THE IMPORTANCE OF WATERSHED MANAGEMENT

IN PROTECTING ONTARIO'S DRINKING

WATER SUPPLIES

EXECUTIVE SUMMARY

MARCH 20, 2001

PREPARED BY: CONSERVATION ONTARIO

LETTER OF TRANSMITTAL

March 20, 2001

Conservation Ontario, on behalf of all Conservation Authorities and specifically in partnership with Saugeen Conservation and the Grand River Conservation Authority respectfully submits this paper, entitled ***The Importance of Watershed Management In Protecting Ontario's Drinking Water Supplies,*** to the Honourable Dennis O'Connor, Commissioner, for the Walkerton Inquiry.

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Ontario's Conservation Authorities look forward to the development of new relationships with the Province of Ontario and its many partners for the protection of Ontario's valuable drinking water resources. It is our hope that the recommendations in this submission will be considered a valuable contribution toward ensuring the safety of Ontario's drinking water.

Respectfully submitted,

Chair
Conservation Ontario

Chair
Saugeen Conservation

Grand River
Conservation
Authority

EXECUTIVE SUMMARY

Watershed Management

Water systems are life supporting, and a healthy water system is essential for a robust economy and a good quality of life. History has demonstrated that almost every action we take on the land shows up in the water systems, for better or for worse. This paper is written from the perspective of local watershed managers, Ontario's Conservation Authorities. It describes how integrated watershed management is an important part of selecting and maintaining cost-effective water supply with minimal impact on the environment. While watershed management is broader in focus than drinking water supply, adequate, safe, and contaminant free water supply can be achieved while maintaining a healthy aquatic ecosystem.

In contrast to the simple, end of pipe solutions (treating the symptoms), this paper focuses on reducing or eliminating problems at their source. The integrated watershed management approach attempts to influence how water is managed at each point of contact: by farmers, landowners, recreationalists, industry, land developers, municipalities, wastewater managers, and water supply managers. Rather than focussing piecemeal on individual problems, an integrated watershed approach takes a holistic view, exploring the cause-effect relationships of human activities on natural functions and processes that extend across jurisdictional boundaries, and finding solutions that minimize negative environmental impacts. This is usually done through the implementation of a watershed action plan that describes what each must do to ensure a safe and secure water supply and a healthy aquatic ecosystem. Therefore, the plan must be prepared in collaboration with those who must take action (e.g., interested parties, government, industry, and the general public).

Recommendations

Based on a review of watershed management in Ontario, the following recommendations focus on ways that the province could improve upon current practices, and thus strengthen the role that watershed management plays in protecting the long-term security of drinking water supplies.

1. **The protection of drinking water sources should be recognized as a permanent and integral part of a long-term, secure water supply strategy.**

   Source protection represents the first layer in a multiple defence system for ensuring that clean water is available to all water users. Source protection is especially vital to water users, such as rural residents and businesses, whose geographic location and low water usage afford them few alternative drinking water supply options and may limit the economic viability of employing end-of-pipe treatment measures. Source protection programs are consistent with practices being adopted by water supply agencies in other international jurisdictions.

2. **The watershed should be recognized as the viable unit for managing water.**

   This is the appropriate unit for the management of both surface and groundwater resources. Valerie Gibbons in her report *Managing the Environment: Executive Summary* (Executive Resource Group, 2001) states that there should be a strategic shift in managing the environment "towards a place-based approach with boundaries that make environmental sense and facilitate a cross-media, cumulative approach (such as watershed management)". While groundwater aquifers sometimes extend beyond surface water drainage boundaries, the human activities and resulting influences occur and can be managed within a surface watershed context. Drinking water source protection programs should be developed as part of an overall watershed management strategy.

3. A provincial integrated water policy should be developed that:

- *Recognizes the principles of watershed management and deals with all aspects of water.*

  The Province should expand its interests in watershed management beyond flood and erosion control operations to achieve maintenance and enhancement of ground and surface water (both quality and quantity) for all users. Watershed management is based upon an understanding of the watershed, its water cycle and its interrelationship with human activities. Watershed management includes identification, protection and enhancement of significant natural features including, headwaters, groundwater recharge and discharge areas, wetlands, vegetated stream buffers and forest areas, while considering historical and current human activities impacting the system.

- *Builds upon the conservation authority model to advance watershed management.*

  As a resource that crosses jurisdictional boundaries while lending itself to so many different and conflicting uses, water defies simple division into federal, provincial or municipal responsibility. Protection of water supply and quality requires collaboration and co-ordination at a level where progress can be made through actions determined by long-term watershed management plans. The conservation authority model provides an opportunity to co-ordinate, focus and streamline local delivery of water management and protection actions. Current strengths need to be built upon and the capacity of conservation authorities increased to provide a base level of watershed management for the benefit of 90% of the provincial population.

- *Clarifies the role of the provincial government in water management.*

  The Province has the broadest jurisdiction over water and therefore has a leadership responsibility in ensuring the best water management for the citizens of Ontario. A provincial water policy should specify the role of the Province in developing consistent standards, implementation procedures, regulations, and enforcement measures to ensure performance at the local level. It should also recommit to the watershed planning initiatives undertaken by the Ministry of Natural Resources and the Ministry of the Environment in order to provide guidance to local and regional authorities in planning appropriate future land use while at the same time, protecting water resources and the environment.

- *Promotes research into water issues and development of decision support tools to ensure the best science, technology and management practices are shared and available for local application.*

  The Province should foster research into water issues and the development, transfer and application of decision-support tools (e.g., water budget models, water quality models) for the implementation of watershed management. These tools provide the basis for implementing provincial regulatory actions (e.g., provincial water taking permits, certificates of approval for wastewater) that support water supplies and quality from a watershed perspective.

- *Supports an adequate monitoring program to measure change and adapt policies and programs accordingly (i.e., adaptive environmental management).*

  Monitoring networks need to be improved, maintained and accessible for effective local watershed management. A commitment must be made to the long-term support of state-of-the-art monitoring networks.

- *Supports the improvement, maintenance and accessibility of resource data for effective local watershed management.*

  Modelling complex water resource systems requires extensive databases such as streamflow, precipitation, water quality and land use. The Province should establish database standards, facilitate data sharing mechanisms and, where necessary, provide support for database development and maintenance.

4. Adequate and stable source(s) of funding should be established to finance watershed management throughout Ontario.

Provincial, municipal and conservation authority investments into securing water supplies and water quality require long-term stable funding to support watershed management operations. A user pay approach can be taken through the municipal water bill and the provincial Permits to Take Water. Where local "user pay" sources are inadequate, the Province should supplement or provide mechanisms for appropriate distribution of funding to these areas to ensure a base level of watershed management. Incentive-type programs and innovative funding opportunities should continue to be pursued to support capital investments (i.e., projects, studies, structures) necessary to implement watershed management plans.

5 The Province should encourage the Federal Government to develop a national framework for water policy and to strengthen co-operative agreements with provinces under the Canada Water Act.

The Federal Water Policy of 1987 was tabled in Parliament but not extended into a national policy. Funding for co-operative agreements with provinces declined from over $12 million in the late 1970s and $8 million in the 1980s to zero in 1998. Since water problems cross political and jurisdictional boundaries and are becoming increasingly global, the Province should encourage the Federal Government to develop a national framework for water policy in close consultation and co-operation with the provinces. The national policy should define the federal government's role in the design of national standards for water quality and environmental monitoring and in providing research, data collection, analysis, and monitoring on a watershed basis to maintain the health of the Great Lakes.

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Respectfully submitted,

Rick Potter
Chair
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PREFACE

General

Conservation Ontario, in partnership with the Saugeen Valley Conservation Authority, and the Grand River Conservation Authority made application to the Walkerton Inquiry Office to prepare a presentation on watershed management and its role in providing an adequate, clean source of water supply in Ontario. The application was accepted, largely because of the experience conservation authorities and their member municipalities have in watershed management.

The conservation authorities are, by definition, a long-standing partnership between the Province of Ontario and municipalities for the management of water and natural resources on a watershed basis. A conservation authority's governing board is comprised of representatives named by the municipal councils in the watershed. It is this board that sets the budgets, policies and directions of the conservation authority. There are 38 conservation authorities in Ontario serving over 90% of Ontario's population.

Purpose of the Report

The purpose of this report is to define the role of watershed management in protecting drinking water supplies, to describe the current practice of watershed management in Ontario, and to identify where current watershed management could be improved to benefit water supply source protection.

Examples

As a leader in advancing integrated watershed management, examples from the Grand River Conservation Authority are used throughout this paper. The examples illustrate the link between watershed management and drinking water supply protection. They also provide the benchmark from which an estimate of investment required to improve watershed management activities in Ontario is made. Other examples exist in other conservation authorities but his paper does not attempt to include them all.

Acknowledgements

This report has been produced with the contributions of several writers (Appendix G). Thanks are also due to many peer reviewers who commented on the draft documents.

1 INTRODUCTION

1.1 What is Watershed Management?

A watershed is an area of land that drains into a common water body, such as a river or lake. A watershed can also be also known as a basin or a catchment. A watershed is an ecosystem with complex interacting natural components. Human activities have a direct influence on the quality and quantity of surface water, groundwater and other natural resources in the watershed. Upstream activities influence river flows and water quality downstream. Surface and groundwater systems have a limited tolerance for stress, and long-term problems can develop that are costly and difficult to remediate.

By its very nature, watershed management must be integrated and address both water and the related land resources that affect or are affected by water. Water includes floods and droughts, surface water and groundwater, water supply and water quality. Related land resources include streams, wetlands, forests, soil, fisheries, flora and fauna. The premise that "everything is connected to everything else" lies at the heart of watershed management. By understanding the natural functions of a watershed *before* change occurs, harmful impacts on the system can be identified so that prevention, remediation, or improvements can be incorporated into management plans.

Watershed management is not so much about managing natural resources, but about managing human activity as it affects these resources. The drainage area of the river provides the natural boundary for managing and mitigating human and environmental interactions. Because human activity includes actions by governments, municipalities, industries, and landowners, watershed management must be a co-operative effort. Effective watershed management can prevent community water shortages, poor water quality, flooding and erosion. The expense of undertaking watershed management is far less than the cost of future remediation. In this era of unprecedented growth in Ontario, watershed management is an essential tool to ensure the continued health, safety, and well-being of Ontario's residents.

1.2 What is the Relationship of Watershed Management to Water Supply?

Water supply typically means water piped to households and businesses by a municipality or water utility. Water supply also means water taken by households for domestic use or livestock watering, by farmers for crop irrigation, and by rural industry for processing or washing. More recently, environmental concerns have led water managers to acknowledge the water needs of aquatic/fishing functions and wetland functions, in effect representing other competing users of the water resource.

Water supply is threatened in three ways by human activities in the watershed. Firstly, the quantity of water available for supply is reduced by activities that decrease the infiltration of water into the ground (e.g., urban pavement) or channel water away quickly before it can infiltrate (e.g., urban and rural drainage). Secondly, the future availability of water supply is threatened by overuse such as excessive demand, inefficient water use, and inappropriate allocation. Thirdly, the quality of water available for water supply is threatened by pollution from both point and non-point sources. The importance of considering watershed management is emphasized because water supply is affected not only by human activities local to the water supply, but anywhere from within the watershed upstream of the point of taking. Thus, the activities of an upstream community can affect the quantity and quality of a downstream community's water supply, even if that downstream community is in another municipality. For example, the quantity and quality of water supply for the City of Brantford is affected by choices made in Dufferin, Perth, Wellington and Oxford Counties, Waterloo Region and the City of Guelph.

The responsibility for planning water supply and pollution control in Ontario's watersheds requires the co-operation of numerous agencies, municipalities, and conservation authorities. It is essential that these institutions agree on a management plan and work co-operatively to protect the natural systems and manage impacts and demands as necessary to ensure safe and secure water supplies. Protecting the quantity and quality of water supply also depends on actions by landowners and industry. A watershed management plan, developed and implemented locally with full knowledge and participation by the landowners and

industries that must take action, will ensure that water quantity and quality are valued and protected at their source before quantity and quality become a problem.

1.3 Ontario's Tradition of Watershed Management

The tradition of co-operative watershed management is long-standing in the Province of Ontario. Recognition of the need to work co-operatively was prompted by severe water problems associated with flooding, drought, and degraded water quality experienced in southern Ontario from the early 1900's. Problems were particularly acute in the Grand River basin. It was recognized that water problems resulting from rapid urbanization and massive deforestation were hindering economic growth and development. The Finlayson Report (Ontario Department of Lands and Forests, 1932) recognized low flow as a health hazard, and considered problems of water supply and sewage disposal as well as flood control. The Province responded by promulgating special legislation enabling eight municipalities to form the Grand River Conservation Commission in 1932 (Statutes of Ontario C. 55, 1932). The Commission was authorized to carry out studies and water conservation projects to ensure a sufficient supply of water for municipal, domestic and manufacturing purposes during periods of drought and to control flood waters. With assistance from both the Federal and Provincial governments, the Shand Dam was completed by the Commission in 1942 for low flow augmentation, water supply, and flood control (Veale et al., 1997).

Concern for water and related-land resources was highlighted by numerous conservation-minded organizations at the Guelph Conference held in 1941 (Guelph Conference, 1942). The Conference recognized that the depletion of renewable natural resources would place a limit on economic growth. It recognized that planned management, based on knowledge and public and private participation, should replace unplanned, individualistic exploitation. As a direct result of the Guelph Conference and with its eye on the Grand River Conservation Commission, the Tennessee Valley Authority (USA) and the Muskinghum Conservancy District (Ohio, USA), as models for water management on a river basin basis, the Province of Ontario passed the Conservation Authorities Act in 1946 (Mitchell and Shrubsole, 1992; Statues of Ontario, C. 11, 1946). Conservation Authorities were established in Ontario as planning, co-ordinating and management agencies to facilitate municipal and provincial partnerships and to promote a comprehensive approach to resource management. Specifically, they were mandated to establish and undertake a program designed to "further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals." (R.S.O. 1990, C.27, s.20).

Co-operative watershed management among various provincial ministries, agencies and municipalities was furthered in 1971 by an Ontario Treasury Board report entitled "Review of Planning for the Grand River Watershed", which discussed issues related to water management in the Grand River watershed. One of the report's recommendations was to "carry out a comprehensive water management plan for the Grand River Basin." (Ontario Treasury Board, 1971). Subsequently, in 1977, the Ontario Ministry of the Environment (MOE) led a multi-agency team to deal with water quality, water supply and flooding issues in the Grand River basin. To focus the Grand River project, MOE housed the basin study co-ordinator, Dr. Tony Smith, at the Grand River Conservation Authority to work with local municipalities and public advisory groups in developing the plan.

The Grand River Basin Water Management Plan was completed in 1982. The co-operative planning project was so successful that the municipalities and the Conservation Authority went on to fully implement the plan even after MOE had moved on to other things. The result was a 75% reduction in average annual flood damages, the return of a self-sustaining sport fishery to the river, and a water supply strategy that will meet local needs for at least another 40 years.

More recently in 1995, several municipalities, recognizing that the plan was no longer current, approached the Grand River Conservation Authority to help them update the plan. This locally funded effort has re-established the basin planning models and tools and will result in integrated water quality, water budget/water supply, and forest and fisheries management plans by 2002. In a collective planning framework, the participants are assessing the cumulative impact of wastewater treatment on river water quality,

determining what needs to be done to improve water quality, refining capital budget forecasts for municipal infrastructure and pollution control programs, and monitoring the resulting water quality. With continued co-operation from the Ministry of the Environment, the plan will set a watershed-wide framework for future wastewater treatment Certificates of Approval, thereby streamlining the infrastructure planning and approval process and ensuring the objectives are met overall. The participants are assessing the cumulative demand for water, identifying where water shortages may occur, and putting drought contingency plans in place. Groundwater sensitivities have been mapped, priority areas for water protection programs are being identified and water protection policies will be incorporated into municipal planning documents. In the well-developed spirit of co-operation, planning, and investment in water management, the Regional Municipality of Waterloo has developed a water protection strategy that includes its recent initiative to delineate wellhead protection areas and in zoning appropriate land uses to protect groundwater aquifers. In addition, the Regional Municipality of Waterloo, Wellington County and the City of Guelph have committed a combined $2.85 million to assist farmers in implementing projects that improve water quality and groundwater protection.

Currently, integrated watershed plans are being developed for a number of other watersheds in Ontario, the scale and complexity of each being determined by local needs and resources.

1.4 Summary

This chapter sets the context for the rest of the paper. An overview of watershed management is provided that defines integrated watershed management and explains, in general terms, the important considerations for protecting water supply and water quality from a watershed management perspective. These points are further illustrated by describing the history of the Grand River Conservation Commission and the events leading to the promulgation of the *Conservation Authorities Act* and the progress that the Grand River Conservation Authority has made in furthering integrated watershed management within their jurisdiction. This paper will further expand upon these overviews.

2 HOW DOES THE WATERSHED WORK?

Natural features and functions within a watershed influence the quality and prevalence of water resources, and determine the extent to which the natural system can moderate the effects of human activities. This chapter describes the natural processes that move water through the watershed and how these processes affect water quality. An understanding of these processes is essential in order to protect them and to manage demands on the system, so that valued water uses can be maintained.

2.1 Watershed Hydrology

A watershed represents a unique physical unit within which water moves continuously in a cycle that begins with rain or snow (Figure 2.1). Within the watershed landscape, plant leaves will intercept some rain and snow, where it will evaporate back into the air. Rainwater and melted snow may infiltrate the soil or flow overland to be stored temporarily in depressions, wetlands or lakes. Groundwater forms when surface water seeps through the soil to varying depths and collects in aquifers. Groundwater can remain stored underground and then re-emerge as springs or discharges to rivers, lakes or wetlands, within a period varying from a few days to thousands of years. Eventually, water flowing over the surface or through the ground makes its way into rivers and lakes, or is taken up by vegetation, where it evaporates or transpires to begin the cycle again (More 1969).

Natural watershed characteristics, such as geology, climate, landform, soils, and vegetation influence the processes responsible for water cycling. Therefore, these characteristics help determine how much water is available as surface supplies in rivers or lakes, or as groundwater in aquifers.

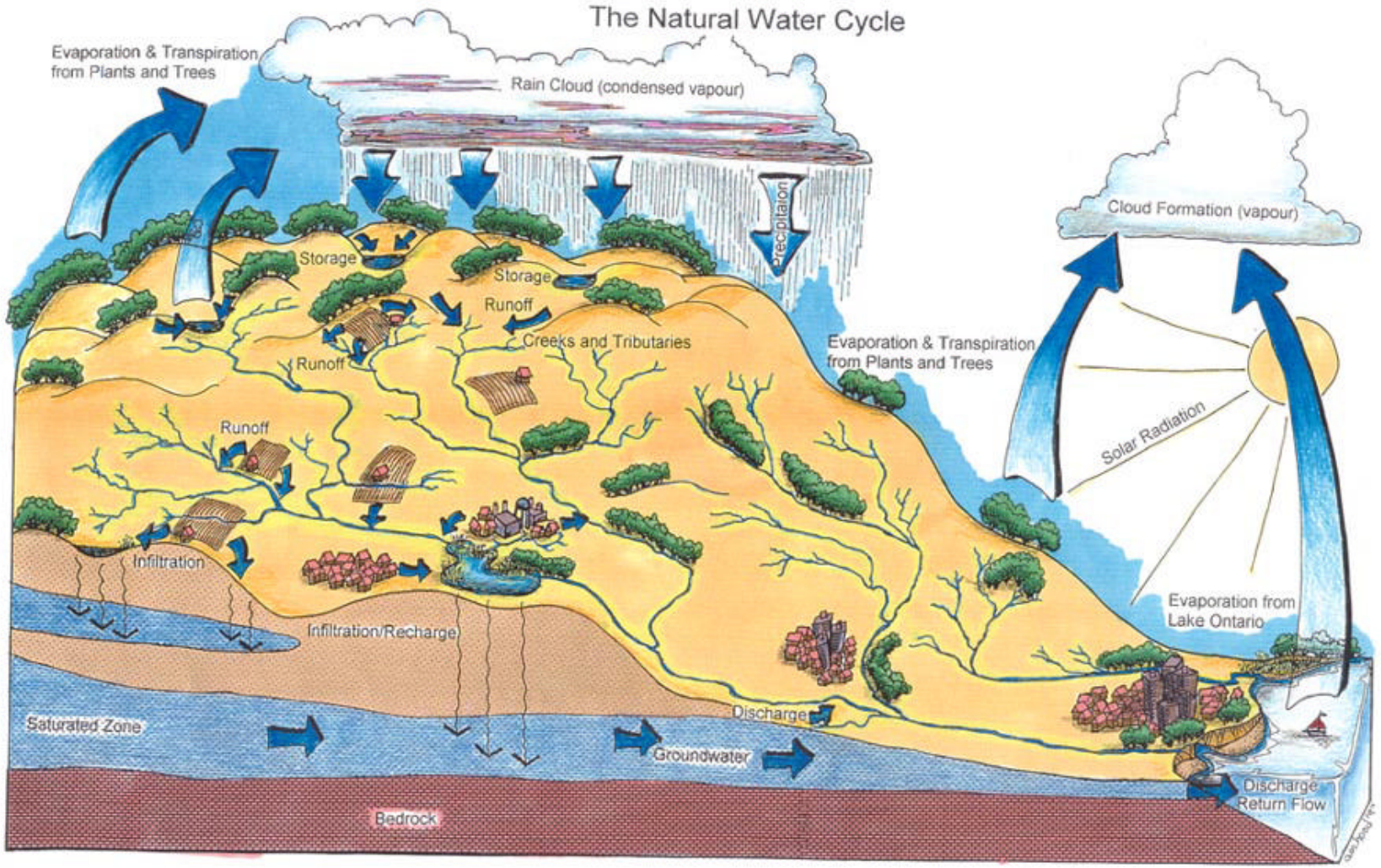
Climate affects the watershed directly by the distribution of rainfall and temperature. Variations in rainfall can be described by the intensity and type of storms, which in part influence groundwater recharge, streamflow and flooding patterns. Light rainfall that extends over a long duration has more time to infiltrate the soil and replenish groundwater supplies. Alternatively, high intensity thunderstorms that deposit large volumes of rainwater in a relatively short period of time cause rapid overland runoff and flash flooding of rivers and streams.

The shape of the land, determined by geology and weather, greatly influences drainage patterns. The density of streams and the shape of a watershed, in turn, affect the rate of overland runoff relative to infiltration. Soil types influence the rate of water movement. For example, finely grained soils, such as clays, have very small spaces between soil particles, inhibiting infiltration and thus promoting greater surface runoff. Conversely, coarse soils, such as sands, have larger pore spaces allowing for greater rates of infiltration and reduced runoff. Soil texture, structure, moisture holding capacity and local topography are important factors determining the susceptibility of land to erosion.

Vegetation plays many roles in the water cycle. It intercepts rainfall, impedes overland flow, and promotes infiltration. Vegetation also uses water for growth. All of these factors reduce the quantity of runoff to streams. Vegetation binds and stabilizes soil, thereby reducing the potential for erosion. Vegetation also stabilizes stream banks and provides habitat for aquatic and terrestrial fauna.

Land use activities that affect climate, landform, soils, or vegetation also impact the natural distribution of water within the watershed landscape. Temperature increases expected over the next 20-50 years, associated with global climate change, are likely to cause more intense storms and longer periods of drought, which will affect the distribution of water resources within Ontario. Water shortages, extreme flood events, and a shift in natural habitats, among other things, are predicted. Activities, such as urbanization and agricultural practices, can alter the slope of land and channel form; pave over or compact soils; remove vegetation; and have many other effects. These effects all result in changes in the water balance. That is, they can change the proportion of rainwater that flows overland relative to that stored, evaporated, infiltrated, or taken up by plants and transpired.

FIGURE 2-1: THE NATURAL WATER CYCLE



2.2 Current Issues in Water Management

2.2.1 Growth

A major watershed issue in southern Ontario is keeping the watershed healthy (economically, socially and environmentally) while accommodating growth. Urban areas are progressively looking for additional surface and groundwater supplies. Increasingly, these supplies are being depleted by others or are being contaminated by pollutants. Growth management includes planning ahead for determining appropriate land uses, ensuring adequate water supply; protecting surface and groundwater quality; allocating water with consideration for long-term planned commitments to future water supply and the environmental needs; and planning growth with consideration for the river and groundwater system capacity to receive wastewater.

2.2.3 Surface water and groundwater quality

Water supply for both human consumption and for maintaining aquatic/fishing resources is dependent on maintaining adequate quality in surface water and groundwater.

2.2.4 Water allocation

Water allocation will become an increasing issue as growth proceeds. Increasing population and intensification of agriculture both result in an increase in water use. Instream demands include recreational and industrial uses (i.e., hydroelectric production, navigation). The aquatic ecosystem, including fisheries, wetland and riparian habitats, is also dependent on a sustainable supply of water for its existence.

2.2.5 River system capacity for wastewater

At a watershed scale, surface water is used to dilute effluent from sewage treatment plants and a variety of non-point sources of pollution. A watercourse's capacity to assimilate contaminants is directly dependent on the quantity and quality of water available for dilution.

2.3 Contaminant Pathways and Treatment Processes

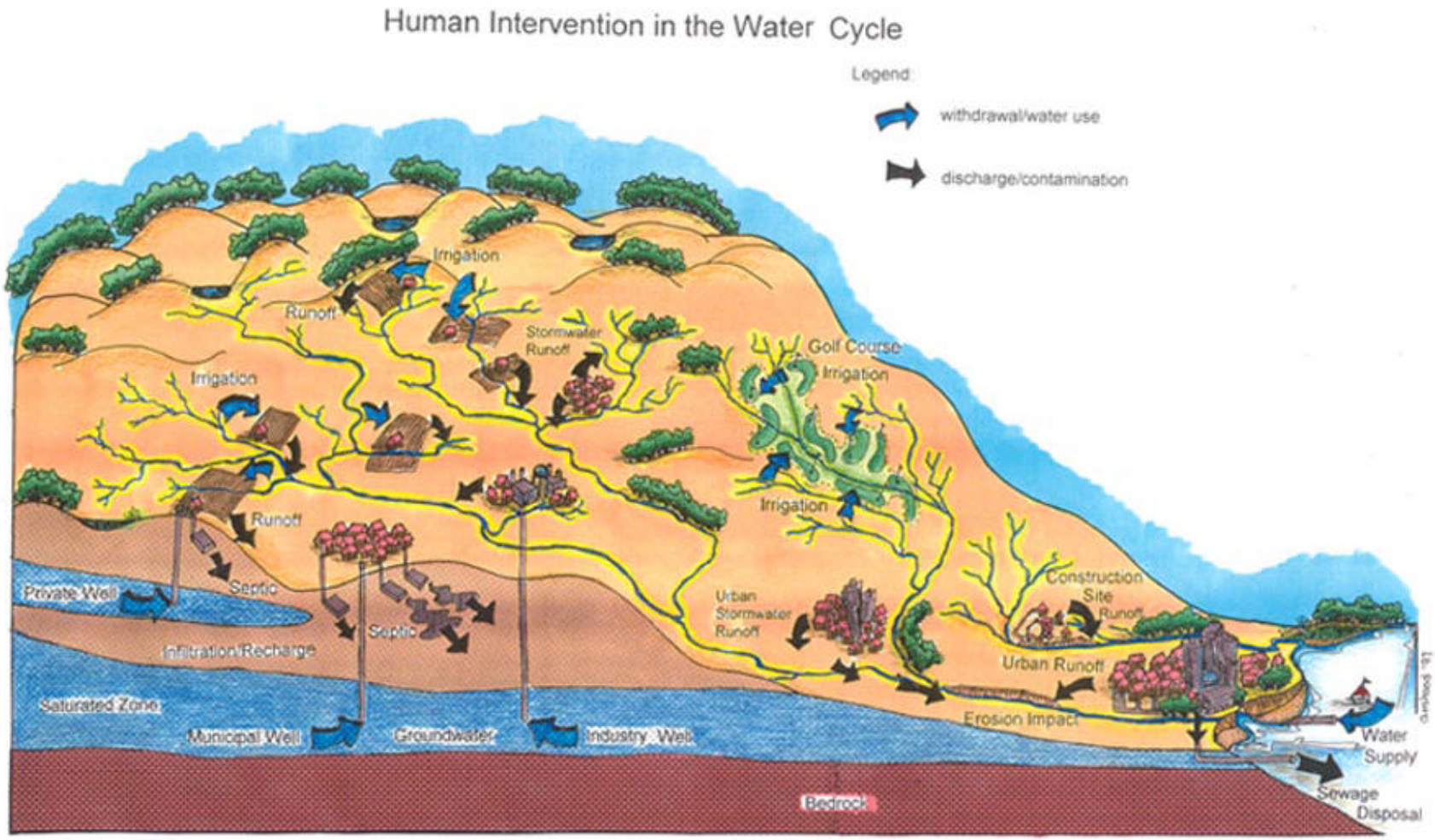
The water cycle serves as a pathway for the transport of natural and introduced materials that influence the quality of the water. However, there are natural purification processes operating within the watershed that help protect the integrity of water supplies and overall environmental health.

2.3.1 Types of contaminants

Inorganic compounds, pathogens, and organic compounds can harm water quality when present in excessive amounts. These contaminants can adversely affect the health of humans, fish and wildlife. Inorganic compounds include all compounds that do not contain carbon. Nutrients (e.g., nitrates and phosphorus) and heavy metals are two examples. Nitrates can cause problems in drinking water, because they become toxic nitrite within the digestive tract. Nitrite causes methemoglobinemia, or blue baby syndrome, which impairs the blood's ability to transport oxygen. Phosphorus promotes plant and algae growth. Algae can taint the taste of drinking water and foul aquatic habitat. Certain heavy metals are toxic to humans and wildlife. Heavy metals include iron, cadmium, mercury, lead and others.

Pathogens, including bacteria and viruses, are the leading cause of water borne disease outbreaks. Cryptosporidium, Giardia, and, well known to Ontario, E. coli. 157, all cause illnesses and sometimes even death when consumed. Organic compounds include Volatile Organic Compounds (VOCs) like benzene, toluene, xylene; semi-volatile compounds like phenol and napthalene; PCBs and pesticides. Today's pesticides are generally less toxic and less persistent than those used in the past, but their presence in water is still a concern as they are thought to be linked to endocrine (hormone) disruption in humans.

FIGURE 2-2: HUMAN INTERVENTION IN THE WATER CYCLE



2.3.2 Potential sources

Many compounds and pathogens occur naturally in soil and water. Certain land use activities, however, can accelerate their release and introduce excessive concentrations of contaminants in localized areas. Sources of contaminants are referred to as either point or non-point. Point sources are easily identified because they usually come out of a "pipe". Examples include sewage treatment plants, combined sewer overflows, industrial plants, livestock facilities, spills, and others. Non-point sources refer to widespread, seemingly insignificant amounts of pollutants, which cumulatively threaten water quality and natural systems. Examples of non-point sources include improperly managed septic systems; agricultural, forestry or mining practices; construction activities; careless household management, lawn care, as well as road, parking lot and other urban runoff (Figure 2.2).

2.3.3 Treatment processes

Physical, chemical and biological functions associated with natural watershed features work together to remove pollutants from water (Hammer 1992). Physical filtration and sedimentation of particles occurs as water flows overland through vegetation or percolates through soils. Dense vegetative cover, shallow grades, and porous soils enhance these processes. As sediment particles are deposited, so too are many other contaminants, such as metals, hydrocarbons and bacteria, that are removed by chemical adsorption to the sediment particles. Storage or temporary detention of water in ponds, lakes or depressions further enhances the opportunity for sedimentation of inorganic contaminants, and also allows time for die-off of bacterial or viral contaminants.

Chemical reactions and biological decomposition may break down complex compounds into simpler substances. Through absorption and assimilation, plants can remove nutrients from the water to aid in their own growth. Plants also take up other contaminants, such as heavy metals, binding them into woody material for long periods of time. A by-product of plant growth is oxygen, which increases the dissolved oxygen content of the water, air, and soil around it. Oxygen aids in aerobic bacterial decomposition of pollutants, as well as sustaining life for many organisms that in turn convert other pollutants to beneficial uses.

Dilution, while not a true treatment process, is sometimes recognized as contributing to the assimilation of contaminants to acceptable levels within a watershed. The cleaner the water body is, the greater its potential assimilative capacity.

The relative significance of each of these processes depends on the natural characteristics of the watershed, and on the degree to which sensitive natural features and their functions are protected from the adverse impacts of land use activities.

2.4 Effect of Watershed Processes on Water Supplies

All natural water cycling and water treatment processes within a watershed play a role in influencing the abundance and quality of water supplies. However, certain processes have a more direct effect than others. In Ontario, domestic water supplies are drawn from three primary sources: 1) groundwater, either via private wells or public communal wells; 2) river-based surface water; or 3) lake-based surface water.

Groundwater supplies are directly affected by changes in the natural rates of recharge (infiltration) and groundwater use. However, even a plentiful groundwater supply may be lost if it becomes contaminated. Groundwater quality can be affected by a variety of land use practices, such as septic fields, agricultural operations, or underground storage tanks. Groundwater supplies are especially vulnerable to contamination when high-risk land uses are located within prime recharge areas.

Sustained baseflow and water levels in rivers and streams is dependent upon properly managed surface runoff and groundwater levels. River and stream water quality reflects the natural geologic setting of the basin. In southern Ontario, most streams are impacted in some way by land use activities that generate pollutants and runoff, and by loss of the natural filtering capacity of wetlands, forests and vegetated

stream buffers. Increased surface runoff and streamflow can erode streambanks adding to the sediments and other contaminants already carried in the watercourse. Streams that receive groundwater discharge can also be impaired by contaminated groundwater.

Similar to rivers, lake water levels are dependent upon properly managed surface runoff within the lake catchment and on groundwater levels. Nearshore lake water quality, while influenced by contaminant loads from the entire lake basin, is affected by contaminants carried down from local watersheds and from direct groundwater and surface water discharges to the lake.

2.5 Summary

This chapter describes the natural processes that move water through the watershed and affect water quality. The water cycle serves as a pathway for the transport of natural and introduced materials that influence the quality of water. The chapter describes the type of contaminants, the source, and the natural functions that work as treatment process to remove contaminants from the water cycle. The watershed processes influence the quantity and quality of water supplies drawn from ground water and surface water.

3 MANAGING THE WATERSHED

3.1 The Watershed Management Process

The watershed management process can be seen as a continuum that includes producing a plan, implementing the plan (act), monitoring the effectiveness of the plan, and evaluating and updating the plan. This seemingly simple process, illustrated in Figure 3.1, is often difficult and complex to carry out. Despite the difficulties, the process is valuable because it promotes a systematic and logical way of thinking and a framework for making decisions with regard to water and land use. This section briefly describes the process.

The watershed partners (province, municipalities, conservation authorities, aboriginals, private water users, the various other interested parties and the general public) are involved in all aspects of the management process. The process can be used for relatively straightforward problems where only one or two participants are involved, as well as complex problems involving a number of partners and participants and a large degree of uncertainty.

3.2 Watershed Planning

3.2.1 Scoping the problem

Key issues and underlying interests should be identified as soon as possible in the planning stage. All affected stakeholders or partners should be consulted as early in the process as possible. Often this is done at the outset by creating an informal group. As the group develops a working relationship and purpose, a more formal structure is developed with a steering committee to clearly define roles and responsibilities for all partners. Partners should be prepared to help develop the watershed plan and implement the plan recommendations.

Typical issues of interest relative to this paper are:

- water supply crises, inadequate supplies of surface or groundwater to meet present and future needs;
- pollution of surface and groundwater systems;
- harmful impacts on wetland and aquatic systems.

3.2.2 Creating a vision, goals and objectives

Once problems or issues are clearly defined, it is necessary to quickly establish a vision, goals, and objectives. The "vision" is the big picture of the desired state of the watershed in the future. This provides a focus for planning and a standard against which progress and management options can be measured. A simple vision for water supply/water quality purposes could be: "We want enough clean drinking water to supply all the needs of a growing community without compromising the health and sustainability of our waterways and forests."

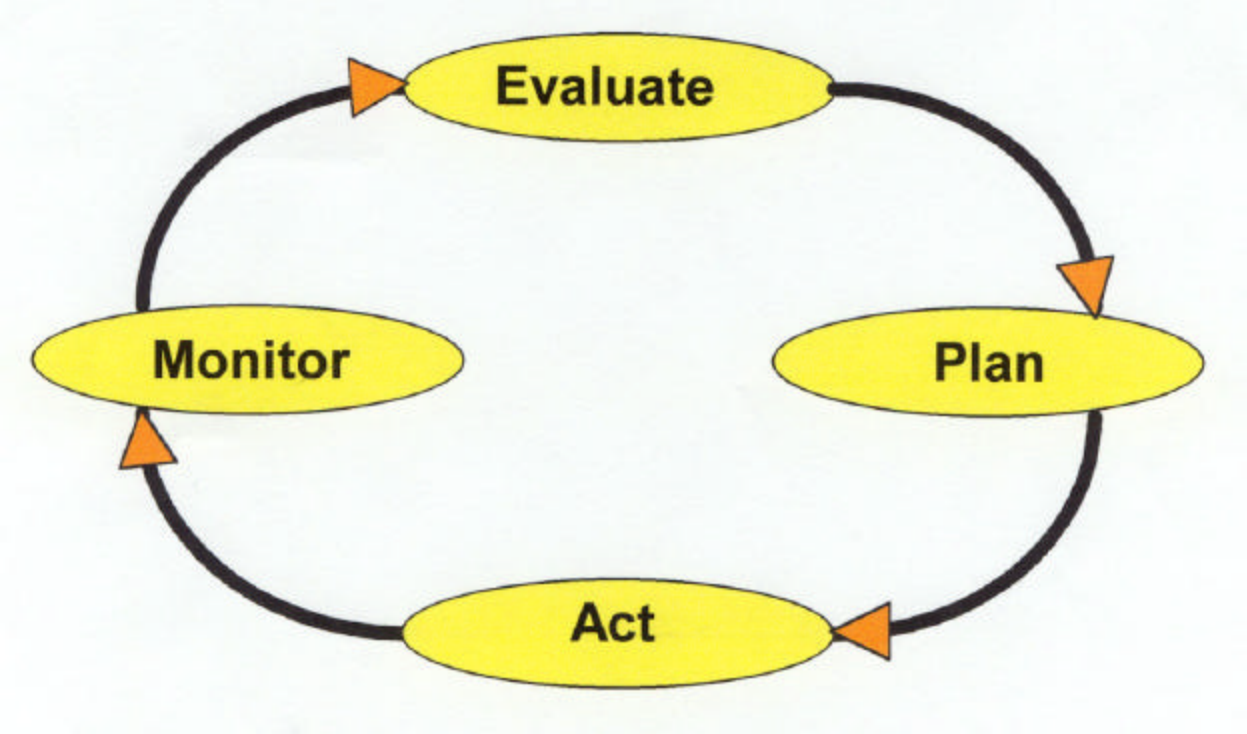
Goals are the specific states we must reach to improve ecosystem and human health in the watershed. Specific goals give the direction for improvement. Compatible goals for our vision would include:

- provide adequate water supply to watershed communities, while still providing sufficient water for environmental concerns;
- restore, protect, and enhance water quality for water supplies and aquatic resources;
- protect and restore the natural resources (land, water, forest, and wildlife) of the watershed.

Objectives are the measures or targets toward achieving the specified goals.

Finally, it is most important to achieve community consensus about the relative importance of the problems or issues and the appropriateness of goals and objectives.

FIGURE 3-1: THE WATERSHED MANAGEMENT PROCESS



3.2.3 Getting the information together

Effective decision making within the framework of watershed management requires a comprehensive understanding of the current state of the natural environment, its historical characteristics, societal values, and where possible, economic influences. Determination of the information required and the level of detail is based on the watershed issues. Watershed planning projects typically begin with a "background review and assessment of available information" in order to identify and initiate efforts to fill information gaps. The completed information base allows the participating watershed partners to have a common understanding of physical features, processes, and community issues that presently exist and once existed in the watershed. This information provides the building blocks with which to create predictive models of the system to evaluate the impacts of proposed management options. Due to funding and time limitations, particular attention should be paid to collecting information needed to address the agreed upon issues.

3.2.4 The participatory process

Ontario's legal and institutional division of water responsibilities among various levels of government and the common property nature of water requires participation from a variety of government, non-government, community, and private interests in decision-making. Through a participatory process, it is possible to:

(a) define the problems more effectively;

(b) access information and understanding that fall outside the scientific realm;

(c) identify alternative solutions that will be socially acceptable;

(d) create a sense of ownership for the plan or solution, which facilitates implementation (Mitchell, 1997, pp 155-156).

Therefore, a participatory process should be part of watershed management, particularly in the following phases:

(a) defining the issues, goals, and objectives;

(b) providing information to aid the understanding of watershed processes;

(c) evaluating options and alternatives in the formulation of the watershed plan;

(d) creating linkages, partnerships, and action plans for implementation.

While a participatory process may extend the time needed during the initial stages of analysis and planning, such an investment is normally "returned" late in the process by avoiding or minimizing conflict. For this reason, public involvement is encouraged as early and as broadly in the process as possible to be most effective (Smith, 1982).

A quarter of a century ago, public involvement was seen as unnecessary and superfluous, if not downright invasive, by many decision-making bodies. Decisions were made at the "top" by provincial and federal agencies with little input from those affected. Today the trend is towards a "bottom up" approach where decision-making takes place at the local level. Watershed management requires a marriage of both approaches. It means that those who implement actions must be directly involved. A shared, collaborative approach is required to ensure that implementation is carried out and that the management plan does not sit on a shelf. This requires government agency participation and support as well as strong community involvement.

Some examples of successful participation and collaboration dealing with water supply and water quality issues include:

1. **The Grand Strategy** – building on the 1982 Grand River Basin Study, a multi-agency study dealing with water supply, water quality, and flood issues, The Grand Strategy, co-ordinated by the Grand River Conservation Authority, provides a forum for partners (municipalities, community groups, agencies, schools, businesses, and others) to pool resources, determine priority actions and celebrate successes. As part of this process, water managers within the watershed meet regularly and progress is being made toward updating the Grand River Water Quality Model, first developed as part of the Basin Study, and completing a water budget and water supply strategy.
2. **The Torrance Creek Subwatershed Study** – undertaken by the City of Guelph, in co-operation with the Grand River Conservation Authority (GRCA), this study investigated the best means of developing the creek without impacting both existing city groundwater supplies, and environmental features such as wetlands. The watershed steering committee included city representatives, developers, golf course owners, and various citizens' groups.
3. **The Maitland Watershed Partnerships (MWP)** – initiated by the Maitland Valley Conservation Authority, 34 organizations and agencies with an interest in resource management have formed a steering committee to examine best management approaches to managing water, agriculture and forestry.

3.2.5 Developing the watershed plan

Once the watershed goals and objectives are clear, tools are then developed to design and evaluate workable management options for achieving the goals. Management options may include measures that use technology or structures (sometimes called structural methods) and those that rely on changes in human behaviour or management practices (sometimes called "non-structural" measures). Generally speaking,

structural measures such as treatment plant improvements are easier to implement, although considerably more costly than non-structural measures. Non-structural measures, for instance, encouragement of crop rotation and the installation of vegetated stream buffers, tend to be inexpensive but are difficult to implement because people must change entrenched behaviours. Most watershed management strategies include a mixture of structural and non-structural measures designed to meet the issues of a particular watershed.

For instance, options that are typically explored to increase water supply are:

(a) increased ground water supplies, from existing or new sources;

(b) surface water withdrawals from local sources or by pipeline;

(c) construction of surface water reservoirs and/or utilization of groundwater storage through recharge or infiltration schemes;

(d) control of water demand by water conservation, programs, etc.

Similarly, to deal with the contamination of ground water aquifers and surface water streams one could implement preventative measures such as:

(a) land-use controls to establish groundwater protection areas;

(b) controls of rural and urban non-point sources of pollution;

(c) increase levels of treatment at sewage treatment plants; or reactive measures such as increases in the level of treatment at water treatment plants.

With the assistance of the watershed partners, various projects or options are combined into management alternatives to meet the goals and objectives of the watershed planning process. These alternatives are then evaluated to determine their effectiveness, costs, benefits, and environmental and social impacts. Modern computer technology greatly facilitates this task. Several tools used to screen and evaluate the effectiveness of various alternatives include:

For water supply alternatives:

- flow simulation models for both surface and groundwater,
- water budget models.

And for water quality alternatives:

- stream water quality model,
- land use water quality model.

Appendix A briefly describes some of the evaluation tools.

Management alternatives are evaluated under present and future scenarios. It is particularly important at this final stage of plan development that the public and interested agencies have an opportunity to comment on the strategies being tested and to recommend different strategies for evaluation.

After due consultation, a preferred management alternative is selected. This alternative is the basis for the watershed plan, which stipulates what actions are needed to accomplish the objectives. Time frames, costs, and responsibilities for implementation are also stipulated in the plan. Action recommendations specify the work needed, the desired result, technical and staffing needs, costs, and a follow-up review for the effects of the action. Recommendations include the logical sequence in which the remediation takes place (e.g., undertake upstream work before downstream work, ensure that cattle access is restricted before repairing stream banks). Phasing of actions allows time to acquire funding for some parts of the project, provides a logical progression for improvement, or fits actions into future agency work plans. Some

actions should be identified that are relatively easy to complete in a short time to provide incentive and encouragement for future work.

3.2.6 Risk assessment

Rather than relying only upon end-of-pipe solutions (increased levels of treatment) to reduce the risk of human exposure to contaminants, the watershed approach advocates preventing problems by controlling their source using various best management practices. Thus risks are diminished and the water supply system reliability may be improved. In planning studies dealing with risk, a key question is, "how much are the risks reduced by source controls?"

"Risk assessment" and "risk management" are procedures that recognize and incorporate elements of uncertainty in the evaluation of alternatives for protecting water supplies. These procedures provide a logical structure to make decisions determining which protective measures are most effective at reducing the risks to acceptable levels. They can be applied to help develop general watershed management policies and to evaluate site-specific water supply conditions for a particular community.

Risk assessments for water supply questions utilize technical information to characterize the magnitude of human health risk. There are three elements of a problem that are relevant to risk assessment. These are:

- A source of contamination exists.
- One or more pathways exist, by which the contaminants may migrate to the well.
- One or more water consumers use the well and may experience health problems from contaminated drinking water.

Appendix B provides a more detailed explanation of risk management and responses that may be used to reduce human health risk.

3.3 Implementing the Plan

Watershed plans are implemented through a variety of tools that are administered by several agencies at the provincial and local level. These tools can generally be categorized under the headings of land use planning, water and wastewater master planning, water resource regulations, land and water stewardship programs, public land acquisition programs, infrastructure development and maintenance, remedial measure programs and other operational activities. The province, municipalities, and conservation authorities will implement the watershed plan if they have been actively involved in developing the plan and if it is socially and economically practical as well as environmentally sound.

Only a small percentage of industries and landowners will take an interest or become involved in developing a watershed plan. The "What's in it for me?" attitude will vary greatly among interest groups, stakeholders and the public, so a range of incentives are required to reach various people. Some just need information; some respond to recognition and applause or to peer pressure; and some may actually participate in order to avoid the courts. The incentives for participants should include education, information, opportunities to participate in planning or "hands-on" action, applause and celebration, cost-sharing incentives, public-private partnerships, and finally, surcharges, regulation, and enforcement (Minshall, 2000). The benefits of an approach employing this range of incentives rather than the traditional regulation and enforcement approach include reduced effort to cause change, longer-lasting change, and broader public support.

In order to gain support for protecting drinking water sources, it is important to involve and educate citizens to protect drinking water and the environment in general. Programs such as the Annual Children's Ground Water Festival are held each year in the Regional Municipality of Waterloo, Peel Region and commencing in the Saugeen River watershed in 2001. This festival helps children and their parents learn about the nature and value of groundwater. The Yellow Fish Road program is another initiative that en-

courages stewardship and promotes awareness of the connectivity of urban storm drains with local creeks and rivers.

Landowner stewardship programs help improve the landowners' management practices for their properties. The soil and crop improvement associations, conservation authorities, and the stewardship councils sponsored by the Ministry of Natural Resources all have various programs in this regard.

Led by municipalities and public interest groups, promotional campaigns to reduce water demand through water conservation methods have been effective in the Grand River watershed. Canadian Heritage River designations of the Grand, Humber and Thames rivers, coupled with river-focussed tourism campaigns have made the public aware of the rivers as an environmental, economic, aesthetic and recreational asset, not as the glorified sewer of past eras. Conversion of abandoned railways running beside the Grand River into recreational trails for hikers and bicyclists increased the visibility and awareness of the river.

3.4 How Can Watershed Management Help Provide Adequate Clean Drinking Water?

3.4.1 Seeing the big picture

This section describes how the watershed management process can aid decision-makers, planners, engineers, ecologists, and citizens in obtaining adequate, clean drinking water and at the same time ensuring that environmental concerns are being addressed. The watershed plan is used as a blueprint for managing and protecting groundwater and surface water supplies. It is at this time future water supplies are identified, risks of contamination are assessed, and the plans for water supply protection are put into place.

3.4.2 Managing watershed groundwater supplies (aquifers)

Municipal planners and engineers need answers to the following questions:

(1) Where are the sources of groundwater supply?

(2) What is the quality of available groundwater?

(3) How much water can the aquifer supply on a sustainable basis?

(4) What are the sensitive areas in the aquifer system that should be protected from development?

(5) What are the environmental impacts of increased water withdrawals from the aquifers? (i.e., effect on wetlands, aquatic systems, well interference, etc.).

A regional groundwater analysis is usually carried out as part of an overall watershed study to help answer these questions. The municipality carries out more detailed well field studies after the regional analysis is completed. The four stages in the analysis are: defining the aquifer system, defining the aquifer characteristics, installing a monitoring system, and modelling the aquifer system. This analysis determines the safe yield of the aquifer, the environmental impacts of increased withdrawals, and requirements for groundwater protection.

An understanding of regional groundwater flows and their interrelationship with surface water can be obtained by the application of water budget and groundwater flow modelling. This is presently done by the Grand River Conservation Authority in co-operation with its member municipalities. More detailed small-scale groundwater studies to define groundwater protection areas and optimize well field operations are usually carried out by municipalities after the regional analysis has been completed.

3.4.3 Managing the regional groundwater system

Under the present planning climate in Ontario, there has been a shift in responsibility for land use decisions away from the provincial level of government to the local level. Groundwater is no different. Before the 1980s, the Ministry of the Environment carried out several regional groundwater studies. Since the 1980s, little work was undertaken to understand groundwater movement on a regional or watershed scale. Some municipalities, such as the Regional Municipality of Waterloo and the Regional Municipality of

Halton, undertook regional groundwater studies and groundwater protection studies. Since 1999, major efforts have been made at the local and provincial level (MOE) to carry out regional groundwater studies. A regional groundwater mapping project was undertaken in 1999 to characterize the groundwater regime in the Grand River watershed. This work, by the Grand River Conservation Authority, is part of the Grand River Watershed Groundwater Study. A suite of colour contour maps was produced displaying subsurface features within the watershed relating to physical geology, hydrogeologic characteristics and resource protection requirements. Municipal planners and engineers now have groundwater mapping readily available to guide land use discussions regarding water supply sources and their protection. Data support was provided by MOE (well logs) and MNR (base mapping). The study cost of $250,000 was funded by the GRCA.

An Eastern Ontario Water Resources Management Study (EOWRMS) was initiated in 1999 by local municipalities to develop an information base and management tools for surface and groundwater. In eastern Ontario, groundwater is the primary water source supplying over 20 communities and 100,000 private users. The $1 million study was largely funded by the MOE Groundwater Protection Fund and embraced many partners (federal, provincial, municipal, conservation authorities and agricultural/rural organizations).

The Groundwater Protection Fund was established by the Ministry of the Environment to provide assistance to municipalities interested in developing groundwater management strategies for their drinking water supplies. The fund has resulted in the start up of many studies, however the challenge is now in ensuring that consistent standards and approaches are followed in the absence of provincial guidelines.

3.4.4 Monitoring the aquifer system

A monitoring network is necessary to evaluate existing and future conditions dealing with groundwater quantity and quality. Because it may take years to detect slow moving groundwater contaminants at the wellhead intake, monitoring ambient groundwater conditions provides an early alert to trends in groundwater quality. Except for some local monitoring networks at municipal well fields, there has been no organized monitoring network within Ontario for approximately 20 years. A recent initiative of MOE will establish a provincial groundwater monitoring network in co-operation with local conservation authorities.

3.4.5 Protecting the aquifer system

A comprehensive groundwater management strategy must address protection of the water sources, management of water use, and management of land use that may present a source of contamination. The sensitive groundwater areas indicated by the regional mapping can be protected by identifying them in municipal official plans and developing appropriate policies. Development in these areas should be limited or prohibited.

Over pumping of the aquifer system can be regulated under the Ontario Water Resources Act administered by the MOE. A good knowledge of the regional groundwater system can make it easier to interpret requests for increased withdrawals in the context of the needs of current users, their long term plans and the requirements of the natural environment.

The Ministry of Agriculture, Food and Rural Affairs introduced an environmental farm plan, which encourages farmers to adopt environmental best management practices. The Ontario Soil and Crop Improvement Association is administering this program. There are many other examples of provincially and federally funded programs for the remediation and protection of water resources. Generally, provincial and federal government assistance for such programs lasted no more than two to five years. While these have been very useful, the efficacy of provincially and federally funded programs is diminished by their temporary nature. Sustained management programs based on stable funding are required to successfully implement aquifer protection measures. Locally initiated programs are more likely to meet this requirement. For example, municipalities in the Grand River watershed, led by the Regional Municipality of

Waterloo, in partnership with farm organizations and the GRCA, are now delivering a rural water quality program with monetary incentives. The municipalities provide the funding and the GRCA administers the program. Similar programs are being delivered at the Upper Thames River, Lake Simcoe Region, and South Nation River Conservation Authorities. The motivation for these initiatives comes from having a goal, a plan, and partners willing to implement the plan.

3.4.6 Sustaining environmental features

It is not enough to have sufficient water for water supply, but there must be enough water to sustain environmental features such as wetlands and aquatic resources. Planning for this can be achieved through the use of water management tools such as water budgets, modelling, and inventories of natural features.

3.5 Managing Watershed Surface Water Supplies

It is generally assumed that natural rivers, streams, and lakes are suitable sources for water supply, but as with groundwater, this assumption must be qualified.

(1) How much water is available for water supply?

(2) Is storage available?

(3) What is the quality of the source water?

(4) What are the legal restrictions on water withdrawal?

(5) What are environmental impacts caused by an increased withdrawal?

The availability of surface water is usually evaluated on a watershed scale using monitoring records, water budgets, and reliability studies.

For example, in 1982, the Grand River Basin Study team selected withdrawal from the Grand River as a means of augmenting water supply for the Regional Municipality of Waterloo. More detailed studies carried out by the municipality further confirmed the project. Based on watershed or regional studies, the Province allocates water by permit through the Ontario Water Resources Act. As competition for water between different users increases, i.e., municipal water supply, recreation (golfing), agricultural, and urban irrigation, it will become increasingly important to have more knowledge about the needs of the water system, particularly environmental or aquatic needs so that proper allocation can occur before a crisis develops.

Where there is insufficient water, the preferred solution is often to increase the reliability of the available supply, by structural measures such as reservoirs or pipelines. Water conservation is often used to reduce demand and prolong the existing supply. Watershed studies, coupled with local municipal studies, are often used to select the appropriate alternative.

The use of water from rivers or streams is commonly subjected to water quality restrictions. Watershed studies can determine the most effective mixture of pollution control to reduce upstream point sources (municipal waste treatment) and upstream non-point sources (agricultural and urban land use).

3.5.1 Managing surface water supplies

Municipalities, conservation authorities and the Province currently carry out management of surface water supplies. The surface water management system is demonstrated in the example given in section 3.5 where, after extensive watershed and municipal studies, the Regional Municipality of Waterloo was able to withdraw water from the Grand River without any negative downstream impacts.

This example may be somewhat atypical because of the extensive background information and analysis that was available to support allocation decisions. It will become increasingly important to develop this type of knowledge about the needs of the water system, particularly the environmental or aquatic needs as the competition for water increases between municipalities, recreational users of water resources, the ag-

ricultural community and other users. There must be assurance that permitted water supply withdrawals do not affect these other users, nor reduce the amount of water necessary for the environmental functions of wetlands, forests and aquatic systems. Rigorous technical analysis is needed to provide this assurance.

3.5.2 Monitoring the surface water system

Stream flow, precipitation, river water quality, groundwater levels, and groundwater quality must be monitored to understand the surface water system and its interconnections with the groundwater system. Surface water monitoring has historically been adequately addressed. However, recent cutbacks occurring at the federal and provincial levels have led to reductions in stream flow and water quality monitoring. Until recently there has been little groundwater monitoring carried out by the Province. A few municipalities such as the Regional Municipality of Waterloo, Regional Municipality of Halton and the Township of Puslinch have carried out groundwater monitoring at a local and regional level.

3.5.3 Protecting the surface water system

Protecting the source areas of water supply from possible contamination, whether it be surface water or groundwater, is the first line of defence in a safe drinking water strategy. Potentially harmful land uses must be eliminated or managed appropriately in those areas where the chance of surface water contamination is high. Agriculture, forestry, gravel extraction, mining operations, sewage disposal and urban development can all contribute to the contamination of drinking water supplies.

Farming activities, in particular, have become a focal point in this regard. Modern day farming operations have grown large and are intensive in response to market forces. As a result, they handle large volumes of inputs. Livestock farms, for example, produce huge volumes of waste, sometimes exceeding the amounts produced by neighbouring communities. In contrast to the heavily regulated waste management systems of urban centres, large livestock farms do not undergo a similar level of environmental scrutiny. Although most farmers would not knowingly pollute ground and/or surface water, the current accepted practices may be putting resources at risk. The current level of regulation and enforcement may not be enough to safeguard water resources. Research is needed to develop new technologies and best management practices in order to reduce the impact of agriculture on water quality. Financial assistance may also be required to help existing family farms meet a new level of environmental excellence. Programs such as the Environmental Farm Plan and the Rural Water Quality Program are examples of programs that are needed to help farmers address the environmental challenges on their operations.

3.6 Water Infrastructure

3.6.1 Wastewater treatment plants

Watershed planning aids municipal and provincial officials in selecting the level of treatment that should be achieved by each wastewater treatment plant, especially in a river system such as the Grand which deals with the combined discharges of many plants. On the Grand River, in-stream water quality models have helped determine the level of treatment at each plant that is needed to protect aquatic life downstream of the plant. The models were initially constructed by MOE in the 1980's, updated by the GRCA in the 1980's and 1990's and applied recently to evaluate treatment options on behalf of the municipalities. The results from the water quality models were then used by the Ministry of the Environment, under the Environmental Protection Act, to establish Certificates of Approval stipulating the treatment levels that each sewage treatment plant along the river system must meet. The objective of the water quality simulations was to determine the accumulated effect of all the plants upon the system.

3.6.2 Dams and reservoirs

Reservoirs for low flow augmentation and water supply are usually owned and operated by the municipalities or the conservation authorities. Many of these reservoirs are multi-purpose. For instance, on the Grand River, multi-purpose reservoirs are used to supply water to the City of Brantford and the Regional Municipality of Waterloo, to provide flood control benefits throughout the river system, to provide low

flow augmentation to ensure a healthy aquatic community and to provide various water-based recreational opportunities. Watershed management studies are used to optimize the operation of these reservoirs so that the reservoir objectives can be better achieved and conflicts between users can be minimized.

3.7 Monitoring and Evaluation

Monitoring the state of the watershed environment is useful for:

(a) evaluating the effectiveness of watershed plans, and

(b) carrying out day-to-day watershed management functions.

In the Grand River basin, an elaborate system of stream flow gauges and water quality monitoring systems (both manual and electronic) are used to monitor the effectiveness of the 1982 Basin Plan in meeting flow targets for water supply and the effectiveness of sewage treatment plants in meeting the water quality objectives of the basin management plan. Physical and chemical water quality monitoring networks are being complemented by the use of biological indicators (benthic invertebrates and fish species). These indicators are an effective method of monitoring environmental health.

During normal operations, the real-time monitoring system enables the GRCA to adjust daily flow targets through the use of reservoir operations. During drought flow conditions, stream flows are adjusted based upon water supply and fishery needs. Fishery needs are determined by an electronic monitoring system measuring dissolved oxygen and temperature.

Most of the Ontario watershed monitoring systems are operated in co-operation with the conservation authorities, the Province and Environment Canada. However, due to recent government cut backs, the provincial and federal authorities are reducing the number of stream flow and water quality monitoring stations they will support.

3.8 Summary

The watershed management process can be seen as a continuum that includes producing a plan, implementing the plan, monitoring the effectiveness of the plan, and updating the plan. With the assistance of the watershed partners, municipal, provincial and public, various water supply and water quality improvement projects are combined into management alternatives to meet the goals and objectives of the watershed planning process. Key to successful implementation of the plan is to have all implementers participate in developing the plan. To reduce the risk of human exposure to contamination, it is suggested that water managers rely upon a suite of solutions including source control as well as increased levels of treatment. Examples of how the watershed management process can aid in providing clean drinking water are given for ground water and surface water supplies.

4 FINANCING WATERSHED MANAGEMENT

4.1 The Cost of Watershed Management

In Ontario, watershed management activities are undertaken primarily by conservation authorities, municipal governments and the province.

The conservation authorities are responsible for a broad range of watershed management activities that fall under the general headings of watershed management and monitoring, environmental advisory services, and stewardship. From 1997 to 1999, total expenditures for these activities averaged $5.80 per hectare or $4.50 per person living within the conservation authority jurisdictions. The total cost of watershed management activities undertaken by the conservation authorities is about $59 million per year.[1]

The municipalities manage water supply, wastewater, and storm water systems as well as rural municipal drains and certain shoreline protection programs. Rural drains and shoreline programs account for a relatively small portion of total costs and are not considered here. From 1995 to 1997, annual municipal expenditures in Ontario on water supply, wastewater, and storm water systems averaged $2.09 billion. This amounts to $273 per person or $660 per household. The overall breakdown of this expenditure is as follows: 51% for water supply, 45% for wastewater services, and 4% for storm sewers.[2]

Provincial ministries enforce environmental protection regulations and sponsor limited watershed management activities directly. These activities are concentrated in the Ministry of the Environment.[3] Readily available data describing the operational expenditures of the Provincial Ministry of the Environment allow only a rough estimation of these expenditures on watershed management. Assuming that one half of the expenditures on compliance and resource conservation are associated with water resources, then total expenditures in 1998-1999 and 1999-2000 have been about $50 million per year or about $4.30 per person in the Province. Provincial ministries also help finance municipal and conservation authority activities, but the associated transfer payments are included in the costs reported above for these jurisdictions.

Watershed planning is an important component of watershed management. The costs for watershed planning are borne by conservation authorities, municipalities and a variety of provincial agencies. The clearest compilation of watershed planning costs is provided in the document, “Inventory of Watershed Management Projects in Ontario, 1990-1995” (Ontario Ministries of Environment and Natural Resources, 1997). This document identifies 84 studies conducted over the five-year period having a total budget of $16.5 million. Allowing for additional studies for which there were no budget figures, the total expenditures on watershed planning were probably in the order of $20 million over 6 years or $3.3 million per year. On a per capita basis, this represents an annual cost of about $0.30.

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[1] The analysis is based on a review of financial statements from 24 of the 38 conservation authorities. This amount does not account for conservation land management costs, which can also contribute to watershed management. Records prior to 1997 were not used due to changes in reporting practices that first occurred in 1997. Average per person expenditures are population-weighted averages.

[2] The municipal costs are based on an analysis of FIR data from MMAH for municipalities in Ontario providing water supply services. 1997 was the last year for which detailed data were available.

[3] The Ministry of Natural Resources provides transfer payments to the conservation authorities for flood and erosion control operations and also finances various MNR forest, fish and wildlife management programs that are in part related to watershed management. Their flood management activities are a component of watershed management but associated costs are reported with those of other activities under the heading “Aviation, flood and fire management.” Total annual costs for flood management activities are about $1.1 million.

The total cost of watershed management amounts to about $282 per capita for persons living in fully serviced municipalities.[4] Municipal governments use by far the largest proportion of this, about 97%, to finance water supply, wastewater, and storm water management systems.

4.2 Paying for WatershedManagement

Estimated revenue sources for watershed management are outlined in Table 4.1. Local taxes and user fees fund 89% of the costs of watershed management or $251 per person while Provincial and Federal funds make up the balance of $31 per person (11%).

TABLE 4-1: SOURCES OF REVENUES FOR WATERSHED MANAGEMENT

Jurisdiction	Total Expenditure per Person	Source of Revenue			
		Local Taxes	Local User Fees	Provincial Funding	Federal Funding
Municipalities[1]	$273.00	18%	73%	8%	1%
Conservation Authorities[2]	$4.50	58%	19%	17%	7%
Provincial Programs[3]	$4.30	0%	0%	100%	0%
Total	$282.00	18%	71%	10%	1%

NOTES:

1. Municipal user fees are the customer billings and other charges for water and wastewater services.
2. The assessment of revenue sources for the conservation authorities is based on revenues measured net of estimated user fee revenues from recreation areas. Local tax revenues for conservation authorities represent the municipal levies. User fee revenues include various service charges as well as donations and miscellaneous revenues.
3. The assessment of provincial funding sources does not account for Federal transfer payments.

4.3 Is Enough Spent on Watershed Management?

This section only addresses the cost of watershed management activities incurred by the conservation authorities. While the average expenditure by the conservation authorities on watershed management is $5.80 per hectare, this value ranges from $0.25 to $37.40 per hectare. Low per hectare expenditure levels occur in smaller rural conservation authorities and high values tend to be seen in the highly urbanized conservation authorities. On a per capita basis, the average is $4.50 per person with a range of $2.70 to $14.50. Per capita costs tend to be lower in conservation authorities with larger populations. But population and size are not the only determinants of cost. There are great differences in the level of watershed management activity across conservation authorities. Some of this variation is explained by differences in resource management issues that the conservation authorities face and some is explained by funding constraints and a lack of technical resources (e.g., staff, equipment, decision support tools) in some of the conservation authorities.

The cost of watershed management for a given watershed is a function of a number of variables. Certainly watershed management costs will vary with the size of the watershed but costs will also vary with the watershed population since this is representative of the intensity of land use and impacts on water. This analysis considers both factors.

[4] The cost to unserviced rural households was not estimated. Overall agency costs for these households is quite modest, however, rural households often face annualized costs exceeding $1,000 for water supply and septic systems and farm operations may spend several thousand dollars annually on drainage.

A benchmark is required to estimate the potential cost of upgrading watershed management activities in all of the conservation authorities to a level that is consistent with the effective planning and management of both ground and surface water resources. For the purposes of a preliminary assessment, expenditure levels for the Grand River Conservation Authority are used as this benchmark for a number of reasons: (1) The GRCA is the only conservation authority having a well-developed ground water management program. (2) GRCA expenditures include the cost of a rural non-point source pollution control program and of ongoing strategic planning activities. (3) GRCA is broadly representative of the southern conservation authorities in terms of land use in that it has large urbanized areas, a large agricultural community and extensive natural areas. In this regard, its population density, at 1.02 persons per hectare is close to the overall average of 0.90. (4) The GRCA's efficiency of resource use as measured by the percentage of costs allocated to overhead expenditures, 13%, is close to the overall mean for conservation authorities of 15%. (5) The GRCA's watershed management cost, at $9.10 per hectare is well above the average cost for all conservation authorities but is less than 50% of the mean cost for the top third of conservation authorities that spend the most on watershed management.

The GRCA costs were prorated across the province by both watershed area and watershed population. Using either approach it was estimated that approximately $45 million would have to be added to annual conservation authority budgets in order to have all conservation authorities spend at least as much on watershed management as the GRCA. This is a rough estimate that fails to account for a number of important factors.[5] It is, nevertheless, a useful order-of-magnitude estimate. In particular, it suggests that the costs of the watershed management efforts of conservation authorities are relatively low when compared to the total watershed management costs including municipal and provincial costs. These efforts provide a relatively inexpensive means of improving the quality and security of water resources that municipalities rely on.

4.4 Financing Options for Watershed Management

4.4.1 Current situation

Watershed management expenditures are of two forms. There are operating costs that occur on a continuing basis and include activities such as operation and maintenance of water management facilities, data collection and monitoring, administration and enforcement of regulations and policies and ongoing implementation of watershed plans. In addition, there are the capital costs of a variety of time-limited projects such as development of watershed plans, construction of water management facilities and implementation of a variety of remedial projects. In assessing future funding opportunities, the need for both operation and capital funding must be considered.

Programs that are delivered by the conservation authorities and the municipalities account for 98% of all watershed management costs. Local taxes and user fees are the primary source of funding for these activities. This funding arrangement reflects the impact of provincial and federal downloading of costs to local agencies over the past decade. Provincial grants are largely limited to flood and erosion control operations.

4.4.2 Future funding options

As documented in section 4.3, consistent implementation of watershed management across the province will require additional funding. This section reviews how both traditional and innovative funding sources can be used to pay for watershed management activities. It is worth remembering, however, that it is always the public that pays for government. Opportunities for innovative funding do not usually

[5] Factors that have been ignored include differences between northern and southern conservation authorities and between rural and urbanized conservation authorities, high infrastructure costs in the GRCA for flood control structures, higher overhead costs for small conservation authorities and the costs of upgrading programs in conservation authorities that already spend more than the benchmark level on watershed management.

change this but they can be used to take pressure off of traditional sources. They may also improve the allocation of costs among members of the public and increase the level of program implementation.

4.4.3 Local tax base

These are taxes paid by property owners based on the assessed value of their property. Local taxes are and will likely continue to be a primary source of funding for watershed management activities of the conservation authorities and for the recovery of municipal storm water management costs. There are some advantages to this in that local decision makers are likely to be more aware of water management benefits and costs, and this funding tends to be more stable than the special program funding generally available from senior government. The local property tax can also be an equitable source of funding for many watershed management activities. However, the local tax base is burdened by increasing costs in other services areas. While local property taxes can be used to fund new watershed management activities in some municipalities, in others will not be a viable source for significant new financial resources.

4.4.4 User charges

User charges are a popular and equitable approach to cost recovery for services used by individual consumers such as utility services. They are already extensively used in the water resources field and are the primary source of funding for municipal water and wastewater services.

The fixed and volumetric charges for water and wastewater services are the principal form of municipal user charges for these services. Other charges now used for these services include development charges imposed on new development to recover infrastructure costs, the excess-strength sewer surcharge for high strength industrial wastewater discharged to sanitary sewers, and a variety of special volumetric charges that are used to promote water conservation. Development charges are already widely used across Ontario. There is scope within municipalities for the expanded use of special charges for excess-strength wastewater and for water conservation. Municipal user charges are also now being developed to recover the costs of storm sewer services based on lot size and, in some cases on surface permeability. These types of charges promote resources management and the equitable recovery of costs from users.

In several jurisdictions within the Greater Toronto Area, a surcharge on the municipal water bill is used to help fund conservation authority initiatives in watershed management. Such surcharges could be applied more widely to help pay for watershed programs that contribute to the development and protection of municipal water supplies.

None of the user charges imposed at the municipal level include a royalty charge for use of the raw water resource. The water resource is, therefore, a free good for both public and private water users. A royalty for water represents a potential new source of funding for water management activities. But the implementation of a royalty could require new legislative and administrative mechanisms. Large water users withdrawing in excess of 50,000 litres per day require a water taking permit from the Ministry of the Environment (MOE). There is currently a charge to obtain these permits but no volumetric charge for the subsequent water withdrawals, although the legislative authority for a water withdrawal charge does exist under the *Ontario Water Resources Act.* Several other provinces already impose a water use charge. By assigning a charge for water use, revenue could be generated to help support the programs necessary to protect the water resource. Such fees may also create an incentive to conserve water.

The municipal water bill and the provincial permit to take water represent existing tools to implement a user pay approach to watershed management. While an equitable user pay approach should apply to all users of the water resource, there is no current mechanism to charge private water users below the 50,000 litre per day threshold. The most feasible approach for implementation could begin with the largest volume users, those on public supply and permitted takings, for which administrative mechanisms are already available. The long-term goal should be a system that has all users contributing in an equitable manner over time.

4.4.5 Provincial funding

Historically, the province was an active funding partner in both operations and capital programs. Although there is still sporadic capital funding through special projects such as the Remedial Action Plans (RAPs), operational costs have migrated to the local level.

Successful implementation of an enhanced watershed management program will require some involvement from senior levels of government. For example, there are areas where senior governments should be involved directly such as setting and enforcing regulatory standards for water resources management, provincial scale monitoring and science and technology transfer.

At the watershed level, funding in the form of transfer payments is also appropriate for those areas of the province where the local tax base cannot fund necessary programs. Senior government funding is also effective in supplying seed funding for new programming initiatives at the local level.

4.4.6 Cost-sharing incentives

Members of the public can often be encouraged to adopt resource management measures through cost-sharing incentives. Successful examples of this include: (1) municipal water efficiency programs which subsidize the cost of water-efficient fixtures and appliances; (2) rural non-point source water quality improvement programs which subsidize the cost of crop and livestock management measures; (3) subsidies to encourage rural residents to secure abandoned wells; (4) industrial programs which subsidize the cost of water efficient and pollution reducing measures. Cost sharing incentives are of greatest value in situations where the enforcement of desirable actions is not possible either because it is too costly, too unpopular, or not authorized by law. The savings to public agencies can be significant. For instance, the annual cost of comprehensive measures to remediate pollution from livestock sources is estimated to be in the order of $30 million.[6] With cost sharing, the costs incurred by a public agency in promoting these measures would probably be less than $15 million.

4.4.7 Private-public partnerships

Under private-public partnerships, enterprises and industrial associations voluntarily participate in resource management activities. Their participation can be motivated by a concern with resources management, a desire to reduce costs, a wish to create good will with the public or a desire to avoid regulatory measures that could be invoked in the absence of voluntary action. Successful examples of public-private partnerships include provincial recycling initiatives, the voluntary adoption of industrial water efficiency measures, and voluntary phase-outs of the use of hazardous compounds.

4.4.8 Involvement in direct action

Much can be accomplished with a minimal budget by means of voluntary public participation in resource management activities. Many people willingly become involved in hands-on projects such as tree planting, river and shoreline clean-ups, trail maintenance, habitat restoration, monitoring of fauna and flora, and staffing of information desks (GRCA, 1998c). These kinds of projects provide opportunities for community involvement and outdoor recreation and for education and information exchange. Volunteers are rewarded by a strong sense of accomplishment and develop a commitment to resources management and stewardship.

All of the above options likely have a role to play in financing an enhanced watershed management program in Ontario and a diverse funding base is likely advantageous in ensuring long term stability of watershed management programs. In terms of securing stable and sustainable operating funding, local user fees and property taxes are the most likely source of new funding although strategic provincial funding

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[6] This estimate is based on an extrapolation of the estimated costs of implementing livestock measures in the jurisdictions of the Quinte and Lake Simcoe Region Conservation Authorities.

may also be necessary. Provincial funding may also be needed to initiate capital programs that are beyond the capacity of local agencies. The remaining options, including cost sharing, private-public partnerships and direct action lend themselves to time-limited projects and are more appropriate for enhancing capital funding.

4.5 Summary

This chapter provides estimates of the total cost of watershed management in the province and it identifies how these costs are funded. A ballpark estimate is made of the cost of upgrading the watershed management activities of conservation authorities to the level required for effective planning and management of water resources. The cost increase is significant when compared to the current conservation authorities' budgets, but not when compared to the total costs of watershed management.

5 INSTITUTIONAL AND ADMINISTRATIVE APPROACHES TO WATERSHED MANAGEMENT

A review of water management approaches elsewhere in the world validates the importance of watershed management to the protection of water supply and improvement of water quality. In fact, in most other jurisdictions reviewed, water supply needs and water quality concerns are the driving force for undertaking watershed management.

The following sections provide an overview of watershed management practices in other developed countries and in other provinces of Canada. A review of the reasons for undertaking watershed management and the lessons learned in other jurisdictions provides a base from which trends in watershed management in Ontario can be compared and recommendations for improving the effectiveness of existing institutional and administrative approaches can be made.

5.1 Global Trends in Watershed Management

Watershed management seeks to develop careful, long-term solutions to problems and provide sustainable access to resources. A review of trends in watershed management in the United States, United Kingdom, France, Australia, and New Zealand indicates that a watershed approach for managing water resources on a watershed basis, particularly for water supply, is a widely-accepted concept in many developed countries. This concept has been fully embraced and articulated at the national level in legislation, policy and/or administrative arrangements in these jurisdictions. Watershed agencies have been set up specifically around water and other environmental issues in France (Water Agencies), United Kingdom (Environment Agency – Planning Areas) and New Zealand (Regional Councils).

The American Water Works Association (AWWA) is an international, non-profit, scientific and educational organization dedicated to the improvement of drinking water quality and supply. Its 50,000 members represent the full spectrum of professionals, water managers and scientists who hold an interest in water supply and public health. The membership includes over 4,000 utilities that supply water to 180 million people in North America. AWWA supports watershed management as an essential element in the effective protection of drinking water supplies. An AWWA background sheet states "The program must begin at the local level and integrate the activities of local, state, provincial and federal governments if total water management programs are to succeed." (AWWA, 1994a). It advocates that a framework for watershed-based management should be established to protect water supplies in the United States, Canada and Mexico. A number of case studies from the United States which illustrate the importance of a watershed approach towards the protection of water supply in New York City, Boston, Spokane County, Oregon State and other watersheds across the U.S. is provided in Appendix E.

The General Assembly of the United Nations recognized that there was an "urgent need to formulate and implement national policies of integrated watershed management in a fully participatory manner aimed at achieving and integrating economic, social and environmental objectives of sustainable development." In 1998, the United Nations Commission on Sustainable Development strongly urged governments around the world to endorse watershed management as a means to manage freshwater (Commission on Sustainable Development, 1997/1998).

The European Environment Agency was recently set up "to deliver timely, targeted, relevant and reliable information to policy-makers and the public for the development and implementation of sound environmental policies in the European Union and other EEA member countries" (European Environment Agency, 1999). A recently proposed Water Framework Directive, when adopted, will rationalize EU water legislation. Its aim is to establish a framework for water protection, both to prevent further deterioration and to protect and enhance the status of ecosystems. It would:

- Require achievement of 'good' surface and groundwater status by 2015;
- Promote sustainable water use based on long-term protection of available resources;

- Support the protection of transboundary, territorial and marine waters;
- Stimulate the progressive reduction of pollution by hazardous substances.

Key features include a requirement to manage surface and ground waters at River Basin or River Basin District level, and an emphasis on the importance of ecological, as well as physical and chemical quality. (Nixon, Lack, Hunt, Lallana, Bosche, 2000).

Since an integrated watershed approach is a long-term process, the benefits are difficult to quantify until common indicators of success have been defined. In the United Kingdom, a recent submission to Parliament from the Environment Agency highlights some significant improvements, which were achieved to improve water quality, reduce waste, improve wildlife habitat, and complete 120 Local Environment Agency Plans (based on subwatersheds) in consultation with local communities. In France, the Master-plans for Water Development and Management (SDAGE) are currently in progress. Appendix F provides a more detailed description of the institutional arrangements with respect to water and watershed management in the United States, United Kingdom, France, Australia and New Zealand.

5.1.1 Lessons learned from international experiences

A review of the literature concerning watershed management in these developed countries has identified components of successful watershed management and has also revealed some common barriers that still need to be overcome before the real benefits can be assessed. Key components of successful watershed management include:

- Political endorsement;
- Enabling legislation;
- Co-ordination and a co-ordinating body and the watershed/subwatershed level;
- Sustainable funding;
- A multidisciplinary, integrated approach;
- Clear goals and objectives;
- Good data, appropriate technical and analytical skills, and useful decision-support tools;
- Public involvement and partner collaboration;
- Shared action plans and a range of incentives to undertake action;
- A continuum of proactive planning, monitoring, and updating;
- Dynamic leadership. (Committee on Watershed Management et al., 1999; Hooper, 1999; Born and Genskow, 2000; Born and Genskow, 2001; U.S. EPA, 1997)

The common barriers include:

- **Lack of sustainable funding** – some watershed agencies are hamstrung by inadequacies in resourcing, and have not been set up with sustainable funding sources (i.e., user pays/polluter pays).
- **Excessive bureaucracy and politics –** the decentralized nature of watershed management can make it difficult to co-ordinate activities, respond to development pressures, secure funding and partnerships throughout the various levels of bureaucracy and the private sector without strong national (and sometimes international) leadership, support and direction.
- **Weak environmental legislation** – weak legislation can undermine implementation of watershed management (i.e., inadequate penalties for environmental violations, lack of national water quality standards and guidelines; and lack of environmental operating standards for industry).

- **Lack of up-to-date watershed data and useful decision-support tools** – basic and applied research is not currently adequate to provide the data, information and tools necessary to make appropriate decisions.
- **Lack of technical expertise and/or technical assistance –** some watershed agencies suffer from lack of staff training and available expertise to tackle the biophysical, social and economic complexities of watershed management.
- **Fragmentation of responsibilities among agencies –** unclear mandates, duplication of responsibilities, and conflicting missions among can inhibit the success of the watershed approach.
- **Resistance to change** – water resources practices typically focus on a supply-oriented biophysical approach rather than a conservation approach of balancing demand with availability and promoting efficient water use.
- **Lack of monitoring and evaluation procedures –** the expense of data collection has caused governments to reduce monitoring sites thereby affecting the quality and quantity of available water data; the state of science around indicators of watershed health is in its infancy.
- **Unrealistic expectations –** some recently established watershed agencies are expected by other government agencies and the public to show immediate results even though water issues develop over a number of years and are cumulative; there is a need for practical procedures for considering risk and uncertainty so that expectations of research and decision-making are reasonable.

From a global perspective, Ontario's Conservation Authorities are seen as being successful working models for effective watershed management. The number of international delegations that study and adapt the Conservation Authority model for implementation in other countries across the world is evidence of the high regard given to it. This international regard was further strengthened as a result of the Grand River Conservation Authority winning the prestigious international Thiess Riverprize 2000 in Brisbane, Australia, for excellence in river management (Krause et al., 2000).

Building on the strengths of current watershed management in Ontario by adding or adapting the best features of watershed management (i.e., legislation, planning processes, funding arrangements, research and decision-support tools, etc.) from other jurisdictions should provide a strong base from which to secure effective watershed management across Ontario.

5.2 Watershed Management in Canada

The constitutional framework for water resources management in Canada is the Constitution Act. The federal government's interest in water is limited almost exclusively to the regulation and control of inland waters with respect to commercial fishing and navigation. The provinces have the primary mandate to deal with water issues and have the broadest jurisdiction over water (Appendix C).

The Canada Water Act provides the framework for joint federal-provincial management of Canada's water resources (i.e., consultative arrangements and co-operative agreements to develop and implement plans for the management of water resources such as the Great Lakes Water Quality and Canada-Ontario Agreements)

In 1987, a Federal Water Policy was developed that states: "The federal government endorses an integrated approach to planning and development of water resources…Increasingly, watersheds are becoming the preferred spatial unit for water resource planning. It is an approach that makes sense at any scale of planning…" (Federal Water Policy, 1987, p.7). At this time, the federal government, with very broad public support, was bent on playing an active, leading role in dealing with the big issues in water management – conservation, efficient use, environmental protection, and coordination across jurisdictions.

Since that time, the federal interest in managing water fell away abruptly and the federal dollars available for cooperative agreements declined sharply. Federal downsizing in 1995 led to a loss of staff and expertise in water management (Pearse, 1998).

In recent years, several Provinces have taken the lead in developing strategies for water management within their jurisdiction based on a grassroots, collaborative watershed approach.

5.2.1 Manitoba

In Manitoba, Conservation Districts, formed in 1972, are based on the partnership of local communities, landowners, non-government groups, industry and government. Eleven local Boards manage the Conservation Districts, set resource management priorities and develop programs to deal with local soil and water management issues on a watershed basis (Manitoba Conservation Districts Association, 1999). Baseline support for the operation of these Boards is provided from the Province.

5.2.2 British Columbia

In British Columbia, "A Freshwater Strategy for British Columbia" was released in 1999 (British Columbia Ministry of Environment, Lands and Parks, 1999). Watershed management figures prominently in many of the initiatives and programs that are part of the strategy. In March 2000, a progress report was released. Integrated watershed management plans are being carried out for the Stawamus River/Mashiter Creek watersheds, and the Haslam Lake/Lang Creek watersheds (Powell River). The plans are part of the drinking water strategy and give clean and plentiful drinking water the highest priority in all local land and resource management decisions. One of the next steps identified will be the completion and release of guidebooks for watershed management (British Columbia Ministry of Environment, Lands and Parks, 2000).

Watershed management has a high profile in British Columbia. The Fraser Basin Council, chaired by Iona Campagnolo is founded on the watershed principle. It's 36 member Board consisting of federal, provincial, local and First Nations representatives promotes sustainability in a river basin that accounts for more than 25% of all the land in BC, 66% of the population and 80% of the gross provincial product (Fraser Basin Council, 1997).

Local community groups banded together in 1997 to form the BC Watershed Stewardship Alliance (BCWSA) "to support communities to develop an information, communications and education base which will promote and advance the development and maintenance of integrated, co-operative watershed management initiatives in BC". (British Columbia Watershed Stewardship Alliance, 2001).

5.2.3 Alberta

Alberta recently enacted a new Water Act, effective January 1, 1999. Through this legislation, the focus of water management was changed from strict allocation of resources to conservation and management guided by the goals of sustainable development. One of the requirements of the new Act is to have a provincial water management-planning framework completed within three years. A discussion draft entitled "The Framework for Water Management Planning" was released in June 1999 (Alberta Environment, 1999) and is currently being revised to incorporate public comments. The geographic limits for water management planning areas are based on watershed boundaries.

The new Act provides the context for such initiatives as the Bow River Basin Plan, being carried out in partnership with Alberta Environment, Bow River Basin Water Council, City of Calgary, TransAlta Utilities, Trout Unlimited and the Eastern Irrigation District. The Bow River and a tributary, the Elbow River are the sole sources of drinking water supply for the City of Calgary.

5.2.4 Nova Scotia

Nova Scotia developed a draft water resource management strategy in 1999 in collaboration with Aboriginal groups, non-government organizations, university organizations, industry and municipalities. The strategy has four principle objectives:

- Integrated resource management
- Protection of water resource quality
- Improved water allocation to achieve harmony among competing environmental, economic and social needs
- Commitment to partnerships in water resource stewardship

Among the many key objectives is the protection of municipal drinking water supplies (Gulf of Maine Council Meeting, 1999). In October 2000, the Nova Scotia's Environment Act Legislative Review Process 2000 Committee Report urged the Province to modify Section 105 to require the time-bound implementation of this strategy, including the use of water stewardship boards (Nova Scotia Department of the Environment, 2000).

5.3 Watershed Management in Ontario

5.3.1 Municipalities

Local municipalities have responsibilities for water and related land management derived principally from provincial statutes. Locating, storing, and distributing water for municipal use and for maintaining a water distribution systems is undertaken by municipalities. The Ontario Clean Water Agency, local municipalities or private companies operate water distribution and sewage treatment facilities.

Municipalities through the Planning Act have the responsibility for local land use planning. The Province has issued a Provincial Policy Statement (PPS) under the Act, which states:

> The quality and quantity of ground water and surface water and the function of sensitive ground water recharge/discharge areas, aquifers and headwaters will be protected or enhanced (Ontario, 1997, p.9).

The PPS encourages a co-ordinated approach to deal with cross-municipal boundary issues. Municipalities must "have regard to" the PPS but it is not legally binding (McCulloch and Muldoon, 1999). The Association of Municipalities of Ontario (AMO) in its Municipal Action Plan – Protecting Ontario's Water (June 2000), states "Ontario's municipalities can play an important part in rehabilitating our water system, and in restoring the public's confidence in the safety of Ontario's water supply."

Where Conservation Authorities exist in Ontario, a co-ordinating mechanism for dealing with water and other cross-boundary issues is already available to municipalities. In areas where Conservation Authorities do not exist, the Conservation Authorities Act gives watershed municipalities an option to band together to create a Conservation Authority. It is recognized that large parts of Ontario's north do not have organized municipalities and other approaches may be required.

A number of watershed plans have been carried out by Conservation Authorities across Ontario to identify the impacts of anticipated land use changes and population growth and to develop an plan of action to minimize anticipated impacts on the surface and groundwater regimes. Many of these plans were cost-shared between municipalities, Conservation Authorities, developers and the Province. However, in recent years, provincial funding for watershed planning and implementation has been reduced dramatically. Since municipalities are faced with significant overall cost increases to carry out long-established and new responsibilities the level of investment in watershed management has also declined. This has happened at a time when watershed management is needed more than ever, because of the rapid growth taking place in Ontario.

5.3.2 Conservation authorities

Ontario has a long history of watershed management. Severe water problems associated with flooding, drought and degraded water quality experienced in southern Ontario from the early 1900s prompted the Conservation Authorities Act, 1946.

This Act embodied three principles:

- the initiative for the establishment and support of a conservation authority with power to carry out conservation works within a watershed must come from the local people (all watershed municipalities);
- the best unit on which to co-ordinate all conservation work dealing with renewable resources is the watershed;
- if local people showed initiative and support, the Ontario government would be prepared to provide technical advice and financial assistance in the form of grants.

Under the Act, 38 conservation authorities were formed to establish and undertake programs, designed on a watershed basis "to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals" (Section 20). Member municipalities participate in the administration and operation of a conservation authority through representation on a Board of Directors. Conservation authorities have worked closely with all levels of government to coordinate and implement programs and services that help to improve water quality, maintain water supply, reduce flood damages, protect natural areas, educate the public and provide quality outdoor recreational opportunities. These programs include:

- watershed and subwatershed planning;
- low flow augmentation and water supply;
- flooding and erosion control;
- reforestation;
- regulation of construction and filling within floodplains and wetlands;
- plan review and advice to municipalities under the Ontario Planning Act to minimize adverse resource and environmental impacts;
- providing assistance and advice to landowners and community groups regarding soil and water conservation practices, manure management, ponds, fisheries, wildlife, and wetland management;
- conservation land acquisition and management;
- conservation information and education;
- outdoor recreation.

Conservation authorities have been very responsive to local resource issues and to the perceived needs of their member municipalities. However, each watershed serviced by a Conservation Authority is unique. Differences in climate, geology, flow regimes, drainage areas, demographics and water use have led to each conservation authority delivering a different range of on-the-ground initiatives. The resources available to a conservation authority also vary depending on the population and assessment of its member municipalities and the nature and extent of resource issues faced. For these reasons, each of the 38 conservation authorities has developed its own programs and services and the necessary technical and professional expertise to deliver them. The resources and expertise of each conservation authority to carry out watershed management are not uniform and varies significantly across the Province.

5.3.3 Provincial government

In Ontario, water management is highly fragmented and administratively complex. While the Ministry of the Environment and the Ministry of Natural Resources are the key ministries involved in water quality and water supply, a large number of other ministries and agencies are responsible for aspects of water management (Appendix C). Ontario does not have a formal strategy for protecting the quality and quantity of our water resources. The lack of a comprehensive water policy and the fragmentation of water responsibilities has sometimes led to uncertainty about specific water management roles and responsibilities and resulted in inconsistent links between planning and implementation.

In spite of legislative fragmentation, Ontario has developed a long-standing institutional framework that promotes a co-operative watershed approach. Through the Conservation Authority structure and other initiatives, watershed municipalities, non-government groups and provincial agencies have had a chance to respond collectively to watershed issues. In 1993, the Province published a set of three documents that recognized the importance of watershed management and encouraged (but did not require) municipalities and Conservation Authorities to undertake watershed management plan. The Province also set aside funds to assist in watershed planning. Between 1990 and 1995, 87 watershed management projects were initiated (Ontario Ministries of Environment and Natural Resources, 1997).

Since 1995, support and funding for watershed management has been substantially reduced. With amendments to the Conservation Authorities Act in 2000, the role of the Province as a partner in watershed management has been reduced significantly (R.S.O. 1990, C.27).

5.3.4 Federal government

Through the enforcement of the federal Fisheries Act and the funding of Remedial Action Plans for "Areas of Concern" in the Great Lakes – St. Lawrence Basin, the federal government participates actively but on a limited basis, in watershed management in Ontario. Other initiatives such as the climate change study being undertaken in the Grand River watershed offer opportunities for the federal government to participate on a project-by-project basis.

5.4 Analysis

The United Nations Commission on Sustainable Development, the European Environment Agency and AWWA strongly support watershed management. Watershed management is widely accepted and actively pursued in the United States, United Kingdom, France, New Zealand, and Australia. A review of international experiences in watershed management has revealed some essential components of and common barriers to effective watershed management.

In Ontario, conservation authorities have practiced watershed management for over 50 years. They have co-ordinated and delivered effective on-the-ground results. Much of the success of conservation authorities can be attributed to the fact that many of the components of successful watershed management identified in the literature are practiced in the Ontario context. Yet, some barriers exist which threaten to undermine the progress and successes achieved to date or impede watershed management (to greater or lesser degrees depending on local circumstances) including:

- Political endorsement at the federal and provincial levels for watershed management is weak.
- Sustainable funding to advance watershed management and address critical water issues at the watershed level is generally not available.
- Resources and expertise varies significantly among conservation authorities and influences their ability to carry out necessary watershed management.
- The collaborative nature of watershed management has not been fully accepted or understood, although public participation processes are very effective. Lead responsibility has to be assigned.

- Fragmentation of water responsibilities in Ontario has resulted in unclear mandates and difficulties in co-ordinating activities.
- Available resource data from federal and provincial sources are either not as accessible or maintained to the extent needed.
- Monitoring networks are being eroded due to federal and provincial withdrawal of funding.

An evaluation of the strengths and weakness of watershed management in the Ontario context is provided in Table 5.1. This exercise reveals that Ontario has a strong base on which to build effective watershed management. While changes are required in order to ensure a base level of watershed management, which will protect water supply and water quality, they are certainly not insurmountable. Time is of the essence. Action must be taken now to ensure adequate water quality and supply for Ontario, now and in the future.

5.5 Summary

In many developed countries, watershed management is widely accepted and actively pursued, particularly to safeguard water supply. This chapter identifies some essential components of and common barriers to effective watershed management based on a literature review. In Ontario, there has been a long tradition of collaborative watershed management. The strengths and weaknesses of watershed management are generally described and examined in the Ontario context.

TABLE 5-1: AN EVALUATION OF WATERSHED MANAGEMENT IN THE ONTARIO CONTEXT

Components of Successful Watershed Management	Advantages	Ontario Context Strengths and Weaknesses	Rating
Political Endorsement	Gives political support for a watershed approach through legislation, policy statements, agreements, guidelines, and shared-funding for research, decision-support tools and infrastructure.	There is little political support for watershed management, although policies in the Federal Water Policy and the 1993 provincial Watershed Planning documents support the watershed approach. Funding support of watershed management has been reduced at the provincial and municipal levels. Current funding is ad hoc and provided on a project-by-project basis.	
Enabling Legislation	Provides the framework for administrative procedures, partnership building, and legitimacy of certain actions.	Ontario has enabling legislation for establishing a watershed approach throughout Ontario, with the exception of the northern part of the province. Through the Conservation Authorities Act, 38 Conservation Authorities exist with the prime purpose to conserve, restore, develop and manage natural resources on a watershed basis. Other federal and provincial legislation can be used in support of watershed management (e.g., Federal Fisheries Act; Ontario Water Resources Act; Environmental Protection Act; Planning Act; Public Utilities Act, Municipal Act).	
Co-ordination and a Co-ordinating Body at the Watershed /Subwatershed Level	Builds trust and goodwill, continuity, a knowledge of context and local conditions, reduces the problems of power-sharing and duplication, matches the scale of the problem, and provides opportunities for sharing or pooling limited resources.	Where Conservation Authorities exist, and where support from other government agencies and water users is sufficient, they have co-ordinated the activities of watershed municipalities with respect to local watershed issues. Conservation Authorities have a long and successful history of partnership building and on-the-ground results. Partners have included municipalities, federal and provincial agencies, First Nations, other conservation authorities, business, educational institutions, landowners and community groups.	
Sustainable Funding	Provides continuity, long-term commitment, competency, capacity, and implementation of projects.	Lack of adequate and sustainable funding for watershed management has been a major challenge in Ontario at all government levels.	
A Multi-Disciplinary, Integrated Approach	Identifies resource functions/processes, cause-effect relations and linkages among watershed components (rivers, wetlands, groundwater, atmosphere, floodplains, upland areas).	The ability of various agencies and organizations to provide staff and expertise for watershed management varies substantially. Many of the larger conservation authorities and municipalities have a multidisciplinary team of professionals and technicians to support watershed management. Others have limited capacity. Some share staff and technical resources to undertake specific aspects of watershed management.	

Table 5-1. An Evaluation of Watershed Management in the Ontario Context (continued)

Components of Successful Watershed Management	Advantages	Ontario Context Strengths and Weaknesses	Rating
Clear Goals and Objectives	Defines the scope and focus for defining issues and problems and finding solutions.	Watershed plans that have been completed across the province to date, have a clear statement of goals and objectives	
Good Data, Appropriate Technical and Analytical Skills, and Useful Decision-Support Tools	Provides a strong base from which appropriate decisions can be made; encourages useful science moving away from analysis towards synthesis.	Available resource data from federal and provincial sources is either not as accessible as required or maintained to the extent needed. Conservation Authorities have differing capacities to obtain good reliable data, interpret the data, and build useful decision-making tools. There are opportunities to share professional and technical expertise and to apply decision-support tools and models developed for one watershed to others.	
Public Involvement	Builds trust, consensus; leverages effort; and ensures implementation and change will occur at the local level.	Public input and involvement has been a key component of watershed planning and management in Ontario for the past twenty years.	
Partner Collaboration		Partner collaboration (or having all the implementers involved) is essential but has not always been part of the watershed management process and is not required by legislation. This can detract from the credibility of watershed management.	
Shared Action Plans and a Range of Incentives to Undertake Action	Includes education, information, opportunity to participate in planning, opportunity to participate in "hands-on" action, applause and celebration, cost-sharing incentives, public-private partnerships, and finally, surcharges, regulation and enforcement.	Watershed management processes which have fostered the broadest degree of participation, including the federal and provincial agencies, have been successful in identifying a range of practical options and developing actions plan which result in on-the-ground actions. This is because the implementers have been involved in the process from the onset (e.g. Grand River Basin Watershed Management Plan).	
A Continuum of Proactive Planning, Monitoring, and Updating	Ensures flexibility and adaptability in dealing with changing environmental, social, and economic issues.	Watershed management must be a continuous planning process in order to be effective in the long-term and to respond to change. Often incentives and funding for monitoring, evaluating and updating is very limited. Federal and provincial agencies are withdrawing from funding monitoring networks. The link between planning and implementation (e.g. through official plans, MOE regulations) is often inconsistent or weak.	
Dynamic leadership	Helps advance efforts, increase involvement and lend legitimacy and credibility to the process.	There are few outstanding champions for watershed management at the federal, provincial or watershed levels. (Notable for her leadership in British Columbia is Honourable Iona Campagnolo, Chair, Fraser Basin Council).	

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Watershed management plays an important role in protecting drinking water supplies and at the same time ensures that a broad range of other environmental, human health, and social *(i.e., culture, recreation.)* concerns are being addressed. The watershed represents a physical unit within which water moves and is influenced by natural processes and the impacts of human activities. Watersheds therefore provide a good basis for management. The watershed management process is a continuum that involves: data collection and analysis necessary for developing a plan; a variety of mechanisms for implementing the plan; ongoing monitoring of the plan's effectiveness; and a process for updating the plan. The watershed approach is globally recognized as a sound basis for water management.

Watershed planning provides a means by which the planning and management for drinking water supplies can be integrated with environmental and other concerns. An integrated approach results in improved effectiveness at meeting overall objectives. The current practice of watershed planning in Ontario has not consistently integrated drinking water supply strategy efforts, typically led by municipalities, with environmental planning efforts, often led by conservation authorities. However, there are examples, such as in the Grand River watershed, where these initiatives are being conducted in a more integrated fashion with successful results. Increasingly, regional water supply strategies are recognizing the importance of identifying and protecting drinking water sources from being diminished or contaminated by various land use activities. Often the approaches used to protect drinking water sources also benefit other environmental systems. At the same time, domestic and industrial water uses can create adverse impacts on other resources, such as fisheries. The watershed management process brings together all key stakeholders, thus providing the opportunity for all important issues to be considered, resources fairly allocated, and plan recommendations to be implemented.

The identification and protection of drinking water sources, as part of an overall watershed management strategy, represents a preventative, long-term approach to risk management. Source protection strategies are often implemented through land use planning, such as municipal zoning of wellhead areas and greenspace areas; public acquisition or protection of sensitive lands; or promotion of sound stewardship practices. Source protection represents the first layer in a multiple defence system for ensuring that clean water is available to all water users. Source protection is especially vital to water users, such as rural residents and businesses, whose geographic location and low water usage afford them few alternative drinking water supply options and may limit the economic viability of employing end-of-pipe treatment measures. Once source protection measures are put in place, they usually remain in place for a long time, requiring little to no effort in upkeep, and therefore providing a sustainable component of a secure water supply strategy.

Watershed management is economically efficient, in that the costs of preventing the loss or contamination of a drinking water source or an environmental resource are much less than costs associated with remedial measures or end-of-pipe treatment. Once put into place, the costs of water source protection measures and their ongoing operation and maintenance are much less than the costs typically associated with remedial end-of-pipe infrastructure operation, maintenance and replacement. Many jurisdictions, such as the New York City, the Regional Municipality of Waterloo, and a partnership of Eastern Ontario municipalities, have found that they could realize significant savings and avoid costly infrastructure investments by investing in source controls identified through watershed planning processes.

The fragmentation of water management responsibilities in Ontario currently presents a challenge to watershed managers. It has led to inefficiencies and duplication of effort, lack of monitoring, and information gaps. Notable gaps are found in the area of groundwater management. Yet, where support from government agencies and water users has occurred, co-ordination has been possible leading to actions that have effectively addressed pressing water issues.

The effectiveness of watershed management across Ontario can be significantly improved with better funding and resources. In recent years, there has been a shift from more stable tax-based provincial funding sources to specialized grant programs. While there is a role for these programs, there are often limitations on eligibility and acceptable types of expenses, which have sometimes proved to be a disincentive to the program. Adequate, long-term funding is essential to sustain the operational and capital needs associated with implementation. Potential funding sources could include the traditional tax-based programs, as well as innovative approaches such as user pay mechanisms, special provincial grant programs, cost sharing incentives, private-public partnerships, and voluntary actions.

Although watershed management is being practised to varying degrees throughout Ontario, there is need for an integrated provincial water policy that mandates watershed management. A provincial water policy should call for the development of, participation in and implementation of watershed management, particularly in areas of rapid growth and land use change. It should also set out the requirements for minimum standards of practice and improved integration of all aspects of water management including supply.

Ontario has a strong administrative and institutional base from which to build effective watershed management and has the potential to return to the world stage as a leader in watershed management. This will require solid direction from the Province, well-defined lines of responsibility and accountability, innovative partners, and a commitment of sufficient resources to get the job done. Dynamic leadership from the public and private sectors (e.g. government, business community, agricultural sector, First Nations, non-governmental organizations) must work cooperatively to champion watershed management throughout Ontario. This is critical if there is to be a safe, secure supply of water for current and future generations.

6.2 Recommendations

Watershed management is the basis for protecting and securing of safe drinking water supplies in Ontario, now and in the future. Conservation Ontario offers the following recommendations for improving current practices and strengthening the role of watershed management in protecting the long-term security of drinking water supplies.

1. The protection of drinking water sources should be recognized as a permanent and integral part of a long-term, secure water supply strategy.

Source protection represents the first layer in a multiple defence system for ensuring that clean water is available to all water users. Source protection is especially vital to water users, such as rural residents and businesses, whose geographic location and low water usage afford them few alternative drinking water supply options and may limit the economic viability of employing end-of-pipe treatment measures. Source protection programs are consistent with practices being adopted by water supply agencies in other international jurisdictions.

2. The watershed should be recognized as the viable unit for managing water.

This is the appropriate unit for the management of both surface and groundwater resources. Valerie Gibbons in her report *Managing the Environment: Executive Summary* (Executive Resource Group, 2001) states that there should be a strategic shift in managing the environment "towards a place-based approach with boundaries that make environmental sense and facilitate a cross-media, cumulative approach (such as watershed management)". While groundwater aquifers sometimes extend beyond surface water drainage boundaries, the human activities and resulting influences occur and can be managed within a surface watershed context. Drinking water source protection programs should be developed as part of an overall watershed management strategy.

3. A provincial integrated water policy should be developed that:

- *Recognizes the principles of watershed management and deals with all aspects of water.*

  The Province should expand its interests in watershed management beyond flood and erosion control operations to achieve maintenance and enhancement of ground and surface water (both quality and quantity) for all users. Watershed management is based upon an understanding of the

watershed, its water cycle and its interrelationship with human activities. Watershed management includes identification, protection and enhancement of significant natural features including, headwaters, groundwater recharge and discharge areas, wetlands, vegetated stream buffers and forest areas, while considering historical and current human activities impacting the system.

- *Builds upon the conservation authority model to advance watershed management.*

  As a resource that crosses jurisdictional boundaries while lending itself to so many different and conflicting uses, water defies simple division into federal, provincial or municipal responsibility. Protection of water supply and quality requires collaboration and co-ordination at a level where progress can be made through actions determined by long-term watershed management plans. The conservation authority model provides an opportunity to co-ordinate, focus and streamline local delivery of water management and protection actions. Current strengths need to be built upon and the capacity of conservation authorities increased to provide a base level of watershed management for the benefit of 90% of the provincial population.

- *Clarifies the role of the provincial government in water management.*

  The Province has the broadest jurisdiction over water and therefore has a leadership responsibility in ensuring the best water management for the citizens of Ontario. A provincial water policy should specify the role of the Province in developing consistent standards, implementation procedures, regulations, and enforcement measures to ensure performance at the local level. It should also recommit to the watershed planning initiatives undertaken by the Ministry of Natural Resources and the Ministry of the Environment in order to provide guidance to local and regional authorities in planning appropriate future land use while at the same time, protecting water resources and the environment.

- *Promotes research into water issues and development of decision support tools to ensure the best science, technology and management practices are shared and available for local application.*

  The Province should foster research into water issues and the development, transfer and application of decision-support tools (e.g., water budget models, water quality models) for the implementation of watershed management. These tools provide the basis for implementing provincial regulatory actions (e.g., provincial water taking permits, certificates of approval for wastewater) that support water supplies and quality from a watershed perspective.

- *Supports an adequate monitoring program to measure change and adapt policies and programs accordingly (i.e., adaptive environmental management).*

  Monitoring networks need to be improved, maintained and accessible for effective local watershed management. A commitment must be made to the long-term support of state-of-the-art monitoring networks.

- *Supports the improvement, maintenance and accessibility of resource data for effective local watershed management.*

  Modelling complex water resource systems requires extensive databases such as streamflow, precipitation, water quality and land use. The Province should establish database standards, facilitate data sharing mechanisms and, where necessary, provide support for database development and maintenance.

4. Adequate and stable source(s) of funding should be established to finance watershed management throughout Ontario.

Provincial, municipal and conservation authority investments into securing water supplies and water quality require long-term stable funding to support watershed management operations. A user pay approach can be taken through the municipal water bill and the provincial Permits to Take Water. Where local "user pay" sources are inadequate, the Province should supplement or

provide mechanisms for appropriate distribution of funding to these areas to ensure a base level of watershed management. Incentive-type programs and innovative funding opportunities should continue to be pursued to support capital investments (i.e., projects, studies, structures) necessary to implement watershed management plans.

5. The Province should encourage the Federal Government to develop a national framework for water policy and to strengthen co-operative agreements with provinces under the Canada Water Act.

The Federal Water Policy of 1987 was tabled in Parliament but not extended into a national policy. Funding for co-operative agreements with provinces declined from over $12 million in the late 1970s and $8 million in the 1980s to zero in 1998. Since water problems cross political and jurisdictional boundaries and are becoming increasingly global, the Province should encourage the Federal Government to develop a national framework for water policy in close consultation and co-operation with the provinces. The national policy should define the federal government's role in the design of national standards for water quality and environmental monitoring and in providing research, data collection, analysis, and monitoring on a watershed basis to maintain the health of the Great Lakes.

7 BIBLIOGRAPHY

Adler, Robert W. (1996). Addressing Barriers to Watershed Management in Proceedings Watershed '96, "Moving Ahead Together" Technical Conference and Exhibition, June 8-12, 1996, Baltimore, Maryland summarized from *Environmental Law*, Volume 25, pp. 973-1106 cited in <http://www.epa.gov/owow/watershed/Proceed/adler.html>.

Alberta Association, Canadian Institute of Planners (AACIP)/Community Planning Association of Alberta (CPAA) Planning Conference (1999) "Session #5: Multi-Jurisdictional Planning Approach", presentation by Menno Homan, Bow River Water Council, <http://www.aacip.com/conference.htm>

Alberta Environment (1999) The Framework for Water Management Planning A Discussion Draft, June 9, <http://www.gov.ab.ca/env/water/legislation/Framework.pdf>

Arnstein, S. (1969) 'A Ladder of Citizen Participation'. *Journal of the American Institute of Planners*, 35, 216-24.

Ashendorff, Arthur, Michael A. Principe, Anne Seeley, John LaDuca, Larry Beckhardt, Walter Faber Jr., and Jeff Mantus (1997) "Watershed Protection for New York City's Water Supply" in *Journal AWWA*, Volume 89, March, pp. 75-88.

Australia Water Association. Water Management Overview Water Resources Management in Australia – A Thumbnail Sketch, <http://www.awa.asn.au/news&info/h2oinfo/WATEROZ2.asp>

AWWA (1988) Quality of Water Supply Sources,, <http://www.awwa.org/govtaff/quawapol.htm>

AWWA (1990) Water Resources, <http://www.awwa.org/govtaff/watrepol.htm>

AWWA (1994a) Total Watershed Management, <http://www.awwa.org/govtaff/totwapap.htm>

AWWA (1994b) Integrated Resource Planning in the Water Industry, <http://www.awwa.org/govtaff/intrepap.htm>

AWWA (1997) Source Water Protection, <http://www.awwa.org/govtaff/sourcpap.htm>

Boehmer, Kevin, Ali Memon and Bruce Mitchell (2000) Towards Sustainable Water Management in Southeast Asia Experiences from Indonesia and Malaysia in International Water Resources Association, *Water International*, Volume 24, Number 3, pp. 356-377, September.

Born, Stephen M. and Kenneth D. Genskow (2000) The Watershed Approach: An Empirical Assessment of Innovation in Environmental Management, National Academy of Public Administration,< http://www.napawash.org/napa/epafile0701.pdf>

Born, Stephen M. and Kenneth D. Genskow (2001) Toward Understanding New Watershed Initiatives, < http://www.tu.org/library/conservation/watershed.pdf>

British Columbia Ministry of Environment, Lands and Parks (1999) A Freshwater Strategy for British Columbia, <http://www.elp.gov.bc.ca/wat/wrs/freshwater/FsforBC.doc>

British Columbia Ministry of Environment, Lands and Parks (2000) A Freshwater Strategy for British Columbia A Progress Report – March 2000, <http://www.elp.gov.bc.ca/wat/fws/FWS_update.doc>

British Columbia Watershed Stewardship Alliance (2001) BC Watershed Stewardship Alliance, http://www.scrn.org/bcwsa/about_the_alliance.htm

Canadian Department of Fisheries and Oceans (1999) Freshwater Initiative Discussion Document <http://www.ncr.dfo.ca/Regions/central/Pub/Fwi_Eng/1Preamble.html>, June.

Commission on Sustainable Development (1997/1998) Report on the Sixth Session (22 December 1997 and 20 April 1 May 1998) in *Economic and Social Council Official Records*, 1998, Supplement No. 9, <http://www.un.org/documents/ecosoc/docs/1998/e1998-29.htm>

7 Bibliography (continued)

Committee on Watershed Management, Water Science and Technology Board, Commission on Geosciences, Environment, and Resources, and National Research Council, (1999) New Strategies for America's Watersheds" Executive Summary, Washington, D.C.: National Academy Press, <http:/www.nap.edu/html/watershed_strategies/>

Consensus for a Sustainable Future: *Putting Principles into Practice*. Government of Canada. Ottawa.

Dobratz, William R., Robert L. Wubbena, and John M. Maxwell (1986) "Protection and Management of Spokane's Sole Source Aquifer" in *Journal AWWA*, Volume 83, September, pp. 62-69.

Environment Agency (2000) Environment Agency Submission to the Environment Sub-committee, <http://www.environment-agency.gov.uk/ourservices/consultations/select_commit.htm>

Environment Canada (1987) Federal Water Policy, <http:/www.ec.gc.ca/water/en/policy/pol/e_pol.htm>

Environment Canada (1994) The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem 1994, <http://www.on.ec.gc.ca/coa/agreement-e.html>.

Environment Canada (2000) *Canada Water Act Annual Report.*1998-99, <http://www.ec.gc.ca/water/en/info/pubs/ar/e_ar98-99/htm>

Environment Canada (2000) Water legislation. <http://www.ec.gc.ca/water/index.htm>

European Environment Agency (1999) Information for improving Europe's environment, Copenhagen, <http://org.eea.eu.int/documents/brochure/brochurefull.pdf>

Executive Resource Group (2001) Managing the Environment A Review of Best Practices, Executive Summary, submitted to the Ontario Cabinet and Clerk of the Executive Council, January.

Fraser Basin Council (1997) Charter for Sustainability, Vancouver, BC.

Garcia, Luis E. "A Role for River Basin Organizations within an Integrated Water Resource Management Strategy"<http://www.oieau.fr/ciedd/contributions/atriob/contribution/iadb.htm>.

Gollnitz, William G. (1988) "Source Protection and Small Utility" in *Journal AWWA*, Volume 80, August, pp. 52-57.

Grand River Conservation Authority (1996) The Grand Strategy: A Shared Management Plan for the Grand River Watershed," Cambridge, Ontario.

Grand River Conservation Authority (1997) State of the Grand River Watershed Focus on Watershed Issues 1996-1997, Cambridge, Ontario.

Grand River Conservation Authority (1998a) Programs and Services, Cambridge, Ontario.

Grand River Conservation Authority (1998b) State of the Watershed Report Background Report on the Health of the Grand River Watershed, 1996-97, Cambridge, Ontario.

Grand River Conservation Authority (1998c) Grand Actions Registry of Accomplishments and Commitments, Cambridge, Ontario.

Grand River Conservation Authority, Credit Valley Conservation (2000) *Developing a Framework for Sustainable Water Management on a Watershed Basis.* Unpublished Proposal. Cambridge.

Grand River Conservation Authority. *Water - Ours to Protect, Rural Water Quality Program Financial Assistance for Wellington County Landowners to Improve Water Quality on their Farms*, Cambridge Ontario

Grand River Conservation Authority. *Water - Ours to Protect, Rural Water Quality Program*, Cambridge, Ontario.

7 Bibliography (continued)

Grand River Implementation Committee. (1982) *Grand River Basin Water Management Study – Summary and Recommendations*, Cambridge, Ontario.

Green Ontario (2000) Green Ontario Provincial Strategy: Clean Water. <http://www.greenontario.org/strategy/water.html>.

Guelph Conference (1942) Conservation and Post-War Rehabilitation, Guelph, Ontario

Guelph Conference (1942) Conservation and Post-War Rehabilitation, Guelph, Ontario.

Gulf of Maine Council Meeting (1999) Comments by Pat Hinch, NS Department of the Environment, December, <http://www.gulfofmaine.org/council/pdf/council_dec9_99.pdf>

Hammer, D. A. (1992) Creating Freshwater Wetlands. Lewis Publishers Inc., Ann Arbor.

Heathcote, Isobel W., Hugh R. Whiteley and Karen E. Morrison. *"Structuring an Efficient Water Management System: Case Studies from France, England and Ontario (Canada).*

Hooper, Bruce P. (1999) *Catchment Management in Australia: A Critique and a Way Forward* submission to the House of Representatives Standing Committee on Environment and Heritage Catchment Management Inquiry. Brisbane Hearing, November 16, 1999, <http://www.catchment.com/Paper_4.htm>.

Hutchings, Don, 1999. *Integrated River Basin Management and its Importance for the Future Wellbeing of Wales.* Environment Agency Wales.

Ilsenhoff, W.L. (1987) "An Improved Biotic Index of Organic Stream Pollution" *The Great Lakes Entomologist.* 20(1) 31-39.

Imperial, Mark T. and Timothy Hennessey (2000) Environmental Governance in Watersheds, National Academy of Public Administration, http://www.napawash.org/napa/epafile08

International Office for Water *Organization of Water Management in France*. <http://www.oieau.fr/anglais/gest_eau/intro.htm>

KAYAK (2000) *Maitland Watershed Partnerships: Total Approach Survey*. Unpublished Report. Maitland Valley Conservation Authority, Wroxeter.

Krause, Peter, Tony Smith, Barbara Veale and Marilyn Murray (2000), The Grand River Conservation Authority, Cambridge, Ontario, Canada, presentation by Grand River Conservation Authority to River-Symposium, Brisbane, Australia, September 7, 2000, <http://www.riverfestival.com.au/2000/archive.asp>.

Leland, David, Steven Anderson, and Donald J. Sterling Jr. (1997) "The Willamette – a river in peril" in *Journal AWWA*, Volume 89, Issue 11, pp. 73-83.

Manitoba Conservation Districts Association (1999) Promoting sustainable resource management on a watershed basis, <http://cici.mb.ca/pvcd/>

Memon, Pyar Ali (1997) "Freshwater management policies in New Zealand" in *Aquatic Conservation Marine and Freshwater Ecosystems*, Volume 7, pp. 305-322.

Ministère de l'aménagement du territoire et de l'environnement (1998) *Water and resources.* http://www.waternunc.com/gb/ageau2gb.htm

7 Bibliography (continued)

Minshall, Lorrie (2000) *"An Example of Collaborative Watershed Management in Ontario"*, facilitated by the Regional Management Centre for the Yucatan Peninsula and the United Nations University / International Network on Water, Environment and Health, organized by National Water Commission General Planning Directorate, October 31, 2000.

Mitchell, B. and D. Shrubsole (1992) Ontario Conservation Authorities Myth and Reality. Dept. of Geography Publication Series No. 35, University of Waterloo. Ontario.

Mitchell, B. (1989) *Geography and Resource Analysis*. Longman. Essex, England.

Mitchell, Bruce (1997) "Partnerships and participation", in *Resource and Environmental Management*, Longman Publishing, Essex, England p. 155-177.

MOEE (1993) *Water Management on a Watershed Basis: Implementing an Ecosystem Approach*. Queen's Printer, Toronto

More, R.J. (1969) "The Basin Hydrological Cycle" in *Introduction to Physical Hydrology*. Edited by R. J. Chorely. Methuen and Co. Ltd., Suffolk.

National Round Table on the Environment and the Economy (1996) *Building*.

New Alberta Water Act <http://www.cwra.org/news/arts/abwatact.html>

Nixon, S.C., T. J. Jack, D.T.E. Hunt, C. Lallana, A.F.Boschet (2000) Sustainable Use Of Europe's Water? State, Prospects And Issues Prepared For European Environment Agency, Copenhagen, <Http://Binary.Eea.Eu.Int:80/W/Water_Assmnt07_En.Pdf>

Nova Scotia Department of the Environment (2000) Nova Scotia's Environment Act Legislative Review Process 2000 Committee Report, <http://www.gov.ns.ca/enla/pubs/Act2000.pdf>

Oldham, M.J., Bakowsky, W.D., Sutherland, D.A. (1995) *Floristic Quality Assessment System for Southern Ontario*. Natural Heritage Information Centre, Ontario Ministry of Natural Resources. Unpublished Report.

Ontario (1997) Provincial Policy Statement, Toronto, Queen's Printer for Ontario.

Ontario Department of Lands and Forests (1932) Report on the Grand River Drainage, (Finlayson Report), Toronto, King's Printer.

Ontario Department of Lands and Forests (1932) Report on the Grand River Drainage, (Finlayson Report), Toronto, King's Printer.

Ontario Department of Lands and Forests (1962) Grand River Hydraulics Report, Second Edition,

Toronto, Ontario.

Ontario Department of Lands and Forests (1962) Grand River Hydraulics Report, Second Edition, Toronto, Ontario.

Ontario Ministries of Environment and Natural Resources (1993) Watershed and Subwatershed Planning Guidelines, <www.ene.gov.on.ca>

Ontario Ministries of Environment and Natural Resources (1997) Inventory of Watershed Management Projects in Ontario, 1990-1995, March.

7 Bibliography (continued)

Ontario Ministry of Natural Resources, Ontario Ministry of the Environment, Ontario Ministry of Agriculture, Food and Rural Affairs, Ontario Ministry of Municipal Affairs and Housing, Ontario Ministry of Economic Development and Trade, Association of Municipalities of Ontario, Conservation Ontario (2000) *Ontario Water Response 2000*. Unpublished Report.

Ontario Statutes of (1946) An Act to Provide for the Establishment of Conservation Authorities for the Purposes of the Conservation, Restoration and Development of Natural Resources, other than Gas, Oil, Coal and Minerals and for the Prevention of Floods and of Water Pollution, Chapter 11, Toronto, King's Printer.

Ontario Treasury Board (1971) Review of Planning for the Grand River Watershed, October, Toronto, Ontario.

Ontario Treasury Board (1971) Review of Planning for the Grand River Watershed, October, Toronto, Ontario

Ontario, Statutes of (1932) An Act to Establish the Grand River Conservation Commission, Chapter 55, Toronto, King's Printer.

Ontario, Statutes of (1946) An Act to Provide for the Establishment of Conservation Authorities for the Purposes of the Conservation, Restoration and Development of Natural Resources, other than Gas, Oil, Coal and Minerals and for the Prevention of Floods and of Water Pollution, Chapter 11, Toronto, King's Printer.

Pearse, Peter H. (1998) Water Management in Canada The Continuing Search for the Federal Role, keynote address at the 51st Annual Conference of the Canadian Water Resources Association, Victoria, BC <http://www.cwra.org/new/arts/pearse.html>

Platt, Rutherford H. and Van L. Morrill (1997) "Sustainable Water Supply Management in the United States: Experience in Metropolitan Boston, New York and Denver" in *Practising Sustainable Water Management: Canadian and International Experiences*, Bruce Mitchell and Dan Shrubsole Eds. , pp. 282-307, Cambridge, Ontario: Canadian Water Resources Association.

Robbins, Richard W., Joseph L. Glicker, Douglas M. Bloem, and Bruce M. Niss (1991) "Effective Watershed Management for Surface Water Supplies" in *Journal AWWA*, Volume 83, December, pp. 34-44.

Roberts, Jode (2000) The State of Ontario's Conservation Authorities: An Examination of Institutional Arrangements," MPA Research Report submitted to the Local Government Program, Department of Political Science, University of Western Ontario, August.

Romaine T.E. and M.J. Romaine (2000) An Assessment of Barriers and Proposed Actions to Advance Watershed Management in British Columbia A Report on Community Workshops, for the British Columbia Watershed Stewardship Alliance, March, <http://www-heb.pac.dfo-mpo.gc.ca/english/programs/hcsp/background/watast.pdf>

Russell, Les (1996) "Appendix 1: Current Commonwealth and State Organisation, Policies and Programs" in *Managing Australia's Inland Waters.* <http:/www.dist.gov.au/SCIENCE/pmsec/14meet/inwater/app1form.html>

Shrubsole, Dan and Bruce Mitchell eds. (1997) *Practising Sustainable Water Management Canadian and International Experiences*. Cambridge, Ontario: Canadian Water Resources Association.

Smith, L.G., (1982) "Mechanisms for Public Participation at a Normative Planning Level in Canada", *Canadian Public Policy*, 8, 561-72.

7 Bibliography (continued)

Toombs, Michael (1994) Legislation and Farming Practices, Ministry of Agriculture, Food and Rural Affairs Fact Sheet, ISSN 1198-712X, Toronto: Queen's Printer for Ontario, <http://www.gov.on.ca/OMAFRA/english/engineer/facts/94-047.htm>

U.S. EPA (1997) Top 10 Lessons Learned, <www.epa.gov/owow>

Veale, Barbara et al. (1997) Watershed Management in Ontario: Two Steps Forward – One Step Back? in A Watershed Approach to Conservation in Canada, prepared for the Soil and Water Conservation Society Conference by Canadian Chapters, Toronto, 23-25 July 1997.

THE IMPORTANCE OF WATERSHED MANAGEMENT

IN PROTECTING ONTARIO'S DRINKING

WATER SUPPLIES

APPENDICES

MARCH 20, 2001

PREPARED BY: CONSERVATION ONTARIO

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APPENDIX A—DECISION SUPPORT TOOLS TO EVALUATE WATERSHED ALTERNATIVES

The intention of this appendix is to briefly describe some of the tools which are commonly used to evaluate various watershed management activities mentioned in Chapter 3. These tools are useful in dealing with water supply, water quality, flooding and various environmental issues.

A.1 Water Quality Models

Rural Water Quality Model

The Grand River Simulation Model, GRSM, is a continuous simulation river water quality model. The model was developed to predict dissolved oxygen (DO) variations throughout a river and to identify periods of dissolved oxygen violation (times when DO levels fall below Provincial water quality objectives). The model incorporates an aquatic plant model, which is capable of simulating the growth of various shallow rooted aquatic plant types typical of the Grand River watershed. The model requires input data or stream flow, point sources such as sewage treatment plants, non-point sources such as agricultural and urban runoff, and various process rate coefficients.

The original model was developed in the 1970s by the Ontario Ministry of the Environment as part of the Grand River Basin Water Management Study. The model has been upgraded by the Grand River Conservation Authority from 1995 to 1998.

The GRSM model was used to predict water quality (DO minimums) of the river system for various water management scenarios that were investigated as part of the study. The scenarios were partly based on projections of population growth, and associated STP discharges to the river system. A 20-year projection of water quality was obtained from the GRSM with various assumptions regarding the operating of STP effluent and rural diffuse source inputs.

Reference: Technical Report 30: *Water Quality Simulation Models and Modelling Strategy for the Grand River Basin.*

Agricultural Area Water Quality Models

The Agricultural Nonpoint Source Pollution Model (AGNPS) was developed by the United States Department of Agriculture in 1986 to obtain estimates of runoff quality from rural lands. Its primary emphasis is on nutrients, pesticides and sediments. The objective of the model is to compare the effects of pollution control practices that could be incorporated into the management of watersheds. It is a distributed model that simulates agricultural watersheds for a single storm event assuming uniform precipitation patterns. Watersheds modelled by AGNPS must be divided into homogeneous square working areas called cells. Subdivision of main cells into smaller sub-cells gives flexibility to account for heterogeneity in the watershed. The hydrology is calculated by the Soil Conservation Service curve number approach. The Universal Soil Loss Equation is used for predicting soil erosion in five different particle sizes, namely, sand, silt, clay, small aggregates and large aggregates. The pollutant transport portion is subdivided into one part handling soluble pollutants and another part for sediment-based pollutants.

The Grand River Conservation Authority has established two pilot study areas (Canagagigue Creek and Lower Conestogo River) to evaluate the use of AGNPS in watershed nutrient management planning. A tool is needed to predict the change in the water quality of a river in response to implementation of agricultural best management practices. This information is needed to predict the change in the water quality of a river in response to implementation of agricultural best management practices. This information may then be used by an in-stream water quality model (GRSM) that assimilates nutrients from both non-point sources (modelled by AGNPS) and point sources such as wastewater treatment plants.

A.2 Watershed Quality Models

GAWSER Hydrologic Model

The Guelph All Weather Sequential Events Runoff model was developed by the University of Guelph in the mid 1970's and was refined in the late 1980's to predict streamflow from rainfall, snowmelt or combined rainfall/snowmelt events. Streamflow can be modelled for long periods of time (years) making it useful for water balance studies. The model also has the ability to simulate sediment loading, pollution wash off and water temperature. Runoff amounts are determined through the use of the Green Ampt approximations for infiltration. The model accounts for a full water budget, runoff, infiltration, evaporation, interflow and deep groundwater percolation.

The runoff response is determined using the area/time method to distribute runoff with time. The unit hydrographs are then routed through the river channel by using the Muskingum-Cunge method of channel routing. Reservoir routing is represented by the Puls routing method with controlled releases.

The GAWSER hydrologic model has been successfully applied in the Grand River watershed and in other watersheds throughout Ontario. It has been used in generating design flood flows, assessing the effect of land use change and providing input to river water quality models such as GRSM. It has also been used in water budget analysis to address drought, and water allocation problems.

Reference: Schroeter & Associates. 1996. GAWSER: Guelph All-Weather Sequential-Events Runoff Model, Version 6.5, Training Guide and Reference Manual. Submitted to the Ontario Ministry of Natural Resources and the Grand River Conservation Authority.

Hydrological Simulation Program (HSPF)

The Hydrological Simulation Program—Fortran (HSPF) simulates for extended periods of time the hydrologic, and associated water quality processes on pervious and impervious land surfaces and in streams and well-mixed impoundments. HSPF uses continuous rainfall and other meteorologic records to compute streamflow hydrographs and pollutographs. HSPF simulates interception soil moisture surface runoff, interflow, base flow, snowpack depth and water content, snowmelt, evapotranspiration, groundwater recharge, dissolved oxygen, biochemical oxygen demand (BOD), temperature, pesticides, conservatives, fecal coliforms, sediment detachment and transport, sediment routing by particle size, channel routing, reservoir routing, constituent routing, pH, ammonia, nitrite-nitrate, organic nitrogen, orthophosphate, organic phosphorus, phytoplankton, and zooplankton. The Program can simulate one or many pervious or impervious unit areas discharging to one or many river reaches or reservoirs. Frequency-duration analysis can be done for any time series. Any time step from 1 minute to 1 day that divides equally into 1 day can be used. Any period from a few minutes to hundreds of years may be simulated. HSPF is generally used to assess the effects of land-use change, reservoir operations, point or nonpoint source treatment alternatives, flow diversions, etc. Separate programs are available for data preprocessing and for postprocessing for statistical and graphic output of any constituent at any time step for any length of time.

Reference: U.S. Geological Survey, June 11, 1997. HSPF Readme File, HSPEF—Version 11. Hydrologic Analysis Software Support Team. Reston, VA.

A.3 Water Budget Modelling

The foundation of modern Hydrology is the Hydrologic Cycle. The Hydrologic Cycle is characterized by the Hydraulic Budget or Water Budget equation. The hydrologic budget for a watershed can be written

for a selected time period as:

$P - R - G - Et = \triangle S$

Where P = Precipitation on the watershed in a given time period

R = Net surface runoff for the selected time period

G = Net groundwater flow for a selected time period

Et = Evapotranspiration for a selected time period

$\triangle S$ = Change in storage (surface and groundwater) of the volume of water on and in the watershed during the selected time period

Introducing water users (such as municipal or industrial water taking) into the equation, the equation now becomes:

$P - R - G - Et - \text{Water Use} = \triangle S$

This can be simplified into:

Water available - Water use = $\triangle S$ or net water available to support natural environmental functions and potential water use.

The Grand River Conservation Authority is currently developing a watershed wide water budget. Once completed, the water budget will address questions related to water takings, with respect to the sustainability of the taking, as well as the possible ecological impacts of such takings. The water budget will also identify basins whose streamflows are naturally sensitive to droughts. Once identified, a drought contingency plan may be developed to deal with expected reductions in streamflow. In addition, a complete water budget will increase the general understanding of the watershed, therefore facilitating a more effective management of the resource.

Determining the water availability component consists of employing a computational procedure to estimate available water. Currently, in Phase 1, the Grand River Conservation Authority is utilizing the deterministic hydrologic model, GAWSER, to estimate streamflow for a 40-year simulation period. Making use of output generated from the modelling exercise, a mass balance approach is applied, as shown in Equation 2, to estimate available water for a given subcatchment. Phase 2 will integrate a finite difference groundwater model, MODFLOW, into the estimation of water availability. By gaining a better understanding into groundwater movement throughout the watershed, regional and local groundwater discharges, which have the ability to dramatically alter the water availability estimate, would be identified.

While the existing water budget is useful in understanding the existing hydrologic processes of the watershed, future water budgets are essential to effective long-term management of the watershed. By projecting possible future scenarios such as, long term climate change, land use change, population increases and agricultural intensification onto the existing water availability and water use, a future water budget can be produced, and with it, the ability to manage the watershed in a proactive sense.

Reference: Bedient, Philip, B., Huber, Wayne, C. 1992. *Hydrology and Floodplain Analysis.* Addison-Wesley Publishing. Reading, Massachusetts.

A.4 Groundwater Model

MODFLOW (Modular three dimensional finite difference groundwater flow model)

There are a variety of groundwater models available to analyze regional groundwater systems as described in Chapter 3.

This appendix briefly describes an industry standard “MODFLOW”, a groundwater flow model developed by the U.S. Geological Survey in 1989 for the computer simulation of groundwater flow. MODFLOW is used to simulate groundwater systems for water supply, contaminant remediation and

mine dewatering. It was used in the Waterloo-Wellington area to model regional groundwater flow for the Mill Creek and Blair-Bechtel watersheds and is presently being incorporated into the Water Budget Model for the entire Grand River watershed (Appendix A.3).

The model has a modular structure that allows it to be easily modified to adapt the code for a particular application. Many new capabilities have been added to the original model. The latest update is called MODFLOW-2000 in order to distinguish it from earlier versions. MODFLOW-2000 simulates steady and nonsteady flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or a combination of confined and unconfined. Flow from external stresses, such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow through riverbeds, can be simulated. Hydraulic conductivities or transmissivities for any layer may differ spatially and be anisotropic (restricted to having the principal directions aligned with the grid axes), and the storage coefficient may be heterogeneous. Specified head and specified flux boundaries can be simulated as can a head dependent flux across the model's outer boundary that allows water to be supplied to a boundary block in a modelled area at a rate proportional to the current head difference between a “source” of water outside the modelled area and the boundary block. MODFLOW is currently the most used numerical model in the U.S. Geological Survey for groundwater flow problems. In addition to simulating groundwater flow, the scope of MODFLOW—2000 has been expanded to incorporate related capabilities such as solute transport and parameter estimated.

The groundwater flow equation is solved using the finite difference approximation. The flow region is subdivided into blocks in which the medium properties are assumed to be uniform. In plan view the blocks are made from a grid of mutually perpendicular lines that may be variably spaced. Model layers can have varying thickness. A flow equation is written for each block, called a cell. Several solvers are provided for solving the resulting matrix problem; the user can choose the best solver for the particular problem. Flow rate and cumulative volume balances from each type of inflow and outflow are computed for each time step.

Reference: McDonald, Michael G. and Arlen W. Harbaugh. (1988). Chapter A1. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, in *Techniques of Water-Resources Investigation of the United States Geological Survey*

A.5 Geographical Information System

The use of geographical information system (GIS) has grown dramatically in recent years. A Geographical Information System is a moderately sophisticated, yet robust tool employed to support the capture, management, modelling and display of geographically referenced data. One of its main uses is mapping the location of features. For example, the Grand River Conservation Authority has mapped the watershed natural hazards by combining data layers including floodlines, steep slopes, wetlands, streams and topography. This natural hazard mapping is then useful for municipal planning throughout the watershed.

Similarly, in groundwater mapping, the Grand River Conservation Authority has used GIS to map groundwater recharge areas and aquifer systems. These mapped areas give an understanding of the system and enable groundwater protection areas to be established. Beyond mapping the locations, GIS also provides a mechanism to monitor change with time. For example, by combining soil/geologic data layers with land use data layers, the impact of land use upon runoff during a storm event for flood concerns and during a season for water supply concerns can be determined.

At the Grand River Conservation Authority (GRCA), GIS technology is used extensively throughout the organization. GRCA’s committed goal for using the technology is to maintain an integrated, watershed-based tool for resource management that meets the evolving needs of the GRCA and its partners. The objective, in terms of using this technology, remains improved business performance. GIS technology has enabled the GRCA to do things unimaginable only a few years ago. Not only does the GRCA have good data, but the data is also being used on a daily basis to make better decisions. In addition, the GRCA has committed to keeping the GIS data current. It is this commitment that enables the GRCA to utilize its GIS technology in support of on-going decision-making.

APPENDIX B - RISK MANAGEMENT

Risk assessments for water supply questions utilize technical information to characterize the magnitude of human health risk. This is accomplished using descriptions of physical features and management practices within the watershed and factual information defining the health effects of human exposure to contaminants arising from within the watershed.

The schematic in Figure B-1 demonstrates the principles implicit in risk assessment and management. Figure B-1 depicts the simple situation of a feedlot, a downgradient water supply well, and a water treatment system prior to delivery of the water to consumers. This illustrates the three elements of a problem that are relevant to risk assessment:

1. **A Source Exists** - a source of contamination, in this situation arising from a confined livestock facility;
2. **One or More Pathways Exist** - a series of pathways exist by which the contaminants may migrate to the well. The pathways in this case involve surface flow and subsurface movement. Various biological, chemical, and/or transport processes act on the water contaminants during migration and affect their fate;
3. **One or More Water Consumers Exist** - one or more water consumers use the well as a drinking water source, and may experience human health impacts from contamination.

These three elements - source, migration pathway(s) between the source and the consumer, and human receptor - must all exist for there to be a risk of human health exposure.

In this simple example, responses to reduce the human health risk might include:

Option I: land use controls to preclude the land use activity;

Option II: divert the surface water flow by recontouring the surface drainage pathway or install sewer pipes that intercept the surface flows;

Option III: Upgrade the water treatment facility;

Option IV: Use an alternative water supply from outside the watershed.

The simple example of Figure B-1 is easily expanded in scope and scale to the level of the watershed. At a larger scale, there will typically be a larger number of potential management options; for example:

Option V: allow continued use of the land as an animal feedlot but require effluent treatment on the surface water runoff from the feedlot,

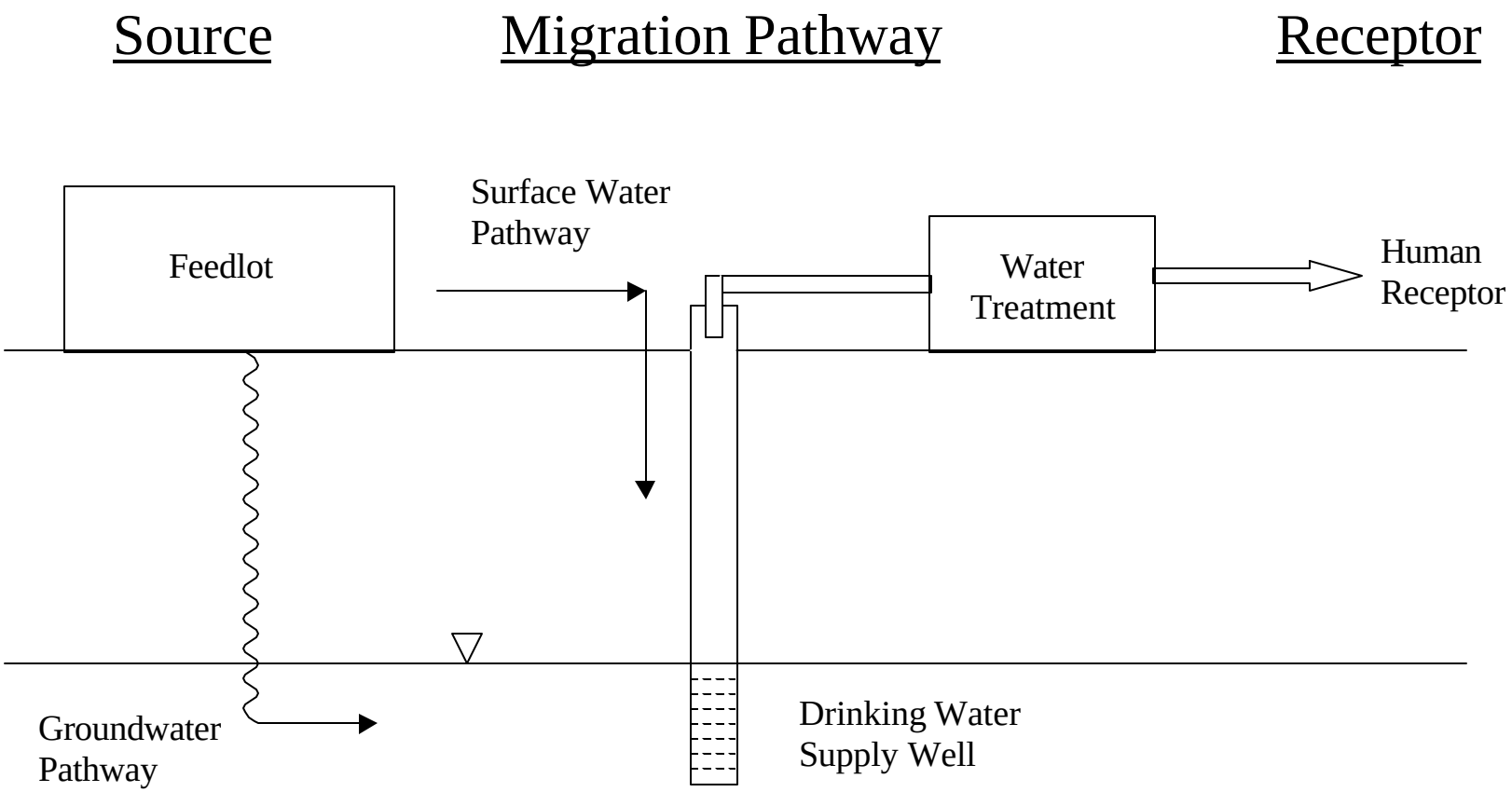
Option VI: overland surface drainage using measures such as infiltration beds or trenches that infiltrate surface drainage to the groundwater. The groundwater pathway to the receptor, being much longer in time, may have the ability to eliminate contaminants,

Option VII: adopt agricultural practices such as grassed swales to reduce particulate concentrations in the feedlot runoff; and,

Option VIII: institute a system of real time water quality monitoring that allows the timely issue of boil water alerts to consumers if the situation warrants.

The above list is not intended to be all encompassing. The intent is to suggest a progression of possible options, each of which reduces the consumer's risk of exposure to contaminants in combinations of one or more, provide effective protection of the water supply. Risk assessment methodologies are used in watershed planning to examine the merits of such measures by predicting the impact they have on the severity, duration, and frequency of human exposure to contaminants.

Figure B—1: SCHEMATIC DESCRIPTION OF RISK ASSESSMENT PROCESS



Schematic Depiction of Risk Assessment Process

APPENDIX C—FEDERAL AND PROVINCIAL WATER QUALITY LEGISLATION

TABLE C—1: Key Federal Water Quality Legislation

Key Federal Water Quality Legislation	Administering Agency	Purpose
Canada Water Act	Environment Canada	Provides the framework for joint federal-provincial management of Canada's water resources.
Canadian Environmental Protection Act, 2000	Environment Canada	Provides pollution prevention and the protection of the environment and human health in order to contribute to sustainable development.
International River Improvements Act	Environment Canada	Provides for licensing of activities that may alter the flow of rivers flowing into the United States
International Boundary Waters Treaty Act	Department of Foreign Affairs and International Trade	Outlines principles and guidelines for the management of boundary and transboundary waters by Canada and the United States, with the primary objective of preventing or resolving disputes regarding the water quality and quantity of shared water resources. The Treaty establishes the *International Joint Commission* (IJC), an independent bi-national body with a regulatory, investigative and adjudicative role. In its regulatory capacity, the IJC's approval is required for any works in boundary waters and certain transboundary waters that may affect levels or flows at the boundary. Its investigative role is initiated by the submission of a reference from one or both governments; and it has not yet arbitrated a dispute.
Fisheries Act	Department of Fisheries and Oceans (DFO) Environment Canada administers the pollution prevention provisions of the Act.	Regulates the harvesting of fish, protects fish habitat, prevents pollution of fishery waters, and ensures safe human use of fish.
Canada Shipping Act	Transport Canada	Provides for the Governor in Council to make regulations with respect to prohibiting the discharge from ships of pollutants and prescribing substances and classes of substances that are pollutants.
Navigable Waters Protection Act	Transport Canada	Ensures public access to, and efficient use of, our waterways.
Related Agreements/Guidelines		
Great Lakes Water Quality Agreement	Environment Canada	Restores and maintains the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem and includes a number of objectives and guidelines to achieve these goals.
The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem, 1994	Environment Canada/DFO/Agriculture and Agri-Food Canada/Health Canada Ontario Ministry of the Environment/Ontario Ministry of Agriculture and Agri-Food, Ontario Ministry of Natural Resources	Renews and strengthens planning co-operation and co-ordination in implementing actions to restore and protect the ecosystem, to prevent and control pollution in to the ecosystem and to conserve species, populations, and habitats in the Grand Lakes Basin.
Federal Drinking Water Guidelines	Department of Health	Identifies substances that have been found in drinking water and are known, or suspected to be harmful and establishes the Maximum Acceptable Concentration of the substance that can be permitted in water used for drinking. To date, guidelines have been established for microbiological, radiological and more than 85 physical chemical parameters.
Federal Water Policy	Environment Canada, 1987	Provides a statement of the federal government's philosophy and goals for the nation's freshwater resource and of the proposed ways of achieving them. Its recognizes that water is, at present, Canada's most undervalued and neglected natural resource – the underlying philosophy is that Canadians must start to view water as a key to environmental health and as a scarce commodity having real value.

Table C—2: Key Provincial Water Quality Legislation

Key Provincial Water Quality Legislation	Administering Agency	Purpose
Ontario Water Resources Act	Ministry of the Environment	Provides for the conservation, protection and wise use and management of Ontario's surface and groundwater.
Environmental Assessment Act	Ministry of the Environment	Provides protection, conservation and wise management of the environment. This act applies to government and municipal activities as well as commercial or business activities. An environmental assessment must be performed for a proposed area of undertaking. The Ministry of the Environment along with the Environmental Assessment Board may approve or deny the proposal to allow the undertaking to proceed.
Environmental Protection Act	Ministry of the Environment	Provides protection and conservation for the natural environment. There are points on general provisions, motors and motor vehicles, water, waste management, vehicle permits (hauling waste), abandoned motor vehicles, sewage system, litter, spills and control and stop orders. In order to deal with the many aspects of this act and assist the Ministry of the Environment, there are provincial officers (to enforce), an appeal board and an environmental council.
Pesticides Act	Ministry of the Environment	Ensures the safe use, management and storage of pesticides.
Conservation Authorities Act	Ministry of Natural Resources/Conservation Authorities	Permits Conservation Authorities to establish and undertake a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals in the areas over which they have jurisdiction. Permits Conservation Authorities to administer the Fill, Construction and Alteration to Waterways Regulation that prohibits construction in floodplains and wetlands, filling in scheduled areas, and the alternation of waterways.
Lakes and Rivers Improvement Act	Ministry of Natural Resources	Ensures flow and water level characteristics of lakes and rivers are not altered to the point of disadvantaging other water users.
Aggregate Resources Act	Ministry of Natural Resources	Provides for the management of aggregate resources, controls and regulates aggregate operations, rehabilitates land that has been excavated, and minimizes adverse impacts on the environment when performing aggregate operations. There are statutes on licences, permits, abandoned pits and quarries, rehabilitation, offences and penalties and areas without municipal organization.
Planning Act	Ministry of Municipal Affairs and Housing	Sets ground rules for land use planning in Ontario and establishes how lands may be controlled and who may control them. The Act allows the province to manage broad provincial interests such as the protection of farmland, floodplains or wetlands and empowers municipalities to create zoning bylaws to control the use of land and regulate the location, type and dimensions of buildings and structures.
Municipal Act		Outlines the powers and authority of Ontario's municipalities. Local municipalities are authorized to provide water and sewage under the Act. Municipalities derive all of their powers through statutory delegation of the provinces.
Public Utilities Act		Permits a local municipality to acquire, establish, maintain and operate waterworks. It may also acquire by purchase or otherwise and may enter on and expropriate land, waters and water privileges and the right to divert any lake, river, pond, spring or stream of water, within or without the municipality, as may be considered necessary for waterworks purposes, or for protecting the waterworks or preserving the purity of the water supply.
Drainage Act	Ministry of Agriculture, Food and Rural Affairs	Provides for the establishment of municipal drains which may allow landowners to obtain an outlet for land drainage.
Agriculture Code of Practice (Certificate of Compliance)	Ministry of Agriculture, Food and Rural Affairs, Ministry of Municipal Affairs and Housing, Ministry of Environment	Provides guidelines for livestock operations to minimize land, water and air pollution potential.

APPENDIX D—INFORMATION REQUIRED FOR GOOD DECISION MAKING

Effective decision-making within the framework of watershed management requires an understanding of the current state of the natural environment, societal values and economic influences. Watershed management projects typically begin with an information collection and assessment stage. This information base allows stakeholders to have a common understanding of physical features, processes and community issues that exist in the watershed. This allows for the beginning of discussions concerning trade-offs and opportunities as the watershed management plan is developed.

Where information is dated, incomplete or missing coverage, of questionable quality or inaccessible, the information gaps are filled. Where it is impractical or impossible to fill these information gaps within the existing time and financial limits of the project, decisions are made and qualified on the basis of 'best available information'.

Raw data is converted or analyzed so that it is useful for decision-making. For example, a table of total phosphorus concentrations as a measure of water quality is of little use to most stakeholders unless it is compared to some standard i.e., 0.03 mg/l as the upper limit for aquatic life or a long term average.

Natural Environment Information

Natural environment features and processes can be categorized many different ways i.e., abiotic or biotic, water based or terrestrial, landforms or flora or fauna. These features and processes are often evaluated or ranked, i.e., impaired or unimpaired. Methods of data gathering range from in-field sample collection and analysis, interpretation of mapping, aerial photography, satellite imagery, use of existing statistical information or some combination of these (Mitchell, 1989).

Water information is typically divided between quantity and quality. Quantity information is best presented as a water budget, which is a comprehensive description and measure of surface and groundwater supply and use. Water budgets are essential for water allocation decisions (GRCA and CVC, 2000). Water quality is generally expressed as long term average concentrations of specific parameters compared to some standard, as number of exceedances over time, or as annual loadings.

Baseline water quantity and quality monitoring networks provide this information. These networks are necessary over a long term to capture extreme events, and at a scale capable of providing subwatershed specific information. Conservation authorities currently operate a climate and streamflow monitoring network for flood forecasting and warning in partnership with the provincial and federal governments, and assist with monitoring of the Provincial Water Quality Monitoring Network. These networks provide long-term baseline information but in most cases are often enhanced with additional conservation authority operated stations to provide the required density for watershed management decisions.

Given the complexity of natural environment features, ‘indicators’ have become popular as surrogate measures of broader system or subsystem health. Examples include the presence of certain benthic invertebrate species as an indicator of good water quality (Hilsenhoff, 1987), and the presence of certain vegetation species as an indicator of woodland disturbance (Oldham, M.J., et. al., 1995). E.Coli. itself is considered an indicator for the presence of pathogens in water.

Societal Values Information

Understanding the value society places on a resource, including water, is important for selecting protection or enhancement strategies as part of a watershed plan. A plan will be more effective if strategies address resources considered a priority by stakeholders.

Public involvement through steering committees, task groups, surveys, questionnaires and public meetings are some of the most common methods of gathering information about societal values. The public are generally asked to rank resources or resource issues as a means of conveying relative importance. This information can then be used by organizations to design implementation strategies.

The Maitland Watershed Partnerships (MWP), including the Maitland Valley Conservation Authority, recently conducted a community mail out survey and interview process to rank the importance of issues such as manure management, soil erosion, drinking water protection, herbicide use, septic maintenance and stream protection. Results indicated highest priority for protection of rivers and streams from hazardous wastes followed by drinking water protection from herbicides and faulty septic systems (KAYAK, 2000). This information will be used by the MWP to design a best management practices implementation program for the watershed.

Most conservation authorities and watershed management agencies conduct periodic reviews of societal values through community surveys, open houses or public workshops.

Economic Information

Economic information is the least developed and least used piece of information for watershed management. In most cases, decision makers can readily assess implementation costs of a management decision. This can be summarized in terms of staff wages, materials and administration. Benefits from effective watershed management can rarely be described in this fashion. The value of clean drinking water, clean rivers and lakes and healthy forests and wildlife is difficult if not impossible to assess. In many cases, decisions are weighed between generalized motherhood values supporting implementation, and precise financial figures demonstrating costs.

Ideally, resources themselves or certain environmental conditions would be assessed economic value. This would permit a fair economic comparison of watershed management benefits and costs. While some work has been attempted in this field (contingent valuation studies), methods and results have not yet been broadly accepted as credible information for watershed management decision-making. However, decision makers are very aware of the value and weight this economic information can carry in decision-making. Further research is required to refine economic assessments for watershed management.

The Current State of Information for Watershed Management

Conceptually, there is a lack of long term, watershed scale baseline water information to support decision-making. The Conservation Authorities, as part of the current provincial Water Resources Information Project (WRIP), have made a list of the information that should be developed across the province to support watershed management and decision-making with respect to water. The Grand River Conservation Authority is documenting the steps it has undertaken to make the required data useful, including overcoming data sharing and accessibility barriers, pooling several sources, straightening out varying formats, cleaning the data and filling in gaps, compiling into a useable database, and linking to analytical tools. While the provincial concern is centred around information sharing, database structures, standards, database integration and information management systems, the Conservation Authorities are most concerned that much of the baseline, in-field information gathering is lacking and must be addressed first.

Federal and provincial baseline monitoring networks have been subjected to a series of financial cuts during the past ten years. Impacts include a reduction in the actual number of monitoring stations, a reduction in parameters being monitored, delays in the distribution of monitoring information and increasing maintenance costs and user fees. The ability of watershed managers to predict extreme events (flood, drought) or understand trends in surface and groundwater quality has been seriously compromised as a result.

Baseline monitoring networks need to be restored and enhanced beyond their previous capabilities. This enhancement will allow for prediction of extreme events, better understanding of water quality trends as well as development of water budgets, water allocation criteria, flood protection, enhanced state-of-the-watershed reporting, targeting of areas for rehabilitation, program evaluation and many other initiatives.

The Conservation Authorities' recommendations for province-wide information improvement include updating soils maps, correcting geology maps, updating well logs, implementing a provincial groundwater monitoring network, developing a biological and chemical assessment network, cleaning

existing climate data sets, enhancing the climate and streamflow monitoring networks, updating the Ontario Base Mapping, ground truthing remotely sensed data (Landsat), and quantifying the benefits of watershed management in general and “best management practices” in particular.

APPENDIX E—CASE STUDIES IN WATERSHED MANAGEMENT

United States

Boston and New York City

Both Boston and New York City have identified watershed planning and management as core components of their long-term water supply strategies and have acknowledged this link through funding commitments. This is because development and changing land near the upland surface water reservoirs, which serve as the cities' water supply source, are causing concern about the negative implications of this development on water quality. A concurrent shift in philosophy from that of "water development" (e.g., more diversions) to "water management" (e.g., demand management, supply protection) has been encouraged by strong watershed citizens' groups.

There are also strong financial reasons for both cities to pursue protection of existing water sources. Neither city provides water filtration because the upland sources are of such good quality. They are attempting to demonstrate that watershed management can forestall the need for filtration while saving Boston approximately $150 million and New York City between $3-8 billion.

New York City has been particularly aggressive in taking steps to improve water quality. It has strengthened water quality monitoring efforts and embarked on a widespread watershed protection program. It has identified specific potential threats to water quality and has developed long-term strategies (such as revised watershed regulations and land acquisition) to deal with these concerns. New partnerships have been created with upstream watershed communities to further the city's water quality goals. One notable example is the Watershed Agricultural Program which encourages upstream farmers to undertake whole farm plans and best management practices with the assistance of a team of professionals and financial incentives paid for by the city and supplemented by available state, federal and local funding. A Watershed Memorandum of Agreement has been signed to strengthen cooperative efforts among stakeholders (Ashendorff, Principe, Seeley, LaDuca, Beckhardt, Faber, and Mantus, 1997).

Platt and Morrill (1997) observed that water managers have been shifting their planning focus away from their long-standing reliance upon supply augmentation towards more efficient management of existing sources. This trend has occurred, in part, in response to fiscal and environmental constraints upon the development of new or expanded external sources and as a response to federal mandates imposed by the Environmental Protection Agency under the Safe Drinking Water Act and the Clean Water Act.

Willamette River, Oregon

In a recent five-year study of the Willamette River in Oregon, it was concluded that water quantity and water quality "can no longer be considered separate issues" and that "water management requires a coordinated whole-basin approach" (Leland, Anderson, and Sterling, 1997). The Willamette River is about 300 km long with eleven storage reservoirs and two re-regulating reservoirs on six of the thirteen major tributary rivers.

The population of the river basin is expected to grow at a rapid rate with more than 500,000 additional people living in the basin by 2015. The responsibility for water management extends among 21 state agencies, 18 federal agencies and 6 regional organizations.

The Willamette River Basin Water Quality Study was undertaken to gather information about the river and to develop tools for its management. Through this study, it was determined that water quality and river health was deteriorating and that without strengthened river basin planning and management, river health would continue to deteriorate in the face of rapidly expanding populations. It was suggested that river health needed to be valued equally with economic gain when management decisions will affect riparian or aquatic habitats. A number of short and long-term recommendations for action were put forward to enhance the quality of the river's water and habitat while at the same time providing a clean and plentiful water supply for the future. Three key recommendations were:

- Price resource use to fund purchase of critical land areas or to fund stream-side restoration projects.
- Develop a comprehensive project review process that integrates and co-ordinates agency project reviews and that considers quality and quantity issues together, effects on groundwater and surface water in the basin and their interrelationships, and cumulative effects on river health
- Explore market incentives to improve water quality (such as making discharges and water rights "tradable" or developing fees for water use), and reduce wastewater disposal and use of pesticides and other chemicals.

The need to monitor and track river health and to undertake studies and develop models to further explain the relationship between various land uses and pollutant levels in the river was emphasized.

Spokane County, Washington

In the above cases, emphasis was on the protection of surface water. In Spokane County, Washington, a US Geological Study undertaken in the mid-1970s showed that contamination of the groundwater aquifer was taking place (Dobratz, Wubben, and Maxwell, 1986).

Rapid urbanization in the area caused the US Environmental Protection Agency to create the Spokane-Rathdrum sole source aquifer in 1978. A Memorandum of Understanding was developed by the EPA with other federal agencies to review activities in the area to ensure that they did not further degrade the aquifer. Subsequent studies to determine how the aquifer functions, to identify potential contamination problems, and to develop the best combination of preventive measures were carried out by the county. Based on this research, committees of technicians and local citizens worked together to develop a regional water quality management plan to protect the aquifer. Components of the plan included a comprehensive land use plan, a comprehensive wastewater management plan, a coordinated water system plan, stormwater and spill control, and solid and hazardous water disposal.

It is interesting to note that with this case study, the researchers observed that while county commissioners worked closely with local citizens' groups in formulating policies and programs, it was not easy to obtain support for preventive action programs unless the problem was dramatically visible. The reduced level of grant funds available from the federal government had shifted the bulk of the financial responsibility to the local level. Therefore, capital-intensive protection programs for water resources will create property assessments and monthly user charges that will be significantly greater in future years. It was concluded that more intense and innovative programs of public awareness and project financing were needed to develop effective protective efforts and offset rising expenses.

AWWA Watershed Survey

In a study undertaken by the American Water Works Association (AWWA) Research Foundation, it was concluded that watershed protection programs can play a strong role in maintaining or enhancing water quality and in providing cost-effective options to the application of advanced water treatment methods. This study included a literature review and analysis of the results of a national survey of watershed management programs conducted by water utilities and state regulatory agencies and 24 case studies of successful watershed management programs (Robbins, Glicker, Bloem, and Niss, 1991).

The results of the water utility survey were based on 272 watersheds. These watersheds were analyzed for the relation between land use and specific water quality concerns. The most frequently cited concerns by water utilities were nutrient loading and pesticide runoff from agricultural activities, followed by bacteriological and viral contamination associated with septic tanks and sewage discharge, turbidity effects from agricultural cropland runoff and bacteriological contamination form recreational land use.

The survey asked respondents to rate a list of typical control measures used to protect the quality of surface water relative to their applicability and effectiveness. The results of the ratings are listed below.

Table E—1:Water Utility Managers' Ratings Of The Effectiveness Of Watershed Controls

Ranking	Watershed Control	Systems Using This Control	Average Rating
1.	Land ownership	25	4.0
2.	Reservoir use restrictions	53	4.0
3.	Watershed entry restrictions	38	3.8
4.	Reservoir buffer strips	35	3.7
5.	Industrial-municipal discharge permits	34	3.7
6.	Sanitary sewers	37	3.5
7.	Hazardous material controls	13	3.5
8.	Septic tank permits	42	3.5
9.	Formal agreements with landowners	16	3.5
10.	Zoning restrictions	29	3.4
11.	Streamside buffer strips	29	3.4
12.	Prohibited land uses	23	3.4
13.	Legal action	28	3.3
14.	Use of best management practices	32	3.3
15.	Stormwater collection treatment	19	3.2
16.	Regulation of construction practices	38	3.2
17.	Ambient water quality criteria	44	3.1
18.	Transfer of development rights	8	3.1
19.	Wildlife control	18	3.0
20.	Informal agreements with landowners	18	2.6

On the basis of the survey questionnaires or through referrals from contacts in the water management industry, the researchers examined 24 effective watershed management programs and practices used by water utilities to provide a foundation for recommendations for effective source water protection.

Despite differences in system size and source characteristics, a common element was the general process used to strengthen watershed protection. This process contains six steps:

1. Watershed inventory (physical characteristics, land use, ownership, water quality)
2. Identification of contaminants of concern and sources of these contaminants
3. Goal setting for a watershed management program
4. Selection of appropriate control measures to protect water quality
5. Implementation through necessary legal, financial and institutional arrangements

6. Monitoring and evaluation

Monitoring and evaluation were considered of critical importance because they supply feedback on whether changes are needed in the program goals, watershed control measures or program implementation.

The study suggested that a mix of structural and non-structural controls can be effective. These can be divided into four broad categories based on land use: 1) general measures that apply to most or all watersheds, 2) control measures for agricultural land, 3) control measures for forest management, and 4) control measures for urban development. It was concluded that water treatment and in-reservoir practices were not substitutes for effective watershed management. In most cases, a combination of watershed management, in-lake or in-reservoir management, and water treatment was used to achieve the desired level of water quality. Controlling contaminants at the source was considered to be the most fundamental way to prevent degradation of water quality in water-supply reservoirs and finished water. Non-structural solutions such as land use controls were favoured over structural solutions such as detention basins since they require financial and institutional commitment for long-term maintenance.

It was observed that a well-evaluated, carefully planned watershed management program is of *"no value if it is not properly carried out. Effective watershed management must therefore include a commitment by water system managers to provide the necessary financial resources, staff, institutional arrangements, and public education to successfully implement the program"*.

For watersheds composed of several political jurisdictions, regional planning agencies were seen to play an important role in facilitating coordination among agencies and agreements to control future development. In some instances, state regulations were enacted to provide minimum statewide standards. Thought to be one of the premier examples of a comprehensive statewide attempt to regulate land use activities in water supply watersheds, the North Carolina law is designed to overcome the jurisdictional conflicts that occur when a community's water supply is located outside its planning and zoning jurisdiction. The law requires local governments to adopt land use plans, ordinances and regulations that are at least as stringent as the minimum state requirements.

Public involvement is critical since public awareness of watershed issues affects the acceptability of mandatory controls, the effectiveness of voluntary controls, and the degree of support received. Water quality monitoring is essential for proper water management. The specific water quality variables that should be targeted in a watershed monitoring program are a function of the natural and human sources of contamination.

It was noted that wholesale application of a program that was successful in one drainage basin may not be appropriate for another, because watersheds are extremely varied in terms of natural environmental features, land use, ownership, and institutional controls. However, the management tools such as watershed models and geographic information systems provide an ever increasingly important role in future watershed planning efforts.

References:

Adler, Robert W. (1996) Addressing Barriers to Watershed Management in Proceedings Watershed '96, "Moving Ahead Together Technical Conference and Exhibition, June 8-12, 1996, Baltimore, Maryland summarized from *Environmental Law*, Volume 25, pp. 973-1106 cited in <http://www.epa.gov/owow/watershed/Proceed/adler.html>.

Ashendorff, Arthur, Michael A. Principe, Anne Seeley, John LaDuca, Larry Beckhardt, Walter Faber Jr., and Jeff Mantus (1997) "Watershed Protection for New York City's Water Supply" in *Journal AWWA,* Volume 89, March, pp. 75-88.

Committee on Watershed Management, Water Science and Technology Board, Commission on Geosciences, Environment, and Resources, and National Research Council, (1999) New Strategies for America's Watersheds" Executive Summary, Washington, D.C.: National Academy Press, <http:/www.nap.edu/html/watershed_strategies/>

Dobratz, William R., Robert L. Wubbena, and John M. Maxwell (1986) "Protection and Management of Spokane's Sole Source Aquifer" in *Journal AWWA*, Volume 83, September, pp. 62-69.

Gollnitz, William G. (1988) "Source Protection and Small Utility" in *Journal AWWA*, Volume 80, August, pp. 52-57.

Leland, David, Steven Anderson, and Donald J. Sterling Jr. (1997) "The Willamette – a river in peril" in *Journal AWWA*, Volume 89, Issue 11, pp. 73-83.

Platt, Rutherford H. and Van L. Morrill (1997) "Sustainable Water Supply Management in the United States: Experience in Metropolitan Boston, New York and Denver" in *Practising Sustainable Water Management: Canadian and International Experiences*, Bruce Mitchell and Dan Shrubsole Eds., pp. 282-307, Cambridge, Ontario: Canadian Water Resources Association.

Robbins, Richard W., Joseph L. Glicker, Douglas M. Bloem, and Bruce M. Niss (1991) "Effective Watershed Management for Surface Water Supplies" in *Journal AWWA*, Volume 83, December, pp. 34-44.

APPENDIX F—WATERSHED MANAGEMENT IN THE UNITED STATES, UNITED KINGDOM, FRANCE, AUSTRALIA, AND NEW ZEALAND

United States

Managing water resources on a watershed basis is not a new concept in the United States. As early as 1908, the U.S. Inland Waterways Commission reported to Congress that each river system, from its headwaters to its mouth, is an integrated system and must be treated as such (U.S. EPA, 1998b).

The Water Quality Act (1965) requires that states develop water quality standards for interstate waters. As a result, river basin compacts were formed to protect systems such as the Delaware and the Colorado Rivers (U.S. EPA, 1998b).

In 1972, the Federal Water Pollution Control Act *"established as a national goal, the restoration and maintenance of the physical, chemical and biological integrity of the Nation's waters"* (U.S. EPA, 1998). The Clean Water Act (CWA) is a 1977 amendment to the Federal Water Pollution Control Act. The national goal spelled out in the CWA was to eliminate all discharge of pollutants into navigable water by 1985. The CWA established a very broad framework of planning, research, financial assistance, and permit systems to further the national objective and goals.

The law gave EPA the authority to set effluent standards on an industry basis (technology-based) and continued the requirements to set water quality standards for all contaminants in surface waters. The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit under the National Pollutant Discharge Elimination System (NPDES) is obtained.

The 1977 amendments focused on toxic pollutants. In 1987, the CWA was re-authorized and again focused on toxic substances, authorized citizen suit provisions, and funded sewage treatment plants (POTW's) under the Construction Grants Program. While CWA provides for the delegation by EPA of many regulatory, administration, and enforcement aspects of the law to state governments, in states with the authority to implement CWA programs, EPA still retains oversight responsibilities.

There is currently a fundamental shift occurring in water management within the U.S. This shift is a moving away from water development (i.e., structural improvements or diversions) to a stewardship ideal (i.e., watershed protection schemes). According to Platt and Morrill (1997), the American system of public water supply is at a turning point:

"The politics of scarcity is giving way to the politics of sustainability. The myth of unlimited sources of new supply, like the myth of national water scarcity, is yielding to the reality that existing supplies must be managed, protected, and wisely allocated. Recognition is also spreading that water supply management in not an isolated, single-purpose enterprise but is part of the larger context of multiple purpose water resource and land management."

Leading this shift is the U.S. Environmental Protection Agency (EPA), who has developed a framework known as the Watershed Protection Approach (WPA). The WPA does not compete with existing clean water programs, but provides a framework within which existing federal, state and local programs are integrated (U.S. EPA, 1998b).

The WPA is based on four elements:

- All priority problems in a watershed should be identified and addressed – problems posing the greatest risk to human health, ecological resources, desirable uses of the water, or a combination of these.
- All parties with a stake or interest in a specific watershed should participate in the analysis of problems and the creation and implementation of solutions.
- Actions taken in a watershed should draw on the full range of methods and tools available, integrating them into a coordinated, multi-organizational attack on the problems.

- Stakeholders should agree on measures of success early and monitor progress throughout the life of the project (U.S. EPA, 1998a).

The WPA builds on CWA Section 303(d) and the Total Maximum Daily Load (TMDL) process. Section 303(d) of the CWA requires states to submit lists of water quality limited water bodies every two years and to develop TMDLs for their water quality limited waters (U.S. EPA, 2000a).

"technology-based effluent limitations or other legally required pollution control mechanisms are not sufficient or stringent enough to implement the water quality standards applicable to such waters." (U.S. EPA, 1999).

TMDLs are defined as the maximum pollutant load a waterbody can assimilate without violating set state water quality standards (Department of Environmental Protection, 2000). This calculated maximum must take into account both point and non-point sources as well as any naturally occurring background conditions. The completed TDMLs must take into account seasonal variations and margin of safety, in addition, the EPA must approve each TDML. In the case of the EPA not approving the submitted TDML, the EPA will establish one itself (U.S. EPA, 1999).

Once the TMDL is set and approved for a specific watercourse, and the pollutant reduction required to meet the TMDL is established, implementation of control actions should proceed. Implementation is the responsibility of the state, or where the EPA established the TDML, the EPA's responsibility. For controlling point sources, the NPDES process can be used to lower effluent concentrations. In the case of non-point sources, both state and local laws may be used to authorize the implementation of non-point source controls, such as Best Management Practices, or land use zoning.

Currently the TMDL process does not specify how discharges must attain the load reduction, however, the EPA is drafting regulations that would require states to submit an implementation plan with the TDML during the approval process. This, however, is meeting with opposition from states who object to federal interference in what they see as a local issue.

Implementation of Section 303(d) was primarily focused on point source pollution. In recent years, non-point source contributions to water quality degradation has become better understood and the EPA and state implementation now includes non-point source pollution problems (U.S. EPA, 1999). By requiring that TMDLs include all sources of pollution, point, non-point and background, the EPA is subtly compelling state and local organizations to adopt the watershed approach in water management.

Although Section 303(d) and the TDML process is a cornerstone of the WPA, several other programs can be integrated as well. Various EPA programs such as the Non-point Source (NPS) Program, Wellhead Protection (WHP) Program and the Sole Source Aquifer (SSA) Program can also be integral parts of any Watershed Protection Approach.

The following is a brief description of these programs.

- **Non-point Source Program—**is a pollution abatement, and resource remediation program designed specifically for controlling and reducing pollution due to non-point sources. Under the 1987 Amendments to the CWA, states were required to conduct statewide assessments of waterbodies and identify those that were either in violation of state water quality objectives, or were likely to violate the water quality objectives some time in the future, because of non-point source pollution. In addition, the states were obligated to develop non-point source management programs, which would address those impaired or threatened waters. Once the EPA has approved the management plan, the states were eligible to receive annual grants from the EPA to assist in implementing the management plan (U.S. EPA. 1998a).
- **Wellhead Protection Program—** is a pollution prevention and management program used for protection of underground water supplies. WHP Programs must be submitted to the EPA for approval, and must contain delineation of the capture zone, an inventory of any source contaminants as well as a source management plan. (U.S. EPA. 2000c)

- **Sole Source Aquifer Program—**is a designation rather than a program. Groundwater aquifers are designated Sole Source if the aquifer is the communities primary source of water, and if contaminated, developing an alternate supply would be extremely expensive. Once identified, any development that occurs within the designated area, which is set to receive federal financial aid, must be reviewed by the EPA to ensure that the development will not endanger the aquifer (U.S. EPA. 2000b)

While the CWA and the WPA are in place to ensure clean surface waters, for all uses, the Safe Drinking Water Act (SDWA) is in place solely to ensure safe and clean drinking water. One aspect to ensuring safe drinking water is to have relatively clean raw water supplies, as a complement to the traditional treatment approach. Realizing the importance of protecting source waters, the EPA is beginning to implement Source Water Protection (SWP) programs.

An EPA goal is to have 60 % of the population, which is served by communal water systems, receive their water from systems with Source Water Protection Programs in place under both WHP and watershed protection programs, by 2005 (U.S. EPA. 1998a). As a first step to realize that goal, an Amendment to the SDWA was made in 1996. This Amendment requires that all states develop and submit to the EPA, Source Water Assessment Programs (SWAP) to analyze and identify existing and potential threats to public water systems.

A state SWAP must:

- Set forth the state's strategic approach to conducting the assessments
- Delineate the boundaries of the areas providing source waters for each public water system
- Identify the origins of regulated and certain unregulated contaminants in the delineated area to determine the susceptibility of public water systems to such contaminants (U.S. EPA. 1998a)

Delineating watershed boundaries and identifying potential and existing problem areas are logical first steps to developing a fully integrated source protection plan. With the development of SWAPs and eventually full SWP programs, the EPA is looking to further integrate the multitude of programs the EPA oversees:

"…. development of state SWAPs and SWP Programs offers a unique opportunity to integrate not only drinking water programs, but also to integrate drinking water, clean water, coastal, solid and hazardous waste, agricultural and other environmental programs…." (U.S. EPA. 1998a).

This wide integration could be made possible under the framework provided by the WPA. The EPA seems to be headed in a direction that will focus federal, state and local government programs and efforts on environmental and public health management within the boundary of a specific watershed.

United Kingdom

The United Kingdom first entered into integrated water management in 1974, with the creation of the Regional Water Authorities. These organizations were not delineated by political boundaries but rather by boundaries of groups of river basins, and were concerned with all aspects of water management other than sewers, local drainage committees and management of the canal system (Morrison, 1995).

With the Water Act of 1989, the Regional Water Authorities were privatized and the National Rivers Authority and the Office of Water were created (Morrison, 1995).

The National Rivers Authority was short-lived. In 1996 the Environment Agency was created, which incorporated the functions of the National Rivers Authority, Her Majesty's Inspectorate of Pollution, and Local Waste Regulatory Authorities.

With the creation of the Environment Agency, the United Kingdom created a statewide organization whose primary aim is:

"…. to protect and enhance the environment and make a contribution towards the delivery of sustainable development through the integrated management of air, land and water." (Environment Agency, 2000a).

The Environment Agency has the following responsibilities:

- Flood Defense
- Water Quality
- Water Resources (Abstractions)
- Navigation
- Fisheries
- Conservation and Regulation
- Process Industries Regulation (PIR)
- Radioactive Substance Regulation (RSR)
- Non-Radioactive Waste Management and Producer Responsibility
- Contaminated Land and Land Quality (Environment Agency, 2000a)

With the above responsibilities falling under one umbrella organization, the Environment Agency is in the unique position to develop and implement fully integrated management plans for air, land and water.

The Environment Agency employs a process known as Catchment Management Planning, which takes advantage of waters natural boundaries in the planning process, and applies it to each of its river catchment basins. This process was designed with the thought of managing water uses, which interact and may conflict with each other, for the overall benefit of the water environment and its users (Butler, 1996).

The Catchment Management Plans (CMPs) are undertaken to:

- focus attention of the water environment of a specific river catchment;
- involve all interested parties in planning for the future well being of the river catchment;
- agree on a vision for the catchment which helps to guide all activities over the next 10 – 20 years;
- establish an integrated strategy and action plan for managing and improving the catchment over the next 5 years;
- identify specific actions, to which the Environment Agency is committed, for inclusion in its business plans (Butler, 1996).

A successor to the CMPs has since been introduced, the Local Environment Agency Plans (LEAPs). These plans provide coverage for all catchments in England and Wales. Like CMPs, LEAP areas are defined by a catchment boundary, or a group of subcatchment boundaries.

The primary goals of LEAPs are to:

- promote openness and accountability;
- develop liaison and partnership with key groups;
- educate the public on local environmental issues which are identified by the Environment Agency;
- prioritize issues and establish an action plan for managing and improving the local area over the next 5 years (Environment Agency, 1997).

The major difference between LEAPs and CMPs is the level of local involvement in the generation of the plan. The general public and key shareholders both have the opportunity to influence which issues are targeted, as well as voice opinions on the proposals and recommended actions. All environmental planning now starts at this local level. Throughout the United Kingdom, 26 local plans have been

completed to date, all developed with collaboration with the public, and public representatives (Environment Agency, 2000b).

The Environment Agency also interacts with the local level in selecting areas to receive funding for flood defense works. Since the funds for flood defense are raised from local levies, council taxes, or drainage rates, Regional Flood Defense Committees (RFDCs) must approve where the funding will be spent. RFCDs comprise various local authority members, in order to safeguard the proper usage of levy funding (CIWEM, 1998).

The Environment Agency reports primarily the Department of Environment, Transport and the Regions (DETR) (CIWEM, 1998). However, the majority of its funding comes from flood defense levies - 36% and charging schemes (producer of pollution pays) - 37%, with remainder coming from the DETR - 16.2 %, the Ministry of Agriculture, Fisheries and Food (MAFF)—5.1 % and the National Assembly of Wales (NAW) - 1.9% (Environment Agency, 2000a).

The water supply industry in the United Kingdom is highly privatized. Private industry treats and distributes potable water, as well as processes sewage. The private industry also owns and maintains all water distribution and sewerage infrastructure.

The water industry follows regulations set by the DETR, which are enforced by the Drinking Water Inspectorate (DWI) who reports directly to the DETR. As well as enforcing the Water Quality Regulations, the DWI also investigates all incidents of below quality drinking water (DWI, 2000).

France

In France, management of surface and groundwater is considered to be a "national common heritage". Water Policy is defined by the State. Dialogue on water policy is institutionalized at three levels:

National Level:

The National Water Committee, chaired by a Member of Parliament, is composed of representatives of the National Assembly, the Senate, institutions and national federations. It provides input on the trends of the national water policy and on drafts of legislative and regulatory texts.

River Basin Level:

Under the Water Law, 1964, the French national territory is divided into six large "river basins" administered by a Water Agency, a public body established under State supervision. It is with these Water Agencies that France has implemented a watershed-based water management system. The Water Agencies report directly to the Ministry of Environment and Ministry of Economy and Finance. The primary roles of the Water Agency are to conduct research on water issues, participate in the financial management of the water resource, and active involvement in water resource issues.

The Water Agencies oversee a system of pollution (polluter pays) and resource (user) fees. These fees are paid by the consumer/user. Using these monies, the agencies provide grants, subsidies and loans to promote water-related activities that are deemed to be in the "common interest" of basin citizens (Morrison, 1995).

In 1992, a new Water Law was passed. Four major innovations are contained in this law which:

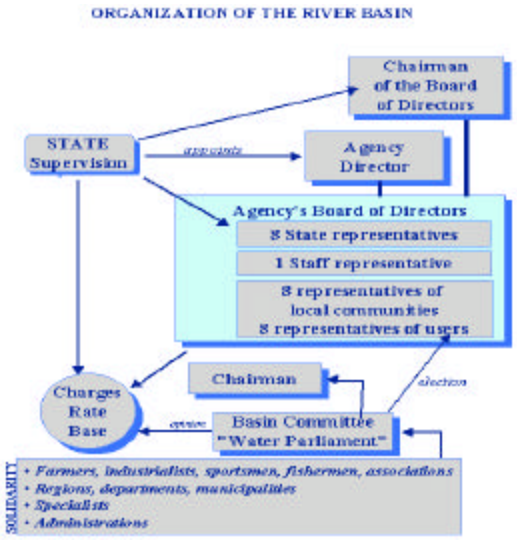
- recognizes the intrinsic value of water beyond its economic value;
- appreciates the water resource as a unique entity requiring a global management;
- requires planning documents for each hydrological basin (the Schéma Directeur d'Aménagement et de Gestion des Eaux (SDAGE) and the Schéma d'Aménagement et de Gestion des Eaux (SAGE);
- increases the power of the local governments with regard to the maintenance and development of the aquatic environment (Barnier, 1993).

Water Agencies are founded on the "user-polluter-pays" principle. The Agency levies charges on water withdrawals and discharges from all users who affect water quality and modify the water regime. The rates applied for calculating charges are determined for each Agency with the agreement of the River Basin Committee. The Agencies provide grants, subsidies and loans to promote water-related activities that are deemed to be in the “common interest” of basin citizens.

Basin Committees oversee the actions of the Water Agencies, also called Basin Authorities. The Basin Committees range in size from 61 to 114 members, comprising elected representatives of the State, water users, socio-professionals and State agencies. The River Basin Committee, chaired by a local elected official, prepares and adopts a Masterplan for Water Development and Management (SDAGE) after consulting with Regional, General and Local Councils. SDAGEs define the objectives for water quantity and quality as well as the developments and improvements to be undertaken to attain them. They define the limits of the sub-basins corresponding to hydrographic units.

The River Basin Committee advises the Water Agency on: 1) the rates and bases of water charges levied for water withdrawals and discharges, 2) the priorities for the Agency's 5-year action programmes, and 3) methods to aid investments and the smooth running of private and public wastewater treatment plants.

Composition of River Basin Committees



Tributary/Sub-Basin Level

At the tributary or subbasin level, a Water Development and Management Scheme (SAGE) is prepared to define objectives for the utilization, development and quantitative and qualitative protection of surface and groundwater resources, and aquatic ecosystems, as well as for the preservation of wetlands. SAGEs must meet the general guidelines set in the SDAGEs.

A Local Water Commission prepares and monitors the implementation of the SAGE. The Commission is composed of representatives from local communities (50%), users (25%) and State representatives (25%).

To help attain the objectives determined by the SAGE, local communities can associate themselves with a “Local Water Community". The " Local Water Community " can be entrusted with the study, the completion and operation of all constructions, installations or equipment of an urgent or general character, aiming at:

- developing a basin or part of a hydrographic basin;

- developing and maintaining a watercourse that is not managed by the State, including accesses;
- water supply;
- controlling stormwater and run-off;
- protecting against floods and the sea;
- controlling pollution;
- protecting and preserving surface and groundwater;
- protecting and restoring sites, aquatic ecosystems and wetlands as well as bordering woodlands;
- developing hydraulic works for civil defence.

The development of watercourses within the framework provided by the SDAGEs and SAGEs must be designed:

- taking the whole basin into account and considering the river and its tributaries from their sources to their mouths;
- contemplating that all water uses be quantitatively and qualitatively satisfied, together with the resulting requirements;
- studying the impacts on the environment and integrating the protection of aquatic ecosystems and the prevention of harmful effects regarding the conservation of natural media;
- ending in a multipurpose design and a consistent management of the various installations and equipment.

Water law enforcement

The Prefect of the region where the River Basin Committee is located, manages and coordinates the State's policy as it concerns water law enforcement and water resources management. This helps maintain the unity and coherence of State decentralized actions in this field, in the regions and departments involved.

The decentralized, departmental or regional State administrations—Regional Directorates of Industry and Research (DRIRE), Departmental Directorates of Agriculture and Public Works (DDAF and DDE) - examine, within their respective responsibilities, all applications for:

- concessions for the use of watercourses and falls, in particular for micro power stations;
- development of rivers, lakes and water bodies;
- extraction of materials and gravel;
- water withdrawal for various uses;
- wastewater discharges, spreading of sludge and liquid manure;
- opening of dumping sites;
- operation of establishments classified as dangerous or insalubrious.

The installations, constructions or activities that can be dangerous for health and safety, have serious impacts on water resources and aquatic ecosystems, are harmful to the free flow of water, or increase the risk of flooding, are subject to administrative authorization. Authorization is given after a public inquiry and can be cancelled or modified, without compensation:

- for sanitary reasons, and to protect the drinking water supply of populations in particular;
- to prevent or stop flooding or in the case of a menace to public safety;

- in the case of a major menace to the media when they are subject to critical hydraulic conditions not in keeping with their preservation;
- when installations are abandoned or not regularly maintained.

Installations subject to authorization or declaration for the withdrawal of surface water or discharges and for the pumping of groundwater must be fitted with appropriate systems for measurement or assessment. Their operators or owners are obliged to install and verify the perfect operation of the system and store the corresponding data in a location that is accessible to the administrative authority. The administration can take the necessary steps for limiting or temporarily suspending water use, when it is confronted with a threat or with the consequences of accidents, drought, floods or the risk of water scarcity. When necessary, specific measures can be taken in highly sensitive areas. In case of accidents presenting a danger to civil safety, water quality, supply or conservation, the administration can force the authorities in charge to take measures and, if they do not comply, can intervene, when necessary, at the expense of the authorities concerned.

France has a water police who are responsible for policing waterways and monitoring the application of the regulations concerning abstraction, discharge permits, and the conservation and management of water resources. In addition, the water police monitor wastes for conformity with regulations (Morrison, 1995).

Water quality objectives

Quality objectives have been defined for the main watercourses in France. Their preparation, based on the 1978 order of the Ministry for the Environment, in compliance with the 1964 water law, helps define and orientate the actions necessary for protecting watercourses. Departmental maps showing quality objectives have been adopted in most departments, on the basis of a wide consultation of local partners.

The Water Agencies, together with the National Fund for Rural Water Supply, contribute to the implementation of consistent programmes for urban, industrial or agricultural pollution control and for the rehabilitation of rivers.

Water supply

In France, the organization of potable water supply services, waste and storm water collection and treatment is under the responsibility of municipalities or groups of communities (Syndicate). There are 15,244 water supply services and 11,992 sanitation services for 36,763 communities. Local communities may entrust the management of their water supply services to a specialized private company or directly manage them by way of a Water Authority.

There are two types of contracts for private services: concession and affermage. A concession contract places the maintenance of the entire water system, including the government owned distribution/collection system, under the private firm's responsibility. Under an affermage contract, the private firm is only responsible for supplying, collecting, and billing. General maintenance and repairing falls under the responsibility of the commune. The maintenance work is usually financed via a surtax added onto the water bill. The private firm collects this surtax and transfers it to the commune. In both cases, the entire system is returned to the commune at the end of the contract (Morrison, 1995).

The duration of a concession agreement may vary from 20 to 50 years, depending on the amount of investments to be made, water consumption and price, while an "affermage" contract lasts from 5 to 20 years. This approach guarantees performance standards with precise contractual obligations and fairly distributes the risks to be taken among the partners.

In France today, the majority of potable water supply, as compared to the number of users covered, is implemented through delegated management (75%). The part of sanitation services entrusted to private companies is rapidly increasing (> 35%).

Where the community or Syndicate directly manages water supply, it takes complete charge of investments for and operation of water supply services, of the relations with users, invoicing and

recovery, generally through a municipal collector. The staff of the water authority is composed of municipal agents with a civil servant status. Today, except in some medium and large towns that have set up their own technical municipal services, water authorities are found in small rural communities.

Other options for water management are available to communities. For instance, communities can decide to operate potable water production and intakes by themselves as water authorities and delegate water supply to private companies.

1) In case of a concession, the private partner finds the necessary funds that are not covered by public assistance. In the other cases (affermage, public authorities, leases), municipalities or groups of communities must gather the funds necessary to build and rehabilitate the installations they own. To avoid a sudden increase in water price, that the user could find unbearable, municipalities can benefit from various kinds of public assistance. They include aids from: 1) the Water Agency, 2) the National Fund for Rural Water Supply (FNDAE), an "urban-rural area solidarity" fund which aims at compensating investment overcosts that villages have to bear because houses are scattered and the areas are not densely populated, and 3) regions and departments that support the investment efforts of rural communities with subsidies or loan interest rebates from their own budgets.

Australia

Australia is a commonwealth consisting of six states and two territories. Within the Commonwealth Government, the Department of Primary Industries and Energy (DPIE) and the Department of Environment, Sport and Territories (DEST) are the main agencies responsible for environmental and resource management. Their role is mainly policy development, leadership and facilitation.

The states are autonomous in the areas of natural resources and environmental management. Thus, the administration of water and the environment varies from state to state.

In Australia, catchment management has been a focus since the 1790's when water shortages were experienced. Later in the 1930's, catchments emerged as a significant focus of land and water management to protect urban water supplies. Recent emphasis has been on integrated land and water resource management for multiple purposes. Australian catchment management is moving towards a collaborative rather than a top-down government directive approach. (Hooper, 1999)

In the 1980's, it was recognized that there was a need to address concerns about the state of the nation’s water resources in an integrated fashion. In 1994, the Council of Australian Governments (COAG) endorsed a comprehensive strategic framework (Water Reform Framework) for the efficient and sustainable reform of the Australian water industry. To manage and report on the establishment of goals for, and the progress of implementation of the framework the Agricultural and Resource Management Council of Australia and New Zealand established an inter-governmental Task Force. Ten “deliverables”, representing elements of the framework were identified:

- Full cost recovery pricing;
- Comprehensive water allocation systems;
- Trading in water entitlements;
- Effective performance monitoring;
- Integrated natural resource management;
- Institutional separation;
- Devolution of irrigation management;
- Public education and consultation;
- Stormwater and waste water re-use;

- Groundwater management.

The States and Territories are undertaking measures to implement integrated catchment management to implement the Water Reform Framework.

The Water Reform Framework provides a blueprint for action. The National Strategy for Ecologically Sustainable Development (ESD) provides an effective basis for addressing sustainability issues. Specific objectives of the strategy are:

- to develop water management policies which are based on an integrated approach to the development and management of water resources (including catchment management, public participation, water allocations to maintain aquatic and riparian environments, and nutrient management);
- to develop and implement the most effective mix of water resource management mechanisms (including pricing, regulation, monitoring, institutional arrangements and property rights).

Australia recognizes local responsibility for resource management. The recognition of the inter-relatedness of role and responsibilities means that cooperative action by all relevant parties is seen as the appropriate basis for implementation.

"*Sustainable natural resource management requires a partnership between the community and all levels of government, in which each partner contributes appropriately in terms of skills and resources in line with its responsibilities and interests*".
(page 4, <www.dist.gov.au/SCIENCE/pmsec/14meet/inwater/app1form.html>)

The Landcare program, which promotes partnerships between the community, industry and government in the management of natural resources is an important aspect of implementation.

One example of a partnership to further wise management of water resources is the Murray-Darling Basin Initiative. This Initiative is a partnership between the governments of the Commonwealth, New South Wales, Victoria, South Australia, Queensland, the Australian Capital Territory and the community. The purpose of the Agreement is to promote and coordinate effective planning and management for the equitable, efficient and sustainable use of the water, land and other environmental resources of the Murray-Darling Basin. The Initiative is the largest integrated catchment management program in the world, covering the watersheds of the Murray and Darling rivers, an area of over one million square kilometres.

The Commission is the executive arm of the Murray-Darling Basin Ministerial Council. It is responsible for managing the River Murray and the Menindee Lakes system of the lower Darling River, and advising the Ministerial Council on matters related to the use of the water, land and other environmental resources of the Murray-Darling Basin.

This Initiative seeks to achieve:

- improvement in, and maintenance of, water quality for all beneficial uses—agriculture, environmental, urban, industrial, and recreational;
- control of existing land degradation, prevention of further land degradation and, where possible, the rehabilitation of land resources to ensure the sustainable utilization of these resources;
- conservation of the natural environment of the Basin and the preservation of sensitive ecosystems.

Two major programs include the Basin Sustainability Program aimed at gathering information and developing partnerships and strategic long-range plans to support decision-making and implementation, and the Water Business Program that includes management, flow regulation and protection of infrastructure investments.

New Zealand

New Zealand has a long history of integrated watershed management. Between 1986 and 1991, a new public bureaucracy was set up to manage freshwater resources. At the national level, two agencies have key roles: the Ministry for the Environment (MfE) and the Department of Conservation (DoC). The MfE is primarily a policy advisory and reporting agency, with a limited regulatory role. DoC is a heritage management agency, with specific "hands on" responsibilities for managing the large public conservation estate. Under the Conservation Act (1987) the DoC has the power to take action against polluters who damage aquatic habitats.

At the sub-national level, a two-tiered system of directly elected regional councils and local authorities (city and district councils, and unitary authorities) undertake environmental functions. Under the Resource Management Act, (1991), 12 elected regional councils, defined on the basis of major water catchments, undertake environmental planning. The Resource Management Act provides a statutory framework for a relatively integrated approach by replacing a large number of separate and sometimes inconsistent and overlapping statutes concerned with the use of natural resources. The purpose of the Act is to promote "the sustainable management of natural and physical resources" and takes into consideration the values of the indigenous Maori people. It encourages public accountability and participation. Decision-making is decentralized within a hierarchical planning framework. This hierarchy is based on the assumption that decisions should be made as close as possible to the appropriate level of community of interest where the effects and benefits arise.

The RMA: Functions by levels of government

Central Government

- Overview role;
- Develop national policy statement and national environmental standards;
- National aspects of coastal management.

Regional Councils

- Integrated management of regional resources;
- Water and soil management;
- Regional aspects of coastal management;
- Manage geothermal resources;
- National hazards mitigation;
- Regional aspects of hazardous substance use;
- Air pollution control.

Territorial Local Authorities

- Control effects of land use and subdivision;
- Noise control;
- Controls for natural hazards avoidance and mitigation;
- Local control of hazardous substances use.

Specific objectives and policies relating to water pollution, water abstractions, works on beds and margins of water bodies, land management, and methods for implementing these are formulated in regional plans. The documents provide the basis for evaluating and making decisions on resource consent applications and to monitor policy effectiveness. Councils are required to be cognizant of cumulative and interactive

effects and cross-boundary issues, and have a duty to consider alternatives and assess their benefits and costs in carrying out their functions. Their plans are binding on district councils and stakeholder user groups. Application of adaptive approaches based on consultation, collaboration and consensus building amongst stakeholder groups is also strongly encouraged by many regional and district councils in carrying out their responsibilities under the Act.

From a procedural stance, the New Zealand system provides a sound framework for resources planning. However, there are some challenges:

- Regional Councils receive little guidance or technical assistance from central government. Agencies at the national level are hamstrung by lack of resources.
- Water resources planning practices traditionally focus on a supply-oriented biophysical approach rather than a conservation approach of balancing demand with availability and promoting efficient water use.
- In the absence of national standards for water quality and because of lack of adequate information to prescribe appropriate numeric standards, regional councils have to rely on more discretionary qualitative standards in regional policy statements and plans.
- Responsibility for riparian land is fragmented between regional councils, territorial local authorities and DoC. Close collaboration is necessary to implement land management policies.
- Three issues are not addressed in the RMA: lack of provision for "user pays" charges in the RMA; the merits of using effects based rules to control point source discharges; and the difficulties of regulating non-point source discharges.
- A full range of monitoring is not currently being carried out. Local councils are dependent on local rate and charging regimes to fund their activities thus one constraint on most regional councils is lack of sufficient resources to undertake adequately the resource monitoring function – even though it is a requirement of the Act (Memon, 1997).

References

Adler, Robert W. (1996) Addressing Barriers to Watershed Management in Proceedings Watershed '96, "Moving Ahead Together Technical Conference and Exhibition, June 8-12, 1996, Baltimore, Maryland summarized from *Environmental Law*, Volume 25, pp. 973-1106 cited in <http://www.epa.gov/owow/watershed/Proceed/adler.html>.

Australia Water Association Water Management Overview Water Resources Management in Australia—A Thumbnail Sketch, <http://www.awa.asn.au/news&info/h2oinfo/WATEROZ2.asp>

Barnier, M. 1993. *La politique de l'eau depuis 1964 jusqu'a nos jours.* Neuilly, France: Ministère de L'environnement, Direction de L'Eau.

Boehmer, Kevin, Ali Memon and Bruce Mitchell (2000) Towards Sustainable Water Management in Southeast Asia Experiences from Indonesia and Malaysia in International Water Resources Association, *Water International*, Volume 24, Number 3, pp. 356-377, September.

Butler, N. 1996. Local Environment Agency Plans on the Internet. Portion of M.Sc. Thesis, Univeristy of Edinborough, Edinborough. Website Address: <http://www.geo.ed.ac.uk/~envag/wandle.htm>

Committee on Watershed Management, Water Science and Technology Board, Commission on Geosciences, Environment, and Resources, and National Research Council, (1999) "New Strategies for America's Watersheds" Executive Summary, Washington, D.C.: National Academy Press, <http:/www.nap.edu/html/watershed_strategies/>

de Loë, L.M. and B. Mitchell. 1993. "Public-Private Partnerships: Water and Wastewater Services in France" *Water International.* 18:137-146.

Department of Environmental Protection. 2000. Fact Sheet: Watershed Management and TMDLs. Commonwealth of Pennsylvania. Harrisburg, Pennsylvania.

Drinking Water Inspectorate (DWI). 2000. *Code for Enforcement.* London, England.

Environment Agency (2000) Environment Agency Submission to the Environment Sub-committee, <http://www.environment-agency.gov.uk/ourservices/consultations/select_commit.htm>

Environment Agency. 2000a. *Corporate Plan Summary 2001/2002.* Bristol, England

Environment Agency. 2000b. Creating an Environmental Vision: Progressing the Environment Agency's Contribution to Sustainable Development by way of a Better Environment in England and Wales. Bristol, England.

Environment Agency. 1997. Local Environment Agency Plan: Middle Severn. Consultation Report. Bristol, England.

Heathcote, I.W., H.R. Whiteley and Karen E. Morrison. (1996) Structuring an Efficient Water Management System: Case Studies from France, England and Ontario (Canada). *Proceedings, American Water Works Association Conserv96 Congress*, Orlando, FL, January 4-8, 1996.

Hooper, Bruce P. (1999) Catchment Management in Australia: A Critique and a Way Forward" submission to the House of Representatives Standing Committee on Environment and Heritage Catchment Management Inquiry. Brisbane Hearing, November 16, 1999. <http://www.catchment.com/Paper_4.htm>

Hutchings, Don, 1999. *Integrated River Basin Management and its Importance for the Future Wellbeing of Wales*. Environment Agency Wales.

International Office for Water "Organization of Water Management in France" <http://www.oieau.fr/anglais/gest_eau/intro.htm>

Memon, Pyar Ali (1997) "Freshwater management policies in New Zealand" in *Aquatic Conservation Marine and Freshwater Ecosystems*, Volume 7, pp. 305-322.

Ministère de l'aménagement du territoire et de l'environnement (1998) "Water and resources" <http://www.waternunc.com/gb/ageau2gb.htm>

Mitchell, B. (1989) *Geography and Resource Analysis*. Longman. Essex, England.

Morrison, K.E. 1995. The effectiveness of administrative structure in the promotion of water conservation in three jurisdictions. Unpublished M.Sc. thesis, University of Guelph, Guelph, Ontario.

Platt, Rutherford H. and Van L. Morrill. (1997) "Sustainable Water Supply Management in the United States: Experience in Metropolitan Boston, New York and Denver" in *Practising Sustainable Water Management: Canadian and International Experiences*, Bruce Mitchell and Dan Shrubsole Eds. , pp. 282-307, Cambridge, Ontario: Canadian Water Resources Association.

Russell, Les () "Appendix 1: Current Commonwealth and State Organisation, Policies and Programs" in Managing Australia's Inland Waters, <http:/www.dist.gov.au/SCIENCE/pmsec/14meet/inwater/app1form.html>

The Chartered Institution of Water and Environmental Management (CIWEM). 1998. *Policy: Flood and Coastal Defense.* London, England.

U.S. EPA. 1998a. *State Source Water Assessment and Protection Programs Guidance*. Office of Water. Washington, DC.

U.S. EPA. 1998b. *Watershed Protection: A Project Focus*. Office of Wetlands, Oceans, and Watersheds. Washington, DC.

U.S. EPA. 998c. *Watershed Protection: A Statewide Approach*. Office of Wetlands, Oceans, and Watersheds. Washington, DC.

U.S. EPA.1999. *Guidance for the Water Quality-Based Decisions: The TMDL Process.* Office of Wetlands, Oceans, and Watersheds. Washington, DC.

U.S. EPA. 2000a. *EPA Revises Water Quality Listing Requirements for April 2000.* Office of Wetlands, Oceans, and Watersheds. Washington, DC.

U.S. EPA. 2000b. *Sole Source Aquifer Protection Program Overview.* Office of Water. Washington, DC.

U.S. EPA. 2000c. *Summary of State Biennial Reports of Wellhead Protection Program Progress*. Office of Water. Washington, DC.

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