologies and applications for each. The focus of this review is on small-scale rural development opportunities with an emphasis on communal wastewater treatment systems and upgrading of existing municipal infrastructure. There are a number of alternatives presented here, all of which may be suitable to Eastern Ontario. Most of the alternatives represent conventional technologies. Wetlands, as a wastewater treatment alternative, are not a new technology but are still not widely accepted by the MOE as a regulated treatment technology. In the EOWRMS area, the applications that have the potential to be used as cost effective servicing alternatives in these areas are:

Septic Tank Systems

Septic tank systems are a MOE Class 4 sewage system and consist of a septic tank (connected to a building sewer), a leaching bed and the piping that transports the tank effluent to the leaching bed. A Certificate of Approval is required for the construction or alteration of a Class 4 sewage system.

The basic function of a septic system is to receive the waste from the building and partially treat it before discharging the liquid portion to the leaching bed. Solids are retained in the tank for later removal.

Septic systems can be designed for single family dwellings in residential areas and for non-residential applications such as shopping plazas and clubs, restaurants and bars. The effectiveness of septic systems can be increased by using water conservation devices in conjunction with the septic system.

Septic systems can be designed for multi-unit applications but are more typically applied to single units.

There is wide application of septic tank technologies in Ontario. Their application in Ontario is governed by appropriate design standards and implementation policy/guideline. Septic systems are considered a cost effective and technically effective treatment alternative.

Small Communal Systems

These types of wastewater treatment systems include many process types and configurations.

The term "Communal Wastewater Treatment Systems" (CWTS) has several connotations. The MOEE (MOEE, 1992, 3) and the MMA (1992, 3) defined communal systems as:

> ...those sewage works, sewage systems and water works to be approved, or approved under Sections 2 & 53, <u>Ontario Water Resources Act RSO 1990</u> [surface discharges], or those under Part VIII, <u>Environmental Protection Act RSO 1990</u> [subsurface discharges] for the common use of more than five units of full-time or seasonal residential or industrial/commercial occupancy or other occupancy as determined by MOEE staff.

Taken literally, a CWTS can be defined as any sewage works that services more than one unit or residence. Definitions do not generally differentiate between CWTS and centralized municipal wastewater treatment systems from a technical standpoint because, with the exception of scale/size, there is no technical difference. Rather, Ontario's legislation refers to sewage treatment works and sewage systems on the basis of their point of discharge (i.e. surface or subsurface).

A background review was completed to establish the most appropriate technologies for application, taking into consideration Ontario's regulatory environment and the system's expected performance, capital and ongoing operating and maintenance costs. The systems that were selected include:

Secondary Processes

- Fixed Film Processes
  - Rotating Biological Contactors (RBC)
  - Trickling Filters (TF)
- Suspended Growth Process
  - Sequencing Batch Reactor (SBR)
  - Extended Aeration (EA)
  - Facultative Lagoons
  - Aerated Lagoons
- Hybrid Systems
  - Biological Aerated Filters (BAF)

Because of the effluent constraints in the EOWRMS area it is assumed that tertiary treatment methods for phosphorus removal, ammonia removal and disinfection would be required in a number of areas. The tertiary treatment possibilities examined include:

Tertiary Processes

- Phosphorus Removal
  - Polishing Ponds
  - Constructed Wetlands
  - Physical / Chemical Treatment
- Nitrogen Removal
  - Biological Nitrification / Denitrification
  - Natural Processes
- Disinfection
  - Chlorination / Dechlorination
  - Ultraviolet Disinfection
  - Ozonation

Complete system descriptions, including selected environmental and health objectives characteristics for these technologies are included in this report as Appendix E.

7.5.4 Biosolids Management

The treatment of wastewater from municipal and industrial sources typically produces two products: clean effluent that is discharged from the system to a nearby water course, and organic biosolids that are retained for future processing. Additional processing is necessary to stabilize the organic material to destroy pathogens and minimize its odour producing potential. Once stabalized, biosolids are typically disposed of through land application, landfilling or incineration. Some biosolids are further processed for reuse as compost or fertilizer

Biosolids can be removed for further processing from each stage of wastewater treatment: primary, secondary or tertiary.

Solids removed during primary treatment are pumped in a slurry form to treatment, usually 3 percent to 5 percent solids by weight. Waste activated sludge is typically taken from the bottom of clarifiers or recycle pipes and has 8,000 mg/L to 12,000 mg/L or 0.8 percent to 1.2 percent solids by weight. Solids from the two processes can be combined directly prior to stabilization; alternatively, one or both can be thickened to reduce the volume that needs to be treated. Thickening can be by gravity, or by mechanical means, such as gravity belt thickeners, resulting in solids concentrations of about 6 percent. Waste activated sludge can be thickened by a variety of methods, including dissolved air flotation, centrifugation and gravity belt thickening. Resulting solids concentrations are usually 5 percent to 7 percent by weight.

Biological methods have traditionally been employed for biosolids stabilization. The most common are anaerobic and aerobic digestion. Anaerobic digestion utilizes anaerobes, bacteria that work without oxygen, to react with the organic matter. The result is a stabilized biosolid product that has undergone about 50 percent reduction in its organic content. These organics have been converted to digester gas.

Aerobic digestion utilizes aerobic bacteria to convert organic matter and stabilize the biosolids. The organic matter is converted to carbon dioxide and water. Aerobic digestion does not provide energy recovery opportunities.

Most anaerobically or aerobically digested biosolids may be directly applied to agricultural land as a liquid or are further treated to reduce their volume, prior to final use. Further volume reduction is achieved by mechanical dewatering utilizing belt filter presses, centrifuges or filter presses. This process results in a solid earth-like material with a solids content of 20 percent to 30 percent.

The recent concerns with water supplies (municipal and private) and their protection resulting from the compromise of the Walkerton water system has heighten public interest in biosolids and manure management. During the course of the EOWRMS project a degree of concern was expressed by the study partners as well as the public regarding biosolids management, particularly with respect to land application. Within the study areas some biosolids from municipal, industrial and privates septic haulers are disposed of through land application, primarily on agricultural land.

There are a number of regulations and guidelines that address how treatment facilities should be designed and govern how biosolids can be utilized or disposed of in Ontario. The guidelines stipulate product quality and, in some cases, the processing requirements and characteristics of the site where the biosolids are utilized/disposed. These regulations and guidelines are discussed in the following sections.

The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) (2000) lists three keys to successful biosolids management: proper application methods, the use of Best Management Practices (BMPs), and nutrient management planning. When applied according to best management practices, biosolids can improve soil fertility and add organic matter; therefore, offsetting the need for some commercial fertilizers and enhancing the overall soil structure. Improperly applied, biosolids (as well as other nutrient sources) can have negative effects on soil and water resources and possibly on human and animal health.

7.5.5 Relevance to Regional Water Strategy

EOWRMS Water Quality Issues and Provision of Adequate Wastewater Treatment

Several surface water quality concerns have been identified within the EOWRMS areas. Our review of surface water quality data indicates that in some river systems the PWQOs have been exceeded for phosphorus and for ammonia (Section 4). The exceedance of phosphorus levels is fairly widespread, while ammonia is exceeded less frequently. In some areas water quality is improving over the time period indicated by available data and in some cases water quality is deteriorating.

The MOE specified its water quality and quantity management approach in its Blue Book (1984). Blue Book Provincial Water Quality Objectives (PWQO) and revised 1991 Objectives and Guidelines set forth surface water quality guidelines and objectives for Ontario streams that will protect the vitality of aquatic life and recreation in the water. Whereas objectives are distinct numerical criteria representing desired levels of water quality in the province, guidelines are based on incomplete scientific evidence and are meant to be augmented with site-specific studies. Canadian Water Quality Guidelines (CWQG) have also been put forward that address many issues, including safe levels for many contaminants of concern.

The following are the surface water quality guidelines and objectives for total phosphorus and ammonia for Ontario streams.

Guidelines	**Concentration**
Total Phosphorus (P)	<0.03 mg/L (MOE)
Total Ammonia	<1.37 mg/L (CWQG)
Objective	
Un-ionized Ammonia Nitrogen (NH_3-N)	<0.02 mg/L (MOE)

There is a possibility that development and associated wastewater discharges to surface waters in the EOWRMS area have the potential to cause additional localized non-compliances with PWQO with regard to phosphorus and ammonia. The MOE Blue Book Surface Water Quality Management Policy 3 emphasizes that the MOE's approach in setting effluent requirements for waste discharges is based on a site-specific assessment of the assimilative (self-purification) capacity of the receiving waters.

Phosphorus discharges, in some reaches within the EOWRMS area, are subject to the MOE Blue Book Surface Water Quality Management Policy 2 which states that "water quality which presently does not meet the Provincial Water Quality Objectives shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the Objectives". Policy 2 also states "where new or expanded discharges are proposed, no further degradation will be permitted ... however, it is recognized that, in exceptional circumstances, it may not be technically feasible, physically possible or socially desirable to achieve this condition in all water bodies in the Province". The objectives for the protection of surface waters are evident in the requirements put forth in the Certificates of Approval (C of As) for all wastewater treatment facilities in the province of Ontario. Meeting these regulations can pose significant challenges for municipalities and can represent significant barriers to implementation of alternative treatment options that are not already in service in Ontario. Many of the existing wastewater treatment facilities in the study area use lagoons and depend on a prescribed window of time (spring months) in which they are required to discharge. Implementation of alternative discharge strategies may also be hindered by these existing regulatory constraints.

From a regional planning perspective, it would be beneficial to develop a wastewater treatment planning tool that would allow for the most effective and efficient servicing and treatment alternatives to be selected for each application on a watershed basis The planning tool could provide some level of consistency in implementation within each watershed and subsequently across the region.

An example of such a regional planning tool is provided:

Option 1 – Which development category does the proposal fall under: near border, just beyond border, or rural area?

Near border: Can the development be linked to full municipal service? Issues such as transmission costs, boundary considerations and operating agreements must be considered. If connection to full municipal service is not possible, then a communal system should be considered, see Option 3. Other development situations for Option 3 include development in rural areas. If connection to full municipal service is possible, then go to Option 2.

Option 2 – Is there adequate capacity at the full service facilities?

A plant capacity assessment should be performed using the MOE guideline document *Calculating and Reporting Uncommitted Reserve Capacity at Sewage and Water Treatment Plants*. If there is insufficient capacity go to Option 5. If there is sufficient capacity then the new development can be serviced by full municipal service facilities.

Option 3 – Can the facilities be expanded?

A receiving water assessment should be performed based on the proposed loads from the expanded Sewage Treatment Plant. If the receiving water cannot accept additional loads, then consider Option 3. If the receiving water can accept additional loads then expansion of the Sewage Treatment Plant should be pursued to accommodate the new development.

Option 4 – Are there sufficient households for a public communal system?

A public communal system which does not have surface discharge should be considered if surface discharge cannot exist. If there are more than 5 households and surface discharge is possible then a surface discharge public communal system should be investigated.

Option 5 – Is a public communal system favourable?

Issues such as future growth, the land use and availability and the soil conditions, are some of the factors that need to be considered. There should be at least five (5) households for a public communal system. There are a number of manuals that should be consulted when considering this option. For example: *Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems, 1982*; *An Introduction to Communal Sewage Systems, 1994*; and *MOEE Guidelines B-7, Incorporation of the Reasonable Use Concept into MOEE Groundwater Management Activities*. If these issues are not favourable for a public communal system then individual private on-site systems should be considered, see Option 6.

Option 6 – Are there less than five (5) households that require sewage service?

If there are less than five households, future growth is projected to be minimal, and site and public conditions are favourable, then individual private onsite systems are to be considered. The following manuals and guidelines should be evaluated when considering private systems: *Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems, 1982*; *Technical Guidelines for Septic Systems: Water Quality Impact Risk Assessment;* Ontario Regulation 358 of the Environmental Protection Act; and Ontario Regulation 903 of the Ontario Water Resources Act.

In applying a wastewater treatment planning tool, there are a number of considerations that must be taken into account. These may include:

- Treatment Technology Issues
  - Ranges of effluent quality required
  - Appropriate technologies
  - Operating experiences of technology in Ontario and other jurisdictions
  - Appropriate hydrogeological investigation / impact assessment
  - Design standards / guidelines from other jurisdictions
- Financial Issues
  - Approaches used to finance various aspects of technology, including long-term operating, maintenance, and replacement costs
  - Cost data comparisons between individual septic systems communal systems and full municipal servicing options

Applicability of Policy and Guidelines

In mid-1992, the MOE and the Ministry of Municipal Affairs (MMA) released guidelines that specifically outlined Ministry positions with regard to the use of CWTS. Both sets of guidelines aim to encourage an effective land use planning process by ensuring environmentally and economically sound growth. In late 1992, the MOE released several interim guidelines that set forth Ministry positions aimed at improving the effectiveness of the MOE Land Use Plan Review Program in the future.

In May of 1996, the Provincial Policy Statement was issued under the authority of Section 3 of the Planning Act. It provides policy direction on matters of provincial interest related to land use planning and development. Section 3 of the Planning Act requires that, in exercising any authority that affects planning matters, planning authorities "shall have regard to" policy statements issued under the Act. The Policy Statement is intended to promote a policy-led system that recognizes that there are complex inter-relationships among environmental, economic, and social factors in land use planning.

Many of the design and implementation guidelines presented here can represent barriers to implementation of alternative treatment options that are not specifically outlined in policies. The approval of specific treatment works and issuance of appropriate C of A's for technologies outside of provincial design guidelines can represent more of a challenge to municipalities.

Specific components of these guidelines and other relevant MOE policy / guidelines / notices, are summarized below as related to CWTS in Ontario.

MOE Policy Manual

- Catalogues MOE polices; including infrastructure, land use, municipal abatement and approvals, and water quality and quantity policy sections

- Policies could affect several aspects of CWTS development, including location, design and approvals

Manual of Policy, Procedures and Guidelines for Onsite (Private) Sewage Systems (MOE, 1982)

- Includes first principles, advice and guidance with respect to the design of onsite sewage systems, including section on soils, Class 4 septic systems, Class 6 proprietary aerobic treatment plants, leaching beds, and large subsurface sewage disposal systems

- Authorities issuing approvals for large subsurface disposal systems adjacent to areas with municipal servicing must ensure compliance with local zoning by-laws and area Official Plans (OP)

- The application of large subsurface disposal systems may be appropriate in areas not likely to be serviced by central municipal systems in the future

MOE Part VIII Notices: Large Subsurface Sewage Disposal Systems

- Notice 7/83: Announces the distribution of Article 14.1 of the Manual of Policy, Procedures and Guidelines for Onsite (Private) Sewage Disposal Systems, which provides a guideline for the design, approval, construction, operation, and maintenance of large subsurface sewage disposal systems

- Notice 3/84: Notes that Part VIII Directors, including Health Unit Directors where Part VIII authority has been delegated, are responsible for the approval of communal sewage collection and disposal systems. The Part VIII Director may request the MOE Approvals Section to review and comment on final plans for communal sewage collection systems discharging to the subsurface in accordance with the Ministry's Guidelines for the Design of Sanitary Sewage Systems and Manual of Policy, Procedures and Guidelines For Onsite (Private) Sewage Systems

- Notice 2/86: Notifies Part VIII Directors that a revised Plumbing Code requires certain works previously deemed “plumbing” (e.g. common piping on private property) be approved under Part VIII as part of a “sewage system” in the future

Guidelines for the Design of Sewage Treatment Works (MOE, 1984)

- Describes MOE first principle design guidelines for municipal sewage treatment plants, including mechanical plants and lagoon systems

- The Guideline describes the MOE’s interim position that municipalities accept responsibility (primarily through ownership) for privately built communal water and sewage systems

Provincial Policy Statement

The Policy states:

> Planning for sewage and water systems will recognize that:
>
> a. Full municipal sewage and water services are the preferred form of servicing for urban areas and rural settlement areas. In areas serviced by full municipal sewage and water services, lot creation will be permitted only if sufficient reserve water and sewage plant capacity will be available to accommodate it.
> b. Communal services are the preferred means of servicing multiple lots / units in areas where full municipal sewage and water services are not or cannot be provided, where site conditions are suitable over the long term.
> c. Lot / unit creation may be serviced by individual on-site systems where the use of communal systems is not feasible and where site conditions are suitable over the long term.
> d. Partial services will be discouraged except where necessary to address failed services, or because of physical constraints.

Although certain proprietary CWTS technologies are ”classified“ by the MOE for use under Part VIII of the Environmental Protection Act, actual Certificates of Approval (C of A) are issued on a site-specific, as opposed to technology-specific, basis.

Biosolids

In Ontario, the treatment of wastewater, which includes biosolids treatment and processing at a wastewater treatment plant, is regulated by the Ontario Water Resources Act . For biosolids processed at a site other than the wastewater treatment plant, the transportation and utilization / disposal are regulated by the Environmental Protection Act and Regulation 347, which regulate odour issues, air emissions and noise. The MOE administers these acts and regulations. Certificates of Approval (C of A) are required by these Acts for the construction and operation of facilities to treat wastewater and biosolids, the processing of biosolids, the transportation of biosolids, and the utilization and disposal of biosolids. The MOE develops guidelines to assist them and proponents in meeting these acts and regulations. Although the guidelines are not legislated, the MOE uses them to assist in preparing C of As. The C of As are legal instruments under the Acts and normally contain enforceable conditions that regulate how the facility must be operated, etc.

The guidelines for the application of biosolids on agricultural land are discussed below. Guidelines are also available for landfilling, landfill cover material production, and composting and fertilizer products.

Biosolids Utilization on Agricultural Land

The MOE’s *Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Lands* contains the criteria for application of digested, dewatered and dried biosolids on agricultural land. The guidelines contain several restrictions on biosolids quality, application rates, handling and spreading of the biosolids and characteristics of the agricultural site to be used. Each agricultural site must be approved by the MOE for biosolids application.

The purpose of the MOE guidelines is to facilitate the use of biosolids and other waste materials on agricultural land, while protecting environmental quality, consumer and animal health, food quality and the productivity of the land. They outline criteria that must be met before biosolids or other waste materials can be considered for use on agricultural land and before approval for use will be given by the MOE. In essence, these materials must be of benefit to crop production or soil health and not degrade the natural environment. The materials should supply essential plant nutrients or organic matter, or other constituents that will maintain crop production of soil health.

The guidelines specifically address the following areas:

- Procedures for obtaining approvals, analytical requirements and for providing monitoring and quality control plans
- Waste material stabilization
- Criteria relating to waste materials, including nutrients, metals, and micro-nutrients
- Criteria related to acceptable spreading rates for anaerobically digested, aerobically digested, dewatered, and dried biosolids
- Criteria related to spreading sites, including separation distances, soil criteria, snow covered and frozen ground, slopes, reducing runoff and soil compaction and suitable crops and waiting periods after spreading
- Waste material handling and spreading, including requirements for storage, blending, and spreading
- Responsibilities and rights of generators, regulators, haulers / applicators, and farmers to ensure utilization is successfully carried out in an environmentally friendly manner with beneficial effects for the agricultural soil
- Complaints regarding spreading methods and interpretation of the guidelines

The guidelines require that biosolids be treated to minimize odour potential and reduce the number of pathogenic organisms and other potentially harmful constituents to an acceptable level. MOE approved anaerobic or aerobic digestion processes provide appropriate stabilization. The MOE reviews other stabilization methods on an individual basis.

The management and approvals for land application could be made more effective if they were coordinated via a total nutrient management planning process on a watershed or subwatershed basis involving a range of stakeholders.

Local Partnerships

The Ontario Rural Wastewater Centre was created by the University of Guelph (Collège d'Alfred and the School of Engineering) in partnership with the Rideau Valley Conservation Authority and many industry and government stakeholders. The mission of the Centre is to promote environmentally sustainable development of rural and unsewered areas through the effective use of wastewater disposal technologies. The center emphasizes technology and solutions in the areas of onsite disposal of household septage nutrient, agri-food waste management and rural municipal wastewater treatment.

The Centre has demonstration sites in Central Ontario at the University of Guelph and paired sites in Eastern Ontario at Collège d'Alfred and at the Baxter Conservation Area. The sites offer a wide variety of wastewater courses using demonstration technologies to provide a truly hands-on learning experience. The Centre researchers bring decades of applied research experience to bear on problems related to rural and unsewered wastewaters.

The location of this centre in eastern Ontario provides and excellent opportunity for the EOWRMS partners to make their residents aware of the activities of the Centre and promote the use of innovative technologies in addressing individual or small communal onsite wastewater issues. The centre is discussed further in Section 9.

7.5.6 Recommendations

The utility of a servicing and treatment planning tool similar to that described in this report should be examined in a regional context.

Also, in a regional context, the opportunities represented by the MOE's Total Phosphorus Management Program for the South Nation River watershed should be incorporated into the assessment of treatment alternatives in the study area. This program was described in this report under Section 4, Surface Water Analysis.

A comprehensive analysis of the level of treatment provided to domestic and industrial discharges across the region should be carried out to determine the potential for application of various servicing options and the net benefit that would be achieved through various implementation strategies.

Opportunities for a regional strategy for seasonal discharge from municipal lagoons should be examined in a watershed context. Currently, there are a variety of strategies exercised in the region for the seasonal (spring) discharge from municipal treatment lagoons. This recommendation was also made in the context of improving surface water quality in the region.

In association with a regional strategy for seasonal discharge, it is recommended that a wastewater allocation study be undertaken to determine the appropriate levels of discharge on a subwatershed basis in Eastern Ontario. This study should include all municipal and industrial point source discharges.

Opportunities to optimize existing capacity at wastewater treatment facilities should be taken where feasible.

The regulatory and monitoring framework for land application of biosolids needs to be reviewed in the context of voluntary compliance and monitoring, watershed management, and total nutrient management planning. The MOE should engage the EOWRMS partners in this process.

Land applied biosolids should be managed on a total nutrient management planning approach and on watershed and subwatershed basis. This would include involving other major nutrient users including golf course operators, the farm community and other land managers (i.e. Conservation Authorities and municipalities). Municipalities should reflect this in current or planned nutrient management bylaws and Official Plans.

7.6 Water Infrastructure Assessment

7.6.1 Overview

The intent of this phase of work is to expand upon the information presented in Phase 1 of the EOWRMS and to evaluate the alternatives in regard to their ability to resolve issues related to existing water supply quality impairment and available water supply quantities. Availability of potable water sources has been a factor in constraining development and will continue to be a factor. The use of alternative water treatment methods that cost effectively reduce these constraints and will potentially allow development to proceed without the need for new capital investments will be the focus of this discussion on treatment alternatives.

The existing infrastructure information from the EOWRMS survey data is used to assist in the determination of additional water treatment alternatives, which may be used within the EOWRMS area to augment or upgrade existing systems or to allow development to proceed in currently undeveloped areas in the most effective way possible.

7.6.2 Characterization and Key Findings

From the survey of area residents, 54 percent of responding residents in P&R and 62 percent of responding residents in SD&G indicated that they were very concerned about the quality of their drinking water. In Ottawa, 60 percent of survey respondents were very concerned about drinking water quality. When asked about their concerns in regard to the quantity of water available, 42 percent of P&R responding residents indicated that they were very concerned while 50 percent of SD&G and 52 percent of Ottawa responding residents indicated that they were very concerned.

Of the residents that responded to the questions on their concerns in regard to water supplies, the most predominant concerns were in regard to iron and sulphur contamination and odour and taste. In P&R, 25 percent of the respondents indicated that they had experienced some change in their water quality while 28 percent of the respondents in SD&G and Ottawa indicated the same. Most indicated that the changes occurred primarily in the physical properties such as taste, odour and colour and that the primary causes may be linked to seasonal/climactic influences or neighbouring land use activity. The survey indicated that approximately 40 percent of the respondents from P&R, 49 percent from SD&G and 60 percent from Ottawa treat their water through some type of treatment system.

The survey information from the municipal servicing jurisdictions in the EOWRMS area indicates that the treatment of municipal potable water supplies is generally accomplished through conventional treatment technologies applied to both groundwater and surface water sources.

The predominant treatment technologies are conventional mechanical plants with clarification and filtration and disinfection. The predominant method of disinfection is the addition of chlorine.

The following is a short summary of the results acquired through survey questions regarding the nature of water treatment. Conditions in any particular municipality may have changed since the data was collected.

Groundwater Systems

Bourget	Chlorination of poor water quality wells requiring upgrades in less than five years
Cheney	Chlorination of poor water quality wells requiring upgrades in less than five years
Clarence Creek	Chlorination and sand filtration of poor water quality wells requiring upgrades in less than five years

Hammond	Chlorination of poor water quality wells requiring upgrades in less than five years
St. Pascal Baylon	Hydrogen Peroxide, chlorination and granulated carbon filtration requiring upgrade in 5 to 10 years
Forest Park	Disinfection of poor quality groundwater to be replaced by new system from Limoges in 2001
St. Isidore	New aeration tower and chemical treatment system
Embrun	New treatment system in 1996 with iron removal
Russell	Aeration and chlorination system replacement anticipated in 11 to 20 years
L'Original	Poor quality water chlorinated at present, new supply from Hawkesbury in next 5 years
Greely (private system)	Private chlorinated system
Glen Robertson	Chlorination system replacement in 5 to 10 years
Lancaster	Chlorination
Chesterville	Chlorination system to be replaced in less than 5 years
Winchester	Chlorination system to be replaced in less than 5 years
Crysler	Chlorination system to be replaced in 5 years to 10 years
Finch	Pressure filters, aeration tower and chlorination needing replacement in less than 5 years
Moose Creek	Chlorination system to be replaced in less than 5 years
Newington	Chlorination needing replacement in 20 years
Osnabruck Centre	Chlorination system to be replaced in less than 5 years
Vars	Chlorination and granular activated carbon filtration requiring replacement in more than 20 years

Surface Water Systems

Rockland	Conventional clarification and filtration and disinfection plant to be upgraded in 5 to 10 years
Casselman	Conventional clarification and filtration and disinfection plant
Alfred – Lefaivre	Conventional mechanical plant with clarification and filtration with replacement in more than 20 years
Plantagenet	Conventional mechanical plant with clarification and filtration with replacement in more than 10 years
Wendover	New mechanical clarification and filtration plant in 1999
Hawksbury	Conventional plant with chlorination
Vankleek Hill	Chlorinated water from Hawksbury
Alexandria	Flouration, sedimentation and filtration to be replaced in over 10 years

Alternative Technologies

Surface water supplies in the EOWRMS area require conventional treatment and disinfection according to the MOE regulations. Groundwater sources for potable water supplies in many areas experience poor water quality and many groundwater sources require treatment beyond the regulated levels of disinfection.

The review of water treatment options that are applicable to the EOWRMS area produced the following alternatives:

- Conventional Clarification Processes / Technologies
  - Conventional Clarification
  - Dissolved Air Flotation (DAF)
  - Upflow Solids Contact Units
- Filtration Technologies
  - Granular Media Filters
  - Biologically Active GAC Filters (BAC)
  - GAC Packed Bed Adsorption
- Membranes
- Oxidants / Disinfectants
  - Chlorine
  - Chloramines
  - Chlorine Dioxide
  - Ozone
  - Ultraviolet Light (UV)
  - Potassium Permanganate
- Backwash Treatment and Recycle
- Filter Backwash Treatment
- Membrane Concentrate Treatment
- Solids Handling Processes
- Thickening
  - Gravity Thickeners
  - Gravity Belt Thickening
  - Dissolved Air Flotation
- Dewatering
  - Centrifuges
  - Belt Filter Press
- Solids Disposal

Complete descriptions of these technologies, including selected environmental and health objectives characteristics for these technologies are included in this report as Appendix E.

7.6.3 Relevance to Regional Water Strategy

From a regional planning perspective, it would be beneficial to develop a water treatment planning tool similar to that put forth in this report for wastewater treatment applications that would allow for the most effective and efficient treatment alternative to be selected for each application across the region.

An example of such a planning tool is provided below:

Option 1 – Which development category does the proposal fall under: near border, just beyond border, or rural area?

Near border: Can the development be linked to an existing municipal service? Issues such as transmission costs, boundary considerations and operating agreements must be considered. If connection to full municipal service is not possible, then a communal system should be considered, see Option 5. Other development situations for Option 3 include development in rural areas. If connection to full municipal service is possible, then go to Option 2.

Option 2 – Is there adequate capacity at the full service facilities?

A plant capacity assessment and a water source availability study should be performed. If there is insufficient capacity or not enough source water then go to Option 5. If there is sufficient capacity and available source water then the new development can be serviced by full municipal service facilities.

Option 3 – Can the facilities be expanded?

The existing water treatment facility should be assessed to determine if there is opportunity to expand the treatment capacity at the facility and if there is adequate water supply available to accommodate the anticipated growth. If there is adequate available supply then this option should be examined. If there is not then another source must be found to accommodate the new development (see Option 5).

Option 4 – Are there sufficient households for a public communal system?

Individual well systems are normally cost-effective for individual or small development units. If there are 5 or more units in a development then a communal system application should be examined from a water availability and cost-effectiveness standpoint.

Option 5 – Is a public communal system favourable?

If it has been determined that an existing full service facility nearby cannot supply enough potable water then the a new communal system should be considered. Communal systems verses individual private systems must be examined from a treatment and supply cost effective perspective.

Option 6 – Are there less than five (5) households that require sewage service?

If there are less than five households, future growth is projected to be minimal, and site and public conditions are favourable, then individual private onsite well systems are to be considered.

The treatment technology issues that must be incorporated into the decision making process for selection of the most effective and efficient water treatment option from a regional perspective are the same as those listed for the application of the tool to waster treatment options.

Applicability of Policy and Guidelines

New MOE Regulations

In mid-2000, the MOE released new regulations that govern the delivery of potable water from municipal treatment systems. The new policy addresses medium sized to large size delivery systems. Regulations are being developed that will address smaller communal type systems. Private well systems are not yet included in the regulations.

The new MOE regulations apply to all water treatment plants capable of supplying more than 250,000 litres of water per day or a system that serves more than 5 residences. The detailed regulations are available from the MOE or can be located on the MOE web site.

The new regulations are meant to provide more guidance to water suppliers in regard to the required reporting procedures, sampling procedures and treatment requirements for potable water supplies across all of Ontario. The regulations have been in place since the latter part of the summer, 2000, and also require that all water suppliers capable of supplying more than 250,000 litres of water per day or a system that serves more than 5 residences have an engineering report on the condition of their water supply system and the maintenance and operations of that system completed by a stipulated time.

The treatment minimums for supplies have also changed and, in a summary form, are:

- The minimum level of treatment is disinfection for groundwater sources.
- The minimum level of treatment for surface water sources is chemically assisted filtration and disinfection or some other treatment that delivers water of equal or better quality.

These new regulations have a few implications for EOWRMS municipalities. All supply systems have been or are being inspected and audited. Results of these audits are now pending to the MOE. It is possible that, in some cases, significant equipment upgrades or replacements will be necessary. Once all of the results are in, the requirements should be reviewed to explore possibilities for regional servicing opportunities.

The regulations do not present technical barriers to small communities in Eastern Ontario. There are technologies available that will effectively meet the regulations. There may, however, be an additional cost of implementation and monitoring in some communities that would not have been required prior to the introduction of the new regulations.

7.6.4 Recommendations

The new MOE regulations set forth a comprehensive set of requirements for the operation and maintenance of water treatment facilities. Once a supply and treatment technology has been selected, the regulations govern their application.

In the determination of the most appropriate servicing options from a supply perspective, the most appropriate water supply and distribution option may be best determined through a strategy that is applied region wide. A simple planning tool, such as the one presented in this Section under “Relevance to Regional Water Strategy”, for the selection of the most effective and efficient means of supplying water to regional residents should be developed and incorporated into official plans and regional planning documents. This planning tool could be developed in a similar format to the example provided earlier for the selection of the most effective and efficient wastewater servicing and treatment alternatives.

It is recommended that the opportunities to most effectively and efficiently meet the requirements of the new MOE regulations be explored from a treatment and servicing perspective. The requirements of the new regulations should be a critical factor integrated into the planning tool for the selection of servicing and treatment options.

The development of this tool should be facilitated through a regional planning study carried out to assess the requirements for additional water supply and treatment in the region over the next 20-year planning period. The planning tool for water supply servicing would also incorporate the existing information about Permits to Take Water and the recommendations made in this report in regard to the decision making process required for additional permits to take water from surface water sources.

7.7 Stormwater Management, Stream Protection/ Remediation and Erosion Control

7.7.1 Overview

Management of stormwater, the protection and rehabilitation of stream corridors and erosion control along watercourses are best approached through an integrated strategy with coincidental best management practices. The selection of appropriate best management alternatives for the study area requires an evaluation of the options available. This evaluation has been carried out based on a review of the appropriate BMPs for stormwater management and watercourse protection including erosion control. The proper management of stormwater is an important consideration in an evaluation of the constraints that can impact the feasibility of development in areas that fall under the EOWRMS.

7.7.2 Characterization and Key Findings

Stormwater Management (Hydrotechnical) BMPs

The contribution of stormwater to receiving-stream impairment can be very site-specific. Therefore, it is necessary to look at a broad range of stormwater control options to develop the most efficient and effective methods for management.

In Ontario, the issues of management of stormwater quantity and quality have been addressed through the guidance of the MOE and the Ministry of Natural Resources (MNR). Stormwater quantity and quality management principles and design practices of the MOE and MNR have been documented in a number of reports, including: *Interim Stormwater Quality Control Guidelines for a New Development*, 1991, *Stormwater Quality Best Management Practices*, 1991 and, more recently, *Stormwater Management Practices Planning and Design Manual*, 1994 (currently being updated). A BMP approach to stormwater management on a watershed basis is the basic premise of the most recent MOE guidelines.

The approval of stormwater management practices is generally carried out through the municipality in conjunction with the local Conservation Authority, the MNR and DFO. Each authority has its own objectives, although the two principle goals are the safe conveyance of stormwater runoff and the protection of aquatic habitats. The MNR and DFO requirements for the protection of aquatic habitat can be a barrier to the implementation of some stormwater management practices that do not address habitat concerns. Similarly, the municipal requirements for flood protection and safety may be a barrier to the implementation of some stormwater management practices that do not provide adequate protection.

The control options have been organized as follows:

- Source control options
- Conveyance control options
- End-of-pipe control options
- Watercourse

Source Controls

- Porous Pavement
- Erosion / Sediment Control
- Footing Drain Disconnection (to surface discharge)
- Water Quality Inlets
- Increase Pervious Areas (Land Use Control)
- Control of Road De-icers
- Control of Fertilizers and Pesticides
- Industrial Runoff Control
- Discharge Bylaw Review / Implementation
- Enforcement of Oil / Grease or Hazardous Material Disposal Bylaws
- Public Education

Conveyance Controls

- Infiltration Trenches and Basins (can also be considered end-of-pipe control)
- Pervious Exfiltration Pipe
- Pervious Catchbasins or Manholes
- Grassed Swales
- Culvert Sizing

End-of-Pipe Controls

- Wetlands
- Wet Ponds
- Dry Ponds

Stream Protection and Enhancement

TABLE 7.2
ALTERNATIVE SOLUTIONS TO STREAM DETERIORATION

Condition or Process Observed	Alternative
Toe erosion and upper bank failure	1. Vegetated geogrid 2. Live cribwall 3. Rock toe with vegetation 4. Conventional riprap
Local bank scour	1. Branchpacking 2. Vegetated geogrid 3. Live cribwall 4. Live fascine 5. Joint planting 6. Tree revetment 7. Conventional vegetation 8. Conventional riprap
Loss of riparian cover or green space linkages	1. Establish Buffer Zones

TABLE 7.2
ALTERNATIVE SOLUTIONS TO STREAM DETERIORATION

Condition or Process Observed	Alternative
	2. Replant riparian areas 3. Establish protected habitat areas

7.7.3 Relevance to Regional Water Strategy

The current integrated planning approach to stormwater addresses both stormwater conveyance issues and ecological stability and enhancement. A brief description of the evolution of stormwater management will provide an understanding of the important considerations in this approach.

In the mid-1970s, concerns over watercourse stability and capacity provided the driving force behind the requirement for stormwater detention facilities in new subdivisions to protect property from flooding and erosion. One of the primary requirements was to maintain peak runoff rates at predevelopment levels for a specified return period. In short, the primary focus was on hydrotechnical solutions.

By the late 1980s, a watershed management approach was becoming an integral part of stormwater management and master drainage planning in Ontario. This approach was an outcome of the realization that facility designers had to take into consideration environmental planning and protection together with drainage design and layout of drainage facilities.

Today, concern for the environment has furthered the evolution of watershed management and drainage planning philosophy. One of the goals of the EOWRMS planning process is to examine an integrated stormwater management strategy that is hydrotechnically sound, environmentally responsible, and fiscally achievable.

Under the term, "integrated stormwater management plan," planning for stormwater management has five overall objectives:

- Ensure appropriate conveyance of urban runoff from developed areas to the stream
- Alleviate potential environmental, drainage, erosion, and flooding concerns
- Protect major stream resources, including riparian and aquatic habitat
- Remediate potential water quality problems
- Allow orderly and planned development to proceed

The goal is to develop an integrated stormwater management strategy that protects property while sustaining natural systems and accommodating growth.

An integrated stormwater management strategy comprises two distinct components:

TABLE 7.3
STORMWATER MANAGEMENT STRATEGY

Component	Management Objective	Hydrotechnical Focus	Type of Impact
Hydrotechnical	Protect property	Infrequently occurring large storms	Dramatic (flood and erosion damage resulting from peak flows)
Environmental (enhanced hydrotechnical)	Protect ecosystems	Frequently occurring small storms	Insidious (water quality deterioration, watercourse erosion, and sedimentation resulting from the increased number of

runoff events per year)

Development of an Integrated EOWRMS Stormwater Management Plan

A set of six strategic objectives that provide a framework for the development of an integrated stormwater management plan is presented in Table 7.4. The goal of the stormwater management plan would be to implement BMPs that mitigate the effects of development so that the rate of stream channel change is stabilized, and to minimize further loss of biodiversity and abundance.

TABLE 7.4
FRAMEWORK FOR DEVELOPMENT OF AN INTEGRATED STORMWATER MANAGEMENT STRATEGY

Action Item	Identification of Strategic Initiative	Synopsis of Associated Strategic Objective
1	Adopt an ecosystem approach to drainage planning	Bring together the environmental and technological paths in addressing the spectrum of stormwater quality and environmental quality issues through the master drainage planning process, and select environmental goals that are achievable
2	Protect environmental resource values	Develop a practical aquatic habitat protection strategy that reflects understanding of sustainability and biodiversity in an urban environment, and that attains a fair and equitable balance between ecological protection and other community goals
3	Integrate stormwater management with land use planning	Adopt a watershed-based approach to sustainable development that considers the relative placement of different land uses and the beneficial impact of alternative stormwater management approaches on the hydrologic regime
4	Construct facilities for stormwater detention and treatment	Assess the feasibility and effectiveness of constructing facilities at strategic locations for peak flow attenuation and/or pollutant removal
5	Implement BMPs	Identify opportunities to apply other BMPs that are appropriate, that can be applied at source, and that mitigate the more subtle changes in hydrology that would otherwise result from increasingly higher percentages of impervious ground cover
6	Protect stream corridors in the urban areas	Assess the cost-benefit implications of restoring ecological functions in greenways, with the objective of preserving the environment while achieving a balance with other demands and goals

Proper stormwater management is essential for the protection of surface water resources. The development of consistent stormwater management strategies is particularly important from a regional perspective because implementation of these strategies is best accomplished on a watershed basis. Conservation Authorities are very proactive in stormwater management and have already initiated many of the strategies discussed above.

The Total Phosphorus Management Program, which is being tested in the region by the MOE, is dependent on the effective characterization of stormwater. The reductions in phosphorus from stormwater must be accurately quantified for the program to be effective.

Protection of surface water resources also includes the protection and enhancement of stream corridors and the limitation of erosion. The surface water quality of many streams can be protected and enhanced through the implementation of an integrated stormwater management program. Implementation of these programs in a regional program ensures that the most benefit is derived.

7.7.4 Recommendations

As this section has described, proper stormwater management has become an important consideration in the protection of surface water resources. To better protect surface water resources there are a number of recommendations for the management of stormwater. These recommendations include:

- The quality of stormwater should be more specifically addressed in Official Plans to include the objectives for stormwater management and applicable technologies that are to be promoted.
- Stormwater management strategies adopted in official plans should be consistent with a defined set of regional objectives for management of stormwater.
- The management of stormwater should be addressed from a subwatershed and watershed perspective that integrates regional objectives. A watershed-based approach will, in turn, provide the most benefit to the region in terms of surface water quality and protection of surface water resources.
- Strategies for improving the levels of contaminants contributed from non-point sources should be developed. These strategies should be developed on a regional basis and implemented on a subwatershed and watershed scale.
- The EOWRMS area has not been characterized in regard to the most effective stormwater management methods that have been applied locally or regionally. This characterization should be carried out to provide a useful starting point or baseline against which the performance of future management plan implementation and operation can be measured.
- It is recommended that stream corridor protection and enhancement measures be developed and implemented on a watershed basis. Stream corridor protection goals and strategies should be entrenched in official plans and consistent with a defined set of regional objectives for management of streams. Existing polices should be reviewed in light of this study.

7.8 Regional Water Demand

7.8.1 Overview

Human demand for and use of the water resource is one component of the hydrologic cycles described in Section 3, and is one of the main drivers of the EOWRMS project. Determining anthropogenic demand for water is a critical factor in assessing overall sustainability of the resource.

In 1996 Statistics Canada reported a total population in the EOWRMS area of approximately 168,400 (P&R 74,013; SD&G 63,898; and Ottawa 30,492) or 59,200 households. Results of the EOWRMS Municipal Infrastructure Survey (EMIS) indicate that approximately 35 percent (58,970) receive their water from municipal supply, while the remainder rely on private service, largely from groundwater.

Accurate figures are available for the water use or demand from municipal systems and some private industrial systems. However, there is very little documented empirical evidence for the more than 300,000 private wells in rural Ontario. This section describes the approach used to estimate human demand for water in the study area.

7.8.2 Data Sources

The paucity of water use data outside of municipal delivery services necessitated the use and application of a number of data sources in order to make reasonable estimates of water demand within the study area. The major sources employed include the following:

- Statistics Canada 1996 Census of Population
- MOE water-well record database
- MOE Permit to Take Water database
- EOWRMS Municipal Infrastructure Survey
- EOWRMS Water Resources Survey,
- Environment Canada's Municipal (water) Use Database (MUD)
- Research by Dr. Reid Kreutzwiser and Dr. Rob de Loë (University of Guelph 2000) and Ecologistics Limited (1993) on agriculture and rural water use
- Research by Marnie Vandierendock (1996) for the MNR on water use in Ontario

Limitations

The MOE water well database is populated almost exclusively by records from drilled wells. Therefore, depending on the geology of a particular region, there can be significant under-representation from dug wells; this is believed to be the case in Eastern Ontario. This limitation has been partially addressed through results obtained from the EOWRMS Water Resources Survey.

There is no current requirement in the MOE Permit To Take Water process to record actual volumes of water used from permitted sites. Only information related to maximum permitted withdrawals is recorded.

There has been very little research in Ontario regarding water use patterns from users of private water supplies. Water use patterns between urban and rural dwellers are believed to be quite different (Vandierendonck, 1996), with rural users using less that their urban counterpart. The per captia estimates used in this study are based on research from the Grand River watershed. Their representativeness to the EOWRMS area has not been established.

7.8.3 Assumptions

The consolidated census division (basically the former Townships in the study areas) was used as the minimum geographic unit of analysis.

Total demand is estimated as agricultural use + municipal supply + private domestic supply + permitted industrial/commercial supply and is expressed in m^3/yr. One m^3 is equal to 1000 litres.

Water use has been attributed to groundwater and surface water sources where possible.

Responses from the EOWRMS Water Resources Survey are assumed to be representative of the study area as a whole.

Responses from the EOWRMS Municipal Infrastructure survey are assumed to reliable.

For computational purposes, agricultural water demand is assumed to rely on ground water sources.

Permits to take water that could not be located geographically or that did not have sufficient data to calculate maximum permitted volumes have been excluded.

Future demand has been based on population projection estimates provided by the EOWRMS municipalities.

7.8.4 Approach and Methods

Demand for water was estimated for the following major categories of water users:

- Rural Domestics Users
- Agricultural Production
- Municipal Supply
- Other non-municipal MOE permitted uses
- Golf Courses

Rural Domestic Water Use

Rural domestic water use is defined as a typical private residential supply system in a rural area that is reliant on groundwater or surface water sources.

MOE water well records provide an indication of the number of drilled wells in the region; however they do not generally account for shallow dug wells or provide any information concerning the volume of water being withdrawn from individual wells or the population served by individual wells. Therefore well records do not provide a robust dataset for calculating estimates.

The estimate of rural domestic water use is therefore based on a population approach. Total population of the study areas is known from the census of population. The EOWRMS municipal infrastructure survey provides information on the population served by municipal water supply systems. Therefore, through deduction, the difference between total census population and population served by municipal water supply would indicate the population supplied by private sources of water.

The EOWRMS municipal infrastructure survey provides data on average annual volumes from municipal systems. These figures provide aggregate water volumes for the combines, residential, commercial, institutional and industrial customers hooked into the system.

The approach for estimating rural domestic water use is based on Vandierendock (1996) *Report to the Ontario Ministry of Natural Resources on Water Use in Ontario. The Water Network, University of Waterloo*. This approach assumes a per capita use of 159 litres per day (approx. 58 m^3/yr) for rural users and is derived from empirical work undertaken in the Grand River Watershed for non-agricultural water use. Comparatively, urban water uses average approximately 300-350 litres per capita per day in Ontario.

Municipal Communal Supply

Most municipal water supply systems in the EOWRMS area require a Permit to Take Water (PTTW) from the MOE. The permit database only contains information on maximum allowable withdrawals. The permitting system and administration does not require or provide for recording of actual water use.

Municipal water supplies are based on the average annual production volumes reported for groundwater and surface water systems in the EOWRMS municipal infrastructure survey. This database provides a more accurate estimate of actual water use for individual municipal systems than the MOE permit database.

Agricultural Water Use

Agriculture is a significant contributor to the economy of Eastern Ontario. Farmers can also be significant users of water for activities such as spraying, washing, cleaning, animal needs, and, in some cases, irrigation.

The agricultural water use estimates were developed by Ecologistics Limited (1993) under contract to the MOE and have been modified and improved by Kreutzwiser and de Loë, (2000). Use estimates are based on a series of coefficients for different activities/processes associated with animal and crop production.

Industrial Water Use

Under the *Ontario Water Resources Act*, water users who plan to withdraw in excess of 50,000 litres (50 m^3) per day require a PTTW from the MOE. Agriculture producers are exempt from this requirement. Permitting data are maintained in a database that includes, among other information, name of permit holder, location and source of withdrawal point, water source (surface or ground), and maximum permitted withdrawals. Maximum withdrawal figures likely overestimate actual withdrawals. Records of actual withdrawals are not required or recorded under the permitting system.

Non-municipal supply users have active permits to take water in the EOWRMS region. These include industry, golf courses, mineral extraction and selected miscellaneous users. Municipal withdrawals have been accounted for in the EOWRMS municipal infrastructure survey.

The study was supplied with permit data for the study area. The database was culled to remove records for expired permits and records that had insufficient information to calculate maximum permitted withdrawals.

Golf Courses

A total of 26 golf courses were identified in the study area, 8 in P&R, 9 in SD&G and 9 in Ottawa. Of these courses, seven have permits to take water. These permitted volumes are accounted for in the permitted sources. For the remaining courses, an 18-hole water demand equivalent of 65,172 m^3/yr was applied. This figure is derived from work completed by Ecologistics Limited (1993) that estimated golf course water use for the province on a regional basis. Water uses coefficients were developed for irrigation, spraying, equipment washing, and other uses.

Source of Supply

Some of the data sources used for this portion of the study provide an indication of the sources (groundwater or surface water) of water supply for most users in the EOWRMS Area. Data sources that provide this information are:

- EOWRMS Municipal Infrastructure Survey
- EOWRMS Water Resources Survey
- MOE Permit to Take Water Database
- Environment Canada's MUD

These sources were used as the basis for partitioning water withdrawals between groundwater and surface water sources.

7.8.5 Future Demand

Population projections were used to estimate future water demand to circa 2020. Projections were obtained from the EOWRMS co-operating municipalities and are provided in the following tables.

TABLE 7.5
POPULATION PROJECTIONS FOR THE UNITED COUNTIES OF PRESCOTT AND RUSSELL, 2001 AND 2019

The MMAH (H) scenario was used as the basis for estimating future water demand.

	UCPR(L) MMAH(M) ROC(H) *	1996	2001	2019	% change 1996 to 2019
Clarence-Rockland	L	18633	22075	30915	70.6%
	M	19998	24136	35767	78.9%
	H	19898	24653	39700	99.5%
Hawkesbury	L	10163	10256	12023	18.3%
	M	10907	11214	13909	27.5%
	H	10852	11454	15439	42.3%
Casselman	L	2877	3368	5526	92.1%
	M	3088	3682	6393	107.7%
	H	3072	3761	7096	131%
Alfred-Plantagenet	L	8315	8423	10043	20.8%
	M	8924	9209	11619	30.2%
	H	8879	9407	12897	45.3%
Champlain	L	8375	8835	10455	24.8%
	M	8989	9660	12095	34.6%
	H	8943	9867	13426	50.1%
East Hawkesbury	L	3296	3408	3948	19.8%
	M	3538	3726	4568	29.1%
	H	3520	3806	5070	44.0%
Nation	L	10478	10742	12229	16.7%
	M	11246	11745	14149	25.8%
	H	11189	11997	14705	31.4%
Russell	L	11877	14007	22751	91.6%
	M	12747	15314	26322	106%
	H	12683	15643	29217	130%
Prescott-Russell	L	74013	81541	107902	45.8%
	M	79436	89154	124837	57.2%
	H	79036	91065	138566	75.3%

TABLE 7.5
POPULATION PROJECTIONS FOR THE UNITED COUNTIES OF PRESCOTT AND RUSSELL, 2001 AND 2019

The MMAH (H) scenario was used as the basis for estimating future water demand.

	UCPR(L) MMAH(M) ROC(H) *	1996	2001	2019	% change 1996 to 2019

* Estimated housing requirements are based on population increase divided by average persons per dwelling for each municipality as stated in the census of 1996 of Statistics Canada.

* Based on population projections prepared by the United Counties of Prescott and Russell Planning Department, the Ministry of Municipal Affairs and Housing (MMAH) and the Region of Ottawa-Carleton.

Source: United Counties of Prescott and Russell, 1999, Official Plan, Planning and Economic Development Department.

Stormont, Dundas and Glengarry

The figures in the table below represent the "Diversification Scenario" that will be the basis for the SD&G forthcoming Official Plan.

TABLE 7.6
POPULATION OF THE UNITED COUNTIES OF STORMONT, DUNDAS AND GLENGARRY
ACTUAL IN 1996, PROJECTED FOR 2001 AND 2021

Diversification Scenario

Population	1996	2001	2021	% change 1996 to 2021
South Dundas	10,866	11,440	13,656	25.7%
North Dundas	11,064	11,443	12,959	17.1%
South Stormont	11,584	12,126	14,293	23.4
North Stormont	6,960	7,079	7,557	8.6%
South Glengarry	12,649	13,287	15,838	25.2%
North Glengarry	10,755	11,527	14,616	35.9%
Total (excluding Cornwall)	63,898	66,902	78,920	23.5%

Source: Statistics Canada and Strategic Projections Inc.
References: Strategic Projections Inc. 2000

City of Ottawa

TABLE 7.7
POPULATION OF THE CITY OF OTTAWA
ACTUAL IN 1996, PROJECTED FOR 2021

Municipality	1996*	2021**	% Change 1996-2021
Rural Gloucester	3,688	5,500	49.1%
Rural Cumberland	10,900	15,000	37.6%
Osgoode	15,904	25,300	59.1%

* Statistics Canada
** Terry Van Kessel, City of Ottawa

7.8.6 Characterization

Source of Supply

Water demand was partitioned according to whether the supply was from groundwater or surface water. The principal surface water sources in the study areas include the Ottawa River, the St. Lawrence River, and the South Nation River.

Rural Domestic

The MOE water well database provides a good source for determining the number of drilled wells in the study area. However, this dataset does not generally contain information on dug wells or private surface water intakes. The EOWRMS Community Survey provides information about the nature and sources of water supply for individual homes and business. Respondents were asked to indicate whether they had a dug well, a drilled well, or supplies from a lake or river. The results are listed below:

Municipality	Dug Wells	Drilled Wells	Surface Water Intakes
United Counties of Prescott and Russell	20%	30%	2%
United Counties of Stormont, Dundas and Glengarry	11%	56%	1%
City of Ottawa	15%	77%	0%

Municipal

The municipal infrastructure survey provided information on the nature and extent of water supply sources. Data was provided for the following systems:

TABLE 7.8
GROUNDWATER AND SURFACE WATER SUPPLY SYSTEMS

Groundwater Supply	Surface Water Supply
Prescott and Russell	
Forest Park	Rockland
Embrun	Village of Casselman
Hammond	Town of Hawkesbury
Village of L'Original	Village of Plantagenet
Clarence Creek	Town of Vancleek Hill
St. Isidore	Village of Alfred
Russell	Hamlet of Lefaivre
Bourget	Hamlet of Wendover
St. Pascal Baylon	
Cheney	
Ottawa	
Greely	
Marionville	
Vars	
Stormont, Dundas and Glengarry	

TABLE 7.8
GROUNDWATER AND SURFACE WATER SUPPLY SYSTEMS

Groundwater Supply	Surface Water Supply
Moose Creek	Alexandria
Winchester	Iroquois
Crysler	Long Sault
Glen Robertson	Morrisburg
Chesterville	Ingleside
Lancaster	
Newington	
Redwood Estates	
Osnabruck Centre	

Agriculture

For computational purposes, agricultural water demand is assumed to rely on groundwater sources.

MOE Permit Data

The MOE Permit to Take Water database records water withdrawals whether the sources of the withdrawals are from groundwater or surface water. The following table provides information on the number of permits used in the water demand calculations. Only data from active permits were included in the analysis

TABLE 7.9
PERMIT TO TAKE WATER GROUNDWATER AND SURFACE WATER-WITHDRAWALS*

Municipality	Groundwater		Surface Water	
	# of Permits	Max. Permitted Use (m^3/yr)	# of Permits	Max. Permitted Use (m^3/yr)
P&R	13	1,413,020	5	425,897
SD&G	3	163,250	0	NA
City of Ottawa	16	4,525,867	10	3,655,653

* Excludes approx. 32 million m^3/yr permitted to Casselman Small Hydro, approximately 15 million max. permitted litres per day with missing data on number of days taking per year, and surface water diversions.

7.8.7 Current Water Demand

Table 7.10 provides an aggregated summary of the water demand by various sectors and sources within the EOWRMS area.

Total annual water demand in the EOWRMS area is estimated at 34.3 million m^3. Approximately two-thirds (63 percent) of the demand is from groundwater. The following chart provides a breakdown of water demand by user type used in the analysis.

Water Demand by Type

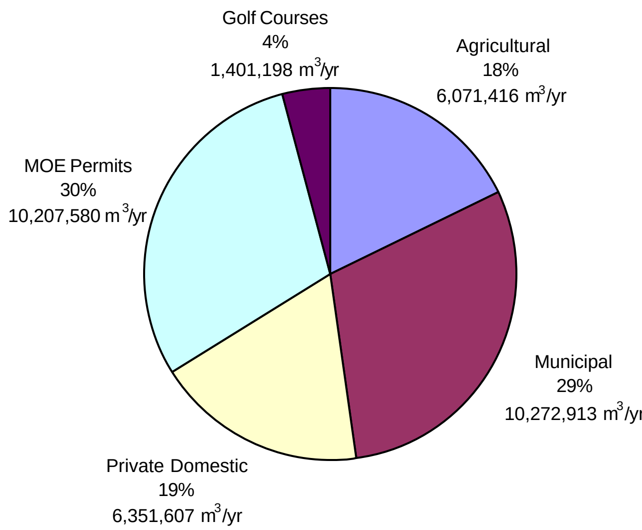

Golf Courses
4%
1,401,198 m3/yr
Agricultural
18%
6,071,416 m3/yr
MOE Permits
30%
10,207,580 m3/yr
Municipal
29%
10,272,913 m3/yr
Private Domestic
19%
6,351,607 m3/yr

TABLE 7.10
WATER USE/CONSUMPTION CALCULATIONS

EOWRMS STUDY AREA WATER DEMAND

Municipality	Water Use from Agriculture (m3/yr) (assume GROUND-WATER source)*	Average Annual Production from Municipal Groundwater Systems (m3/yr) **	Average Annual Production from Municipal Surface Water Systems (m3/yr) **	TOTAL Municipal Water Production m3/yr (Y+Z)	Domestic Private GROUND-WATER Use (based on population) m3/yr (S*58.04) ***	Domestic Private SURFACE WATER Use (based on population) m3/yr (R*58.04) ***	Total Domestic Private Water Use (based on population) m3/yr	MOE Permitted GROUND-WATER Withdrawals m3/y r@	MOE Permitted SURFACE WATER Withdrawals @@	Golf Course Use GROUND-WATER based on 65, 172 m3/yr/18 hole equivalent #	Golf Course Use SURFACE WATER based on 65, 172 m3/yr/18 hole equivalent #	Total Withdrawals from GROUND-WATER Sources (including PTTW data) m3/yr	Total Withdrawals from SURFACE WATER Sources (including PTTW data) m3/yr	Total Withdrawals from ALL Sources (including PTTW data) m3/yr
Prescott & Russell U.C.														
Total P&R	2,273,189	1,311,037	2,731,979	4,043,016	1,837,241	85,914	1,923,155	1,413,020	425,897	179,223	179,223	7,013,710	3,423,013	10,436,723
Stormont, Dundas & Glengarry U.C.														
Total SD&G	3,010,961	1,199,697	4,895,646	6,095,343	2,682,494	37,086	2,719,580	163,250	0	228,102	228,102	7,284,504	5,160,834	12,445,339
Region of Ottawa-Carleton														
Total ROC	787,266	134,554		134,554	1,708,872	0	1,708,872	4,549,761	3,655,652	325,860	325,860	7,506,313	3,981,512	11,487,825
EOWRMS AREA Totals	6,071,416	2,645,288	7,627,625	10,272,913	6,228,607	123,001	6,351,607	6,126,031	4,081,549	0	0	21,804,527	12,565,360	34,369,887

NOTES
* from Kreutzwiser and de loe (1999)
** from EOWRMS Infrastructure Questionnaire
*** 58.04 m3 is estimated per capta volume of rural water use per year from Vandierendonck 1996
@ excludes approx. 32 million m3/yr permitted to Casselman Small Hydro
@ excludes approximately 15 million max. permitted litres per day with missing usage (days taking per year) in MOE database
@@ excludes surface water diversions
# excludes MOE permitted use

7.8.8 Future Water Demand

Future water demand for private and municipal sources was estimated based on population projections to approximately 2020. Estimates are based on current observed trends in water demand.

It is estimated that combined surface and groundwater water demand will increase by approximately 20 percent over the next 20 years as a result of projected population increases. Groundwater demand is projected in increase by 18 percent and surface water use by 25 percent. Table 7.11 provides a breakdown on a study area basis.

TABLE 7.11
2020 ESTIMATED FUTURE WATER DEMAND

Municipality	2020 Estimated Future Groundwater Demand		2020 Estimated Future Surface Water Demand		2020 Estimated Future Total Water Demand	
	m^3/yr	% Change	m^3/yr	% Change	m^3/yr	% Change
P&R	9156418	+30.5	5158663	+50.7	14315081	+37.2
SD&G	8074624	+11.3	6483248	+26.4	14557872	+17.6
City of Ottawa	8425876	+12.2	3981512	N/C*	12407388	12.3

*Data on surface water withdrawals in the Ottawa portion of the study area is derived exclusively from the PTTW database. There is insufficient data to identify use trends to forecast future conditions.

7.8.9 Key Findings

Annual estimated water demand in the study area is 34.3 million m^3/yr.

Sixty-three percent (28.1 m^3/yr) of this demand (of this demand is from groundwater sources).

The majority of surface water demand is associated with the Ottawa and St. Lawrence rivers as major sources of municipal supply.

Together municipal and private domestic demand accounts for almost half of the annual water demand in the study area (29 percent for municipal and 19 percent for private domestic).

Future demand will increase by 12 to 30 percent from groundwater and 26 to 51 percent from surface water based on existing use trends and population projections.

7.8.10 Relevance to Regional Water Strategy

The importance of water resources cannot be overstated. In Ontario there are abundant supplies of fresh water from both groundwater and surface water sources. But the location and quality of these resources is diverse and not unlimited. The MOE has admitted that it does not know how much water is available in the province for taking purposes (Environmental Commissioner of Ontario, 2001). The MOE introduced the Water Taking and Transfer Regulation in 1999 (O. Reg. 285/99) that established criteria for MOE staff to consider when issuing PTTW, including a requirement to give precedence to the impact of the PTTW on natural functions of the ecosystem. A critical review of the PTTW system by the Environmental Commissioner of Ontario (2001) revealed that MOE is not effective in administering the program, nor does it have the information or qualified staff to assess ecosystem impacts of permits.

In the absence of provincial leadership, a regional water budget approach is critical to quantifying how, where, when, and how much water is available in the system.

The regional water budget analysis demonstrates that, on a regional aggregate basis, there is an adequate availability of water in the system to support current and future rates of demand. However, the nature of the water resource is such that high quality supply (quantity and quality) is not uniformly distributed across the study area. But specific targets need to be developed, even on an interim basis, for the needs of different water uses, including natural systems.

The province of Ontario does not currently have an operation program to promote and achieve water conservation (McCullough and Muldoon, 1999). However, a number of municipalities have proactively implemented water efficiency and demand management programs. It has been demonstrated that these practices can reduce average daily water consumption in the 10-25 percent range and peak daily consumption by as much as 50 percent (CG&S, 1998).

Water conservation and demand management of water supplies makes good sense for a number of reasons including:

- Defer or reduce new infrastructure(water and wastewater) requirements[1]
- Reduce or moderate seasonal shortages, particularly on areas reliant on groundwater
- Reduce possible ecological impacts associated with waster shortages and drawdowns
- Increase efficiency of septic systems
- Increase public awareness of water use

7.9 EOWRMS Water Efficiency

7.9.1 Overview

Water efficiency should be an integral component of any water resources management strategy. Using water resources, both surface and groundwater, wisely and efficiently is simply good stewardship of a valuable resource.

There is very little information available on actual implementation strategies for water efficiencies and even less on success rates. Most programs have been established for municipalities but do not include a broader range of water users in the industrial, commercial, institutional, or rural water use sectors.

In this Section of the report, the results of the EOWRMS Water Resources survey, in regard to attitudes towards water supplies and the availability of supplies, are examined and options for implementation of water efficiency strategies are recommended.

[1] A more detailed discussion of the implication for demand management for municipal infrastructure is found in Section 7 Servicing infrastructure

7.9.2 Characterization and Key Findings

The survey information collected from the area municipalities indicates a number of problems with the availability and quality of adequate water supplies. The following table provides information on system flows and capacity utilization, as reported by area municipalities.

TABLE 7.12
TYPE OF WATER SUPPLY – AS REPORTED BY SURVEY RESPONDENTS

Study Area	Groundwater Supply	Surface Water Supply	Tot Pop Served	Avg Day Prod	Max Day Prod	Capacity Utilization	Per cap demand (m^3/d)	Max Day Factor
Prescott Russell								
Bourget	v		1,437	283	535	113.3%	0.394	1.89
Cheney	v		407	19	30	18.3%	0.093	1.59
Clarence Creek	v		1,002	270	480	77.2%	.540	1.78
Hammond	v		490	103	190	158.3%	0.420	1.84
Rockland		v	8,100	2,659	4,442	61.2%	0.328	1.67
St. Pascal Baylon	v			116	260	52.8%		2.25
Forest Park	v		537	142	265	19.2%	0.265	1.86
St. Isidore	v		766	298	469	51.7%	0.388	1.58
Embrun	v		4,040	1,311	2,190	40.4%	0.325	1.67
Russell	v		3,311	943	1,990	70.7%	0.285	2.11
Casselman		v	2,755	1,047	1,716	54.0%	0.380	1.64
Alfred – Lefaivre		v	2,200	977	2,147	74.0%	0.444	2.20
Plantagenet		v	980	472	689	40.5%	0.482	1.46
Wendover		v	984					
L'Orignal	v		1,800	650	860	79.3%	0.361	1.32
Vankleek Hill		v	1,803	570	870	20.9%	0.316	1.53
Hawkesbury		v	12,207					
Stormont Dundas Glengarry								
Alexandria		v	3,500	3,546	5,455	80.0%	1.013	1.54
Glen Robertson	v		120	31	43	19.1%	0.255	1.40
Glen Walter		v	450	357	875	87.9%	0.793	2.45
Lancaster	v		750	200	585		0.267	2.93
Chesterville	v		1,553	666	1,078	38.8%	0.429	1.62
Winchester	v		2,600	1,750	2,698	59.5%	0.673	1.54
Iroquois		v	1,368	2,720	3,860	91.9%	1.988	1.42
Morrisburg		v	2,570	2,507	5,301	101.4%	0.975	2.11
Ingleside		v	1,550	3,040	4,438	57.2%	1.961	1.46
Long Sault		v	1,820	1,607	4,010	82.8%	0.883	2.50
Chrysler	v		221	175	408	24.2%	0.790	2.33
Finch	v		205	232	465	67.3%	0.880	2.00
Newington	v		150	69	92	20.5%	0.460	1.33
Osnabruck Centre	v		12					
City of Ottawa								
Vars	v		825					
Greely - private subdivision	v		224					

Note: Includes only municipalities where data was reported in the survey.

Groundwater Systems

Bourget	Low water table impacts supply from poor water quality wells
Cheney	Low water table impacts supply from poor water quality wells
Clarence Creek	Low water table impacts supply from poor water quality wells
Hammond	Low water table impacts supply from poor water quality wells
Embrun	Growth is limited by availability of supply
Russell	Dry weather is limiting availability of supply
L'Original	Insufficient water supply
Winchester	Insufficient capacity

Surface Water Systems

Rockland	High demand
Alfred – Lefaivre	High demand
Hawkesbury	Limitations on supply during peak demand
Vankleek Hill	Limitations on supply during peak demand
Alexandria	Limitations on supply during peak demand

Water Efficiency Measures

A number of water conservation measures have been initiated by municipalities in Canada, the United States, and worldwide in an effort to use water more efficiently. From previous experience, a comprehensive list of measures was developed that is applicable to the EOWRMS strategy.

These measures focus on both supply side and demand side management aspects of water efficiency as a means of reducing the amount of water used and the overall demand on the supply systems. The resulting decrease in water demand can have a positive impact on long-term capital expenditures, operating / maintenance and other infrastructure costs.

The wide range of conservation / efficiency measures adopted by other municipalities includes a number of alternatives. A list of those alternatives and a general description of their potential impacts on average or peak water demand is provided in Table 7.13.

Descriptions of the alternatives are included in this report as Appendix E.

TABLE 7.13
SELECTED DEMAND MANAGEMENT PRACTICES

Conservation Measure	Target Sector	Reported Ranges in Water Reduction	Cost Range (approx. 1993 dollars)	Comments
Home Conservation Kits	Residential	15 percent total supply (6) 10-17 percent per home (7) 10-40 percent per home (8) 5.5 percent per home (9) 5.3-13 percent per home (10) 22 percent per home (11) 18 percent per home (12)	$40-$50 per home (13) $15 per home (10) $125 per home (11) $25 per home (9)	Installation of Low flow showerheads, toilet flapper valves and faucet aerators but not low or ultra low volume toilets
Home Conservation Retrofit	Residential	33 percent per home (6) 25-30 percent per home (13) 30-50 percent per home (14) 35 percent per home (4) up to 32% per home (32) 7-10% of total demand (32) 20% per single family home (29)	$150-$400 per home (13)	Includes home conservation kits above plus low or ultra low volume toilets but not replacements of dishwashers, washing machines or water softeners
	High Den. Res.	30-40 percent per building (4) 40% per multi-family building (29)	$150-$400 per home (13)	Includes low or ultra low volume toilets
Increased Meter Reading	Residential	ND	ND	Increased frequency of reading
Water Recycling	Residential	30 percent per home (17)	ND	Impractical in most homes
Water Reuse	Commercial	ND	ND	Golf courses, car washes, laundries, industrial facilities
Municipal Bylaws	Residential	Impacts future demand potential	No direct cost	No load development agreements with developers
	Residential and ICI	Impacts outdoor water use	Monitoring and enforcement cost	lawn watering restrictions or bans
	Residential	Impacts future demand potential	No direct cost	Require the development of a conservation strategy as a prerequisite to building permit issue
Public Education	System-wide	2-5 percent during non-crisis period (22) 5-15 percent (14) 4-5 percent (1,28) 1% (33)	$1/person/yr for large utility with aggressive program (22)	Very dependent on the type of program Generally used to support other initiatives, must therefore be careful not to double count impacts
	Residential	5-10 percent (9) 9-16 percent L/CPD (18) 3% (29)	$0.50 to $1.00 per person (29)	
	Industrial	ND	ND	
Conservation Rate Structure	Residential	27 percent (4) 10 percent (4) 13 percent (4) 3-7 percent (19) 15-20 percent (10)	No direct cost	Data from Tampa, Fl. Data from Tucson, Az. Reduction represents percent drop with a 10 percent increase in price Peak pricing strategy (70 percent increase) can involve various price strategies
		1% (34)	ND	Increasing block rates in Phoenix
		8% (34)	ND	Increasing block rates plus water conservation program in Seattle
		2% (35)	ND	Excess use rate, Windsor
		19% residential use (35)	$1.25 million/year total program costs	Very aggressive increasing block rate structure combined with a comprehensive water conservation program, Irving Ranch

TABLE 7.13
SELECTED DEMAND MANAGEMENT PRACTICES

Conservation Measure	Target Sector	Reported Ranges in Water Reduction	Cost Range (approx. 1993 dollars)	Comments
Pressure Reduction	Low Den. Res.	1 percent (9) 3-6 percent per home (1)	ND $75 per home (1)	Results estimated for new developments
	High Den. Res.	12 percent (9)	ND	From Edmonton, Canada study
Water Audits	Residential	180 L/d per home (20)	$65 per home (20)	From Everett, U.S. study
	Industrial (large)	15-70 percent per facility (9) 10-51 percent per facility (20)	$5,750 per facility (20)	Laundry facilities Car washes
	Ind./Comm./Inst.	15-80 percent per facility (10)	ND	From Reg. Mun. of Waterloo
Inventory of Unmetered Water Usage	System-wide	ND	ND	Will allow for better estimation of effort required for leak detection and repair
Fixture Meters/ Timers	Residential	ND	$1 to $20	Meter/timer can be fixed to shower or other fixture to encourage user awareness
Fixture Leakage Repair	Residential and Institutional	91 L/d per repaired toilet (30) 20 percent of homes have plumbing leaks (8,30) The average toilet after 6 years of use, leaks bet. 27 & 455 L/day (8)	ND	

Notes: (a) Bracketed numbers refer to reference number of source documents
(b) ND refers to no data available at the time of review

1. Environment Canada, 1991. Residential Water Conservation, A Review of Products, Processes and Practices.
2. Metro Toronto, 1991. Water Conservation Strategy.
3. CH2M HILL Inc., 1992. Water Shortage Contingency Plan, Boise, Idaho.
4. Rocky Mountain Inst., 1991. Water Efficiency: A Resource for Utility Managers, Community Planners and Other Decision Makers.
5. Gore and Storrie Ltd., 1993. Water Efficiency Workshop Report.
6. Town of Cochrane, 1993. Water Conservation Program.
7. World Watch Institute, 1993. Plug the Leak.
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A number of these options are discussed in more detail in the following section.

7.10 Non-Structural Servicing Options

7.10.1 Overview

Non-structural options for water supply and wastewater services are understood to be options that can be used to meet servicing requirements without relying on water or wastewater infrastructure investments, although they do not preclude other types of capital investment for resources management. Servicing requirements include capacity requirements for water and wastewater treatment plants, and quality requirements for wastewater discharge and for drinking water quality. Non-structural options may or may not be more cost-effective than structural options in meeting servicing requirements. Therefore, choice between structural and non-structural options requires a strategic planning analysis that considers servicing requirements and life cycle costs as well as planning considerations such as system reliability and the social and environmental impacts of alternative measures.

This section describes a number of non-structural servicing options and provides some information on cost and impact for these options.

7.10.2 Demand Management for Water Supply

Demand management for water supply includes a variety of measures that can be used to reduce the volumetric requirement for water production and thereby increase the number of customers that can be serviced by a given capacity. Certain of these measures focus on the customer's demand for water while others address non-revenue water.

Customer Metering

Customer metering is the single most significant measure that can be used to reduce the customer's demand for water. Metering works by linking the amount of water that a customer uses to the size of the water bill, thereby giving the customer an economic incentive to use less water. Metering is most effective when it is accompanied by a rate structure featuring a significant volumetric charge.

Typically, smaller communities will meter their non-residential customers but many do not meter residential customers. For instance in the study area, 21 percent of respondents to the municipal survey indicated that residential customers were metered, while provincially, 46 percent of small municipalities meter residential customers.

The impact of metering is evident in Table 7.14 which provides statistics on per capita water demands for metered and un-metered communities. Based on the sample averages, metering leads to a 22 percent reduction in average daily water flow per capita and a 27 percent reduction in maximum daily water flow per capita.

TABLE 7.14
IMPACT OF RESIDENTIAL METERING ON WATER DEMAND

	No. of Observations	Average	Median	Minimum	Maximum
Metered (at least 50% metered, average = 97%)					
Service Population (#)	73	2,256	2,183	35	4,836
Average day per capita (L/d)	73	477	437	126	1,060
Maximum day per capita (L/d)	52	944	778	305	4,130
Not Metered (no more than 30% metered, average = 1%)					
Service Population (#)	82	2,182	1,950	300	4,985
Average day per capita (L/d)	82	612	557	273	2,065
Maximum day per capita (L/d)	48	1,286	1,003	442	4,671

Source: Analysis of Environment Canada 1996 MUD data for Ontario

Meter installation in an un-metered community is usually contracted out to firms that specialize in metering and related services. Metering costs will depend on a variety of factors including manufacturer, meter reading methodology, and the total number of meters to be installed. For example, purchase and installation costs can range from $200 to over $400, with the lower end of the range representing the cost for a manual direct read system and the upper end representing the cost for automatic meter reading systems. Additional operating costs include the cost of reading the meters at $1.00 or more per read and the cost of testing and changing out the meters every 10 to 20 years.

Municipal Water Efficiency

Municipalities use water efficiency programs to reduce the amount of water that customers use. These programs are usually designed to reduce water use by 5 percent to 10 percent—a 10 percent target requires an aggressive program. Water efficiency programs for demand management are adopted in conjunction with supply management programs. Ideally, the two components are planned together in a master planning exercise in order to achieve a cost-effective mix of demand and supply management measures.

The target of the water efficiency program may be average day, maximum day, or seasonal demand, or a mix of these. The choice will depend on the nature of the water supply system and the constraints on supply that motivate the interest in water efficiency. For instance, a water supply system with an abundant source of surface water that is treated in a conventional plant operating close to capacity will be interested in reducing the maximum day demands that determine the timing of the next plant expansion. Conversely, systems that rely on limited sources such as groundwater aquifers and smaller surface water reservoirs will likely be interested in controlling average day or seasonal demands.

Water efficiency programs comprise a choice of water efficiency measures that are being promoted to reduce demand and a mix of promotional and educational efforts that are the program’s delivery mechanisms.

There are currently no policies for the regulation of water use on a volume basis outside those imposed through municipal bylaws.

Municipal Water Efficiency Measures

Water efficiency measures include water saving practices, devices and appliances that can be used by residential and ICI (Industrial, Commercial, Institutional) customers. Water savings for a few measures that are commonly promoted in water conservation programs are described in Table 7.15.

TABLE 7.15
WATER EFFICIENCY MEASURES

Measure	Description	Savings (m^3/year)
Toilet replacement	Replace 13 or 20 L flush toilets with 6 L toilets, install water efficient commercial urinals and flushomatic toilets	Residential – 15 to 30 m^3/year per toilet ICI – 40 m^3/year per toilet in a high use area
Residential plumbing retrofit kits	Low flow shower heads, faucet aerators, toilet retrofit devices	less than 15 m^3/year per household
Clothes washer replacement	Replace standard top loading washing machines with water efficient top or front loading models.	Residential – 15 to 20 m^3/year ICI – 100 m^3/year (high use machine)
Dish washer replacement	Replace standard dish washer with water efficient model.	less than 10 m^3/year per household
Odd/even lawn watering regulations	Lawn watering restricted to alternate days of the week	Shaves maximum day peaks but does not likely affect total volume of water used
Public awareness of best management practices in the home	Adoption of water saving practices (e.g. repair leaks, wash only full loads in dishwasher and washing machine)	3 to 6 m^3/year per household
Efficient irrigation	Stop waste of 25% to 50% in poor irrigation methods	3 to 5 m^3/year per household in a humid area like Ontario
Rain barrels	Install rain barrels to capture roof run off	3 m^3/year per rain barrel
ICI water audits	5%+ reduction of ICI customer's water use	varies by customer

The municipal cost of water efficiency measures will be the cost of general advertising, education and promotion, plus the direct costs of financing device rebates and free products. Rebates are used to promote the adoption of water efficient fixtures and appliances. Typically, a rebate of $50 to $100 would be offered to a householder to install a low flush toilet and a rebate of $100 to $200 would be given for installing water saving clothes washers. At these levels, the rebates cover about 50 percent of the total householder's capital cost. Remaining capital costs may be partially or fully offset by savings for utility services. Products that are given to householders include retrofit kits at $15 to $40 per kit and rain barrels at about $70 each.

Water Efficiency Delivery Mechanisms

An effective water efficiency program can not be implemented without a carefully planned program to promote the selected water efficiency measures. Delivery mechanisms used in water efficiency programs include financial incentives, legal sanctions and public education. Financial incentives include:

- Rebates for fixture and appliance replacements that go to customers or contractors
- Loans and grants for instance to fund ICI water audits
- Capacity buy-back schemes that compensate large ICI customers for adopting measures that cause a permanent reduction in their demand
- The adoption of conservation-oriented rate structures to give customers an economic incentive to use less water.

Legal sanctions are municipal water use bylaws that permanently prohibit certain types of water use (e.g. once through water cooling), and that authorize the enforcement of lawn watering restrictions (e.g. odd / even lawn watering), lawn watering bans, and other water use bans on a discretionary basis. Examples of education measures include: media advertising, bill stuffers, public speakers programs, school programs, publications, technical workshops and seminars, awards programs, demonstration projects and advisory services.

The budgets for water efficiency programs in large municipalities (population > 75,000) would normally include at least one full time equivalent staff position, funds to finance individual elements of the program, such as toilet rebates, and a budget for public education. The annual cost of public education is in the range of $1 per capita. A total annual program cost of $200,000 or more is common. Obviously, smaller municipalities can not afford this level of effort. Moreover, they do not require the range of residential and ICI measures that a large municipality would use. A basic program involving toilet rebates of $75 to $100, basic education tools and part time staff support might cost about $100 per household over the life of the program or about $20 per household per year for a five year program. However, a regional based water efficiency program, with participating municipality contribution or proportionate share of program and staff costs, should be considered.

Controlling Non-Revenue Water

Non-revenue water (NRW) is the difference between water that is produced and water that is sold to end users. It includes:

- Authorized water uses for main and hydrant flushing, water used in fire fighting, and water used in public parks; some of these uses may be quantified by metering or by indirect estimation.
- Apparent losses caused by illegal customer connections and water that is used by metered customers but that does not register because their meters are worn or defective or are not properly sized for the customers flow.
- Losses from distribution system leakage.

The Canadian experience with non-revenue water is summarized in Table 7.16.

TABLE 7.16
NON-REVENUE WATER IN CANADA (PERCENT OF TOTAL PRODUCTION)

	Median	Low*	High*
Total non-revenue water	14%	8%	22%
Losses due to leaks and breaks	10%	4%	16%

Source: “Canadian Utility Profiles”, AWWA, 1995
* Upper and lower limits of the 50% range

High levels of NRW can be a significant financial concern. In the case of illegal connections and defective meters, they represent losses in water sales revenue. In addition, NRW will increase operating costs for treatment, pumping and maintenance and, if it is high enough, can lead to the premature expansion of capacity.

When NRW in a municipality is high relative to industry performance levels, a water audit should be conducted to identify likely sources of the NRW and to estimate the associated financial losses. In fully metered municipalities, NRW is quickly determined from a comparison of total water production and metered water sales. In un-metered or partially metered municipalities, indirect methods relying on examinations of late night water production records and available estimates of the typical usage of un-metered residential customers can be used to estimate NRW.

A goal for total NRW should be based on local conditions including the ongoing costs of NRW. The cost of water losses includes operational costs, lost sales revenue and the costs of providing capacity sooner than is otherwise necessary. The costs of a leak detection and control program for the distribution system can be estimated based on the experience of comparable municipalities, the costs of acquiring and operating leak detection equipment, the cost of contract services for leak detection and the estimated cost of leak repairs. Leak detection and control efforts should not be taken beyond the point at which they are no longer cost-effective. Sample testing of customer meters will reveal the extent to which NRW is caused by metering inaccuracy. If it is, the appropriate response is a meter replacement program.

7.10.3 Demand Management For Wastewater Flows

High levels of municipal wastewater flow, like high levels of water demand, have an adverse financial impact on wastewater operations. The costs of high wastewater flows include elevated operating costs for energy and chemicals and the costs of expanding or upgrading wastewater treatment capacity sooner than would otherwise be necessary. In addition, high wastewater flows can cause a deterioration of wastewater effluent quality. Higher dry weather or base flows in a treatment plant can reduce the plant's pollutant removal efficiencies. High wet weather sanitary flows caused by surface water inflows and ground water infiltration into the sanitary sewers (referred to as I/I) further deteriorates the plant's ability to remove pollutants and can cause bypassing of partially treated or untreated wastewater into receivers.

In some instances, a significant amount of the total I/I to a sanitary sewer can be the result of storm drains, sump pumps, or weeping tiles that are improperly connected to sanitary sewers. If these sources are contributing to the flow, elimination of these contributions can significantly reduce wet weather flows in the sanitary sewer system.

High levels of municipal water demand are usually directly associated with high levels of wastewater production. Evidence of this association can be seen in the data on wastewater production provided in Table 7.17. Municipalities with high levels of customer metering have average daily wastewater flow per capita that are 27 percent lower than un-metered municipalities.

TABLE 7.17
IMPACT OF METERING ON WASTEWATER FLOWS

	No. of Observations	Average	Median	Minimum	Maximum
Metered (at least 50% metered)					
Service Population (#)	63	2,241	1,950	8,000	30
Average day flow per capita (L/d)	63	515	426	2,151	4
Not Metered (no more than 30% metered)					
Service Population (#)	76	2,215	1,887	6,000	300
Average day flow per capita (L/d)	75	705	634	2,066	249

Source: Analysis of Environment Canada 1996 MUD Data for Ontario

Measures such as customer metering and water efficiency programs will therefore benefit wastewater treatment operations by reducing wastewater influent to the treatment plants. Water efficiency measures that benefit wastewater operations are those that reduce water that is used inside buildings and discharged to the sanitary sewers such as low flush toilets.

Water efficiency measures will not help reduce I/I unless distribution system losses happen to make their way into the sanitary sewers. Management of I/I requires ongoing inspection and maintenance of the collectors coupled with a program of sewer separations or storm-water containment and treatment in cases where combined sewers are in place.

7.10.4 Non-Point Source Options

Non-point source (NPS) pollution originates from smaller, widely distributed sources that reach receiving waters at multiple points of entry. Unlike point sources, which have concentrated flows which are amenable to end-of-pipe treatment processes, NPS flows are generally small and can not be readily treated using end-of-pipe systems.

NPS pollution originates from both urban and rural sources. In the EOWMS, rural NPS pollution is the primary concern. Rural sources of NPS pollution from human activity include:

- Cropland and stream bank erosion
- Runoff contaminated with manure from storage areas, pastures, feedlots, and fields spread with manure
- Direct contamination of surface water with faecal material at sites where livestock have access to streams
- Discharges from faulty septic systems
- Discharges of milk house wastewater
- Incidental contamination caused by poor or negligent practices such as release of pesticide sprayer wash water to surface waters and dumping of manure and other wastes into surface waters

The adverse impacts of rural NPS pollution are pervasive, just as the benefits of its control are numerous. Ecosystem benefits include the protection or restoration of littoral and aquatic habitats and the prevention of eutrophication caused by excessive nutrient loadings to streams and lakes. These changes will improve the aesthetic quality of streams and may help create or enhance sport fisheries. Within the rural community, NPS pollution control also reduces the risk of water borne disease in humans and livestock through direct contact with surface water.

The benefits to municipal water supply of NPS pollution control are both financial and social in nature. From a social perspective, NPS pollution control provides the first barrier in a multiple barrier approach to risk management in water supply. It minimizes the risk of contamination of municipal sources of supply with pathogens and hazardous compounds such as pesticides. NPS controls may also improve the aesthetic quality of drinking water and reduce the cost of treatment through the reduction of nuisance growths of algae, which contribute to taste and odour problems.

The benefits of NPS pollution control to municipal wastewater operations are indirect but can be significant nevertheless. NPS pollution control can help lower wastewater treatment costs by maintaining the assimilative capacity of receiving streams, thereby delaying or eliminating the need for advanced wastewater treatment. In jurisdictions that have aquatic pollutant offset programs, wastewater operators can realize very significant cost savings by financing the implementation of NPS measures instead of implementing advanced treatment to be in compliance with their discharge permits.

A number of rural NPS pollution control measures are described in Table 7.18.

TABLE 7.18
RURAL NPS POLLUTION CONTROLS

Measure	Description	Cost	Comments
Septic system replacement	Conventional septic system tank and leach bed	Capital - $5,000 to $8,000/system Operating - $33/yr	10 year life (pump out every 3 to 5 years)
	Septic system in a constrained location or an alternative system (e.g. peat bed, aerobic filters)	Capital - $10,000 to $17,000/system Operating – no data	no data
Feedlot and barn yard runoff control	Direct runoff away from contaminated areas using roof drains, etc	Capital - $1,700/farm Operating – 5% of capital/yr	20 year life
Manure storage	Covered storage areas, lagoon storage	Capital - $9,800/farm Operating – 5% of capital/yr	20 year life
Milkhouse wash water	Divert to manure storage	Capital – minimal cost if there is adequate storage volume Operating – increased spreading costs	Wash water has little nutrient value
	Treatment system (e.g. constructed wetland, coagulation system)	Capital - $7,000 to $30,000/system Operating – no data	Septic systems can be cheaper but are prone to clogging
Cattle access control	Fencing, controlled crossings, alternative source of water	Capital - $7,300/site Operating – 5% of capital/yr	10 year life
Conservation tillage	Variety of tillage and vegetative practices	Capital – $20,000 per tillage implement Operating – 5% of capital/yr	10 year life, systems are often profitable for the farmer
Retirement of crop land	Land acquisition to eliminate all farming practices	Capital – depends on land value	Permanent

Source: Draper, Fortin and Bos, 1997. *Phosphorus Trading Program Evaluation and Design – Final Report* Personal communications, 20/02/02: S. Bonte-Gelok, Ont. Rural Wastewater Centre at the University of Guelph; and C. Kinsley, Ont. Rural Wastewater Centre at Alfred College

7.10.5 Alternative Approaches to Service Delivery

Small municipal water and wastewater operations often face challenges that do not arise in larger operations. Economies of scale can not generally be achieved in capital works or in operations. With a small budget for staff, there is no opportunity for the utility to hire individuals with specialized expertise and certain services must therefore be hired under contract or are simply not used. Small municipalities may also experience static or declining populations and may have larger populations of fixed income or low-income households. These demographics increase the pressure to keep costs low and they complicate the task of recovering full costs from customers.

A number of alternative methods of service delivery are available to small municipalities to help overcome the constraints imposed by size. Perhaps the simplest of these entails the wholesale purchase of water or wastewater services from adjacent larger municipalities. This arrangement currently exists between Vanleek Hill and Hawkesbury and L'Original will also secure water from Hawkesbury within in next 5 years. It allows the smaller municipality to benefit from the economies of scale in the larger municipality and may confer other benefits such as securing access to a better source of supply or a receiving stream with greater assimilative capacity. The main disadvantage of this arrangement is the cost of infrastructure required to connect the systems. In addition, the wholesale municipality will often charge a mark-up on its local rate to allow for a return on investment or to account for the fact that the retail customers have not contributed to investments in existing capital works. A mark-up is common for water services provided to outside municipalities in Ontario (Table 7.19).

TABLE 7.19
SURVEY OF WATER SUPPLY CHARGES TO OUTSIDE MUNICIPALITIES

Municipality	Supply Charge to Other Municipalities (% of local rate)	
	Wholesale	Retail
Average	135%	152%
Max	200%	200%
Min	87%	100%
Median	110%	150%

Source: OWWA, 1997, Survey of municipal water rates and operations benchmarking in Ontario

The use of a wholesale supplier is a step in the direction of regionalization. Regionalization keeps utility services in the public domain but replaces individual municipal organizations with a single regional organization charged with the responsibility for service delivery to all member municipalities. In Ontario, regionalization is used to restructure the entire municipal government in an area. Ontario's regional municipalities provide water and wastewater services using either a single tier structure or a two-tier structure in which the regional government provides a wholesale service to the lower tier retailers. Elsewhere in Canada, regionalization has been used as a means of restructuring only the utility service, the Greater Vancouver Water District being a case in point. The benefits of regionalization to small municipalities within the region include cost sharing with the larger municipalities, improved standards of service, improved access to professional services and specialized equipment, improved access to capital finance and increased opportunities to participate in cost effective regional infrastructure schemes. But while regionalization may provide the utility service in a cost-effective manner to small municipalities, it is not necessarily less expensive than the service offered by the local authority prior to regionalization. The reasons for higher costs after regionalization include the upgrading of local standards of service to regional levels and increases in local wages and salaries to levels found in the larger municipalities.

Municipalities can enter into partnership arrangements with other agencies to provide specific services on a cost recovery basis. This gives the municipalities access to expertise and equipment that it can not finance in house or that are more efficiently delivered and managed by others. There are numerous examples of these types of arrangements in the study area including the City of Ottawa septic program, conservation authority delivery of Ottawa's Rural Water Quality Program, and plan review by conservation authorities for Ottawa and P & R.. Other services that could conceivably be delivered in this manner by Conservation Authorities include the design and implementation of wellhead protection programs and water quality monitoring programs.

There is of course a long tradition of municipal water and wastewater operations contracting for design and construction services. In Ontario, there is also extensive experience with the use of contract services for operations, these being provided primarily by OCWA. The benefits of contracting for operations include ready access to professional services and specialized equipment provided by the contractor, a built-in incentive to control costs through the contracting process and a contractual mechanism to enforce standards of service.

The continued success of OCWA in wining service contracts following its privatization suggests that this form of service delivery is attractive to municipalities because it is less expensive than self supply and / or because the standards of service are better. The prevalence of OCWA in the study area indicates that municipalities are already taking advantage of this method of service delivery. OCWA is the dominant operator of municipal waste and wastewater systems in Eastern Ontario.

Contract services for design and construction and for operations bring private sector operators into the municipality and are a first step towards privatisation. Turnkey projects take privatization one step further by having a single contractor design, build and operate a facility using public financing. Concession contracts are similar to turnkey projects but are based on contractor financing of capital works. In this case, the contractor recovers the investment over the course of a long term operating contract. With full privatization of water and wastewater services, the private sector operator owns the facilities and operates them for profit. Full privatization would require regulation of user rates by a public sector body much as the Ontario Energy Board regulates energy rates.

Advantages of concession contracts and full privatization over less ambitious models of privatization include improved access to capital funds and opportunities to reduce the municipality’s exposure to risk. The principal disadvantage of privatization is the loss of direct municipal control over service delivery especially if contractual arrangements do not clearly stipulate the required standards of service and the conditions attached to the achievement of those standards. Any municipality, whether small or large, with an interest in but little experience with privatization should secure professional help to guide it through the process of tendering and awarding a privatization contract.

Privatization will not necessarily lower the costs of water and wastewater services. While privatization may improve the efficiency of service delivery it may also lead to a higher, and more expensive, standard of service and increased costs for labour and equipment as these are upgraded. Privatization will also tend to increase costs by introducing a return on equity as a cost of service.

7.11 Case Study Analysis

7.11.1 Overview

Municipalities in the study area are facing a number of water resource management issues and constraints. In this chapter, a case study approach is used to demonstrate the strategies that can be used to address these. The case study analysis was undertaken using available data and generic approaches for capacity planning and costing. The results are only intended to demonstrate the potential impact of demand management and should not be used as a basis for making any capital planning decisions.

It is useful to compare study area municipalities to small municipalities elsewhere in Ontario with respect to water and wastewater resources. Median water use rates of municipalities in the study area are lower than Provincial levels, while wastewater rates are comparable (Tables 7.20).

TABLE 7.20
COMPARISON OF WATER AND WASTEWATER PRODUCTION STATISTICS

	No. of Observations	Average	Median	Minimum	Maximum
A) **Study Area (**Source: Municipal survey)					
Water					
Service Population (#)	30	1,963	1,176	12	12,207
Capacity utilisation	27	58%	57%	0%	158%
Average day per capita (L/d)	25	589	420	93	1,988
Maximum day per capita (L/d)	25	1,009	694	147	2,863
Maximum day / average day	26	180%	166%	132%	293%
Wastewater					
Service Population (#)	26	2,030	1,434	28	10,266
Capacity utilisation	22	72%	70%	6%	201%
Average day per capita (L/d)	17	822	548	295	2,261
B) **Ontario Wide** (Source: analysis of Environment Canada 1996 MUP Data)					
Water					
Service Population (#)	155	2,217	1,998	35	4,985
Average day per capita (L/d)	155	548	500	126	2,065
Maximum day per capita (L/d)	100	1,108	900	305	4,671
Maximum day / average day	104	201%	178%	0%	1547%
Wastewater					
Service Population (#)	139	2,227	1,940	30	8,000
Average day per capita (L/d)	138	619	555	4	2,151

7.11.2 Assumptions

The following assumptions are used in the case study analysis:

- Costing for water and wastewater capacity expansions is based on updated USEPA cost curves provided in *Water and Sewage Infrastructure Project Phase 2A, Final Report* (August 2000, Strategic Alternatives, Enermodal Engineering, Public Works Management Inc., M. Fortin, Consulting Economist)
- Residential customer metering assumptions: Unit cost of $225 / household, meter reading and billing at $2 per customer per read, 20 percent reduction in average and maximum day residential water demand and wastewater production
- Water efficiency program assumptions: 5 year program, $20 per household per year, 10 percent reduction in average and maximum day residential water demand and wastewater production
- In stream phosphorus control program assumptions:

	Total Annualized cost ($/kg/yr)	P load Reduction
WWTP	$6000	0.04 kg/person/yr
Rural NPS measures	$100 -240*	not applicable

*South Nation Conservation Authority, 2001

- Discounting assumptions: 7 percent real discount rate, 20 year planning horizon

7.11.3 Case Studies

Bourget

TABLE 7.21
BOURGET - DESCRIPTIVE STATISTICS (FROM MUNICIPAL SURVEY)

Water	
Type of Source	GW
Population served	719
Customers – Residential	na
Customers – Non-Residential	25
Production:	
Max day (m^3/d)	535
Capacity (m^3/d)	472
Max. day / capacity	113%
Avg day (m3/d)	283
Avg day / pop (Lpcd)	394
Max. day / avg day	1.89
Customer metering	no
Water Use Restrictions	yes

Water Resource Issues

- High water use
- Exceedance of ODWOs
- Freeze on growth

TABLE 7.22
BOURGET – MANAGEMENT OPTIONS

Option	Description	Present value cost
Expand GW supply	Immediate expansion based on new wells plus disinfection to a total capacity of 800 m^3/d	Capital – wells: $134,000 Operating – no change in unit cost
Meter customers	Meter all customers and add new capacity in 2004	Capital, wells: $118,000 Capital, meters: $54,000 New operating - $1,900/year

There is insufficient time to implement a water efficiency program in order to delay a capacity expansion. Immediate metering will delay expansion by about 4 years but the overall cost of this option exceeds the option of expansion without metering.

Hammond

TABLE 7.23
HAMMOND - DESCRIPTIVE STATISTICS (FROM MUNICIPAL SURVEY)

Water	
Type of Source	GW
Population served	440
Customers – Residential	Na
Customers – Non-Residential	8
Production:	
Max day (m^3/d)	190
Capacity (m3/d)	120
Max. day / capacity	158%
Avg day (m3/d)	103
Avg day / pop (Lpcd)	420
Max. day / avg day	1.84
Customer metering	No
Water Use Restrictions	Yes

Water Resource Issues

- High water use
- Exceedance of ODWOs
- Freeze on growth

TABLE 7.24
HAMMOND - MANAGEMENT OPTIONS

Option	Description	Present value cost
Expand GW supply	Immediate expansion based on new wells plus disinfection to a total capacity of 300 m^3/d	Capital – wells: $72,000 Operating – no change in unit cost

There is insufficient time to implement either a metering or a water efficiency program in order to delay a capacity expansion.

Rockland

TABLE 7.25
ROCKLAND – DESCRIPTIVE STATISTICS (FROM MUNICIPAL SURVEY)

Water		Wastewater	
Type of Source	SW	Type of Plant	WWTP
Population served	8,100	Population served	8,100
Customers – Residential	na	Customers – Residential	na
Customers – Non-Residential	na	Customers – Non-Residential	na
Production:		Production:	
Max day (m^3/d)	4,442	Total Inflow (m^3/d)	3,120
Capacity (m3/d)	7,260	Capacity (m^3/d)	6,800
Max. day / capacity	61%	Inflow / pop (Lpcd)	385
Avg day (m3/d)	2,659	Inflow / capacity	46%
Avg day / pop (Lpcd)	328		
Max. day / avg day	1.67		
Customer metering	yes		
Water Use Restrictions	yes		

Water Resource Issues

- High water use

TABLE 7.26
ROCKLAND - MANAGEMENT OPTIONS

Option	Description	Present value cost
Water efficiency	Implement a toilet replacement program to achieve a 10% reduction in demand	Program budget - $54,000/year for 5 years

The reported capacity appears to be adequate for several years, but the municipality identified a water shortage problem that has led to water use restrictions. Since the municipality is already metered, a water efficiency program is their remaining demand management option. In the long run, this will have a beneficial impact on both the water and wastewater systems.

Alfred

TABLE 7.27
ALFRED – DESCRIPTIVE STATISTICS (FROM MUNICIPAL SURVEY)

Water		Wastewater	
Type of Source	SW	Type of Plant	Lagoon
Population served	2,200	Population served	1,200
Customers – Residential	802	Customers – Residential	485
Customers – Non-Residential	92	Customers – Non-Residential	62
Production:		Production:	
Max day (m^3/d)	2,147	Total Inflow (m^3/d)	1,072
Capacity (m3/d)	2,900	Capacity (m^3/d)	713
Max. day / capacity	74%	Inflow / pop (Lpcd)	871
Avg day (m3/d)	977	Inflow / capacity	150%
Avg day / pop (Lpcd)	444		
Max. day / avg day	2.20		
Customer metering	no		
Water Use Restrictions	yes		

Note: Water data are for Alfred-Lefaivre water supply system.

Water Resource Issues

- High water use
- Alfred has high levels of wastewater production per capita
- WW production is considerably higher than water production (possible I/I problem)

TABLE 7.28
ALFRED – MANAGEMENT OPTIONS

Option	Description	Present Value Cost
Expand WWTP	Immediate expansion of WWTP to 1,700 m^3/d	Capital cost - $190,000
Meter customers to reduce the size of the WWTP	Meter all customers to reduce wastewater flows and build an immediate expansion of WWTP to 1,500 m^3/d	Capital, WWTP: $185,000 Capital, meters: $180,000 New operating - $6,400/year
I/I control program	Reduce wastewater flows to 130% of per capita water demands (690 m^3/d) and resize WWTP	Capital, WWTP: $174,000 New operating for I/I program - ?

Per capita wastewater flows are almost double the per capita water demands suggesting a significant problem with I/I. Metering should cause a 20 percent reduction of water use but this implies only a 12 percent reduction of wastewater volumes due to the influence of I/I. Neither metering nor an I/I reduction program will have a significant impact on capital costs or the timing of an expansion. However, the impact would be more significant if the municipality is required to implement tertiary treatment as a result of high nutrient loadings associated with the high effluent flows.

Plantagenet

TABLE 7.29
PLANTAGENET - DESCRIPTIVE STATISTICS (FROM MUNICIPAL SURVEY)

Water		Wastewater	
Type of Source	SW	Type of Plant	Lagoon
Population served	980	Population served	950
Customers – Residential	443	Customers – Residential	413
Customers – Non-Residential	30	Customers – Non-Residential	29
Production:		Production:	
Max day (m^3/d)	689	Total Inflow (m^3/d)	665
Capacity (m3/d)	1,700	Capacity (m^3/d)	561
Max. day / capacity	41%	Inflow / pop (Lpcd)	679
Avg day (m3/d)	472	Inflow / capacity	119%
Avg day / pop (Lpcd)	482		
Max. day / avg day	1.46		
Customer metering	yes		
Water Use Restrictions	no		

Water Resource Issues

- Poor raw water quality for WTP
- Plantagenet has high levels of wastewater production per capita
- WW production is considerably higher than water production (possible I/I problem)

TABLE 7.30
PLANTAGENET - MANAGEMENT OPTIONS

Option	Description	Present Value Cost
Expand WWTP	Immediate expansion of WWTP to 1,040 m^3/d	Capital cost - $164,000
I/I control program	Reduce wastewater flows to 120% of per capita water demands (540 m^3/d) and expand WWTP to 880 m^3/d	Capital, WWTP: $159,000 New operating for I/I program - ?

An I/I reduction program will not have a significant impact on capital costs or the timing of an expansion.

Morrisburg

TABLE 7.31
MORRISBURG - DESCRIPTIVE STATISTICS (FROM MUNICIPAL SURVEY)

Water		Wastewater	
Type of Source	SW	Type of Plant	WWTP
Population served	2,570	Population served	2,570
Customers – Residential	1,081	Customers – Residential	1,007
Customers – Non-Residential	144	Customers – Non-Residential	141
Production:		Production:	
Max day (m^3/d)	5,301	Total Inflow (m^3/d)	4,561
Capacity (m3/d)	5,228	Capacity (m^3/d)	2,273
Max. day / capacity	101%	Inflow / pop (Lpcd)	1,775
Avg day (m3/d)	2,507	Inflow / capacity	201%
Avg day / pop (Lpcd)	975		
Max. day / avg day	2.11		
Customer metering	yes (ICI)		
Water Use Restrictions	no		

Water Resource Issues

- Require new WTP and WWTP
- High levels of water and wastewater production per capita
- WW production is considerably higher than water production (possible I/I problem)

TABLE 7.32
MORRISBURG - MANAGEMENT OPTIONS

Option	Description	Present Value Cost
Meter customers to reduce the size of the WWTP	Meter all customers to reduce wastewater flows and expand WWTP to 5,300 m^3/d immediately. WTP expansion of 6,700 m^3/d not needed for 19 years	Capital, WWTP: \$238,000 Capital, WTP: \$410,000 Capital, meters: \$230,000 New operating - \$8,600/year
I/I control program plus customer metering	Reduce wastewater flows to 130% of per capita water demands (2,600 m^3/d) and expand WWTP to 3,400 m^3/d immediately. WTP expansion of 6,700 m^3/d not needed for 19 years	Capital, WWTP: \$211,000 Capital, WTP: \$410,000 Capital, meters: \$230,000 New operating - \$8,600/year New operating for I/I program - ?

Demand management options may have a significant impact on the costs of water services due to the possibility of delaying the WTP expansion by about 19 years.

7.11.4 Relevance to Regional Water Strategy

It has already been discussed in this report that water supplies from surface water sources in Eastern Ontario, other than the St. Lawrence River and the Ottawa River, are limited. Also, many groundwater supplies are also limited and require costly treatment prior to use. The reduction of water use within the region would help to ensure the efficient use of water as a valuable resource and save on the costs of developing new water supplies and treatment of existing supplies. A reduction in the demand for water can have a significant impact on the costs of both water supply and distribution systems and wastewater treatment facilities.

Impact on Capital Costs

A very effective water efficiency program can help to extend the life of water supply facilities by dropping peak and average demand. If savings resulting from efficiencies are permanent, it is conceivable that facilities could be downsized. The capital savings achieved would be a function of the economies of scale, fixed costs, unit process sizes, and contingencies. While the capital costs of treatment plants and possibly trunk mains and sewers can be impacted by water demand reduction, rarely can the sizing of pipes in the local distribution system or local sewer system be reduced based on the impact of a demand reduction program.

An important factor in evaluating whether new facilities or facility expansions can be influenced by demand management is the rate of growth in the community. If the growth rate is flat, the number of years over which the delay of capital expenditures can be extended may be significant. If the growth rate is high, delaying plant expansions may not be possible.

Impact on Operating Costs and Operations

Water and wastewater system operating costs include:

- Energy
- Chemicals
- Labour
- Maintenance
- Management
- Taxes
- Insurance

Demand management may have a nominal impact on energy requirements for pumping operations and the use of chemicals. Operating costs related to labour and maintenance are often a function of minimum staffing requirements and maintenance schedules. Generally, labour, maintenance, and management, taxes, and insurance are not impacted by demand management.

Impact on Water and Wastewater Quality

Drinking water quality is normally not impacted by demand management measures. In areas on well systems, however, there may be a positive benefit in terms of the sustainability of the local well field.

A reduction in wastewater flow through demand management provides for an increase in the ability of a WWTP to better treat normal sewage flows and to accommodate wet weather flows during wet weather events. The increase in surplus treatment capacity can, in some instances, reduce the volume of untreated or partially treated wastewater that is otherwise bypassed from the plant; this reduces the contaminant loading to receiving waters.

The economic risks associated with demand side management include the uncertainty over the cost of maintaining a long-term conservation program and how this cost might impact the overall costs of the water delivery system. There is also an economic risk associated with a shortfall in revenues received by the water utility because of decreased sales associated with a successful water conservation program.

Demand side management is best viewed as complementary to the traditional approach of developing additional supply to meet demands. Recently, utility managers have been integrating water demand management into Integrated Resource Planning for water utilities (Call, 1996; Hoffman, 1996; Ruzicka and Hartman, 1996; and Hasson, 1993). Demand management, from an integrated resource planning perspective, allows the utility manager to look at a wide range of options for meeting water demands, includes all stakeholders in the process, and allows for a more cost-effective analysis of options. The City of Barrie and the Region of Waterloo have been quite successful in this regard.

Table 7.33 provides information from the public related to their support for different water conservation measures. Promotion of water conservation is supported by the majority of people in the study area.

TABLE 7.33
PUBLIC SUPPORT OF WATER CONSERVATION MEASURES

Measure	Prescott and Russell		Stormont, Dundas and Glengarry		City of Ottawa	
	#	%	#	%	#	%
Install water meters	609	26%	339	19%	119	12%
Restrict watering of gardens / lawns	881	38%	555	31%	271	28%
Increase cost of water	195	8%	151	8%	92	9%
Promote water conservation	1264	54%	1000	56%	569	58%
Conserve wetlands	1139	49%	1025	57%	570	58%

7.11.5 Recommendations

From a regional perspective, water efficiency should be part of all Official Plans as a good stewardship practice. Municipal by-laws should incorporate water efficiency components to ensure the conscientious use of water as a valuable resource. Water efficiency should also be promoted to rural water users through an overall stewardship program.

Water efficiency measures are normally “packaged” together into an effective strategy. The strategy might be directed at residential users or industrial, commercial or institutional water users. The target water user group would determine the efficiency measures that would best be packaged together. An assessment of the water conservation practices and descriptions of appropriate implementation presented in this report should be carried out in order to determine the best possible approach to achieving objectives for water use efficiency.

There are a number of objectives that could be introduced in a water efficiency strategy. These may include simply, good stewardship, but may also have specific targets of water use reductions and water quality improvement. The objectives in specific areas may also include reductions or deferrals in capital expenditures and limitations on operations and maintenance costs. It is recommended that water efficiency be included in an Integrated Resource Management Plan developed on a regional basis. Specific recommendations and targets for performance should be incorporated into the management plan.

8. Public Consultation

8.1 Overview

A major component of the Eastern Ontario Water Resources Management Study (EOWRMS) study was the program for public consultation. A variety of consultation techniques were used to interact with the public. The intent of the public consultations was to raise the awareness of water resources management issues and to encourage dialogue. In order to encourage public involvement, over 64,000 households and businesses in the study area were sent a survey and a newsletter that described the EOWRMS study and objectives. Therefore, everyone affected by the study was given an opportunity to participate and to learn about this study, the activities and programs of other agencies, and the importance of wise management of water resources. The public consultation also provided an opportunity to obtain information and input from the public. The public's input served to confirm observations or findings made by the consultant team. It also brought forth new information and new perspectives on study issues.

The consultation program provided an opportunity for agencies to participate including municipalities, agricultural and rural organizations, and public service organizations. The EOWRMS steering committee members provided important contributions to the consultation process, materials and interpretation of some of the findings. Overall, the consultation program fulfilled the objective of appealing to a wide audience of concerned / interested parties throughout the period of the study.

8.2 Data Sources and Limitations

The primary information sources for the public consultation included:

- A water resources survey administered to more than 64,000 households
- An open house survey
- Comment sheets and evaluation forms submitted at open houses
- Focus group sessions
- Agency meetings
- Email correspondence
- Literature sources

Limitations to the information was a function of the level of public participation over the course of the study. Increased attendance at open houses and public meetings would have provided more input concerning the public's perspective of water resources issues. Due to the poor attendance at public meetings, one set of proposed open houses was cancelled in favor of the distribution of EOWRMS Newsletter #4 throughout the study area. In consultation with the project steering committees, the distribution of the newsletter was viewed as a more appropriate approach to conveying information to all residents in the study area.

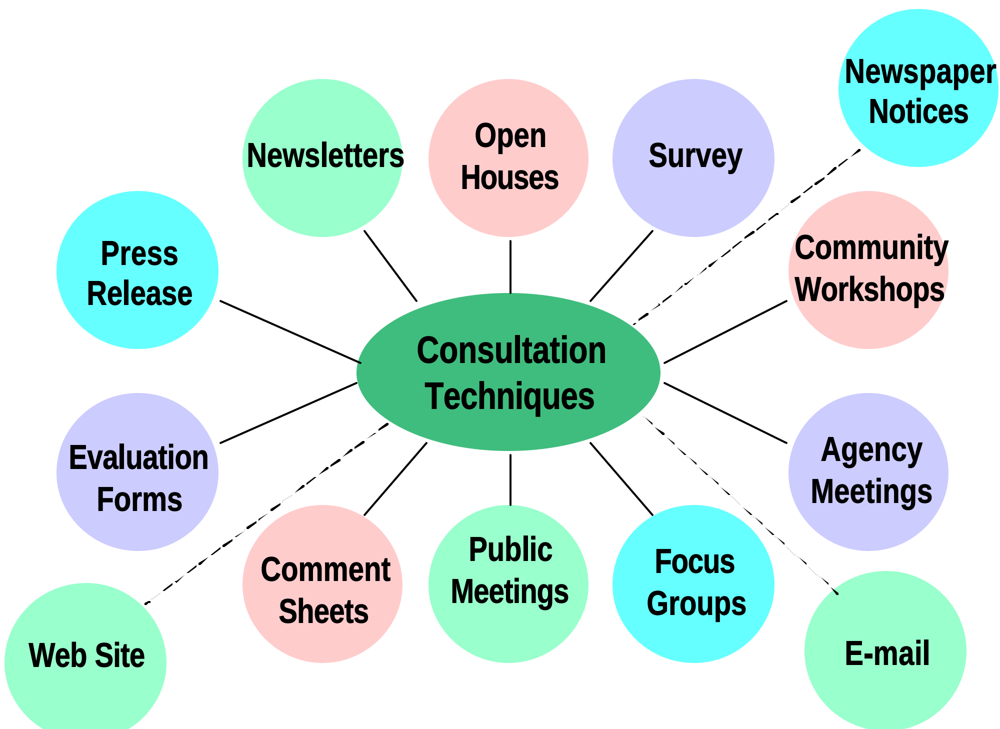
The data received through returns of the water resources survey was considered to be representative and served to corroborate other information received from those members of the public who did attend open houses and public meetings.

8.3 Assumptions

A communications plan was a vital component of the overall study program. It was assumed that the plan would consist of a multi-faceted public consultation program as well as a reporting requirement (communication reports). The need to provide a bilingual program was also recognized. While there was no advance knowledge on the extent or number of people who would participate, it was felt that the scope of the program had to appeal to a variety of public bodies in order to stimulate genuine public interest and awareness for the results to be valid and legitimate. It was assumed that public meetings and open houses would be a good method of reaching a significant component of the population; however, based on the poor attendance at these events, this assumption proved to be wrong.

8.4 Approach and Methods

The approach to public consultation was to design a program to both convey and receive information:



Recognizing the size of the study area and population, the number and variety of interest groups and the fact that the public responds in different ways, the program was designed using a variety of consultation techniques including:

- Newsletters
- Open houses
- Community water resources survey
- Agency meetings
- Focus group sessions
- Public meetings

A master contact list was developed for the purposes of distribution of the newsletters and to identify interest groups who might participate in focus groups or other sessions. Members of the Technical Advisory Committee and the Steering Committees were also on the list for the distribution of consultation materials. During the course of the study, this list was expanded to include individuals and organizations who had provided comments or requested to be added to the list. The final newsletter was distributed to the full master contact list.

A study logo, mission statement, and web site were created as a means to generate a project identity and to facilitate public queries or to convey information.

Public consultation materials were produced in both French and English and public meetings were conducted in French or English, depending on the audience. Bilingual staff were available at all public open houses and public meetings to respond to questions or provide information in the language of preference.

Through the project steering committees, a review process was incorporated into the consultation program to verify the accuracy of the translated materials and the content of public open house materials. This review included a practice presentation of the materials to be presented at the public meetings held in November 2000.

The print and electronic media were initially contacted through the distribution of a Press Release at the outset of the study and were sent a copy of each of the newsletters generated during the course of the study.

Sign-in sheets were used to record attendance at open houses and public meetings. Comment sheets were provided as a means of facilitating public input and evaluation sheets were given out in order to obtain a performance review for the public presentations. A fact sheet about the EOWRMS study and an open hose questionnaire were provided at the first series of open houses.

The consultant team recognized the need to tailor the content of consultation materials to the individual audience. Since the study was very technical in nature, it was important, as an approach, to use 'public-friendly' language as well as visual materials and graphics to convey information. The Hydrologic Cycle diagram, as an example, became the basis for explaining the water partitioning concept and the relationship of ground and surface water. A working aquifer model was used to explain groundwater flow. Finally, a video and, a bilingual slide presentation (produced by Environment Canada) were used to explain water resource management and conservation techniques.

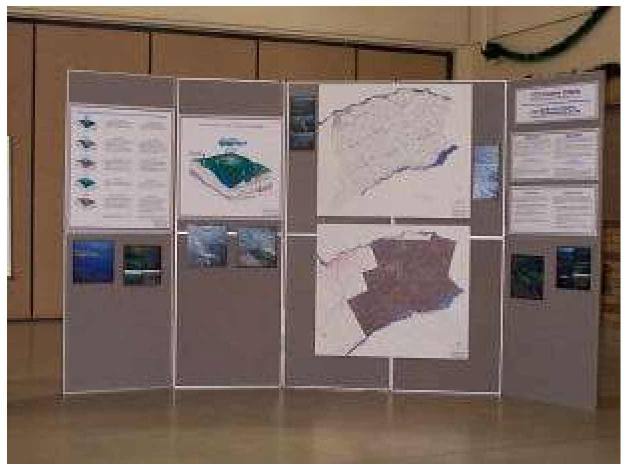
8.4.1 Newsletters

Five newsletters were issued during the course of the study (#1 - June 1999, #2 - January 2000, #3 - April 2000, #4 - October 2000 and # 5 - Spring 2001). Newsletters three and four were distributed to over 64,000 households and businesses across the study area. Newsletter #3 included a Water Resources Survey. Over 5,000 responses to the water resources survey were received. As a response to the public's interest in well and septic tank maintenance expressed at the first round of public open houses in May-June 2000, Newsletter # 4 included an insert on *Household Water Tips*.

The content of the newsletters advised readers of the purpose of the study, the study area (map), the study partners, the study progress, the dates and means for participation and the names of contacts.

8.4.2 Open Houses

Two series of six open houses were held. Public service notices were placed in local newspapers to advise the public of the time and location. The first series was held in late May and early June 2000 at six locations (Alfred, Clarence Creek, Alexandria, Greely, Casselman and Winchester), over a six-hour period (3:00 – 9:00 p.m.). A second series of open houses was held in conjunction with public meetings at the same six locations in November 2000. The open house component was from 3:00 – 7:00 p.m. and the floor was opened to public questions/comments from 7:00 – 9:00 p.m.



EOWRMS Open House Display Board

Total attendance for the first series and second series of open houses/public meetings was 135 and 61, respectively.

Display panels were created to provide a self-directed walk-through for the public. Consultant team staff were available to answer questions and to explain display materials. Handouts for the second series of open houses included a wide variety of materials (e.g. biosolids, nutrient management, well and septic tank maintenance, etc.). At three of the sessions in the first series and one session in the second series, water sampling bottles were made available to enable the public to obtain water samples for analysis.

Thirty-one questionnaires and 25 evaluation forms were completed during the first series of open houses; while only 10 evaluation forms were returned in the second series.

8.4.3 Community Water Resources Survey

A community water resources survey, including prepaid return envelope, was distributed to homes and businesses throughout the study area as “ad-mail” in April 2000. The survey canvassed public opinion on the quality and quantity of domestic water, usage of bottled water, supply source, conservation measures, and the interest in receiving subsequent newsletters. Over 5,000 responses were received which represented approximately an 8 percent return.

8.4.4 Agency Meetings

An offer was made to rural organizations for members of the consultant team to meet with these groups to explain the purpose of the study program and to respond to questions. The Dundas County Dairy Producers was the only organization to request a meeting. This meeting was held in early November 2000 and was attended by 10 farmers representing nine farming operations. An introductory presentation was made followed by an extensive question and answer period.

8.4.5 Focus Group Sessions

A focus group session was held in each section of the study area, Prescott and Russell (P&R), Stormont, Dundas and Glengarry (SD&G) (June 2000), and the City of Ottawa (August 2000). Attendance for the focus groups was by invitation only. Approximately ten people attended each of the three sessions. These people represented a diverse range of interests including agriculture, industry, local government, conservation authorities, non-government agencies, local businesses, and landowners. An overview of the EOWRMS study program was provided and some basic factual materials were distributed to participants.

The focus groups were asked to identify issues/concerns that they would like to see addressed as part of the study, some possible directions or solutions for water management within the study area and potential water resources management tools.

8.4.6 Public Meetings

A series of six public meetings was held in November 2000 in conjunction with the second series of open houses. A formal presentation using overheads was prepared, although, due to the limited turn-out, the full presentation was only made in three locations. An abbreviated version was presented in the other three locations. The presentation covered the objectives and key findings of the study, the elements of the hydrologic cycle, characteristics of the surface and groundwater, potential components of action plans, and a proposed future plan of action.

An interactive question and answer period followed the presentation in which the public was invited to express their concerns or provide comments to the consultant team.

8.5 Characterization

It was evident through the public consultation process that there is an increasing awareness towards the value of water resources management. Undoubtedly, some of this increase in public concern was motivated by the unfortunate incidents in Walkerton, Ontario. However, the lack of public knowledge concerning water resources and their management was also evident. Nonetheless, the complexity of the subject and the fragmented organizational structure for water resources management engenders public apprehension on who, how, what and when a comprehensive approach to water resources management will be undertaken. Certain notable trends were identified during the consultation process including:

- An increase in well water testing
- An increased awareness of the need for household maintenance programs for wells and septic tanks
- A pressing and increasing need for more public education about water resources
- A sense of a gradual and continuing decline in water quality in some areas
- Farm consolidations leading to larger farming operations
- Improved farming practices and a greater consciousness of the need for water resources management

Limitations to growth are being experienced by urban communities because of the lack of adequate water supply and wastewater servicing ability.

It was also evident that arriving at a solution to water resources management planning is a bottom up and top down process. Homeowners, businesses, and farmers must recognize their role in water resource management as must the government and other agencies. Integrating and coordinating the mutual interests of these groups is viewed as crucial to effective management of the water resources of the major watershed areas.

8.6 Key Findings

The following section presents a summary of findings and suggestions made by the public during the public consultation process. In some cases findings have been interpreted by the consulting team for consolidation and reporting, but were originally derived from either the questionnaires, focus groups, meetings or informal discussions with members of the consulting team during open houses.

8.6.1 Public Education

Public education is vital to increasing the awareness of the importance of managing water resources responsibly and influencing the public policy agenda. Public education was viewed as taking many forms including:

- Workshops on water-well and septic tank maintenance for the general public
- Household environmental audit kits to enable householders to evaluate water usage and conservation practices, ground and surface water protection, use of herbicides and pesticides, water well abandonment and capping, septic tank maintenance as well as other water and non-water related assessments
- Curricula for schools to inculcate 'water resource management' values at a young age
- Workshops or educational programs for elected officials on water resources issues, one of which is the value and importance of wetland protection
- Agricultural community needs forum to exchange ideas on farm practices related to water resources management

The general public is not well informed about the need for water-well testing on a regular basis. Many of the participants at open houses admitted that they have not had their wells tested since purchasing their home. The need for wellhead protection was also expressed, especially where the wells were located close to a manure storage or livestock operation. Homeowners appreciated the sample bottles that were distributed at some of the open houses and indicated their intention to have their water tested immediately. Water testing is a service provided without charge by the local Health Unit but is limited to bacterial tests; however, the public is not generally aware of what agencies provide testing services and at what cost.

Public knowledge about proper testing of septic tanks was similar to the situation for well testing. Many homeowners were not aware of how often septic tanks should be pumped out, how often bacteria should be introduced into the tanks, the benefits of separating gray water from human wastes, or the impacts of bleach are on sewage disposal systems. There are no regulatory controls for regular pump outs by municipalities and the condition of septic tank facilities varies from discharge into a dry well, a wooden holding tank, etc. Questions were raised as to what new technologies were available for private onsite sewage disposal systems.

8.6.2 Inspection Practices

Well drillers, although licensed, are not subject to an independent inspection or audit of their well installation practices on a regular basis. Provincial inspections are limited. Comments were made that standards for well-water testing, as part of the installation of new wells, should be improved in order to provide more accurate data for assessing ground water conditions.

8.6.3 Conservation Practices

Many homeowners are concerned about both water quality and water quantity.

Water Quality

Residents reported varying degrees of water quality across the study area: from regions with salt, iron, or sulfur and hardness, to areas with extremely good quality water. People with dug wells were generally more sensitive to potential impacts. Water quality was also cited as an issue with respect to some communal (municipal) systems.

Water Quantity

Water quantity has become more of an issue with a dry summer season (1999) and has precipitated conservation practices on an individual basis. Water quantity varies from region to region with notable fluctuations during dry summers. Some communities are currently limited in their water supply capacity, which is prohibitive to further community development.

It was notable that those participants who had lived in European countries were much more conscious of the need for water conservation practices. These people commented on wasteful practices such as washing down driveways, abusing lawn-watering restrictions, not installing water efficient showerheads, etc. Comments were made about the benefits of universal metering of municipal water and the potential metering of private wells.

8.6.4 Wastewater Treatment Facilities

Limitations on receiving stream flows may limit growth along such river systems as the South Nation. Consideration should be given to programs where innovative technologies are utilized by municipalities to improve flows or treatment practices. Zoning should be used as a control for growth management.

8.6.5 Wetlands and Woodlands

Members of the public who raised the issue of wetland conservation support it. The Alfred Bog, the Newington Bog, the Moose Creek Bog and other local wetland areas were identified as areas that should be protected for their water conservation value. The necessity of protecting woodland areas that function as recharge areas was also expressed.

8.6.6 Nutrient Management

Numerous comments were made with respect to the location of a manure storage facility and its proximity to a well supplying water to the village of St.-Isidore. The farm community recognizes the importance of nutrient management practices and the introduction of provincial regulations and standards. However, the imposition of regulatory controls must be reasonable and should reflect a fair balance between the costs that farmers may bear and the costs that urban communities should bear as their share of water resources management.

Many farmers have prepared Environmental Farm Plans as a means to improving farm practices (e.g. constructed wetlands, building / improving manure storage facilities, building a containment facility for fuel storage, etc.). Farmers indicated that the $1,500 subsidy should be extended as an incentive to continue further improvements. This funding appears to lever a greater level of expenditures (e.g. three or four times the value of the grant).

Nutrient management should not be limited to farming operations. Concerns were raised about the potential impact of biosolids on water resources; therefore, biosolids applications, on golf courses and any rural use that may generate nutrient loadings, were identified as other rural uses that should undergo nutrient management. The key is that nutrient management planning needs to be undertaken and managed on a comprehensive basis.

8.6.7 Livestock Disposal

There was a great deal of concern about the potential for contamination of groundwater from decomposed or buried livestock.

8.6.8 Aquifers and Recharge Areas

The issue of aquifers and recharge areas was raised at several open houses / public meetings. Land use policies should prevent activities, such as active or closed / abandoned landfill operations, former service stations, pesticides and herbicides, that may contaminate these areas.

8.6.9 Demonstration Projects

Interest was expressed about projects that might apply to an individual property owner, such as the installation of new technologies for a private sewage disposal system or the availability of funds for municipal projects. Participants of the public meetings felt that public education should be viewed as a major objective as people are eager for accurate information concerning conservation practices, system maintenance, etc.

8.6.10 GIS Information Base

The project has developed a significant digital database related to water resources and land use. The public and local governments should have access to the water resources database (i.e. through the Internet).

8.6.11 Monitoring and Testing Programs

Whether conducted by provincial or local government authorities, water monitoring and testing programs were considered by the public to be essential to determining the current state (quality and quantity) of water resources and to recognizing trends or changes in water resources, particularly a decline in water quality. An example cited was the impact of leachate from active and closed landfill sites. Leachate should be monitored in order to avoid the contamination of private wells. Monitoring should also include a review of the performance of communal water and sewage disposal systems.

8.6.12 Growth Management

Current Official Plans are not “water sensitive” and do not include water resource management policies to assist decision makers in designating locations where development should and should not be permitted. Policies and criteria for water conservation need to be incorporated into Official Plans; however, municipalities need accurate information on which to formulate their policies. More stringent provincial directives on water resources management practices need to be instituted and the province should play a greater role in groundwater management including opposing development that threatens water quality and quantity. Growth management may require the transfer of development rights.

8.6.13 Roles and Responsibilities of Local Government

The local municipal governments within the study area should institute educational programs detailing proper well and septic tank maintenance and the benefits of metering and installing water conservation devices. (Educational programs are currently being undertaken to some degree.) Local governments should make provisions for long term planning including the maintenance of and improvements to water and sewer infrastructure, and best management practices for stormwater management and treatment. Municipalities should facilitate the use of a communal well and septic tank program in communities where population densities warrant such a provision (i.e. where 5 or more properties can share a well and / or septic tank).

8.6.14 Roles and Responsibilities of Property Owner

Environmental home audits to assess water conservation and other environmental practices should be included among the roles and responsibilities of property owners. A program of regular well-water testing and maintenance of wells, as well as a regular program of septic tank maintenance, commensurate on usage, should be instituted. The use of pesticides and herbicides should be controlled, either through banning or certifying individuals to use products safely. Property owners should also attempt to conserve privately owned wetlands.

8.6.15 Roles and Responsibilities of the Agricultural Community

The preparation of nutrient management plans for members of the agricultural community should be included among their roles and responsibilities. Protocols for well head protection should be regulated and overland drainage should be managed through best management practices or through a stormwater management plan. Natural wetlands should be conserved and the construction of treatment wetlands encouraged, including retaining cattails in ditches and swales. Buffering of livestock from water courses, as well as stream bank erosion controls, should be required.

8.6.16 Roles of other Agencies

The potential role of conservation authorities should involve the maintenance of a water resources database and assistance to local governments in application and use of data. Agencies should have a continued role in the sponsoring/administering of water resource management programs (i.e. South Nation Clean Water Program to assist in water conservation measures; buffering livestock from waterways, identifying and capping abandoned wells, constructing wetlands, etc.).

The Ministry of the Environment (MOE) should initiate a universal groundwater monitoring program.

8.6.17 Organizational Structure

The public recognized and responded to the suggestion of the need for an organizational structure that would take into account the fact that the management of water resources is fragmented and that watersheds cross political boundaries. Therefore, there is a need for an organizational structure that can play a coordinating role in the management of water resources on a regional basis, especially in municipalities where there is a threat to the quality or quantity of water (e.g. discharge of communal lagoons).

8.7 Relevance to Regional Water Strategy

The stewardship of water resources is as much the responsibility of individual property owners as it is of a municipality or a conservation agency. The onus is on all parties to recognize that responsibility for water resource conservation and management must be shared, since those who do not participate in water conservation/management practices may well affect the access of others to a safe and potable water supply.

The findings of the public consultation process serve to confirm the public's interest and support for measures to conserve and protect water resources within the South Nation and Raisin Region watersheds. There is a need for a comprehensive policy and regulatory framework to guide land development and the operational decisions of government and property owners in maintaining water resources infrastructure, be it a communal sewage system or an individual well. There is a limited supply of water; therefore, water conservation practices must be initiated. Conservation practices could be regulated, but they can also be instituted by a public who is well informed and is willing to initiate measures such as installing low flow fixtures and appliances etc. However, public education is vital to raising public awareness. Due to the fact that natural features play a role in the regeneration of clean water (i.e. the conservation of wetlands), there is an interest in the conservation of privately owned and publicly owned wetlands as well as the development of new wetlands.

Incorporating water resource management practices as an integral component of land management is an imperative goal of government and property owners. Efficient water resource management entails a commitment towards the protection of sensitive aquifers and recharge areas, universal nutrient management, and an ongoing program of monitoring the impact of development on the quality and quantity of the water resource. In accordance with these principles of water management, much of what the public and agencies expressed during the public consultation process is relevant to the development of a regional water strategy.

8.8 Public Consultation Recommendations

The following recommendations were developed by the consulting team based on the key findings derived during the public consultation process:

8.8.1 Public Education

A comprehensive program of public education should be undertaken consisting of the preparation of instructional brochures or booklets on water well and septic tank maintenance, water testing, water conservation practices, water well abandonment procedures, the use of herbicides and pesticides, environmental home audits and community resources. (*Note: it is recognized that the Region of Ottawa-Carleton produced a booklet entitled "How Well is Your Well", September 2000, as a backdrop to a series of workshops on well and septic tank maintenance in the fall of 2000.*)

Area school boards and / or the Ministry of Education should be encouraged to incorporate 'water resources conservation and management' materials into the curriculum so that students may develop a water resources 'ethic' at a young age. Consideration should be given to organizing local partnerships to provide a unified lobby for conservation education.

The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), in conjunction with the Ontario Federation of Agriculture, should develop an educational program and forum for exchanging information and ideas on farm practices related to water resources management (e.g. stream bank erosion controls, nutrient management, stormwater manage-6ment, water course buffering from livestock watering, constructed wetlands, water well abandonment, well head protection, fuel storage, etc.).

8.8.2 Inspection Practices

Water quality testing on new wells should be more formalized through lab testing and the results should be incorporated into a public database on a geo-referenced basis. Consideration should also be given to instituting a procedure for adding water quality information to the database for shallow or dug wells. In addition, consideration should be give to procedures for adding water quality information to the database based on the submission of well-water test results on a voluntary basis. Well-water testing should be facilitated through the local Health Unit or through by-law enforcement for the regular inspection of sewage disposal systems as a means to maintain septic tanks and filter/tile beds in optimal operation condition. A provision for septic tank maintenance should include a prescription for the regular pump-out of septic tanks commensurate with use.

8.8.3 Conservation Practices

The local government should initiate a water conservation program involving the installation of water efficient fixtures and appliances and water meters.

8.8.4 Wetlands and Woodlands

Official Plans and zoning by-laws should incorporate provisions for the protection of water resources through the designation and protection of wetlands and woodlands by demonstrating the specific correlation of these natural features to water resource management. Reference should be made in particular to the protection of recharge and discharge areas. Land use designations should also provide for the conservation and protection of constructed wetlands.

8.8.5 Nutrient Management

A nutrient management plan should be instituted for all significant rural uses including farming operations, golf courses, and commercial and industrial uses. Provisions should also be made for the management of biosolids.

8.8.6 Environmental Farm Plan

The federal and provincial governments should be encouraged to provide ongoing funding for the development of Environmental Farm Plans.

8.8.7 Aquifers and Recharge Areas

Official Plans should incorporate a comprehensive approach to the identification and protection of sensitive aquifers and recharge areas. (Note: Information on an aquifer and recharge locations can be derived from this study.) The protection program should include provision for the prohibition or strict control of land uses proposed or in proximity to aquifers and recharge areas (i.e. ‘zone’ system based on time-of-travel or similar criteria).

8.8.8 GIS Information Base

The GIS information base (metadata) should be made available to local government and the public at the earliest opportunity. The GIS information base should also be incorporated into the land use planning and review process.

8.8.9 Monitoring and Testing

The province, in conjunction with local government, should institute a groundwater and surface water testing program (quality and quantity) within the South Nation and Raisin Region watersheds. A centralized database should be established to maintain the results of the testing. The database should also include an inventory of point-source contamination sites and the testing and results of contaminants, where applicable (i.e. landfill sites, active and abandoned industrial sites, etc.).

8.8.10 Growth Management

Official Plans should be reviewed with the objective of formulating a comprehensive policy framework for the conservation and management of water resources on a regional and local basis. Policies should incorporate a development application review that designates water resources protection as a significant criterion. Policies should also include water-related growth management principles and / or best management practices on a watershed basis. The objective should be to avoid any further decline in the net quality of water and wherever possible seek to achieve an improvement in quality (i.e. quality of water in-take should be the same or better as water discharge).

A water budget should be established that correlates the demand and supply requirements of municipalities with a regional water budget. The water budget should also be correlated to Permits to Take Water for individual users such that there is a balance between supply and demand that does not tax the supply. The MOE should be obliged to issue Permits to Take Water only when it is within the framework of the water budget.

8.8.11 Infrastructure Planning

Long-term infrastructure planning should be undertaken on a watershed basis, by area municipality, in conjunction with County governments or with the new City of Ottawa. Infrastructure includes water supply and distribution systems, wastewater collection and treatment systems and stormwater management facilities. Consideration should also be given to policies that provide for communal water and sewage disposal systems for rural properties where population densities warrant such action (e.g. 5 to 10 properties utilizing one well or septic tank).

8.8.12 Role of Agencies

Conservation authorities should be assigned a broader role in water resources management (e.g. review and administration of nutrient management plans, administration of a watershed (regional) water budget, application review of development proposals for their impact on aquifers, recharge areas, wetlands, woodlands, etc.). Consideration should also be given to the role of conservation authorities in managing a water resources database and in the continued delivery of programs for water resources management (i.e. Clean Water Program sponsored through South Nation Conservation).

8.8.13 Organizational Structure

The County governments and the City of Ottawa should establish a regional management board as a mechanism to coordinate the management of water resources on a watershed basis and to make recommendations to their respective members on measures to conserve, manage, or improve the quality and quantity of water resources.

8.8.14 Public Consultation

A deliberate and focused public consultation program should be continued. As plans and proposals become more defined and available to the public, the degree of public involvement in the process is likely to increase significantly. Maintaining public involvement in future decision-making will help contribute to successful implementation of a water resources strategy. It will also contribute to public education needs and goals. Utilizing a broad-based consultation/communication process will be important in communicating with and receiving input from a range of potentially impacted parties. This approach should involve a variety of public consultation techniques that are tailored to the size, age and geographic area of the audience and that can be adjusted or adapted to the circumstances. A broad based approach using varied techniques proved very effective in the public consultation for the EOWRMS study, particularly when it became apparent that public participation at the open houses was significantly less than originally anticipated. For example, ad-mail became the most effective way to reach a large number of households and businesses.

9. Demonstration Projects

This section of the report highlights potential demonstration protects for water resources management and protection and outlines an approach for implementing them. The suggested projects are based on the analysis and recommendations put forth in the preceding sections of the report and recognize other initiatives underway in the study area.

9.1 Overview

The Eastern Ontario Water Resources Management Study (EOWRMS) is founded in principles of collaborate participation and pragmatic approaches to water resources management. Demonstration projects provide one means of delivering information and experiences on water resources planning and best management practices (BMPs).

The theory behind using demonstration projects is based largely on people's predisposition towards trying or avoiding new things. Traditionally, demonstration projects provided a means of showcasing a technology or practice under conditions familiar to people with an interest in "adopting" the technology or practice. Simple examples would be the "test-drive" of a new farm implement (e.g. a chisel plough) or looking at a new model home. Increasingly, demonstration projects are being applied to programs and behaviours (e.g. water conservation, recycling, or energy efficiency). Regardless of the focus, the primary aims of demonstration projects generally involves increasing the adoption rate of new methods by demonstrating their effects and benefits.

The EOWRMS Terms of Reference asked the consultant team to "develop community demonstration projects that provide integrated solutions to water resource issues on a local and/or regional basis" and to "develop and promote tools and action plans to protect the quality and quantity of regional water and related land resources". Given such direction, a broad definition of demonstration projects has been adopted, one that combines practices, technologies, and programs.

The approach is also strategic in that recognition is given to past, ongoing, and planned initiatives and projects within the study area that promote and demonstrate different methods and technology to help protect and enhance water resources. The Provincial Water Protection Fund is a major contributor to the study; other current initiatives in the study area include[1]:

- Rural Clean Water Program: City of Ottawa
- Clean Water Program: South Nation Conservation
- Tributary Restoration Project: Raisin Region Conservation Authority
- Baseline Water Well Testing Program: Ontario Federation of Agriculture
- Livestock Manure Prevention Program

[1] This list is not meant to be exhaustive, but rather illustrative of some current initiatives within the study area.

- Regional Environmental Information System (REIS): Agriculture and Agri-Food Canada (AAFC)
- Nutrient Management Planning: Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
- Water Efficiency Campaign: City of Ottawa
- Waterlinks: City of Ottawa
- Agricultural Environmental Stewardship Initiative (forthcoming)
- Subwatershed Studies
- Ongoing public education and awareness

9.2 Data Sources and Limitations

The following data sources were used in developing demonstration project options:

- Literature and internet resource review
- EOWRMS water resources analysis (Phase 2)
- EOWRMS Water Resources Survey
- EOWRMS Focus Groups
- EOWRMS Technical Advisory Committee
- EOWRMS Steering Committees

9.3 Assumptions

It is assumed that the information presented here is a guide and not a specific set of instructions. As is discussed later, organizing and implementing a particular project, or a suite of projects, often requires a unique combination of partners and settings in order to work effectively. Information in this section provides some initial direction and tools to aide the project partners. Putting these suggestions into practice will likely necessitate modifications in approach, objectives, and evaluation to meeting funding, partner, or other expectations and requirements.

It is also assumed that current projects and emphasis on existing programs do not need to be mirrored in this exercise. The suggested demonstration projects are strategic in that they have not generally been addressed by other means on a broad scale.

9.4 Approach and Methods

A key goal of the demonstration project component of the study was to develop projects relevant to the situation in the EOWRMS study area. Relevancy was established by a number of means. The water resources analysis conducted throughout the study (i.e. Phase 2) was used to identify sensitive areas with respect to groundwater and surface water. This analysis provided a preliminary basis for targeting demonstration projects within the region.

Based on the targeting of sensitive areas, specific projects were developed through a combination of literature review, review of previously initiated technologies and projects, and a review of the focus of current programs (listed above). Information from the

EOWRMS Water Resources Survey and suggestions from the focus groups were also used to further refine the list of demonstration projects. Input from the Technical Advisory Committee and reviews conducted by the different project steering committees were particularly useful in shaping the relevance of the suggested demonstration projects.

The Water Resources Survey, provided a general polling of citizens attitudes and preferences for different water conservation, protection, and enhancement measures.

Respondents to the Water Resources survey were presented with a list of possible measures and were asked to select those that they thought would help improve water quality or quantity in their community. Results of the survey question are presented in Table 9.1.

TABLE 9.1
PUBLIC SUPPORT FOR MEASURES TO HELP IMPROVE WATER RESOURCES

Measure	Prescott and Russell		Stormont, Dundas and Glengarry		City of Ottawa	
	#	%	#	%	#	%
Install piped water system	248	11%	155	9%	188	19%
Improve treatment of municipal water supply	551	24%	409	23%	101	10%
Repair sewer pipes to eliminate water infiltration	482	21%	353	20%	123	13%
No increase in erosion with land development	840	36%	660	37%	411	42%
Land use/development does not contaminate groundwater	1,138	49%	915	51%	544	56%
Improve/Upgrade sewage treatment	716	31%	544	30%	234	24%
Conserve/Construct treatment wetlands	891	38%	744	42%	445	46%
Protect/Recharge aquifers	826	35%	648	36%	388	40%
Replace/Retrofit defective septic tanks and tile fields	724	31%	530	30%	375	38%
Retain/Return shorelines to natural state	778	33%	608	34%	294	30%
Control quantity/quality of drainage from new developments	940	40%	755	42%	451	46%
Control/Reduce pesticide and herbicide use	1,081	46%	873	49%	486	50%
Nutrient Management for agriculture	831	36%	632	35%	374	38%
Eliminate sources of contamination	1,185	51%	947	53%	537	55%

In addition, respondents to the same survey were asked to indicate whether they would support a series of conservation measures to better manager water resources. Results of this survey question are presented in Table 9.2.

TABLE 9.2
PUBLIC SUPPORT FOR WATER CONSERVATION MEASURES

Measure	Prescott and Russell		Stormont, Dundas and Glengarry		City of Ottawa	
	#	%	#	%	#	%
Install water meters	609	26%	339	19%	119	12%
Restrict watering of gardens /lawns	881	38%	555	31%	271	28%
Increase cost of water	195	8%	151	8%	92	9%
Promote water conservation	1,264	54%	1,000	56%	569	58%
Conserve wetlands	1,139	49%	1,025	57%	570	58%

9.4.1 Characterization of Demonstration Projects

Suggested demonstration projects where characterized in matrix form according to a series of factors (see Table 9.3 in Section 9.5). Individual factors are described below.

Sensitive Area

The sensitive area category, in combination with the nature of the sensitivity, provides a link to the overall EOWRMS study analysis. It provides the top-level basis for targeting where projects would be the most effective or where broader programs or initiatives could be directed. It should be noted at this point, that it is not necessary to target all initiatives. Some suggestions, such as water conservation measures, have broader application and effective-ness across the region.

Sensitive areas have been identified previously in the report and should be used as a basis for make future decisions on proceeding with projects.

Nature of the Sensitivity

This factor provides elaboration of the specific issues, concerns or risks associated with identified sensitive areas. Together, the sensitive area and the nature of the sensitivity define a potential problem to be addressed and provide the rationale for a particular demonstra-tion project suggestion.

Project Objectives

This factor provides basic objectives to be addressed by each project. They also provide the basis for developing measures against which the success of a particular project can be gauged. Specific objectives are not prescriptive, but in some cases provide a range of goals to pursue, or point to multiple projects that could be undertaken within an individual category.

Nature of Expected Benefits/Results

This category describes the general nature of results and benefit that could be expected to be achieved as a result of particular projects. The exact nature of the results depends on the methods used to implement and evaluate individual projects.

Evaluation

This factor describes some potential measures and / or indicators that can be used to measure the success or effectiveness of individual projects. GIS resources being developed by the study, in combination with other monitoring networks, could potentially play a useful role in monitoring and tracking changes in water resources as a result of demonstration projects. The specific utility depends on the nature of the projects involved.

Environmental and Health Objectives

This factor lists environmental and / or health objective that can be addressed by each project.

Potential Project Partners and Stakeholders

The management of regional water resources a responsibility shared among, municipalities, agencies, farmers, residents, cottagers, businesses or industries, everyone has a contribution to make. This criterion aims to identify stakeholders for the demonstration project; both those who might be involved in the implementation and those who might receive future benefits. In some cases they may be the same, in other cases they may be different. The list is not meant to be exhaustive.

Given the nature of the study, it has been assumed that local municipalities and conservation authorities will be key partners across all initiatives. In this regard, these organizations could be considered as key partners in implementing projects. However, this assumption should be reviewed on a case by case basis as projects are brought forward. Factors such as funding source and limitations, past partnerships, matching requirements, experience, and politics will uniquely affect the specific organization and administration of strategic partnerships formed for specific projects.

Relative Project Costs

This factor uses both a qualitative and quantitative method to categorize the basic cost of the project. Cost estimates are guides for planning purposes and costs can vary; therefore, the estimates are stated relatively, as they will ultimately depend, in many cases, on the application or uptake of a particular project. Capital expenditures can vary significantly depending on supplier or if used or if used equipment is available for purchase or can be donated to the project. Other costs that are difficult to quantify are administration and overhead costs associated with staff for programs that are of a longer duration and or require more intensive support and management than anticipated.

Costing has been estimated based on projects occurring in isolation (i.e. the worst-case scenario). Increased efficiency could be achieved through the management of a number of projects in coordination; for example, well head and recharge area protection planning, or public awareness projects. The degree to which public agencies might be able to lever staff and / or equipment and facilities is project and time specific and could have a significant impact on reducing costs.

Ease of Implementation

This factor is subjective and provides a simple indication on both the complexity of the suggested project and the ease with which results can be demonstrated to the broader public.

A project rated as "high" would be relatively straightforward to implement and the results would be apparent within a fairly short time period. An example of a project with a high ease of implementation rating might be the distribution of a newsletter or organization of a public meeting. The logistics of these activities are generally known, the process is linear, some results are immediate (i.e. number of newsletters mailed or number of meeting participants) and the duration of the activity is relatively short.

Conversely a project such as a pollution trading pilot program has a low ease of implementation rating. This type of project is a complex process that involves many stakeholders. There is limited experience in the application of such a project and the results could take many years to become apparent. While the ultimate impacts on environmental or health objectives could eventually be significant, the mechanisms for obtaining the environmental/ health benefits are complex.

EOWRMS Cross Reference

This factor identifies the major areas of the EOWRMS study that provided the cross-reference to the proposed demonstration project. Projects were either suggested based on results, input, or feedback from these sources.

9.5 Characterization

The following matrix (Table 9.3) presents the characterization of suggested demonstration projects. Projects are grouped under the broad headings of Surface Water, Groundwater, Servicing Infrastructure / Water Conservation, and Public Education and awareness. This grouping is largely for organizational purposes, as a number of projects could be applied within various groups.

9.5.1 Implementation Considerations

The success of demonstration projects can ultimately be linked to the effective involvement of local people and organizations in the design, planning, promotion, implementation, and management of projects.

The following section provides one approach that could be used as a framework for implementing projects. In practice, individual projects, or groups of related projects, will often require a unique combination of partners and management / administration practices to achieve a high level of success. These practices are sometimes influenced by the funding sources and formulae. In fact, many of the EOWRMS project partners have gained valuable experience over the years determining the most effective practices under different circumstances and project constraints.

The approach outlined below is based in the concept of Social Marketing (e.g. Novartis Foundation for Sustainable Development 2000, Weinreich 1999, Shewchuk 1994,). The purpose of presenting this information is not to suggest that past approaches in the region have been ineffective or could be improved, but rather to expose the project partners to a developing, innovative, and increasingly successful approach. A social marketing approach can be used to build on past success, or can be modified to suit local needs as projects, priorities, and objectives dictate.

TABLE 9.3
POTENTIAL DEMONSTRATION PROJECTS CHARCTERIZATION

				Performance Measures						
POTENTIAL DEMONSTRATION PROJECTS	**Sensitive Area**	**Nature of Sensitivity**	**Project Objectives**	**Environment and/or Health Objectives**	**Nature of Expected Benefits/Results**	**Demonstration of Results**	**Potential Stakeholders/Partners (in addition to munici-palities and CAs)**	**Relative Project Costs**	**Ease of Implementation / Demonstration of Results**	**EOWRMS Cross Reference**
Surface Water										
Alternative Residential/ Municipal Weed Control	Residential and muni-cipal areas treated with herbicides/pesticides	Inappropriate or excessive use of chemicals may affect groundwater and sur-face water resources	Demonstrate practical alternatives to chemical intensive management of lawns and gardens	Improve quality of runoff from lawns and gardens Reduce risk to drinking water from shallow wells	Increase pubic aware-ness Reduction of "unneces-sary" chemical use"	Number of visitors/ brochures Survey of applicator/ retailers	• Landowners • Municipal parks and recreation departments • Landscape companies	Low Advertising and aware-ness campaign ($10K per year)	High	• Focus Groups • Open Houses • Community Survey
Residential Septic Audits	Areas served by septic systems in proximity to surface water and groundwater resources	Septic systems may be contributing nutrient and bacteria to surface water and/or wells due to improper main-tenance, poor/inade-quate design or failure.	Conduct onsite audits of septic system operation and integrity on a volun-tary basis and provide written assessment with recommendations Consider a complimen-tary or cost-shared pump out as an incentive	Reduce pollution to water resources from malfunctioning section systems	Increase public aware-ness Improve efficiency of inspected systems Identification on non-functioning systems Minor improvement to local water quality	Number of audits Follow up records of actions taken Surface water moni-toring for several cases on a willing participant basis/Dye study	• Pumping contractors • Construction contrac-tors • MOE • Health Unit	Moderate 1 staff person, half time plus travel ($15-30K/yr) Advertising and aware-ness campaign ($10K per year)	High	• Focus Groups • Community Survey • Key Informants • Open Houses • Phase 2 rural servicing analysis
Alternative Toilets (e.g. composting) or other alternative septic technologies	Areas where soils are less then ideal for stan-dard septic systems	Future development of private services may be limited by the suitability of soils to attenuate standard septic effluent on desired lots sizes	Demonstrate selected alternatives to traditional septic systems/toilets Measure potential savings/benefits (e.g. water use, nutrient control, compost)	Reduce water con-sumption Reduce nutrient and/or bacteria loading to water resources in sensitive areas	Increase aware of "choices" Showcase environ-mental benefits of technology	Number of visitors/ brochures Survey of distribu-tors/retailers Focus groups or inter-views with demon-strators and adopters	• Technology manufacturers • Ontario Rural Wastewater Centre • MOE • Health Unit • Local Organizations	Low to Moderate $1,200 to $1,600 per until retail, plus installa-tion	Moderate	• Study Team • Phase 2 Rural Servicing Analysis
Pollution Credits/Trading	Surface Water bodies receiving treated wastewater effluent from municipal and industrial sources	Nutrient loading (particularly P) to receiving water body and impaired assimilative capacity of streams	Build on existing ground-work and partnerships to evaluate the effective-ness and feasibility for wastewater discharge application Provide additional support and resources for current initiatives Test methods for measuring/tracking credits Showcase rural NPS BMPs currently being promoted	Moderate P loadings to surface water resources Improve assimilative capacity of streams	Evaluation of feasibility of expanding trading in Eastern Ontario Develop monitoring network Showcase effective rural NPS BMPs	Water quality moni-toring "Credits" accounting Survey of participants Field level monitoring of effect of reducing loading of selected pollutants	• Local Businesses and industry • Municipal wastewater facilities • MOE • OMAFRA • AAFC • Ontario Rural Wastewater Centre	Moderate Largely overhead costs plus monitoring. 1 person full time at $50k as project manager plus expenses of $10K per year	Low	• Key Informants • Focus Groups • Phase 2 WQ Analysis

TABLE 9.3
POTENTIAL DEMONSTRATION PROJECTS CHARCTERIZATION

				Performance Measures						
POTENTIAL DEMONSTRATION PROJECTS	**Sensitive Area**	**Nature of Sensitivity**	**Project Objectives**	**Environment and/or Health Objectives**	**Nature of Expected Benefits/Results**	**Demonstration of Results**	**Potential Stakeholders/Partners (in addition to munici-palities and CAs)**	**Relative Project Costs**	**Ease of Implementation / Demonstration of Results**	**EOWRMS Cross Reference**
Treatment Wetland Municipal/Industrial Wastewater Polishing	Surface Water bodies receiving municipal/ industrial treated wastewater discharge	Nutrient loading (parti-cularly P) to receiving water body and impaired assimilative capacity of streams	Install a constructed wetland for waste water effluent polishing on a cost-share basis Demonstrate cost effec-tive improvement of effluent quality Demonstrate environ-mental benefits of the technology Explore potential/ feasibility for develop-ment of a shared use (e.g. municipal, indus-trial, agricultural) facility	Moderate P loadings to surface water resources Improve assimilative capacity of streams Increase local habitat diversity Augment base flow	Increase awareness of the effectiveness and benefits of this technology Installation of an opera-tional facility to assist one or more stake-holders in the study area Increase the effluent quality from an existing generator Build partnerships among stakeholders	Number of visitors/ brochures Effluent monitoring (inflow/outflow) from wetland Benefit-cost analysis of effluent quality improvements com-pared to traditional technology for similar improvement Identification of habitat or other benefits observed Survey of operators experience	• Municipal waste water facility • Industrial wastewater facility • Local naturalists and sportsmen groups • Ducks Unlimited • OCWA • MOE	High $125K per ha constructed including design fees (based on recent project in Brighton, ON)	Moderate	• Focus Groups • Infrastructure Survey • Key Informants • Phase 2 WQ Analysis
Treatment Wetland for Rural Residential Sewage Treatment	Surface water receiving effluent from defective/ deficient septic systems or areas where soil conditions are less than ideal for standard septic systems	Septic systems may be contributing nutrient and bacteria to surface water or wells due to improper maintenance, poor/inadequate design or failure	Install a selected number residential scale constructed wetlands for treatment of household wastewater Compare efficiencies to standard septic systems for given soil conditions Identify additional environmental benefits of wetland systems	Reduce nutrient and/or bacteria loading to water resources in sensitive areas Increase local habitat and biodiversity	Demonstrate cost effective alternative to standard private septic systems Encourage adoption of technology as an alter-native to new septic systems Quantification of bene-fits through effluent monitoring	Number of visitors/ brochures Effluent monitoring (inflow/outflow) from wetland Benefit-cost analysis of effluent quality improvements com-pared to traditional technology for similar improvement Identification of habitat or other benefits observed Survey of residents experience	• Private Landowners • Rural Waste Water Centre • Contractors • Technology leaders • Ducks Unlimited • MOE • Health Unit	Low $1.5K to 7K depending on size and design requirements	Low	• Community Survey • Open Houses • Focus Groups • Phase 2 Rural Servicing Analysis
Precision Farming	Areas of intensive cropping	Application of nutrients above crop/field require-ments increasing nutrient loading to surface water and affecting assimilative capacity of receiving stream	Evaluate the cost effectiveness of using precision farming methods for reducing on-farm chemical use Evaluate the environ-mental and economic benefits of any reduction in chemical use	Reduce nutrient and chemical application to agricultural land Maintain or improve agricultural production Reduce nutrient and chemical loading to surface water in sensi-tive areas	Provision of additional local data and experience to area farmers Quantification and assessment of relative environmental and economic benefits for Eastern Ontario Conditions	Quantification of input reduction Cost benefit analysis of time, input and yields versus cost of technology, etc. Identification of environmental benefits from reduced inputs, fuel cost and equip-ment passes Farmer feedback on the experience/process	• Farmers • Equipment manufac-turers/retailers • Chemical suppliers • AAFC • OMAFRA • Agricultural Organizations	Low to Moderate	Moderate	• Community Survey • Phase 2 Agricultural Assessment • Open Houses

TABLE 9.3
POTENTIAL DEMONSTRATION PROJECTS CHARCTERIZATION

				Performance Measures						
POTENTIAL DEMONSTRATION PROJECTS	**Sensitive Area**	**Nature of Sensitivity**	**Project Objectives**	**Environment and/or Health Objectives**	**Nature of Expected Benefits/Results**	**Demonstration of Results**	**Potential Stakeholders/Partners (in addition to munici-palities and CAs)**	**Relative Project Costs**	**Ease of Implementation / Demonstration of Results**	**EOWRMS Cross Reference**
Catch Basins/Ponds (manure/sludge spreading)	Land areas receiving livestock manure or sewage sludge treat-ments	Weather conditions and/or applications accidents/spills	Installation and monitors as a means of moderating nutrient delivery to surface water bodies Use catch basin to monitor potential nutrient delivery under different conditions and times of year Examination implica-tions for nutrient management planning	Reduce nutrient and chemical loading to surface water in sensitive areas Reduce risks associated with spills or rain during spreading	Demonstrate the bene-fits/effectiveness of catch basins in moderating nutrient transport to surface waters following manure/sludge applica-tions Demonstrate possible water quality conse-quences of application under less then ideal conditions Examine efficiency of nutrient management on a farm enterprise basis	Water quality and sediment monitoring Calculation of reduced loadings Farmer feedback on the experience/process	• Farmers/ Landowners • Sludge Disposal Contractors/ Companies • Technology Manufacturers • Contractors • OMAFRA • AAFC • Farm organizations	Low $2-6K depending on size, plus modest staff time for monitoring	Low to Moderate	• Community Survey • Phase 2 Agricultural Analysis
Livestock Manure Composting	Areas of livestock-based agriculture with high volumes of manure for use/disposal	Volumes of manure produced can be in excess of the capability of the land base to accommodate application in “raw” state	Evaluate the chemical, environmental and economic impacts of on farm composting technologies for animal manure	Reduce nutrient and bacteria loading to stream from run off associated with manure spreading	Evaluation of the effects and appropriateness of manure composting methods for Eastern Ontario conditions Documentation of potential reductions in volumes of raw manure requiring disposal and implications for nutrient management and farm enterprise planning	Cost-benefit analysis Nutrient content analysis of composted product versus uncom-posted Yield effects Field level monitoring of runoff Farmer feedback on the experience/ process	• Farmers/ Landowners • University Researchers • Farm Organizations • Technology Manu-facturers/ Leaders • OMAFRA • AAFC	Moderate 1 project manager/ principal researcher (full time depending on number of trials) Could use a graduate student for lower cost) $40-50K plus $3-5000 per diem/expenses per cooperating farmer.	Moderate to Low	• Phase 2 Agricultural Analysis • Open Houses • Community Survey
Stormwater Effluent Monitoring	Area receiving discharge from stormwater detention facilities	Quantification of stormwater quality in the study area is largely undocumented	Develop a protocol and collect monitoring data for selected stormwater control facilities Determine effectiveness of facilities in improving water quality Suggest/Modify develop-ment standards for new facilities based on monitoring results Coordinate data collec-tion with the Ontario Stormwater Assessment Monitoring and Perfor-mance (SWAMP) Program	Improve effectiveness of stormwater detention facilities in improving water quality	Provide baseline data for monitoring the effectiveness of existing and new stormwater management facilities Assist in targeting and demonstrating other proposed projects (e.g. household garden chemical use) Provide information to support development of local standards for new development Data coordination and sharing with SWAMP	Water quality monitoring results (inflow out flow) for desired parameters	• SWAMP/MOE • Developers • Technology Leaders • Contractors • Residents Associations	Low Staff person sample collection plus lab fees $1K per year per site plus reporting time	High	• Household Survey • Phase 2 WQ Analysis
Buffer Strips	Areas of Intensive Cropping or Livestock Activities in proximity to surface water resources	Field run off can carry nutrients and other chemicals loadings directly to surface water affecting quality and assimilative capacity of receiving stream	Promote the installation and maintenance of buffer strips	Reduce nutrient and/or bacteria loading to water resources in sensitive areas Increase local habitat and biodiversity	Increase public aware-ness Increase adoption of the BMP Improvement of local water quality and stream habitat	Area and number of strips installed 2- or 3-year follow up inspection	• Farmers/ Landowners • Contractors • OMAFRA • AAFC • Farm organizations	Low Approximately $500-2,000 depending on length, width and plantings	Moderate	• Technical Advisory Group

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Groundwater										
Wellhead Protection Planning **(The concepts and practice of wellhead protection planning are well developed in the US; however this has been very rare practice, particularly in rural Ontario)**	Municipal water supply wells/well fields	Risks to quantity/quality of drinking water supply from potential effects of adjacent land uses and activities	Development of method(s) and guide-lines for undertaking a wellhead protection planning exercise in rural Eastern Ontario Develop a partnership with a municipality to undertake the exercise on a pilot basis	Enhance and protect the integrity of groundwater resources Minimize risks to groundwater supply contaminant	Increase public aware-ness of wellhead pro-tection planning and groundwater resources Formal identification of potential threats to secure groundwater supply Development and testing of planning methods and approaches for rural areas A locally endorsed well-head protection plan	Development of a multi-stakeholder committee to oversee process Ratification of a Terms of Reference for the projects Completed well head protection plan docu-ment Formal survey/feed-back from participant stakeholders	• Industry • Farmers • Local Businesses • Other landowners • MOE • MNR • OMAFRA • OCWA	Moderate to High depending on scale of project and nature of any desired implemen-tation Assume 1 full time project manager at $40-50K per year Expenses for $10K for coordination, plus possible consulting fees for studies	Low to moderate	• Technical Advisory Group • Focus Groups • Open Houses • Community Survey • Key Informants • Phase 2 Ground-water Analysis
Recharge Area Protection Planning	Groundwater recharge areas	Risks to groundwater aquifer quality and quantity from potential effects of adjacent land uses and activities	Development of method(s) and guide-lines for undertaking an aquifer recharge and protection planning exercise in rural Eastern Ontario Develop a partnership with a municipality to undertake the exercise on a pilot basis	Enhance and protect the integrity of groundwater resources Minimize risks to groundwater supply contaminant Maintain and protect habitat and biodiversity	Increase public aware-ness of aquifer recharge protection planning Formal identification of potential threats to secure groundwater supply Development and testing of planning methods and approaches for rural areas A locally endorsed aquifer recharge area protection plan	Development of a multi-stakeholder committee to oversee process Ratification of a Terms of Reference for the project Completed recharge protection plan document Formal survey/feed-back from participant stakeholders	• Industry • Farmers • Local Businesses • Other landowners • MOE • MNR • OMAFRA • OCWA • Ducks Unlimited	Moderate to High depending on scale of project and nature of any desired implementation Assume 1 full time project manager at $40-50K per year Expenses of $10K for coordination, plus possible consulting fees for studies	Low to moderate	• Focus Groups • Community Survey • Phase 2 Aquifer Recharge/Discharge Analysis
Private Well Audits/Risk Assessment	Private water supply wells	Many landowners are not fully aware of proper well functioning, maintenance and safety practices	Conduct onsite audits of water well system operation and integrity on a voluntary basis and provide written assess-ment with recommen-dations	Reduce risk of con-tamination of drinking water supply Improve drinking water quality	Increase public awareness Improve efficiency/safety of inspected systems Identification of major deficiencies/risks	Number of audits Follow up records of actions taken, including cost of remediation Before and after sampling of in-house water quality for water quality improvement following actions	• Landowners • MOE • OMAFRA • Health Unit • Local Organizations • Baselline Water Well Testing Program	Low $200-300 per property	High	• Focus Groups • Community Survey • Key Informants • Open Houses • Phase 2 rural servicing analysis
Abandoned Well Identification/Capping	Abandoned/unused wells	Abandonment or improper decommis-sioning of wells can contribute to ground-water contamination	Assist landowners in the identification of unused wells Inspect integrity of pre-viously decommissioned wells Provide information/ guidance on landowners responsibility for proper decommissioning of wells and funding pro-grams	Reduce risk of contami-nation of drinking water supply Improve drinking water quality Reduce safety hazards associated with aban-doned wells	Increase public aware-ness of unused wells Identification of unused wells Enhance the effective-ness of existing local initiatives Increase rate of aban-doned well decommis-sioning	Number of wells identified Number of well capped Monitoring for water quality effect on adjacent supply wells	• Landowners • Contractors • MOE • Local organizations • Colleges and Universities	Low 1 or two qualified summer students ($6-14 k per year)	High	• Focus Groups • Community Questionnaire

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Residential Treatment Technologies (e.g. reverse osmosis)	Private water supply wells	Poor intrinsic potable water quality	Demonstrate effective-ness of commercially available treatment technologies to improve the intrinsic water quality from private services	Improve drinking water quality from private wells	Demonstrate the ability to improve water quality from private sources Demonstrate feasibly of providing higher quality potable water from private supplies Reduce expectations for "municipal" services	Number of units installed/sold Pre and post instal-lation water quality monitoring Feedback and testi-monials from users	• Landowners on private water supply • Technology manufacturers • MOE • Contractors	Moderate $400-2000 per unit retail plus installation	High	• Open Houses • Focus Groups • Community Questionnaire
Fuel Storage Technology	Farms and other businesses required to store large quantities of fuel	Risk to surface and groundwater resources from fuel leaks or spills due to inadequate storage or handling	Demonstrate effective-ness and proper use and maintenance of commercially available fuel storage tech-nologies	Reduce/Minimize risk for water resource contamination from fuel leaks or spills due to inadequate storage or handling Improve local water quality	Reduce risk to water resources from inade-quate fuel storage and handling	Number of visitors/ brochures	• Landowner • Technology manu-factures/retailers • Fuel dealers • MOE • OMAFRA • Local organizations	Moderate $5-25K depending on the nature and extent of the site	High	• Technical Advisory Group
Servicing Infrastructure/ Water Conservation (Demand management of water can reduce or delay infrastructure cost for municipal and private water and wastewater systems.)										
Water Use in the House (metering/use calculations)	Groundwater and surface water supplies and septic systems	Many homeowners are unaware of the quantity of water that they use Data on rural domestic consumption patterns is lacking	Actively measure household water use across a range of households/businesses	Reduce water use	Increase public aware-ness of volumes domes-tic water consumption Provide a benchmark for assessing/measuring effectiveness of water conservation actions	Number of participant/ subscribers	• Technology Manufacturers • Local organizations • MOE • OPG	Low 1 project coordinator half time @ $15-20K If meters uses $200-300 per meter installed	High	• Open Houses • Community Questionnaire • Focus Groups
Residential Water Audits and Retrofit Kits, including toilet replacement	Municipal and Private Servicing Infrastructure	Capacity of municipal and private systems to effectively/economically meet water supply and wastewater treatment demands Reduced water supply and wasterwater treatment demand	Conduct residential water audits and distribute retrofit kits Incentives for toilet replacements to low volume models	Reduce water use Improve efficiency of septic systems	Public education and awareness of simple water conservation techniques Immediate reduction water uses and waster water generation	Number of kits/toilets distributed and/or sold Estimates of water and wastewater use savings (municipal and or private)	• Equipment Manufac-turers • Local business and organizations • Utilities	Low Retrofit kits $20-30 per unit, low flow toilets $200 per unit plus installation Contractor audit @ 100/houhehold Self audit via education material with retrofit kit. Cost of developing material, $2-3K plus printing	High	• Phase 2 Water Budgeting • Community Survey • Open Houses • Focus Groups
Water Metering **(some communities have water meters installed but do not use them for water pricing/cost recovery)**	Municipal infrastructure and public awareness of water consumption and costs	Water supply and wastewater treatment demand	Institute a water metering/pricing strategy in selected communities	Reduce/ defer municipal water and wastewater treatment requirements/ costs	Demonstrate the effec-tiveness of municipal water metering in reducing water use and cost recovery for con-servation programming and infrastructure maintenance	Measured water savings	• Equipment manufac-turers • OCWA	Moderate $225-per meter installed depending on manufac-tures and technology (e.g. manual read or remote-electronic read)	Moderate to high	• Phase 2 Water Budgeting • Community Survey • Open Houses • Focus Groups

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Lawn Watering Restrictions	Municipal and Private Servicing Infrastructure	Peak demand (daily and seasonally) Low yielding wells or municipal supply systems with limited capacity (peak or average)	Formalize water use regulations in selected jurisdiction	Reduce water use	Demonstrate the effec-tiveness of reduce water use and cost recovery for conservation programming and infrastructure main-tenance	Measured/calculated water savings	Community Organizations OCWA	Low Advertising and aware-ness campaign ($10K per year)	Low	• Phase 2 Water Budgeting • Community Survey • Open Houses • Focus Groups
Education and Awareness										
Continue EOWRMS Newsletter	Public Awareness and support	Maintain regional focus and increase momen-tum generated by the Study	Use the EOWRMS newsletter as a vehicle for promoting and communicating with the public on regional water management beyond the study	Increase development of a water ethic through-out the region Increase adoption rate of relevant BMPs with associated water quality improvements	Provide a regional focus and identify to water management issues in Eastern Ontario	Secure funding/ commitment to con-tinue water resources reporting to the public on a regional basis	• EOWRMS Partners • Local organizations and businesses • Schools and Universities • Government agencies and departments	Moderate Newsletter development cost of $3-5K per issue, plus printing and distribution costs assuming full regional distribution	High	• Phase 1A Communications Plan Development • Open Houses • Community Questionnaire
Demonstration Project Database	Dissemination of prac-tical local experience with surface water and groundwater protection and enhancement	There is no a central resource for local initiatives	Develop and promote a user-friendly database showcasing results and lessons learn from projects undertaken in Eastern Ontario	Increase development of a water ethic throughout the region Increase adoption rate of relevant BMPs with associated water quality improvements	Increase public aware-ness of local BMP successes and partner-ships Provision of valuable information for people and partnerships contemplating similar projects Creation of a “community memory” for land and water resources stewardship	Number of records in the database Use tracking via internet access or other means	• Schools and Universities • Local organizations and businesses • Internet Service Providers • AAFC	Moderate 1 full time staff at $30-35K per year, assume 10-16 months to develop and implement database	High	• Focus Groups • Open Houses
Farm tours	Community awareness of agricultural and environmental management	Possible misconcep-tions/misinformation within the non-farm community concerning net environmental implications of farming	Provide the non-farm public with first hand experience of on-farm environmental manage-ment and production agriculture	Increase development of a water ethic throughout the region Increase adoption rate of relevant BMPs with associated water quality improvements	Increased public aware-ness of agriculture and environmental manage-ment	Number of cooperating farmers Number of tour partici-pants Formal evaluation of the experience of cooperators and parti-cipants	• Farmers • Schools and Universities • Travel clubs • Local organizations • Farmers markets	Low $5-20K depending on volunteers, sponsor-ships, and fees	Moderate	• Focus groups • Community Survey • Open Houses
Special Water Days/Events/ Festivals (general, kids, high school, seniors, business)	Public awareness and appreciation of the role and importance of water to community develop-ment and health	Need to heighten public awareness and capacity development and develop partnerships	Develop and implement a local “water festival(s)”	Increase development of a water ethic throughout the region Increase adoption rate of relevant BMPs with associated water quality improvements	Increase public awareness of the role and importance of water Develop community partnerships across sectors	Nature and extent of cooperators/donors Number of participants over time Formal evaluations of experience	• Local schools and business • Childrens' Water Institute	Moderate $15-40K based on experiences in other regions, plus sponsor-ship and nominal fee for participants	Moderate	• Focus Groups • Open Houses

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Existing Demo (Implemented)Project Tour	Numerous projects in place and functioning in the study area	Lack of public aware-ness of local practical and successful projects because local informa-tion is limited	Create a tour or demon-stration days program to showcase existing successes	Increase development of a water ethic throughout the region Increase adoption rate of relevant BMPs with associated water quality improvements	Increase public aware-ness of existing pro-grams and enhance receptiveness to under-take projects of their own	Number of cooperators Number of tour participants Formal evaluation of the experience of cooperators and participants	• Existing demo project cooperators • Local organizations • Travel Clubs	Low $5-20K depending on volunteers, sponsor-ships and fees	High	• Open Houses • Key Informants
Committees/Coordination of water related information and programs	Overlapping political, watershed and aquifer/ recharge areas and programs	Coordinating and leverage of existing and future programs, proposals, funding, on a water resource basis	Create and test a regional body to assist in the development, delivery and manage-ment of programs on a water resource basis	Increase development of a water ethic throughout the region Increase adoption rate of relevant BMPs with associated water quality improvements	Realization of benefits of economies of scale for selected programs (e.g. water conserva-tion) Moving beyond water-shed for the protection and management of groundwater resources	Ratified Terms of Reference for Committee	• Everyone	Moderate 1 half time coordinator @ $15-18K per year	Low to moderate	• Focus Groups
Guest Speaker Series	Motivation of the public and stakeholder to take action	Uncertainty among individuals or groups about taking on challenges and the possible benefits of small steps or actions	Develop a speakers series to motivate local citizens/groups to be proactively involved in water resource manage-ment	Increase development of a water ethic throughout the region Increase adoption rate of relevant BMPs with associated water quality improvements	Motivation of citizens through hearing/learning of success of others	Nature and extent of series Number of participants Formal evaluation Media and other exposure	• Individual and/or organizations with success stories to share in community-based water resource management • Local organizations • Schools and Universities	Low $1-3K per event depending on volun-teers, sponsorships and fees	Moderate	• Open Houses
Information Clearing House/Coordination centre	Public Awareness and information	Public awareness and Economies of scale from regional level programming	Develop a regional "water resources infor-mation center" to pro-vide a central focus for information dissemi-nation and possible coordination of regional events and sponsor-ships	Increase development of a water ethic throughout the region Increase adoption rate of relevant BMPs with associated water quality improvements	Streamline services for citizens to gain infor-mation/referrals on local/regional water resources and issues	Use and profile of the service Number of "clients" using the service and materials Future regional house-hold survey on percep-tion and attitudes and actions on water resources and their management	• Local organizations • Schools and univer-sities • Federal and Provincial Government agencies	Moderate Cost highly variable depending on the nature of collaborative arrangements and potential to lever existing institutions Assume 1 person half time @ $15-20K plus operating expenses of $10K	High	• Open Houses • Focus groups
Conference/Workshop	Public Awareness and information	Provide feedback to share results and lessons learned from EOWRMS demo projects	Organize a conference/ workshop to share and disseminate results of implemented EOWRMS Projects and initiatives	Increase development of a water ethic throughout the region Increase adoption rate of relevant BMPs with associated water quality improvements	Provides a central and coordinated vehicle to share and disseminate information	Nature and extent of events Number of participants Media and other exposure Formal evaluation	• Everyone	Low to moderate $5-20K per event depending on scale, scope, volunteers, sponsorships and fees etc.	High	• Open Houses • Focus groups

Social Marketing

Social marketing involves the planning and implementation of programs designed to bring about social change using concepts developed from traditional commercial marketing. One example of marketing for social change might be water conservation in the home. Social marketing seeks to influence social behaviours in a way that benefits the target audience (e.g. homeowners) and general society (watershed and its water resources), rather than benefiting the marketer.

Like commercial marketing, the primary focus is on the consumer—the goal is to learn what people want and need rather than attempting to persuade them to “buy” what the marketer is producing. Commercial marketing talks to the consumer, not about the product. The planning process takes this consumer focus into account by addressing the elements of the “marketing mix.” This refers to decisions about:

1. Product
2. Price
3. Place (distribution)
4. Promotion

Collectively, these are often called the "Four Ps" of marketing. Social marketing adds a few more “Ps”, as discussed below (Weinreich, 1999).

Product. The social marketing “product” is not necessarily a physical offering, it is often an idea or a behaviour. A continuum of products exists, ranging from tangible, physical products (e.g. low flow toilets), to services (home inspections), practices (e.g. chemical free gardening) and finally, more intangible ideas (e.g. environmental or water resources protection). In order to have a viable product, people must first perceive that they have a genuine problem, and that the product offered is a valid and realistic solution for that problem. The role of research in marketing is to discover consumers’ perceptions of the problem and the product and to determine how important they feel it is to take action against the problem.

The EOWRMS project has produced extensive “marketing” information on people’s perceptions and attitudes regarding water resources protection and management. A significant resource for this information is the Water Resources Survey and feedback back from the public consultation program.

Price. “Price” refers to what the consumer must do in order to obtain the social marketing product. This cost may be monetary (e.g. the purchase of a low flow toilet), or it may instead require the consumer to give up intangibles, such as time or effort, or to risk embarrassment and disapproval. If the costs outweigh the benefits for an individual, the perceived value of the offering will be low and therefore it is unlikely that it would be adopted. However, if the benefits are perceived as greater than the costs, the chances of trial and adoption of the product is much greater.

There are many issues to consider in setting the price, particularly for a physical product, such as home water retrofits kits. If the product is priced too low, or provided free of charge, the consumer may perceive it as being of low quality. On the other hand, if the price is too high, some consumes will not be able to afford it. Social marketers must balance these considerations, and will often end up charging a nominal fee in order to increase consumer perception of quality and to confer a sense of "dignity" to the transaction. The perceptions of costs and benefits can be determined through research and are used in positioning the product. The experience of offering the same products in different locations can also be invaluable. An example to consider is the Region of Waterloo's contribution of a small grant to local households to replace their toilets with water efficient models.

Place. "Place" describes the way that the product reaches the consumer. For a tangible product, this refers to the distribution system--including the warehouse, trucks, sales force, retail outlets where it is sold, or places where it is given out for free. For an intangible product, place is less defined, but refers to decisions about the channels through which consumers are reached with information or training. This may include libraries, Conservation Authorities, town halls, the media, or site-specific demonstration projects. Another element of place is deciding how to ensure accessibility of the offered product and quality of the service delivery.

Promotion. The final "P" of commercial marketing is promotion. Because of its visibility this element is often mistakenly thought of as comprising the whole of marketing. However, as can be seen by the previous discussion, it is only one element of the marketing process. Promotion consists of the integrated use of advertising, public relations, promotions, media advocacy, personal selling, and entertainment vehicles. The focus is on creating and sustaining demand for the product. Public service announcements or paid ads are one method, but there are other methods such as mailings, media events, editorials, annual festivals/events, etc. Research is crucial to determine the most effective and efficient vehicles to reach the target audience and increase demand for the product. The primary research findings themselves can also be used to gain publicity for the program at media events and in news stories.

The Additional "Ps" of Social Marketing

Partnership. Environmental issues are often so complex that one agency can't make a significant impact by itself. Teaming with other organizations in the community can significantly increase efficiency. A key step in building partnerships is to identify which organizations have similar goals and methods of working together to create win-win situations for projects and water resources.

Policy. Social marketing programs can motivate individual behavioural change. However, this motivation can be difficult to sustain unless the environmental policy supports that change for the long run. Often, policy change is needed, and effective media advocacy programs can complement a social marketing program. Support and buy-in from local government and politicians is crucial to the success of programs.

Politics. The issues addressed by social marketing programs are often controversial, such as water metering or nutrient management, or complex, such as groundwater protection. Political diplomacy with community organizations and potential protect partners is necessary to gain support, to acquire access to the target audience, or to deal with confrontation or misinformation.

9.5.2 Social Marketing in Practice

The preceding section has provided a background on the fundamentals of a social marketing to addressing environmental issues. OMAFRA has suggested a six-step process for putting social marketing ideas into action (Shewchuk 1994). These steps are present below and would be applicable to demonstration project programming in Eastern Ontario.

Step 1 – Getting Started

Define the issue and research its key details. Learn all you can about the subject; then assess your resources, the things in your favour. Current public attitudes and social are vital considerations in determining favourable resources; something that was a valuable resource a decade ago may now be viewed as a liability.

Step 2 – Planning and Developing the Strategy

Identify the target audience, establish project goals and objectives, identify the benefits to you and your audience, and select techniques to assess project progress. The project goals and objectives must be realistic and tangible

Step 3 – Developing Materials and Activities

Decide what the central message will be; then plan the media activities, special events and other promotions that will help communicate the message.

Step 4 – Write Your Communications Plan

This is the 'make or break' point. Carefully review everything done so far and note the following: issue, goal, objectives, target audience, benefits to audience, delivery methods, resources, potential problems, indicators of success, and assessment methods. Then set a manageable time frame for the program. This timeframe becomes the project's road map for action; therefore, it must be recorded.

Step 5 – Implement The Plan

Prepare the launch of your campaign. Work with community leaders to help ensure the message is at least considered by the people who can influence the project. As the plan unfolds, don't hesitate to review and revise as necessary; nothing is so damaging as proceeding with something that is known to be flawed.

Step 6 – Measure Your Results

This is the step that determines if the process was successful. Write an honest, detailed assessment report; this can help pinpoint both the weak and strong points for any future campaigns.

Much of the literature and experience with social marketing is rooted in health care applications. Health Canada provides an online tutorial that helps community groups define and develop a social marketing program. While the focus is health planning, the content of the tutorial is largely generic and can be easily applied to the EOWRMS context for demonstration projects. This tutorial can be accessed at: http://www.hc-sc.gc.ca/hppb/socialmarketing/.

It is suggested that a regional committee be established to coordinate the detailed development and implementation of demonstration projects. This committee could serve as a central body to develop required level funding proposals, although specific projects could be undertaken on a partnership and / or subcommittee basis.

9.5.3 Example Funding Sources for Demonstration Projects

A look at the promotional material for almost any rural or environmentally focused program or demonstration illustrates the importance of partnerships in bringing good ideas to action. The multitude of actors involved in these programs is a result of both multi-stakeholder nature of the issues as well as government funding requirements and restrictions. Often government programs can provide a significant contribution toward projects and initiatives (i.e. typically up to 50 percent of project costs), with the expectation that the remaining portions will be provided from other sources. Sources for additional funding typically include other governments, non-government organizations, private foundations, donations, and in-kind contributions.

The following list of funding programs is designed to provide the EOWRMS partners with a starting point for developing strategic arrangements to implement demonstrations in the future. The list is not meant to be exhaustive, but to provide a basis of departure. Specific programs will ultimately require a unique mixture of partners to bring each to fruition.

Healthy Futures for Ontario Agriculture (Ontario Ministry if Agriculture and Food)

http: / / www.gov.on.ca / OMAFRA / english / infores / hfoa /

Healthy Futures for Ontario Agriculture invests in three main program initiatives:

- Rural Water Quality...focuses on implementing BMPs or technologies in the agree-food sector to safeguard water quality and quantity in rural Ontario.
- Field to Fork Food Safety and Quality...provides funding and access to technical expertise to the agri-food sector to assist it to maintain and expand its capacity to meet domestic and export market demands with regard to food safety and quality.
- Healthy Futures Innovation...provides business assistance to support applied research, new product development, expanded market access and the creation or adoption of technologies, practices and processes that enhance food safety and water quality. This includes implementing new verification and reporting systems.

The bottom line:

- In most cases government funding is available at up to 50 percent of total project costs
- Under special circumstances government funding may be available at up to 70 percent of total project costs
- Up to 25 percent of eligible costs can be for equipment needed for the project
- Funding from other provincial or federal programs will be included in the calculation for determining the Healthy Futures investment
- In-kind contributions will not be recognized

Canadian Rural Partnerships Pilot Projects

http://www.rural.gc.ca

The 1998 Federal Budget confirmed funding of $20 million over four years for the Canadian Rural Partnership (CRP). The CRP is designed to support rural community development by adopting new approaches and practices to respond to rural development issues and concerns. Beginning with a series of pilot projects in 1998-99, the CRP works through partnerships that support rural Canadians as they pursue creative, community-based responses that promote sustainable community development.

Proposals for funding from the CRP should:

- Be innovative
- Demonstrate local impact
- Contribute to government priorities
- Demonstrate a multi-partner approach, including shared contributions
- Include an evaluation framework

Funding through the Canadian Rural Partnership is normally available up to a maximum of $50,000 per project or 1/3 of project costs, whichever is less. Proposals need to be done on a partnership basis, often including a federal department, as well as other partners, such as a province, the private sector, or a non-governmental agency. Preference will be given to projects with more than one partner. The Pilot Projects Initiative will be continued until 2002.

Agricultural Environmental Stewardship Initiative (AESI)

http://www.adaptcouncil.org/

On June 9, 2000, Agriculture and Agri-Food Canada (AAFC) announced the $10 million, three-year (2000–2003) Agricultural Environmental Stewardship Initiative (AESI). The AESI is a national program that allocates funds to the agriculture and agri-food sector in each province or territory. The AESI program will assist in supporting projects involving education and awareness, technology transfer, and stewardship tools that will help address the impact of agricultural practices on water, soil, air, and wildlife biodiversity. The Ontario portion of this program is approximate $2.5 million and is being administered by the Agricultural Adaptation Council (AAC) in partnership with the Ontario Farm Environmental Coalition (OFEC). Pending the outcome of ongoing consultation the Ontario AESI will focus on: on-farm implementation of BMPs specific to water quality improvement, food processor manufacturing process audits, and wildlife habitat demonstration projects.

Great Lakes Sustainability Fund (Environment Canada)

http://www.on.ec.gc.ca/green-lane/cuf

The Government of Canada’s Great Lakes Sustainability Fund was announced in July 2000. This $30 million, five-year program will fund projects that accelerate the restoration of environmental quality in Canada's 16 remaining Areas of Concern. The Fund will ultimately result in an improved quality of life for basin residents and an important legacy for future generations. This program is the predecessor to the Great Lakes Clean up Fund.

EcoAction Community Funding Program (Environment Canada)

http://www.on.ec.gc.ca/ecoaction/home.html

The EcoAction Community Funding Program provides financial support to community groups for projects that have measurable, positive impacts on the environment. Non-profit groups and organizations are eligible to apply to the Funding Program. This includes, but is not limited to: community groups, environmental groups, aboriginal groups, and First Nations councils, service clubs, associations, and youth and seniors' organizations.

EcoAction encourages projects that protect, rehabilitate or enhance the natural environment, and build the capacity of communities to sustain these activities into the future. Projects require matching funds or in-kind support from other sponsors. Priority for funding is given to projects that will achieve results in the following areas: Clean Air and Climate Change, Clean Water, and Nature. Submission deadlines to the Funding Program are February 1st and October 1st annually. Funding is available up to a maximum of $100,000; however, the average amount is $25,000

The program Internet site provides links to many online resources to help community organizations prepare funding applications and proposals and also contains suggestions for build partnerships to implement projects. This site also has an online catalogue of organizations that provide funding for environmental projects.
(http://www.on.ec.gc.ca/ecoaction/funding.html).

Green Municipal Investment Fund (GMIF) and the Green Municipal Enabling Fund (GMEF) [Government of Canada and Federation of Canadian Municipalities (FCM)]

http://www.fcm.ca/

Agreements signed between FCM and the federal government in March 2000 established two multi-million dollar funds to encourage investment in best practice and innovative municipal environmental projects; the $100-million Green Municipal Investment Fund (GMIF) and the $25-million Green Municipal Enabling Fund (GMEF). Fund priorities include improvements in air, water and soil quality, and climate protection – through more efficient energy, water, wastewater, transit and solid waste management systems, for example. Intense competition for scarce financial resources often prevents municipal governments from launching such beneficial and cost-effective environmental projects due to high up-front capital costs, long payback periods, cautious traditional lenders, municipal policies, or provincial/territorial regulations. The funds will help municipal governments target initiatives that improve the eco-efficiency of their operations.

Municipal governments and/or their public or private sector partners can apply to the Funds (with the exception of provincial/territorial governments). The Enabling Fund will cover up to 50 percent of the cost of feasibility studies, while the Investment Fund will offer a range of financial services aimed at improving the financial performance of proposed projects.

Municipal governments, particularly small or rural communities, could access interest-bearing loans (generally covering no more than 15 percent of the capital costs of projects) or loan guarantees from the Investment Fund to supplement their own and / or provincial/ territorial government grants or private sector financing.

Fund initiatives focus on improving the energy or process efficiency of:

- Energy services (i.e. community energy systems, waste heat capture or landfill gas recovery)
- Municipally-owned and / or operated buildings and facilities
- Public transportation technologies and / or fleets
- Renewable energy technologies
- Solid waste management
- Storm runoff management
- Wastewater treatment services
- Water distribution and / or water conservation

The Funds were announced in Finance Minister Paul Martin's 2000 budget, and will be administered by the FCM in coordination with provincial counterparts.

In addition to the above, there are federal and provincial government programs to assist with youth and student employment. These programs could be levered to staff some demonstration project needs.

9.6 Key Findings

There is broad based public support for undertaking a more proactive and direct approach to conserving, protecting and enhancing water resources in the study area.

Study partners already have significant experience in developing, implementing and managing demonstration project water resource protection and enhancement initiatives.

A total of 30 demonstration projects and initiates are identified for application to water resources issues and concerns within the study areas. Some projects have universal application and others can be targeted to sensitive areas within the study.

Some potential project partners have already stepped forward in the course of the study and offered to assist in implementing selected projects.

9.7 Relevance to Regional Water Strategy

Demonstration projects are about influencing behaviours and attitudes. They are intended to serve as models of best practice. Demonstration projects are one of the tools to help effect promotion and implementation of specific actions under of the regional water strategy. Municipal by-laws are another tool.

Demonstration projects are also about building partnerships, knowledge, and wisdom. Like air, water is a shared common resource in Canada. Water is used and reused countless times within a watershed by all sectors of society. Given the cross cutting nature of the resource, partnerships are essential for building good demonstration projects. Bringing together diverse interest with shared, or at least similar, goals helps in building a water ethic within the community. Part of this ethic also involves recognizing the circumstances, practices and constraints of others in the region who use, value and effect the resource in different ways. The development, nurturing and endurance of this ethic is a critical factor that will lead to the long term success of the strategy.. This ethic can go along way to enhance the resource and deferring or eliminating infrastructure requirements.

9.8 Recommendations

All of the project suggestions in this study have merit. Some of the projects have universal application (e.g. public education or water conservation), while other have a more targeted application (e.g. buffer strips or storm water monitoring). The following recommendations are made to the recognition of existing programs and initiatives (e.g. clean water programs).

Based on the results of the study the following projects are suggested for priority implementation. These projects are deemed to have the greatest potential for yield water resource improvement or protection. These projects support the specific initiatives and actions suggested in the regional strategy and, in some cases, serve to strengthen or complement existing programs.

- Universal Application
  - Residential Water Audits/Retrofits
  - Well and Septic Audits
  - Abandoned well identification and capping
  - Water resource information centre
  - Water festival/event
- Targeted Application
  - Buffer Strips
  - Constructed Wetland for Municipal Waste Water Treatment
  - Wellhead Protection Planning
  - Recharge Area Protection Planning
  - Total Phosphorus Management

10. Action Plans and Implementation

10.1 Study Highlights

The policy and regulatory framework for water resources management in Eastern Ontario is highly fragmented. The existing database could be characterized as incomplete, inconsistent, and scattered amongst a variety of agencies. No comprehensive inventory or assessment has ever been undertaken of what information exists and how it could be best used in making decisions on water resources management.

A key accomplishment of this study, therefore, was to identify, assemble, and produce a regional-scale digital water resource database. This database has brought together information on climate, water quality, water quantity, servicing infrastructure, land use, and public opinion from diverse sources. This information has been reformatted digitally to produce a comprehensive tool for managing the single most important natural resource in the area. This tool will become an invaluable resource within the study area for community planning; managing water and sewage infrastructure; and empowering municipalities, conservation agencies, rural organizations, and the public to take action, monitor change, and take charge of managing their water resources.

The database has been used in the study to analyze groundwater and surface water resources and to develop models for the management of land and water resources. These activities have consolidated the different data sets to provide a broad and detailed account of water resources in the study area. Some of these are described below.

A regional water budget was developed to model in detail the various components of the hydrologic cycle as they affect the quantity and quality of water across the study area. This approach provided, on an annual basis, the net amount of groundwater and surface water available for use and development. The use of geographic information system (GIS) and digital data allowed this analysis to be undertaken on a 30-m grid basis, which provides a level of high resolution for a regional study. This is essential information for water resources planning and the allocation of water resources for various users.

Surface water analysis was undertaken for both the quantity and quality of water. A key component of this work was the assembly and manipulation of an incredibly large volume of raw data into a useable and interpretable form. This activity was essential for the identification and analysis of long-term trends in stream flows and surface water quality on a watershed and subwatershed basis.

Groundwater is also a key component as over two-thirds of the population depend on groundwater for their water supply. The groundwater analysis in this study developed a detailed characterization of groundwater resources across the region. Data from approximately 40,000 water well records were used to aid in the characterization. A groundwater system characterization at this level of detail was previously unavailable in the study area. The analysis identified aquifers with good potential for water supplies, identified critical recharge and discharge areas, provided an identification of the vulnerability of different aquifers to contamination, and highlighted the risks associated with water supplies from shallow overburden aquifers. The groundwater analysis provides a strong basis for development of land use and other policies for effective groundwater resources management on a local and regional basis.

The operation and maintenance of municipal water and sewage works is a local municipality responsibility. A major undertaking of the study was the development of a comprehensive database of all servicing infrastructure in the study area. This information had not been previously available in an aggregated form. A detailed list of different technology alternatives for meeting some of the challenges identified by the infrastructure characterization was developed. Case study analysis revealed that for municipalities facing critical capacity challenges, significant infrastructure expenditures will not be avoidable in the short-term. This analysis also pointed out the possible longer-term benefits of water conservation and demand management.

The characteristics of water demand were also developed on a regional basis. The overall level of water demand from municipal and private sources was allocated between surface and groundwater sources. This information had not been previously available and is critical in planning for water resource management. This analysis also identified significant gaps in the data on water use and demand and, consequently, the need to gain a better understanding of rural domestic water uses.

There was a strong emphasis on engaging the public in this study. A significant accomplishment was the universal mailing of two newsletters and a water resources survey to over 64,000 households and businesses in the study area. This survey provided important information for all aspects of the study in the areas of water quality and domestic treatment, types of water sources, and public attitudes towards water conservation and water resources management strategies.

10.2 Regional Water Resources Management Action Plans

The results of the characterization of regional water resources, land resources, and servicing infrastructure reinforce the need to develop and promote action plans to ensure that the quality and quantity of regional water and related land resources are maintained and possibly improved. A Regional Water Resources Management Strategy would comprise specific short-term and long-term action plans. Such a management strategy must incorporate conservation, preservation, protection, development, and long-term stewardship if the strategy is to be successful.

The Ontario Ministry of the Environment (MOE) is responsible for the management of water resources under the administration of the Ontario Water Resources Act. Other provincial ministries with interests in water management include Natural Resources (MNR), Agriculture, Food, and Rural Affairs (OMAFRA), and Municipal Affairs and Housing (MMAH). There also exist numerous federal, provincial, and municipal policies, bylaws, Acts, and regulations related to our water resources (Environmental Commissioner of Ontario, 2000). The effectiveness of this shared responsibility has been questioned, and perhaps the need to complete a study such as the Eastern Ontario Water Resources Management Study (EOWRMS) demonstrates the lack of coordination and leadership in managing water resources across the province. As a result, the responsibility for implementation of the action plans outlined in this report may be in question. However, as it has been widely acknowledged that management of water resources must be on a watershed basis, consideration should be given to delegating the responsibility for leading the implementation of the action plans to a single agency. Such an organization would need to be supported by all levels of government, both financially and technically. A proposed program to initiate the implementation is presented following the recommended action plans.

On the basis of the characterization of regional water resources, land resources, and servicing infrastructure presented in the preceding sections of this report, it is recommended that a Regional Water Resources Management Strategy for Eastern Ontario comprise preparation of the following principal action plans:

- Groundwater Resources Management Plan
- Surface Water Management Plan
- Water Efficiency Plan
- Wetland and Forest Preservation Plan
- Information Management and Distribution Plan
- Public Education and Awareness Plan

A summary of the key tasks that would need to be completed in order to implement these action plans is presented below.

10.2.1 Groundwater Resources Management Plan

The principal focus of a Groundwater Resources Management Plan would include:

- Groundwater Recharge and Discharge Area Protection
- Wellhead Protection
- Management of groundwater withdrawals

The four major steps in developing a groundwater resources management plan are:

1. Understanding the groundwater flow system and identifying areas that contribute water to the system
2. Identifying potential contamination sources, particularly in the sensitive areas that would be identified during Step 1
3. Developing and implementing policies and programs to manage potentially harmful land uses and activities in the sensitive areas, including establishing protection zones around municipal wells based on contaminant time-of-travel analyses
4. Developing awareness and education programs to make residents aware of groundwater resource management issues and to support strategy initiatives

Understanding the Groundwater Flow System

The completion of the groundwater analyses for the EOWRMS has addressed Step 1 on a regional scale, with the limitations described in Section 5. Future localized analyses of the groundwater system are appropriate where municipal and other high-capacity groundwater supplies have been developed.

Flow modelling of the groundwater system at a regional and local scale would provide a more detailed and reliable estimation of the groundwater flow budget and the supply capability of aquifer units. A groundwater model could also be used to evaluate future water quantity and quality conditions, such as the impacts of best management practices (BMPs), water conservation, climate change, etc. The groundwater mapping developed in this study provides the basis for constructing the three-dimensional groundwater model. Such a model can provide a useful tool to guide additional data collection efforts based on the most uncertain parameters and enhance understanding and groundwater quantity and quality predictions once that data has been obtained. Local-scale groundwater modelling should be used to define capture zones of municipal/communal well fields and evaluate their vulnerability.

Water quality data is currently sparse and outdated and this represents the greatest data gap in the groundwater analysis. Prior to developing a local groundwater supply, additional local-scale investigations would be designed to better characterize the local water quality, both from natural geologic and surficial contaminant sources. Once this data is available, potential groundwater supplies can be better evaluated considering the operational treatment costs of the water supply.

Well location accuracy checks would be undertaken locally in areas of potential additional groundwater supply to verify the water well data used to generate the maps in this study.

Identifying Potential Contamination Sources

The regional groundwater vulnerability analysis would be expanded to incorporate municipal/communal well capture zones, where available. Well capture zones will outline the surficial areas where recharge eventually reaches the existing supply well(s). Overlaying the well capture zones with the vulnerability zones will highlight the most sensitive areas for the current water supply wells, such that management and education efforts can be focussed in those essential areas.

An inventory of abandoned wells is required to evaluate the potential for any such wells being conduits for surficial contamination to reach otherwise protected aquifers. Improperly abandoned wells can be a significant problem in any area.

A contaminated sites inventory would highlight areas of concern within the mapped vulnerable areas and evaluate the risk of aquifer contamination. This information can be used to identify areas that should have development restrictions due to the vulnerability of the aquifer.

Developing and Implementing Policies and Programs

Currently in Ontario there are very few examples of policies and programs that have been developed and implemented to manage potentially harmful land uses and activities in the sensitive areas. One example of such an initiative is the Region of Waterloo's Water Resource Protection Strategy. A staff report titled *Policies to Protect Municipal Water Supplies* (Region of Waterloo, 1999) states:

“The following key principles were established as the fundamental basis on which the Region should develop and implement successful, proactive water resources protection programs:

- The Region's approach to source water protection should include a balance of cooperative / voluntary and regulatory measures
- The Region should move relatively quickly to implement source water protection measures that are within its current authority
- The Region should continue to investigate the possibility of using existing provincial, regional or local municipal regulations for groundwater protection, or advocate the development of new regulations if necessary

Priority was given to address sources of contamination with the highest potential for contaminating regional groundwater supplies, and toward source types that can be dealt with in the most proactive manner possible using the Region's current authority. Regional Council agreed that the three highest priority source types are:

- Rural non-point sources
- Current urban point sources
- Future urban point sources

Working groups were then formed to develop programs and policies for each high priority source type. The working groups consisted of various agency staff and stakeholders.

In another example, the Province of British Columbia's Well Protection Toolkit suggests that communities undertake the following steps in undertaking a well protection plan:

1. Form a community planning team
2. Define the capture zone (recharge area) of the community well
3. Map potential sources of pollution in the capture zone
4. Develop and implement protection measures to prevent pollution
5. Develop a contingency plan against any accidents
6. Monitor, evaluate, and report on the plan annually

The Province of New Brunswick has recently enacted legislation as the basis for a "zoned" approach to wellfield protection. This is based on a time-of-travel approach for contaminants to reach the groundwater system. Within the most sensitive zone closest to a wellfield, certain land uses are prohibited (i.e. service stations, dry cleaning plants) (Department of Environment and Local Government, 2000).

In Ontario, the construction of water wells is governed by Regulation 903 under the Water Resources Act. Improvements to Regulation 903 that have been under review by the MOE for several years may address some of the common concerns with respect to water well construction. However, enforcement of this regulation may continue to be limited; therefore, during the development and implementation of policies and programs, consideration should also be given to programs such as the *Well Compliance Program and Well Construction Requirements* implemented in the former Township of Osgoode (1998).

Developing Awareness and Education Programs

A common task in each action plan is the development of a public awareness and education program. As noted above a Public Education and Awareness Plan has been designated as one of the principal action plans of the Regional Water Resources Management Strategy for Eastern Ontario. This action plan is described in Subsection 10.2.6.

Management of Groundwater Withdrawals

At present groundwater withdrawals in excess of 50,000 L/day, such as communal water supply systems and industrial/commercial operations, are subject to the Permit to Take Water regulation under the Ontario Water Resources Act. Groundwater withdrawals of less than 50,000 L/day do not require such a permit and therefore the number of water takers and total groundwater usage can only be estimated (as presented in Section 7.8), which presents a water management difficulty insofar as it limits the ability to make decisions on how much increase in regulated withdrawals can be permitted.

Further refinements of the estimated total groundwater use are needed on a groundwater watershed basis. Up-to-date population statistics combined with per-capita consumption statistics and population distribution mapping would be required. Analysis of surface water consumption would also be required (refer to Section 10.2.2) to account for all water uses.

Information collected and analyzed as part of this initiative could then be provided to the MOE (or possibly another agency that is authorized to approve permits on behalf of the MOE) to assist with technical review of applications for Permits to Take Water. Applications for new, or renewal of existing Permits to Take Water could then be based on a watershed-based groundwater allocation strategy. This strategy would be developed using the data and assessment of groundwater availability and regional water budget presented in this report, along with the information that would result from the estimated groundwater withdrawals. The allocation strategy would be based on targets for the total allowable withdrawal within each groundwater watershed. These targets or limits should be based on the approach presented in this report.

10.2.2 Surface Water Management Plan

The review of streamflow data has resulted in the following findings that are particularly relevant to the development of a regional water resources management strategy:

- Streamflow regime throughout the study area has high seasonal variability. The magnitude and duration of low flows likely presents constraints on the expanded use of surface waters as sources of water supply for purposes such as irrigation, livestock watering, or communal water supply systems.
- The magnitude and duration of low flows also presents constraints on development by virtue of the resulting limits on the ability of watercourses to assimilate contaminant loadings. The low summer flow period means that waste discharges and overall contaminant loadings must be carefully managed if water quality is to be protected and enhanced to meet environmental objectives such as those related to management of aquatic habitat and ecosystems.

In terms of surface water quantity, these findings point to the need for careful management of water resources to ensure that sources of streamflow such as groundwater discharge zones and wetlands are protected through appropriate land-use planning, and that surface water withdrawals are managed and allocated in a way that recognizes the limits of the available resource.

A fundamental requirement for managing surface water quantity is a set of clear targets with respect to the amount of streamflow that should be maintained through critical periods (especially the summer low-flow period) for the purposes of meeting overall objectives for ecosystem and aquatic habitat management. The total amount of acceptable surface water withdrawal during a critical period can only be determined once such ecosystem-based management targets are set.

In the context of a regional water resources management strategy, the findings of high levels of total phosphorus in most surface waters, as indicated by the analyzed data, show that there is very little opportunity for surface waters to assimilate additional waste loads. In fact, the data indicates that surface waters are generally deteriorated below what is considered to be a level (of total phosphorus) sufficient to protect aquatic life in many areas. Effectively, there is no capacity for watercourses to assimilate increased phosphorus loadings.

The current state of the receiving waters indicates that habitat conditions are deteriorated and measures need to be taken to improve the quality of surface waters. Therefore, a number of strategies or action plans must be employed that will manage wastes discharged to receiving streams in a manner that promotes the improvement of water quality across the region.

Protection of Streamflow Sources

As noted above, an important management objective is the protection of sources of streamflow, particularly those that sustain streamflow during dry periods. It is recommended that land-use planning policies and regulations be put in place to protect identified sources of stream baseflow. This could include protection of specific areas where groundwater discharge is occurring, possibly including wetland areas that are known to be supported by groundwater discharge. Protection of such discharge areas or zones should be considered as part of an overall strategy to protect groundwater resources in a way that protects the annual amount of water recharge to groundwater aquifers.

Identification and mapping of groundwater discharge zones and other sources of stream baseflow is needed to assist with long-term management of streamflow sources through land development planning and land-use regulation. The location of these sources of streamflow would be identified through a watercourse baseflow source investigation (refer to Section 4).

Management of Surface Water Withdrawals

The seasonal variation in streamflow and the magnitude and duration of low-flow periods that characterizes the streamflow regime throughout the study area means that surface water withdrawals need to be carefully managed.

At present, there are generally two types of withdrawals: those that are subject to regulation (Permit to Take Water for withdrawal of more than 50,000 L per day) under the Ontario Water Resources Act, such as communal water supply systems and industrial/commercial operations, and those that do not require a formal Permit to Take Water, such as livestock watering.

The number of water takers and total water usage associated with unregulated withdrawals is largely unknown or unconfirmed. This presents a water management difficulty insofar as it limits the ability to make decisions on how much increase in regulated withdrawals can be permitted.

An inventory of all surface water users and their estimated water withdrawal amounts should be created and maintained, for the purpose of allowing better management of regulated water takers. This inventory would be a watershed-based activity that is best carried out by the Conservation Authorities in cooperation with member municipalities and local agricultural groups. Information collected as part of this initiative can then be provided to the MOE (or possibly another agency that is authorized to approve permits on behalf of the MOE) to assist with technical review of applications for Permits to Take Water.

Applications for new, or renewal of existing, Permits to Take Water could then be based on a watershed-based surface water allocation strategy. This strategy would be based on the data and statistics on streamflow and regional water budget presented in this report, along with the information that would result from the inventory of all surface water withdrawals. The allocation strategy would be based on targets for the total allowable streamflow withdrawal at various locations within each watershed. These targets or limits should be based on statistics on streamflow presented in this report and the level of streamflow that should be maintained to protect aquatic habitat and other water-related environmental features.

Surface Wastewater Discharge Management

As explained above, nutrient enrichment of watercourses is the dominant concern for surface water quality. A significant challenge is to address the acknowledged importance of non-point sources (NPS), which include soil erosion and direct runoff from agricultural land, manure runoff, watercourse channel erosion, and leakage from faulty septic systems.

From a practical management perspective, it needs to be recognized that there are various forms of NPS distributed throughout each watershed, some of which may be active only at certain times of the year. Dealing with all of these potential sources in an efficient and economical manner will require time, and will also require the cooperative effort of landowners and various regulatory agencies that have a mandate to deal with water quality and land-use regulation. The “Clean Water Programs” of the Ottawa and South Nation Conservation (SNC) are excellent examples of initiatives to help address these issues. Support for these programs should be strengthened and expanded to the Raisin Region watershed.

Part of the solution is to continue to work towards higher levels of sewage treatment at municipal treatment facilities; this is being pursued on case-by-case basis by municipalities in cooperation with the MOE. However, because of the dominant effect of NPS, it should be recognized that improved nutrient removal at municipal sewage treatment facilities will not have any substantial effect unless NPS is also dealt with, as stated in the 1992 South Nation River Wastewater Allocation Study.

The need to manage NPS has been recognized through the development of the Total Phosphorus Management pilot program for the South Nation River watershed. This program is a cooperative effort of the MOE, SNC, and local farm operators and land owners.

In a regional context, the opportunities presented by the MOE’s Total Phosphorus Management (TPM) program for the South Nation River watershed should be explored and monitored for application to other watersheds in the study area. When there is a recognized need to expand a municipal or industrial waste treatment system, this program allows for two options: provide higher levels of phosphorus treatment and removal or put resources toward non-point source control measures. The NPS control measures option, as a method of improving receiving stream conditions and allow for additional waste discharge from a municipal or industrial source, currently requires a number of conditions to be met. These conditions include:

- Analysis that clearly shows environmental benefit
- Assurance of investment
- A 4:1 offset ratio for phosphorus reduction such that the estimated total phosphorus load reduction caused by the NPS controls would be four times that of the proposed discharge from the regulated point source

Opportunities for a regional strategy for seasonal discharge from municipal lagoons should be examined. Currently, there are a variety of strategies exercised in the region for the seasonal (spring) discharge from municipal treatment lagoons. A program for discharge from the lagoons, coordinated on a regional basis, may provide additional stream water quality benefit. Such a program might also ease some seasonal capacity issues at municipal facilities.

There may also be additional opportunities for effluent polishing from municipal lagoons that could provide significant reductions in total phosphorus loading to receiving streams. Effluent polishing technologies such as treatment wetlands, which provide additional habitat and ecological benefit, should be examined. In addition to the conventional methods now employed across the region, other waste management technologies, such as communal wastewater treatment systems, should be examined for new developments.

The stream water quality sampling programs of the various agencies should be incorporated into a regional program to ensure that adequate data is collected over the next 20 years in the most effective and efficient manner possible.

The impact of additional development should be a component of all Official Plans in the region, both from a rural and an urban perspective. Additional development opportunities would be required to provide sufficient evidence of proper waste management to ensure that additional receiving water deterioration is not a factor.

10.2.3 Water Efficiency Plan

Typically water efficiency plans have been developed for communities served by municipal systems, and also for industries and institutions that use significant quantities of water. Given that a significant percentage of the population in Eastern Ontario (i.e. 65 percent) currently derives water supply from private individual systems, a water efficiency plan must also address this sector.

The development of water efficiency plans have often focussed on the following four areas (The Canadian Water and Wastewater Association, et al, n.d.):

- Protecting current water supply sources – Preserving the water quantity and quality by taking no more than necessary and returning water in the condition that you would want to receive it
- Improving operating efficiencies – Through the detection and repair of leaks in a water supply system and reducing operational costs
- Encouraging efficient and responsible water use – By using less water money can be saved and, in some instances, even more can be saved by deferring or avoiding infrastructure expansion or replacement. Demand can be reduced through practical measures such as promoting water-saving fixtures, installing meters, imposing summer lawn-watering restrictions, and implementing consumption-based rate structures
- Developing public awareness – By making people aware of water issues and enlisting their support and involvement, the effectiveness of water efficiency measures can be increased

The development of a water efficiency plan for all sectors of Eastern Ontario (i.e. Prescott and Russell (P&R), Stormont, Dundas and Glengarry (SD&G), and the City of Ottawa) would likely include all of these activities; however, the manner in which they are applied will vary relative to the type of water supply system (i.e. municipal vs. individual). However, regional level coordination provides some efficiencies in terms of conservation programs as well as bulk purchases of equipment (e.g. water meters, household conservation kits, or contracting of inspection and monitoring services).

A common task in each action plan is the development of a public awareness and education program. As noted above, a Public Education and Awareness Plan has been designated as one of the principal action plans of the Regional Water Resources Management Strategy for Eastern Ontario. This action plan is described in Subsection 9.2.6 below.

10.2.4 Wetland and Forest Preservation Plan

Second only to agricultural land, forests and wetlands occupy slightly less than forty percent (38.8%) of land cover in the study area. Unfortunately, during this study, updated digital wetland boundary files were not yet available on a regional basis. The land cover analysis therefore includes wetland areas within the classified forest areas.

Wetlands are a key link in watershed management. Essentially, wetlands are the transition between dry land and water (streams, rivers, lakes, and coastlines). Wetlands take many forms including the familiar marshes, swamps, and bogs. In their natural state, wetlands provide habitat and food sources for hundreds of plant and animal species, and some wetlands can perform important functions in maintaining, protecting, and enhancing water quality and quantity. Not all wetlands provide all functions to the same degree. The following is a list of broad benefit opportunities that could be provided by wetlands in a watershed context.

- Improve water quality by trapping, breaking down, removing, using, or retaining nutrients, organic waste, and sediment carried to the wetland with runoff from the watershed
- Reduce severity of floods downstream by retaining water and releasing it during drier periods

- Protect stream banks and shorelines from erosion
- In some locations, contribute to groundwater recharge potentially reducing water shortages during dry spells
- Provide fish and wildlife—including numerous threatened, vulnerable or endangered species—food habitat, breeding grounds, and resting areas
- Provide food and other products for human use.
- Provide opportunities for recreation and education—bird watching, waterfowl hunting, photography, etc.

Similarly forests can have both a quantitative and qualitative effect on water resources. The amount of water interception, uptake, throughfall, and evaporation and the quality of runoff and infiltration water are all influenced by the flora, the structure of the forest stand, the soil type, and the age of trees.

Forests act as physical and biological filters for many non-point source pollutants, whereas cleared lands can, in the absence of BMPs, serve as conduits for eroding soils and contaminants that flow directly into streams and rivers, or indirectly through groundwater.

Forest removal or deforestation is associated with a decrease in transpiration, an increase in streamflow and an increase in loss of particulate material and dissolved nutrients. In a commercial setting, soil compaction can occur by logging equipment and skidding of logs. Increased soil compaction decreases the soil's ability to absorb water, thereby resulting in increased runoff rates

Downstream effects of deforestation may include eutrophication of rivers and lakes due to increased nutrient loadings. Additionally, the acidity of drainage water may increase as organic material from the previous forest floor decomposes. This potential increase in acidity may be toxic to many invertebrates and fish, and also result in a release of metals from the sediment into the open water.

Many current research studies in deforestation are examining the global climate effects, which have local environmental consequences. Deforestation leads to increases in solar radiation received at the ground surface, which may cause changes in surface temperature. These changes may have dramatic impacts on both terrestrial and aquatic species. Deforestation also affects albedo, interception by the canopy and surface roughness, as well as the radiation reaching the ground. All of these potential changes have major impacts on energy and water balances.

Forest and wetland resources are important ecosystems component affecting water resources in Eastern Ontario. Environment Canada (1988) has developed habitat rehabilitation guidelines to assist Remedial Action Plans (RAPs) to rehabilitate ecosystems at the 16 Areas of Concerns (AOCs) across the Great Lakes Basin. The guidelines provide a framework for the identification and prioritization of wetland, riparian and forest habitat, many of which are applicable to Eastern Ontario. These are summarized in Table 10.1.

TABLE 10.1
GUIDELINES FOR MANAGEMENT OF WETLAND, RIPARIAN, AND FOREST HABITAT

Parameter	Guideline
Wetland Habitat Guidelines	
Percent Wetlands in Watershed and Subwatersheds	Greater than 10 percent of each major watershed in wetland habitat; greater than 6 percent of each subwatershed in wetland habitat
Amount of Natural Vegetation Adjacent to the Wetland	Greater than 240-m width of adjacent habitat that may be herbaceous or woody vegetation
Wetland Location	Headwater areas for groundwater recharge, floodplains for flood attenuation, and coastal wetlands for fish production
Riparian Habitat Guidelines	
Percent of Stream Naturally Vegetated	75 percemt of stream length should be naturally vegetated.
Amount of Natural Vegetation Adjacent to Streams	Streams should have a 30 m wide naturally vegetated buffer on both sides.
Total Suspended Sediments	Suspended Sediment concentrations should remain below 25 mg/l for the majority of the year.
Percent of an Urbanized Watershed that is Impervious	Less than 15 percent imperviousness in an urbanized watershed should maintain stream water quality and quantity, and leave biodiversity relatively unimpaired.
Fish Communities	Targets are set based on knowledge of underlying characteristics of watershed (drainage area, surficial geology, flow regime), historically and currently occurring fish communities, and factors presently impacting the system and their relative magnitudes.
Forest Habitat Guidelines	
Percent Forest Cover	30 percent of watershed should be in forest cover.
Size of Largest Forest Patch	At least one 200 ha forest patch that is a minimum 500 m wide
Percent of Watershed that is Forest Cover 100 m and 200 m from Forest Edge	Greater than 10 percent forest cover 100 m from edge; greater than 5 percent forest cover 200 m from edge
Forest Shape and Proximity to other Forested Patches	Forest patches should be circular or square in shape and in close proximity (i.e., 2 km) to adjacent patches.
Fragmented Landscapes and the Role of Corridors	Corridors designed to facilitate species movement should be a minimum of 100 m wide and corridors designed for specialist species should be a minimum of 500 m wide.
Forest Quality - Species Composition and Age Structure	Watershed forest cover should be representative of the full diversity of species composition and age structure found in that ecoregion.

Source: Modified from Environment Canada 1988

These guidelines are not targets, but provide for the ecological needs of fish and wildlife species in the three habitat types. They also provide a baseline against which the status of these resources can be evaluated on a watershed and a regional basis. They can also be used to guide the implementation of the recommendations of this report by being translated as natural environment objectives for planning policy and implementation documents (e.g. Official Plans, Master Plans, subwatershed management plans, zoning by-laws, site plan control, impact assessments, etc.).

Programs managed by MNR and Conservation Authorities (CA's) need to continue and be more proactive, visible, and have the support and involvement of the public.

10.2.5 Information Management and Distribution Plan

A data management strategy is being developed by Agriculture and Agri-Food Canada (AAFC) in conjunction with the project partners (i.e. P&R, SD&G, and the City of Ottawa). This includes the development of a system that will make many of the EWORMS results available to the public over the Internet.

10.2.6 Public Education and Awareness Plan

As noted previously, a public consultation plan was developed for the EOWRMS. It included the following activities:

- Newsletters
- Water Resources Survey
- Open Houses and Public Meetings
- Focus Group Sessions
- Organization Meetings
- Advertising (newspapers)
- Communication Reports

Each of these activities was successful insofar as they each provided information to the public regarding the study. The water resources survey, the focus group sessions, and the organization meeting were each successful in terms of receiving input from members of the public. The open houses and public meetings were not well attended and it is therefore recommended that this method of consultation be abandoned in favour of other methods of distributing information to the public-at-large.

Based on the responses received from the public during the EOWRMS, an initial step in developing a public education and awareness plan could be the distribution of a list of where to obtain information. This can be distributed in a variety of ways such as a bulletin from the local municipality included with a tax bill, a bulk mailing, through libraries, schools and organizations, or a web site.

10.3 Implementation

10.3.1 Federal Government

Departments of the federal government, such as Environment Canada and AAFC, have various responsibilities related to water; these include research, data collection and distribution, and enforcement of related Canadian laws.

Environment Canada's mandate is to preserve and enhance the quality of the natural environment, including water, air and soil quality; conserve Canada's renewable resources, including migratory birds and other non-domestic flora and fauna; conserve and protect

Canada's water resources; carry out meteorology; enforce the rules made by the Canada – United States International Joint Commission (IJC) relating to boundary waters; and coordinate environmental policies and programs for the federal government (Department of Environment Act). Environment Canada's mission is to make sustainable development a reality in Canada by helping Canadians live and prosper in an environment that needs to be respected, protected and conserved.

Examples of Environment Canada's role in environmental issues is as follows (source: Environment Canada Web site):

- Making more than 20,000 inspections and nearly 600 prosecutions for offenses against Canada's environmental laws over five years (see the Environmental Law Enforcement Web site)
- Assessing and controlling the most dangerous chemicals among the 23,000 or so in use in Canada (see the Commercial Chemicals Web site)
- Providing expert scientific advice and environmental impact assessments in over 1,000 significant spill incidents
- Implementing or supporting 350 environmental technology advancement projects in Canada and abroad
- Funding of over 190 community action projects in support of cleaner air and water, and the reduction of emissions linked to climate change (see the EcoAction 2000 Web site)

Environment Canada must therefore be considered as a important partner in the implementation of the study recommendations and the water resources management action plans.

As stated previously, AAFC has been a key participant during the completion of the EOWRMS. Staff have provided leadership and technical skills related to compilation and evaluation of a variety of data, but of particular relevance agriculture data. Ongoing active participation by AAFC will be critical in the implementation of the study recommendations and the water resources management action plans.

10.3.2 Provincial Government

As stated previously, in Ontario, the principal mandate to deal with water issues rests with the provincial government. Notwithstanding, no single agency, policy or ministry has a complete oversight, coordination, or management role for water. Different ministries and provincial bodies have authority for different aspects of water, including MOE; OMAFRA; MMAH; MNR; Conservation Authorities; and the Ontario Clean Water Agency.

This situation is illustrated with the example of water quality. Within the context of water quality there are at least four different policy frameworks that relate to its management. These frameworks depend on the source of the pollution and more specifically how and where it is being discharged (McCulloch and Muldoon, 1999). One framework governs direct discharges into Ontario's water (e.g. direct discharges into lakes, and streams). Another framework covers discharges into sewers and sewage treatment facilities. Groundwater management is covered under a separate framework. Fourthly, is a framework dealing with drinking water (currently under review).

In the last number of years, municipalities have been required to assume greater responsibilities including some aspect of water resources management; most notably water and sewage infrastructure, including onsite septic systems. This change in emphasis has been largely precipitated by trends within the political agenda of the province including deregulation, government downsizing, and downloading (McCulloch and Muldoon, 1999).

10.3.3 Municipal Land Use Planning

Land use planning documents have been in place in the study area for many years. More recently, however, the United Counties of P&R have adopted a County level Official Plan, which has been approved with some exceptions. The United Counties of SD&G have initiated the preparation of a County level Official Plan while the City of Ottawa has an approved Official Plan in place.

United Counties of Prescott and Russell

This County covers an area in excess of 2 000 km^2 and lies between the Ottawa River on the north side, the City of Ottawa on the west side and the United Counties of SD&G on the south side. The landscapes and settlement patterns are varied. The County is characterized by extensive areas of productive agriculture, mineral aggregates as well as large expanses of wooded areas and significant natural heritage features such as the Alfred Bog. The settlement area is predominantly rural with a scattering of small but vital urban communities (e.g. Hawkesbury, L'Orignal, Vankleek Hill, Casselman, Rockland, Embrun, Limoge, and Russell).

The new Official Plan has several themes, of which the stewardship of renewable and non-renewable resources is key. The intent is to protect prime agricultural lands for foodland production, provincially significant wetlands and woodlands for their ecological benefits and to guide the extraction of mineral aggregates. Planned water and sewer infrastructure will be the basis for directing and strengthening the growth of the villages and hamlets in the County. The distribution of growth is projected on the basis of a 60-30-10 ratio urban-rural-agricultural. This will accommodate a projected population increase from an estimated 81,541 in 2001 to up to 138,566 over the life of the plan (2019). The plan recognizes that "the groundwater resource is crucial" and that there is a significant dependence on this as the source of domestic water supply. The plan sets out a framework for protecting groundwater based on developing a water resources database and the identification of "sensitive groundwater recharge areas, sensitive hydrogeological areas and areas with known groundwater quality and quantity constraints". The plan also recognizes the need for an education program "aimed at reducing groundwater consumption and pollution".

Approved in December 1999 , the plan has had regard for the Provincial Policy Statement (1996). The intent of the new plan is to replace existing lower tier plans with the exception of larger urban communities, which will be covered by secondary plans.

United Counties of Stormont, Dundas and Glengarry

This County initiated the preparation of a new County level Official Plan in December 1999. Currently, Official Plan coverage exists at the lower tier level. The vintage of existing Official Plans varies, with the Township of North Glengarry being the most recent.

The County is strategically located on the Highway 401 corridor, being adjacent to the United States and within commuting distance of Montreal. The County has a diverse character dominated by its rural setting and settled with a number of small urban centres (e.g. Morrisburg, Iroguois, Ingleside, Long Sault, Chesterville, Winchester, Alexandria, Finch, Lancaster, Maxville, and Moose Creek) The planning area is also endowed with a rich resource base. Agricultural activities are a major resource activity as in the extraction of mineral aggregates and commercial forestry. There are also significant natural heritage features including the Newington Bog, Winchester Bog, Moose Creek Bog, Cooper’s Marsh, Loch Gary Marsh, and the Upper Canada Bird Sanctuary .

Issue papers have been completed for population, growth and settlement, and municipal infrastructure. The population scenarios that have been developed include a “diversification” scenario. Based on diversification of the economic base, this scenario targets an increase of 12,897 over a 20-year planning period (2001–2021). The distribution of the settlement pattern will be directed primarily to communities with urban services and secondarily to rural areas. A primary objective of existing Official Plans, as is expected to be an objective for the new County Plan, is to manage the natural resource base and to permit development that does not conflict with this objective. Infrastructure improvements are required to sustain existing development in the County as well as to provide for new development over the next 20 years.

City of Ottawa

Planning document coverage within the City of Ottawa (restructured as one City municipality, January 1, 2001) includes a regional Official Plan as well as lower tier Official Plans. The Official Plan was approved in April 1999 and coverage includes the rural areas of Cumberland, Osgoode, and Gloucester within the South Nation River basin. The plan’s goals and principles include safeguarding the natural environment, conserving agricultural and mineral resources, and providing infrastructure effectively and affordably, amongst others. Detailed policies are set out for servicing infrastructure for the villages that dot the landscape in the east (e.g. Marionville and Carlsbad Springs) to provide for sustainable potable water supply in other areas based on private systems.

The Official Plan does not provide a dedicated policy for groundwater or surface water management. It does provide for the management of water resources in Section 5.2 and commits the region to undertake a major aquifer management study. The intent of the plan is to ensure that development in general can be properly serviced and that due regard is given to protecting the environment. The plan sets out a strategy for growth and settlement that echoes the Provincial Policy Statement by directing settlement first and foremost to urban communities and secondarily to rural areas. This strategy complements the plan’s intent to conserve and manage the natural resource base.

Given the backdrop described above, there are a number of tools immediately available to municipalities to assist in water resource management. Some of these are summarized in Table 9.2.

TABLE 10.2
PRINCIPAL MUNICIPAL PLANNING TOOLS FOR WATER RESOURCES MANAGEMENT

Information and Monitoring

- Water resources characterization
- Assessing and monitoring water resource conditions and land use activities
- Integrating, managing, and updating information for decision making

Source Controls

- Septic Systems: Building Code Act
- Sewer Use By-laws
- Water Use By-laws
- Delegated Approval/Inspection/Abatement Functions

Land Use Planning

- Official Plan policies for protecting and designating source areas, servicing policies, performance standards, stormwater management, etc.
- Zoning by-laws for prohibiting land uses and buildings or structures on land that is a sensitive groundwater recharge area, a headwater area, or on land that contains a sensitive aquifer.
- Alternative development standards encouraging preventative site planning measures (e.g. clearing and grading, impervious surface area, stormwater and wastewater management)

Private Land Stewardship

- Conservative easements to limit or preclude uses or activities that might jeopardize identified groundwater objectives
- Incentive programs for best management practices and private land stewardship
- Public recognition programs for voluntary land stewardship to protect source areas

Pollution Prevention Planning

- Public education and outreach related to use and disposal of hazardous material, water conservation, stewardship activities
- Voluntary pollution prevention planning to reduce or eliminate the use, generation and release of targeted hazardous substances and wastes (e.g. house and garden chemicals)
- Reporting environmental performance in accordance with standards for environmental conduct and responsibility

Modified from Neufeld, 1998

Program for Implementation

Implementation of the recommendations of this report will be carried out in a variety of ways. In some respects, implementation is already underway through the initiatives of the City of Ottawa, designed to better maintain their wells and septic tanks and through land use planning activities of the United Counties of SD&G. This, however, is only a start. The program for implementation needs a concerted effort by government, rural and other types of organizations, and the public alike in developing and using the tools to use water resources more wisely.

The following summarizes a proposed program for implementation of the study recommendations and action plans:

1. ***Adoption of the report***: This signifies both an acknowledgement as well as a commitment towards water resources management by community leaders. It may be advisable to seek the tacit approval or acceptance of the report by other key stakeholders (i.e. conservation agencies, area municipalities, provincial ministries).

2. ***Who does what:*** The various project partners have taken an active role in directing this study. The on-going support of these individuals and organizations will be critical to the successful implementation of the study recommendations and action plans. Therefore, an initial implementation committee should be formed under the continued direction of the project partners. Such a committee would then be responsible for identifying and recommending how the Regional Water Resources Management Strategy should be implemented, particularly what agency or organization should assume a leadership role in this long-term activity.

3. ***Prioritization***: Once a leadership role is assigned to an agency or organization, the activities of implementation should be prioritized in greater detail than is described in this report (i.e. determine which should be carried out immediately or in the short-term and which may be left until later). Invariably, there will be certain activities that will be carried out in parallel. Priorities will emerge and change as funding opportunities and strategic partnerships are explored and developed.

4. ***Scheduling and Resources***: Effective implementation implies the commitment of resources and establishing a timetable or schedule to carry out activities. The lead agency / organization would be responsible for developing a timetable and assembling the resources for implementation. The shared resources of the project partners could augment the technical capabilities of the lead agency.

5. ***Monitoring and Review***: The lead agency / organization should monitor the progress of implementation and review the results. This may lead to adjustments in the timing or measures being undertaken. An implementation committee may choose to meet at regular intervals (e.g. quarterly) to monitor progress. A review may be an annual activity by the project partners.

11. Recommendations

The recommendations from each of the sections on key study areas are provided in this section.

11.1 Regional Water Budget

While it is recognized that most elements of a regional water strategy involve more specific and detailed analysis, it is recommended that the regional water budget be used to:

1. Target areas within the Eastern Ontario Water Resources Management Study (EOWRMS) region where additional care in development planning is needed and also where additional data collection and information may be required to support development. For example, the areas that show larger contributions to groundwater should have land use policies that protect groundwater quality, while areas where contribution is primarily to surface water would benefit from programs that protect streambanks and buffer surface water from adjacent land uses.

2. Evaluate the kinds of programs, actions and costs that will best achieve the objectives of quantity and quality for water resources and identify who will benefit from improvements in the water resources. There will be cases where the major costs occur in one sector of society while the major benefits will accrue to another; for example, improving agricultural practices to maintain surface water quality by taking land out of production for stream buffers would prolong the functional life of a municipal water treatment facility. Planning activities, such as the Rural Water Quality Program in the Regional Municipality of Waterloo, provide examples of how the benefits and costs of maintaining the water resource can be equitably shared across all sectors of society.

3. Provide a context for analysis for more localized municipalities and areas by providing an estimate of surface and groundwater resources and showing how they depend on ‘upstream’ communities and can impact on ‘downstream’ communities. The analysis is most relevant at a broad regional level; on more localized scales, the approximations used in the model may cause serious deviations from the actual situation.

4. Show the limitations for resource development based on the limited groundwater resources in the area by highlighting the limited areas of significant recharge and how these and the underlying aquifers are shared between communities.

5. Indicate the potential to increase development based on increased management of the water resources to achieve better consistency of flow throughout the year. (Please see Section 4 for more detailed discussion.)

In addition to these recommendations designed to guide sustainable development, the regional water budget study showed a large variability between modelled and measured annual water quantities. This variability suggests that the components of the hydrologic cycle are not well quantified and that:

1. Additional care and effort should be devoted to gathering complete data on surface and groundwater quantities across the region.
2. Individual development proposals should be analyzed in greater detail at a more localized scale to provide a better model for the water budget as a tool to confirm the feasibility and desirability of the proposed development.
3. The current regional water budget can and should be used to target areas within the region which are important to surface and groundwater resources and that these areas should be analyzed in greater detail to ensure the reliability and sustainability of the water resource.

11.2 Surface Water

11.2.1 Protection of Streamflow Sources

An important management objective is the protection of sources of streamflow, particularly those that sustain streamflow during dry periods. It is recommended that land-use planning policies and regulations be put in place to protect identified sources of stream baseflow. This could include protection of specific areas where groundwater discharge is occurring, possibly including wetland areas that are known to be supplied by groundwater upwelling. Protection of such discharge areas or zones should be considered as part of an overall strategy to protect groundwater resources in a way that protects the annual amount of water recharge to groundwater aquifers.

Identification and mapping of groundwater discharge zones and other sources of stream baseflow is needed to assist with long-term protection of streamflow sources through land development planning and land-use regulation. It is recommended that the location of these sources of streamflow be identified through a watercourse baseflow source investigation. Such an investigation would involve a program of systematic measurement of baseflow at a number of locations within each subwatershed, to determine where flow is originating in dry-weather periods. The program should consist of spot measurements of volumetric streamflow rate during dry periods in the summer. The program should be structured such that investigations proceed in an upstream direction along the major watercourses and then upstream along various tributaries. The initial program could consist of baseflow measurements at all roadway crossings. The program might need to extend over a number of weeks or months depending on resources available. As the flow readings are made, they must be recorded in a consistent format and collated in a central data record. Once sufficient readings are made, data can be mapped. When observed baseflow rates are considered, along with information on estimated upstream surface drainage area, flow sources and probable groundwater discharge locations should reveal themselves. Additional flow measurements would then be required to home in on discharge zones.

Section 5 of this report provides information on the groundwater conditions across the study area, including generalized mapping of probable groundwater discharge zones, as determined through the water budget analyses carried out during this project. This information can be used to help guide the flow measurement program.

11.2.2 Management of Surface Water Withdrawals

The seasonal variation in streamflow and the magnitude and duration of low-flow periods that characterizes the streamflow regime throughout the study area means that surface water withdrawals need to be carefully managed.

At present, there are generally two types of withdrawals: those that are subject to regulation (Permit to Take Water for withdrawal of more than 50,000 L per day) under the Ontario Water Resources Act, such as communal water supply systems and industrial/commercial operations, and those that do not require a formal permit to take water, such as livestock watering.

The number of water takers and total water usage associated with unregulated withdrawals is largely unknown or unconfirmed and must be estimated (see Section 7). This presents a water management difficulty insofar as it limits the ability to make decisions on how much increase in regulated withdrawals can be permitted.

It is therefore recommended that an inventory of all surface water users and their estimated water withdrawal amounts be created and maintained, for the purpose of allowing better management of regulated water takers. It is recommended that this inventory be a watershed-based activity that is best lead by the Ministry of the Environment (MOE) and could carried out with the assistance of Conservation Authorities in cooperation with member municipalities and local agricultural groups. This information is critical for the MOE to fulfill its responsibilities as outlined in the Water Taking and Transfer Regulation (O. Reg. 285/95).

It is recommended that applications for new Permits to Take Water or renewal of existing Permits to Take Water be based on a watershed-based surface water allocation strategy. It is recommended that this strategy be based on the data and statistics on streamflow and regional water budget presented in this report, along with the information that would result from the recommended inventory of all surface water withdrawals. It is recommended that the allocation strategy be based on targets for the total allowable streamflow withdrawal at various locations within each watershed. These targets or limits should be based on statistics on streamflow presented in this report and the level of streamflow that should be maintained to protect aquatic habitat and other water-related environmental features.

11.2.3 Surface Wastewater Discharge Management

As explained above, nutrient enrichment of watercourses is the dominant concern for surface water quality. A significant challenge is to address the acknowledged importance of non-point sources (NPS), which include soil erosion and direct runoff from agricultural land, watercourse channel erosion and leakage from faulty septic systems.

From a practical management perspective, it needs to be recognized that there are various forms of NPS distributed throughout each watershed, some of which may be active only at certain times of the year. Dealing with all of these potential sources in an efficient and economical manner will require time, and will also require the cooperative effort of landowners and various regulatory agencies that have a mandate to deal with water quality and land-use regulation.

A number of programs exist in the study area that are helping to improve surface water quality and habitat by targeting and reducing NPS contributions. These programs include the Clean Water Program (SNC), the Rural Clean Water Program (COO), and the Tributary Restoration Program (RRCA). Funding and support for these programs should be at least maintained or expanded.

Part of the solution is to continue to work towards higher levels of sewage treatment at municipal treatment facilities; this is being pursued on case-by-case basis by municipalities in cooperation with the regulatory agency, the MOE. However, because of the dominant effect of NPS, it needs to be recognized that improved nutrient removal at municipal sewage treatment facilities will not have any substantial effect unless NPS is also dealt with, as stated in the 1992 South Nation River Wastewater Allocation Study.

The need to manage NPS has been recognized through the development of the “Total Phosphorus Management” pilot program for the South Nation River watershed. This program is a cooperative effort of the MOE, South Nation Conservation, and local farm operators and landowners.

In a regional context, the opportunities presented by the MOE’s Total Phosphorus Management (TPM) program for the South Nation River watershed should be explored and incorporated into other watersheds in the study area. When there is a recognized need to expand a municipal or industrial waste treatment system, this program allows for two options: provide higher levels of phosphorus treatment and removal or put resources toward non-point source control measures. The NPS control measures option, as a method of improving receiving stream conditions and allow for additional waste discharge from a municipal or industrial source, currently requires a number of conditions to be met. These conditions include:

- Analysis that clearly shows environmental benefit
- Assurance of investment
- A 4:1 offset ratio for phosphorus reduction such that the estimated total phosphorus load reduction caused by the NPS controls would be 4 times that of the proposed discharge from the regulated point source

Opportunities for a regional strategy, coordinated on a watershed basis, for seasonal discharge from municipal lagoons should be examined. Currently, there are a variety of strategies exercised in the region for the seasonal (spring) discharge from municipal treatment lagoons. A program for discharge from the lagoons, coordinated on a regional basis, may provide additional stream water quality benefit. Such a program might also ease some seasonal capacity issues at municipal facilities.

There may also be additional opportunities for effluent polishing from municipal lagoons that could provide significant reductions in total phosphorus loading to receiving streams. Effluent polishing technologies such as treatment wetlands, which provide additional habitat and ecological benefit, should be examined. In addition to the conventional methods now employed across the region, other waste management technologies, such as communal wastewater treatment systems, should be examined for new developments.

The stream water quality sampling programs of the various agencies should be incorporated into a regional program to ensure that adequate data is collected over the next 20 years in the most effective and efficient manner possible.

The impact of additional development should be a component of all Official Plans in the region, both from a rural and an urban perspective. Additional development opportunities would be required to provide sufficient evidence of proper waste management to ensure that additional receiving water deterioration is not a factor.

Southern Ontario uses particularly high volumes of road salt. Municipalities and road maintenance contractors in Eastern Ontario should be made aware of the potential and persistent effects to the environment from road salt as described in the Environment Canada, Health Canada 2000 assessment report. They should also be encouraged to voluntary adopt the suggested mitigation strategies and actions in advance of likely future federal requirements.

11.2.4 St. Lawrence River Remedial Action Plan (RAP) Recommendations

There are a number of recommendations that were put forward in the St. Lawrence River RAP (Dreier.et al., 1997) that are relevant to the findings and recommendations of EOWRMS. The RAP recommendations pertaining to regional surface water management are listed here along with their RAP recommendation number. RAP recommendations specific to particular industrial sources or particular site specific contaminant sources have been omitted from the list presented here because they are not regional in nature.

TABLE 11.1
ST. LAWRENCE RIVER REMEDIAL ACTION PLAN RECOMMENDATIONS

Number	Recommendation
1.	Ask the federal and provincial governments to show more tangible evidence of their commitment to the goal of virtual elimination of persistent toxic contaminants by using their legislative authorities to ban the use of mercury and production of persistent toxic compounds like dioxins and dibenzofurans.
5.	Establish federal and provincial regulations banning the manufacture and sale of all detergents containing phosphates.
6.	Recommend that OMAFRA vigorously pursue its pesticides reduction goal in the Great Lakes-St. Lawrence River Basin by encouraging improved chemical herbicide/pesticide application practices, integrated pest management and other alternative farming practices that reduce the environmental impact of pest and weed control.
7.	Recommend that all authorities involved in managing public lands, transportation routes and transmission corridors in the Great Lakes-St. Lawrence River Basin do the following: • Provide an inventory of their herbicide and pesticide use • Develop and implement strategies that will reduce their use of these chemicals in the Basin by 50 percent by the year 2002
31.	Control stormwater discharges from municipalities other than Cornwall, particularly roads and communities along the Raisin and St. Lawrence Rivers, by collecting and treating stormwater.
32.	Install proper septic systems on private shoreline properties where land is sufficient and can meet existing regulations; carry out inspections to ensure compliance.
34.	As a long-term plan, install sewage treatment plants for river communities, including Summerstown, South Lancaster, Pilon Island, Cornwall Island and Bainsville.
35.	Inspect park and campground sewage disposal systems and correct deficient systems.
37.	Eliminate livestock access to surface waters by providing education and financial incentives to farmers and by enforcing existing regulations.

TABLE 11.1
ST. LAWRENCE RIVER REMEDIAL ACTION PLAN RECOMMENDATIONS

Number	Recommendation
38.	Inspect manure piles and milkhouse waste disposal systems which have the potential to be sources of surface water contamination, and correct by: • Providing education to farmers on how to correct the problem • Providing financial incentives to farmers • Enforcing existing regulations • Incorporating into municipal zoning by-laws, the Agricultural Code of Practice regarding manure/milkhouse wastes • Establishing a bioconversion facility for production of fertilizer from manure and other organic sludges pending feasibility study (to determine available manure supply, interest in participation etc.)
39.	Endorse the Farm Environmental Plan program described in *Our Farm Environmental Agenda* as part of the development of an agricultural land stewardship program.
48.	Encourage municipalities to continue to implement the Provincial Natural Heritage Policy (1996) which requires all planning agencies to have regard for provincially significant wetlands in their planning decisions. The Policy calls for no development in provincially significant wetlands and no development on adjacent lands if the wetland will be affected. This policy is to be interpreted as part of all the new Planning Act policies by municipalities and agencies.
49.	Encourage municipalities to protect wetlands that are not designated provincially significant by requesting that they include development constraints and buffer zones around these areas.
51.	Continue to use existing legislation (including the federal Fisheries Act, Public Lands Act, Lakes and Rivers Improvement Act, Conservation Authorities Act and Environmental Protection Act) to protect aquatic habitats (including fish habitat and wetlands) where this legislation applies. Continue to require a minimum compensation of 1:1 (new habitat created : habitat altered) for fish habitat harmfully altered by development activities. Minimum compensation should be 1:1 for like habitat on site; 1:2 for like habitat offsite or replacement habitat onsite; and 1:4 for replacement habitat off site.
58.	Encourage the enhancement of the protection, number, size, quality and distribution (i.e. reduce fragmentation) of certain terrestrial habitats (i.e. mature and over-mature forests, riparian habitats) and their dependent species.
60.	For specific problem areas, design the appropriate stabilization technique and implement the work as a government initiative either with public funding only or on a cost-shared basis with the landowner.

11.3 Groundwater Analysis

The groundwater analysis provides an excellent two-dimensional model of the regional groundwater systems in Eastern Ontario. This analysis has highlighted the Contact Zone Aquifer as having the greatest supply potential but has also identified areas that are vulnerable to contamination. The results of this regional-scale analysis should be used as a guide for water supply and protection efforts and should be augmented with local-scale studies for site-specific decision-making.

11.3.1 Additional Data

The following are recommendations for additional data regarding the groundwater system (listed in no particular order):

- The vulnerability analysis should be expanded to incorporate municipal/communal well capture zones, where available. Well capture zones will outline the surficial areas where recharge eventually reaches the existing supply well(s). Overlaying the well capture zones with the vulnerability classes will highlight the most sensitive areas for the current water supply wells, and protection and education efforts can be focussed in those essential areas.

- An inventory of abandoned wells should be carried out to evaluate their potential as conduits for surficial contamination to reach otherwise protected aquifers. Improperly abandoned wells can be a significant problem even in vulnerability Class 3 and 4 areas.
- A contaminated sites inventory should be completed to highlight areas of concern within the mapped vulnerable areas and evaluate the risk of aquifer contamination. This information can be used to identify areas that should have development restrictions because of the vulnerability of the aquifer.
- Water quality data is sparse and outdated, and represents the greatest data gap in the groundwater analysis. Prior to developing a local groundwater supply, additional local-scale investigations should be designed to better characterize the local water quality, both from natural geologic and surficial contaminant sources. Once this data is available, potential groundwater supplies can be better evaluated considering the operational treatment costs of the water supply.
- A large data gap currently exists in the understanding of groundwater quality in Eastern Ontario. The compilation of groundwater quality data from a variety of sources into a database would significantly improve this understanding and would assist in developing watershed-based monitoring programs.
- Well location accuracy checks should be undertaken locally in areas of potential additional groundwater supply to verify the water well data used to generate the maps in this study.
- Additional local-scale investigations are needed in the vicinity of fault zones to characterize groundwater flow conditions along faults. These fault zones are potentially higher yield aquifer zones and thus may warrant additional study.
- Additional local-scale investigations are needed along the suspected esker (or moraine) features to more accurately map and characterize local groundwater flow conditions. These permeable overburden features are potentially higher-yield aquifer zones that are typically an excellent supply of fresh water and may warrant additional study.
- Long-term monitoring programs, such as those currently being implemented by MOE (in cooperation with SNC and RRCA) and OFA, of water levels and water quality must be implemented to develop baseline data. This baseline data can be used to assess a change in conditions over time. The ability to detect changes in quantity or quality of water will allow for planning to mitigate the effects of deterioration, and to measure the effects of water conservation initiatives and/or aquifer protection strategies.

11.3.2 Application of Groundwater Analysis Results for Groundwater Management Initiatives

The groundwater analysis developed in this study provides a strong basis for developing groundwater management plans and undertaking further management initiatives. Groundwater management plans will undoubtedly have the following components:

- Water Supply: planned development to ensure the existing groundwater supply is not over-extracted; recharge to the Contact Zone Aquifer is maintained; and discharge to streams, lakes, and wetlands is sufficient to continue to support the existing local ecology

- Water Quality: planned water supply treatment initiatives to ensure that the water supply is aesthetically pleasing even under additional pumping conditions
- Source Vulnerability: planned development of supplies in low vulnerability areas (ensuring proper sealing of any abandoned wells) to avoid the likelihood of contamination events impacting water supply wells. Additionally, an inventory of potential contaminant sources and plans to minimize high-risk surficial activities should be implemented, particularly in vulnerable areas that might impact water supply wells, as described above.

Local-scale analyses (well capture zone scale) should be undertaken to confirm / refine this regional analysis. The local-scale analysis should include a series of standard tests to refine the delineation of aquifer extents and determine the specific characteristics of the aquifer and overlying aquitard material.

In consideration of the high vulnerability of many areas in Eastern Ontario, land use policies and guidelines should be created to manage development in these sensitive areas. Such policies and guidelines should include a requirement that the proponent of a development must perform a site-scale investigation of aquifer vulnerability and demonstrate that the proposed development will not contaminate the aquifer. This investigation would involve local characterization of the aquitard overlying the Contact Zone Aquifer and estimation of the travel time to the aquifer. At a minimum, this type of policy or guideline should be applied in areas that are identified as vulnerability classes 1 or 2, but would represent a good practice in all areas.

Areas mapped as vulnerability classes 1 or 2 should be considered areas where the drinking water supply is sensitive to surficial activity. In accordance, these areas should have:

- Tighter constraints and more stringent requirements for proposed land developments
- More stringent chemical storage and handling procedures for existing businesses and residences
- Focussed education programs to raise awareness of the potential effects of surficial activities on local water quality

In addition, action plans should be developed to deal with spill events within these sensitive areas. These planning efforts should be most rigorous within vulnerability class 1 areas.

As part of the public education plans, individuals relying on shallow groundwater supplies, either through dug or shallow drilled wells, should be made aware of the vulnerability of their water supply to surface contamination. These individuals should be advised to have their wells tested regularly for common bacterial contamination, as a minimum. They should also be aware of alternative water sources and the potential costs associated with developing an alternative (i.e. deep groundwater) source and applying appropriate treatment technologies, as needed.

The principal components of a proposed groundwater resources protection plan are summarized in Section 10.

11.3.3 Further Groundwater Analysis

The limitations of the two-dimensional model of the groundwater systems should be addressed by three-dimensional flow modelling. A three-dimensional groundwater flow model would provide a more reliable estimation of the groundwater flow budget and the supply capability of aquifer units. In addition, a groundwater model could be used to evaluate future water quantity and quality conditions, such as the impacts of best management practices (BMPs), water conservation, climate change, etc. The groundwater mapping developed in this study provides the basis for constructing the three-dimensional groundwater model. The model can provide a useful tool to guide additional data collection efforts based on the most uncertain parameters, which will enhance understanding of groundwater quantity and quality predictions.

Local-scale groundwater modelling should be used to define capture zones of municipal/ communal well fields and evaluate their vulnerability.

11.4 Land Use Analysis

The land use analysis results in the following recommendations:

- It is recommended that the agricultural land use analysis be used to provide general guidelines and interpretations and identification of target areas at a regional level. For example:
  - From the standpoint of surface water quality, the central area of the South Nation River watershed has a high proportion of the land in agriculture and a substantial proportion of that agricultural land is close to the surface drainage network. Annual crops are an important part of agricultural practice in this area and the estimated soil loss from erosion is moderate. It would be appropriate to target this area for BMPs, which buffer streams from nutrients and sediment. These practices would deal with cropped area and would relate to both overland flow and tile flow.
  - Similarly, the land in the southeastern part of the study area appears to be significant from the standpoint of crop production and potential for soil erosion. It should also be targeted for more detailed study
  - From the standpoint of livestock production, areas around Casselman through to St. Isidore appear to be most intense. These areas would be appropriate to target for BMPs related to livestock rearing and manure management, such as fencing to restrict livestock access to streams and manure management practices consistent with nutrient management guidelines.
  - In many cases these target areas and the nature of agricultural activities have already been recognized locally and programs such as RAPs, Environmental Farm Plans, Total Phosphorus Management, Clean Water Programs and Tributary Restoration are already in progress. The regional analysis can be used to ensure that local programs target the most appropriate areas and also it can be used to track changes over time as agricultural development proceeds.

- It is recommended that additional more detailed analysis be conducted to support any local water management strategy or development. The application of AGNPS within the South Nation River watershed is an example of such analysis.
- Because the areas defined as groundwater watersheds are substantially larger than the surface subwatersheds, this analysis does not provide the same level of resolution and is subject to a higher degree of uncertainty. This uncertainty results from the transfer of information about the nature and intensity of agricultural activities from EA groupings to these relatively large watershed areas. Similarly, the averaging process used to transfer information from satellite imagery to these areas increases the level of uncertainty. It is recommended that more localized areas of interest for groundwater be defined and the analysis repeated for use in assessing development potential.
- In light of the limitations noted above, it is not appropriate to make recommendations related to specific kinds of agricultural activities within vulnerability classes 1 and 2. However, it should be noted that while the proportion of agriculture within these zones is relatively small the land use within vulnerability classes 1 and 2 is generally greater than 50 percent agricultural over much of the project area. It is therefore recommended that the kinds of agricultural activities within vulnerability classes 1 and 2 be characterized and that programs promoting management practices that protect groundwater resources be implemented. These include careful nutrient and pesticide management in areas where the connection between the land surface and the aquifer is most direct.
- Several of these recommendations have identified the need for nutrient management plans (NMPs). These plans are an equally important part of minimizing the impact of agricultural activities on both surface and groundwater. Currently they are promoted as most important for livestock based activities where the farmer must manage nutrients from both organic and inorganic sources. With increasing urbanization and industry, there is an increasing need for land on which to manage nutrients from biosolids (sewage sludges, industrial sludges, composts etc). In recognition of the need for land to receive biosolids, it is recommended that, in addition to the MOE requirements for a Certificate of Approval, an NMP be developed and adhered to for all areas receiving these materials. The application of biosolids in accordance with a valid NMP will ensure the appropriate rate of nutrient application for crop requirements, regulate time of application and incorporation to minimize loss to the environment and establish appropriate buffer areas around sensitive water resources.

11.5 Servicing Infrastructure

The utility of a servicing and treatment planning tool similar to that described in this report should be examined in a regional context.

Also, in a regional context, the opportunities represented by the MOE's Total Phosphorus Management Program for the South Nation River watershed should be incorporated into the assessment of treatment alternatives in the study area. This program was described in this report under Section 4, Surface Water Analysis.

A comprehensive analysis of the level of treatment provided to domestic and industrial discharges across the region should be carried out to determine the potential for application of various servicing options and the net benefit that would be achieved through various implementation strategies.

Opportunities for a regional strategy for seasonal discharge from municipal lagoons should be examined in a watershed context. Currently, there are a variety of strategies exercised in the region for the seasonal (spring) discharge from municipal treatment lagoons. This recommendation was also made in the context of improving surface water quality in the region.

In association with a regional strategy for seasonal discharge, it is recommended that a wastewater allocation study be undertaken to determine the appropriate levels of discharge on a subwatershed basis in Eastern Ontario. This study should include all municipal and industrial point source discharges.

Opportunities to optimize existing capacity at wastewater treatment facilities should be taken where feasible.

The regulatory and monitoring framework for land application of biosolids needs to be reviewed in the context of voluntary compliance and monitoring, watershed management, and total nutrient management planning. The MOE should engage the EOWRMS partners in this process.

Land applied biosolids should be managed on a total nutrient management planning approach and on watershed and subwatershed basis. This would include involving other major nutrient users including golf course operators, the farm community and other land managers (i.e. Conservation Authorities and municipalities). Municipalities should reflect this in current or planned nutrient management bylaws and Official Plans.

11.5.1 Water Infrastructure Assessment

The new MOE regulations set forth a comprehensive set of requirements for the operation and maintenance of water treatment facilities. Once a supply and treatment technology has been selected, the regulations govern their application.

In the determination of the most appropriate servicing options from a supply perspective, the most appropriate water supply and distribution option may be best determined through a strategy that is applied region wide. A simple planning tool, such as the one presented in the report, for the selection of the most effective and efficient means of supplying water to regional residents should be developed and incorporated into official plans and regional planning documents. This planning tool could be developed in a similar format to the example provided earlier for the selection of the most effective and efficient wastewater servicing and treatment alternatives.

It is recommended that the opportunities to most effectively and efficiently meet the requirements of the new MOE regulations be explored from a treatment and servicing perspective. The requirements of the new regulations should be a critical factor integrated into the planning tool for the selection of servicing and treatment options.

The development of this tool should be facilitated through a regional planning study carried out to assess the requirements for additional water supply and treatment in the region over the next 20-year planning period. The planning tool for water supply servicing would also incorporate the existing information about Permits to Take Water and the recommendations made in this report in regard to the decision making process required for additional permits to take water from surface water sources.

11.5.2 Stormwater Management, Stream Protection/Remediation and Erosion Control

Proper stormwater management has become an important consideration in the protection of surface water resources. To better protect surface water resources there are a number of recommendations for the management of stormwater. These recommendations include:

- The quality of stormwater should be more specifically addressed in Official Plans to include the objectives for stormwater management and applicable technologies that are to be promoted.
- Stormwater management strategies adopted in official plans should be consistent with a defined set of regional objectives for management of stormwater.
- The management of stormwater should be addressed from a subwatershed and watershed perspective that integrates regional objectives. A watershed based approach will, in turn, provide the most benefit to the region in terms of surface water quality and protection of surface water resources.
- Strategies for improving the levels of contaminants contributed from non-point sources should be developed. These strategies should be developed on a regional basis and implemented on a sub-watershed and watershed scale.
- The EOWRMS area has not been characterized in regard to the most effective stormwater management methods that have been applied locally or regionally. This characterization should be carried out to provide a useful starting point or baseline against which the performance of future management plan implementation and operation can be measured.
- It is recommended that stream corridor protection and enhancement measures be developed and implemented on a watershed basis. Stream corridor protection goals and strategies should be entrenched in official plans and consistent with a defined set of regional objectives for management of streams. Existing polices should be reviewed in light of this study.

11.5.3 Case Study Analysis

From a regional perspective, water efficiency should be part of all Official Plans as a good stewardship practice. Municipal by-laws should incorporate water efficiency components to ensure the conscientious use of water as a valuable resource. Water efficiency should also be promoted to rural water users through an overall stewardship program.

Water efficiency measures are normally “packaged” together into an effective strategy. The strategy might be directed at residential users or industrial, commercial or institutional water users. The target water user group would determine the efficiency measures that would best be packaged together. An assessment of the water conservation practices and descriptions of appropriate implementation presented in this report should be carried out in order to determine the best possible approach to achieving objectives for water use efficiency.

There are a number of objectives that could be introduced in a water efficiency strategy. These may include simply, good stewardship, but may also have specific targets of water use reductions and water quality improvement. The objectives in specific areas may also include reductions or deferrals in capital expenditures and limitations on operations and maintenance costs. It is recommended that water efficiency be included in an Integrated Resource Management Plan developed on a regional basis. Specific recommendations and targets for performance should be incorporated into the management plan.

11.6 Public Consultation

The following recommendations were developed by the consulting team based on the key findings derived during the public consultation process:

11.6.1 Public Education

A comprehensive program of public education should be undertaken consisting of the preparation of instructional brochures or booklets on water well and septic tank maintenance, water testing, water conservation practices, water well abandonment procedures, the use of herbicides and pesticides, environmental home audits and community resources. (*Note: it is recognized that the Region of Ottawa-Carleton produced a booklet entitled "How Well is Your Well", September 2000, as a backdrop to a series of workshops on well and septic tank maintenance in the fall of 2000.*)

Area school boards and / or the Ministry of Education should be encouraged to incorporate 'water resources conservation and management' materials into the curriculum so that students may develop a water resources 'ethic' at a young age. Consideration should be given to organizing local partnerships to provide a unified lobby for conservation education.

The Ministry of Agriculture, Food and Rural Affairs (OMAFRA), in conjunction with the Ontario Federation of Agriculture, should develop an educational program and forum for exchanging information and ideas on farm practices related to water resources management (e.g. stream bank erosion controls, nutrient management, stormwater management, water course buffering from livestock watering, constructed wetlands, water well abandonment, well head protection, fuel storage, etc.).

11.6.2 Inspection Practices

Water quality testing on new wells should be more formalized through lab testing and the results should be incorporated into a public database on a geo-referenced basis. Consideration should also be given to instituting a procedure for adding water quality information to the database for shallow or dug wells. In addition, consideration should be give to procedures for adding water quality information to the database based on the submission of well-water test results on a voluntary basis. Well-water testing should be facilitated through the local Health Unit or through by-law enforcement for the regular inspection of sewage disposal systems as a means to maintain septic tanks and filter / tile beds in optimal operation condition. A provision for septic tank maintenance should include a prescription for the regular pump-out of septic tanks commensurate with use.

11.6.3 Conservation Practices

The local government should initiate a water conservation program involving the installation of water efficient fixtures and appliances and water meters.

11.6.4 Wetlands and Woodlands

Official Plans and zoning by-laws should incorporate provisions for the protection of water resources through the designation and protection of wetlands and woodlands by demonstrating the specific correlation of these natural features to water resource management. Reference should be made in particular to the protection of recharge and discharge areas. Land use designations should also provide for the conservation and protection of constructed wetlands.

11.6.5 Nutrient Management

A nutrient management plan should be instituted for all significant rural uses including farming operations, golf courses, and commercial and industrial uses. Provisions should also be made for the management of biosolids.

11.6.6 Environmental Farm Plan

The federal and provincial governments should be encouraged to provide ongoing funding for the development of Environmental Farm Plans.

11.6.7 Aquifers and Recharge Areas

Official Plans should incorporate a comprehensive approach to the identification and protection of sensitive aquifers and recharge areas. (Note: Information on an aquifer and recharge locations can be derived from this study.) The protection program should include provision for the prohibition or strict control of land uses proposed or in proximity to aquifers and recharge areas (i.e. 'zone' system based on time-of-travel or similar criteria).

11.6.8 GIS Information Base

The GIS information base (metadata) should be made available to local government and the public at the earliest opportunity. The GIS information base should also be incorporated into the land use planning and review process.

11.6.9 Monitoring and Testing

The province, in conjunction with local government, should institute a groundwater and surface water testing program (quality and quantity) within the South Nation and Raisin Region watersheds. A centralized database should be established to maintain the results of the testing. The database should also include an inventory of point-source contamination sites and the testing and results of contaminants, where applicable (i.e. landfill sites, active and abandoned industrial sites, etc.).

11.6.10 Growth Management

Official Plans should be reviewed with the objective of formulating a comprehensive policy framework for the conservation and management of water resources on a regional and local basis. Policies should incorporate a development application review that designates water resources protection as a significant criterion. Policies should also include water-related growth management principles and / or BMPs on a watershed basis. The objective should be to avoid any further decline in the net quality of water and wherever possible seek to achieve an improvement in quality (i.e. quality of water in-take should be the same or better as water discharge).

A water budget should be established that correlates the demand and supply requirements of municipalities with a regional water budget. The water budget should also be correlated to Permits to Take Water for individual users such that there is a balance between supply and demand that does not tax the supply. The MOE should be obliged to issue Permits to Take Water only when it is within the framework of the water budget.

11.6.11 Infrastructure Planning

Long-term infrastructure planning should be undertaken on a watershed basis, by area municipality, in conjunction with County governments or with the new City of Ottawa. Infrastructure includes water supply and distribution systems, wastewater collection and treatment systems and stormwater management facilities. Consideration should also be given to policies that provide for communal water and sewage disposal systems for rural properties where population densities warrant such action (e.g. 5 to 10 properties utilizing one well or septic tank).

11.6.12 Role of Agencies

Conservation authorities should be assigned a broader role in water resources management (e.g. review and administration of nutrient management plans, administration of a watershed (regional) water budget, application review of development proposals for their impact on aquifers, recharge areas, wetlands, woodlands, etc.). Consideration should also be given to the role of conservation authorities in managing a water resources database and in the continued delivery of programs for water resources management (i.e. Clean Water Program sponsored through South Nation Conservation).

11.6.13 Organizational Structure

The County governments and the City of Ottawa should establish a regional management board as a mechanism to coordinate the management of water resources on a watershed basis and to make recommendations to their respective members on measures to conserve, manage, or improve the quality and quantity of water resources.

11.6.14 Public Consultation

A deliberate and focused public consultation program should be continued. As plans and proposals become more defined and available to the public, the degree of public involvement in the process is likely to increase significantly. Maintaining public involvement in future decision-making will help contribute to successful implementation of a water resources strategy. It will also contribute to public education needs and goals. Utilizing a broad-based consultation / communication process will be important in communicating with and receiving input from a range of potentially impacted parties. This approach should involve a variety of public consultation techniques that are tailored to the size, age and geographic area of the audience and that can be adjusted or adapted to the circumstances. A broad based approach using varied techniques proved very effective in the public consultation for the EOWRMS study, particularly when it became apparent that public participation at the open houses was significantly less than originally anticipated. For example, ad-mail became the most effective way to reach a large number of households and businesses.

11.7 Demonstration Projects

All of the project suggestions in this study have merit. Some of the projects have universal application (e.g. public education or water conservation), while other have a more targeted application (e.g. buffer strips or storm water monitoring). The following recommendations are made to the recognition of existing programs and initiatives (e.g. clean water programs).

Based on the results of the study the following projects are suggested for priority implementation. These projects are deemed to have the greatest potential for yield water resource improvement or protection. These projects support the specific initiatives and actions suggested in the regional strategy and, in some cases, serve to strengthen or complement existing programs.

- Universal Application
  - Residential Water Audits / Retrofits
  - Well and Septic Audits
  - Abandoned well identification and capping
  - Water resource information centre
  - Water festival / event
- Targeted Application
  - Buffer Strips
  - Constructed Wetland for Municipal Waste Water Treatment
  - Wellhead Protection Planning
  - Recharge Area Protection Planning
  - Total Phosphorus Management

12. Glossary and List of Acronyms

12.1 Glossary

Aerobically – Carried out in the presence of oxygen

AGNPS – Agricultural Non-point Source

Anaerobically – Carried out in the absence of oxygen

Aquifer – (1) A geologic formation, a group of formations, or a part of a formation that is water bearing. (2) A geological formation or structure that stores or transmits water, or both, such as to wells and springs. (3) An underground layer of porous rock, sand, or gravel containing large amounts of water. Use of the term is usually restricted to those water-bearing structures capable of yielding water in sufficient quantity to constitute a usable supply. (4) A sand, gravel, or rock formation capable of storing or conveying water below the surface of the land. (5) A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Aquifer Capability – The maximum rate of withdrawal that can be sustained by an aquifer without causing an unacceptable decline in the hydraulic head of the aquifer, or causing unacceptable changes to any other component of the hydrologic system. Capability is calculated on a groundwatershed scale in terms of a budget whereby groundwater extraction does not exceed 50 percent of groundwater recharge.

Aquifer Recharge Area – An area in which water can infiltrate the soil and replenish an aquifer relatively easily. Aquifer recharge areas allow precipitation to reach an aquifer by infiltration. Recharge areas are often much smaller than the total aquifer area and are therefore very important to the aquifer. Artificially increasing runoff in a recharge area through paving or clearing can devastate an aquifer.

Aquifer Vulnerability – An intrinsic property of a groundwater system that depends on the sensitivity of that system to human and / or natural impacts. *Intrinsic Vulnerability* depends solely on the hydrogeologic properties of an aquifer. *Specific Vulnerability* depends on hydrogeologic properties of an aquifer and an imposed contaminant load.

Average Day Demand – The average volume of water required by a water supply system to meet water user's needs on a daily basis.

Bioaccumulation – The increase in contaminant concentrations found in the tissue of an organism as it feeds on other contaminated food sources.

Biomagnification – The increase in the concentration of a contaminant at higher levels in the food chain.

Biosolids – The end product from the processes used to treat wastewater, often from municipal, industrial or institutional sources. Biosolids are primarily organic materials but can contain other trace elements, e.g. metals. **Cadastre –** A public register or survey that defines boundaries of public and / or private land for the purposes of ownership and taxation.

Demand Management – Water management programs that reduce the demand for water, such as water conservation, drought rationing, rate incentive programs, public awareness and education, drought landscaping, etc.

Digital Elevation Model (DEM) – A model of terrain relief in the form of the matrix. A digital representation of the ground surface topography.

EPI – Extent Proximity Intensity

Esker – Winding ridges of sand and gravel, unrelated to surrounding topography, and derived from glacial processes.

Geographic Information System (GIS) – A computer software system with which spatial information may be captured, stored, analyzed, displayed, and retrieved.

Groundwater – Water that infiltrates the earth's surface. Groundwater originates as precipitation and is suspended by the soil for varying lengths of time depending on soil type, vegetation cover, and land use. Groundwater is responsible for feeding vegetation and for recharging aquifers.

Groundwatershed – An area defined by groundwater divides; or locations where water on one side of the divide will flow into one groundwater system; whereas, water recharging on the other side of the divide will flow into another groundwater system or groundwatershed. (Analogous to a **watershed**)

Hydraulic Conductivity (K) – A coefficient of proportionality describing the rate at which water can move through an aquifer or other permeable medium. In the Standard International System, the units are cubic meters per day per square meter of medium (m^3 / day / m^2) or m / day (for unit measures).

Hydrogeologic – Those factors that deal with subsurface waters and related geologic aspects of surface waters.

Hydrogeology – The part of geology concerned with the functions of water in modifying the earth, especially by erosion and deposition; geology of ground water, with particular emphasis on the chemistry and movement of water.

Hydrologic Cycle (Water Cycle) – The circuit of water movement from the earth's atmosphere to the earth and back through sequential stages such as precipitation, runoff, infiltration, evaporation, transpiration, etc. The hydrologic cycle has many different variations. Typically, water vapour in the atmosphere falls to the earth as rain. It is then transported to an open body of water via streams and rivers or through runoff or aquifer discharge. It is then evaporated and returns to the atmosphere as vapour. Alternately, once water enters the soil it may be absorbed by plants and returned to the atmosphere through transpiration (evaporation of water from the leaves of a living plant).

Hydrology – The science of earth's water resources. The scope of hydrology includes water's occurrence, distribution, circulation, physical and chemical properties, and reactions with and effects on the environment.

Infiltration/Inflow (I/I) – Groundwater or storm water flow into a sanitary sewer system through cracked pipes or improper connections.

Leachate – Liquid that percolates through the ground, such as water seeping through a landfill. Leachate refers to the contaminated water that runs off of and out of sanitary landfills. It has the potential to contaminate rivers, lakes, etc.

Lithology – (Geology) (1) The scientific study of rocks, usually with the unaided eye or with little magnification. (2) Loosely, the structure and composition of a rock formation. (3) The description of rocks, especially sedimentary *Clastics* and especially in hand specimen and in outcrop, on the basis of such characteristics as color, structures, mineralogic composition, and grain size.

Moraine – An accumulation of boulders, stones, or other debris carried and deposited by a glacier. Moraines, which can be subdivided into many different types, are deposits of *Glacial Till*. *Lateral Moraines* are the ridges of till that mark the sides of the glacier's path. *Terminal Moraines* are the material left behind by the farthest advance of the glacier's toe. Each different period of glaciation leaves behind its own moraines.

Non-Point Source Pollution (NPS) – Pollution discharged over a wide land area rather than from a specific location. Non-point source pollution actually originates from numerous small sources. It is quickly spread out and diffused, and it generally infiltrates the soil contaminating the groundwater or is deposited by runoff into rivers and lakes. NPS is much more difficult to measure and control than pollution from a specific point such as a sewer drain or a smoke stack. Agricultural chemicals and exhaust deposits in streets are examples of non-point source pollution.

Overburden – Any loose unconsolidated material, which has been deposited upon solid rock (i.e. sand or clay).

Peak Day Demand – The maximum volume of water required by a water supply system the meet water users needs during high use periods on a daily basis.

Permits to Take Water (PTTW) – Permits issued by the Ministry of the Environment for large-volume surface or groundwater withdrawals. Permit sets out the location, source maximum volume, number of days of extraction, expiry date of permit.

Pumping Test – A method used to determine the hydraulic characteristics of an aquifer whereby water is pumped from a well and the discharge from the well, and the drawdown of the water level are measured over time. These values are used in an appropriate well-flow equation to quantify the hydraulic characteristics of an aquifer and the capacity of a well.

Recharge – The addition of water to the groundwater system by natural (precipitation and infiltration) or artificial processes.

Relational Database – A collection of data stored in a number of data tables that are linked by common relationships that can be easily and efficiently converted into information through database queries and other operations.

Runoff – Rainwater that does not infiltrate the soil but flows across the earth's surface into a body of water. The proportion of rainwater that penetrates the soil varies considerably depending on soil type and area covered by impervious materials. Runoff has the potential to "carry" contaminants resting on the earth's surface into streams, lakes, reservoirs, etc. A watershed with a high percentage of its area covered by impervious materials (pavement and buildings) will have a comparatively high rate of runoff. Runoff is especially problematic in agricultural areas where residues from agricultural chemicals and high concentrations of animal waste rest on the earth's surface.

SWATRE –A transient, one-dimensional soil water flow model which uses soil physical properties, crop characteristics and weather data to estimate the soil water balance on a daily basis.

Till (Glacial) – Unstratified drift, deposited directly by a glacier without reworking by meltwater, and consisting of a mixture of clay, silt, sand, gravel, and boulders ranging widely in size and shape.

Transmissivity – The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient.

Water Budget - A water budget is general model of the complete hydrological cycle. For this study, the water budget provides estimates of: the quantity of water cycling through the study area (average annual precipitation); the quantity of water returned to the atmosphere by evapotranspiration, the quantity of water contributed annually to surface water resources, and the quantity of water that contributes to groundwater resources.

Water Resources – The supply of groundwater and surface water in a given area. Water resources is a general term used to describe all of the usable water in a specific geographical area.

Water Table – The level of groundwater saturation. The depth of the water table is determined by the quantity of groundwater and the permeability of the earth material and fluctuates accordingly. The water table is often the upper surface of an unconfined aquifer.

Watershed – A region or area over which water flows into a particular, lake, reservoir, stream, or river; a drainage basin. Watersheds are separated by ridges or areas of high ground. The boundary between two watersheds is a line connecting points of runoff divergence. Generally, a river or stream runs through a watershed collecting runoff. The stream then flows into another watershed downstream or into the sea.

Watershed Management – The process of analyzing and maintaining the land and water resources of a watershed in order to conserve those resources for the benefit of the watershed's residents. Since watersheds are defined by natural hydrology, watershed management is the most logical water conservation approach. Many problems are better solved at the watershed level than by addressing individual problems within a watershed. Effectively managing a watershed requires knowledge of it attainable only through thorough research. The watershed's natural resource base, health status, threats, and land use patterns as well as the needs of its residents must be understood. Good watershed management takes advantage of community resources and involves cooperation of various community organizations and residents.

12.2 List of Acronyms

AAFC	Agriculture and Agri-food Canada
AES	Atmospheric Environment Service, Environment Canada
AET	Actual Evapotranspiration
BAF	Biological Aerated Filters
BMP	Best Management Practice
C of A	Certificate of Approval
CFA	Consolidate Frequency Analysis Package (Environment Canada)
CoA	Census of Agriculture (Statistics Canada)
CURB	Clean up Rural Beaches
CWQG	Canadian Water Quality Guidelines
CWTS	Communal Wastewater Treatment Systems
DWSP	Drinking Water Surveillance Program
EA	Enumeration Area
EC	Environment Canada
EPI	Extent / Proximity / Intensity
EOWRMS	Eastern Ontario Water Resources Management Study
FCM	Federation of Canadian Municipalities
FIMS	Farm Input Management Survey
GIS	Geographic Information System
GREF	Green Municipal Enabling Fund
GRIF	Green Municipal Investment Fund
I/I	Inflow, Infiltration
ICI	Industrial, Commercial, Institutional
MNDM	Ministry of Northern Development and Mines
MNR	Ministry of Natural Resources
MOE	Ministry of the Environment
MUD	Municipal Water Use Database (Environment Canada)
NMP	Nutrient Management Planning / Plan
NPS	Non-Point-Sources
NRVIS	Natural Resource Values Information System
NRW	Non-Revenue Water
OBM	Ontario Base Map
OCWA	Ontario Clean Water Agency
OFA	Ontario Federation of Agriculture
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
OPG	Ontario Power Generation
P&R	Prescott and Russell
PTTW	Permit To Take Water
PWQO	Provincial Water Quality Objectives
RBC	Rotating Biological Contactors

REIS	Regional Information Management System (Agriculture and Agri-Food Canada)
RRCA	Raisin Region Conservation Authority
RUSLEAC	Revised Universal Soil Loss Equation for Application in Canada
SBR	Sequencing Batch Reactor
SD&G	Stormont, Dundas and Glengarry
SNC	South Nation Conservation
SWATRE	Soil Water Actual Transpiration Extended
TAG	Technical Advisory Group
TP	Total Phosphorous
TPM	Total Phosphorous Management
WQ	Water Quality
WSC	Water Survey of Canada
WWTP	Wastewater Treatment Plant

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