# VALUING BENEFITS FROM WATERSHED MANAGEMENT

A Supplement to the Report

***"The Importance of Watershed Management in Protecting Ontario's Drinking Water Supplies"***

A submission to the Walkerton Inquiry

On behalf of Conservation Ontario

**October 15, 2001**

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## BACKGROUND

Conservation Ontario, in partnership with the Saugeen Valley Conservation Authority, and the Grand River Conservation Authority was invited by the Walkerton Inquiry Office to prepare a presentation on the benefits of watershed management to complement their earlier paper, *The Importance of Watershed Management In Protecting Ontario's Drinking Water Supplies* (March 2001).

# INTRODUCTION

The first report submitted to the Inquiry by Conservation Ontario described how watershed management is carried out and how it is used to protect the quality and quantity of our water resources. Watershed management ensures protection of the water resource through management decisions that are based on an understanding of physical, ecological and socio-economic dimensions of the resource. In keeping with the mandate of the Inquiry, the focus of that report was the contribution that watershed management makes to the protection of drinking water sources. The report identified the benefits created through effective watershed management activities, but no attempt was made to quantify the value of those benefits. The current report is concerned with the value of those benefits.

The purpose of this report is to provide a summary of evidence on the benefits and value of watershed management. Benefits of likely interest to the Inquiry relate to the role of watershed management in protecting drinking water supplies. But watershed management activities fulfil a number of objectives in addition to the provision of clean and abundant water for municipal water supply systems (see examples in Table 1). In fact the watershed management approach grew out of our need to address multiple objectives relating to the use of water and related land resources within watersheds. It provides a forum for stakeholders with, at times, competing interests to co-operate and search for consensus in the planning process. Multiple objectives are explicitly acknowledged and evaluated in the watershed management planning process, while the implementation of watershed management activities often involves the co-ordinated participation of multiple agencies having overlapping resource management interests.

Often no single objective, by itself can justify the effort and expenditure required for effective watershed management. But watershed management is efficient and cost-effective precisely because it can be used to pursue multiple objectives in an optimal manner. The benefits associated with the full range of objectives typically considered in watershed management readily justify the cost of a watershed management approach. For this reason, watershed management objectives are never taken in isolation in developing watershed management plans. In this report, we consider the full range of benefits that are considered in planning watershed management activities.

Case studies drawn from a variety of sources are used below to illustrate the range and magnitude of values that are created by effective watershed management. The closing discussion highlights how benefit valuation can be used in watershed planning and management and in the development of sustainable funding formula for watershed management. The Appendix provides technical background on the methods used to value the benefits arising from watershed management and summarises the findings of selected studies to value specific types of benefits.

**TABLE 1 – SOME EXAMPLES SHOWING HOW WATERSHED MANAGEMENT ACTIONS CREATE BENEFITS**

| WATERSHED MANAGEMENT ACTION | BENEFICIARIES AND BENEFITS OF WATERSHED PLANNING ACTIVITIES |
|---|---|
| **Agricultural measures**:<br><br>Use various means to keep livestock and manure runoff out of streams. This reduces water contamination from livestock excreta and trampling of the streambed and stream banks.<br>Use no-till or reduced tillage systems to control erosion and reduce loadings of sediment and other pollutants to streams from surface runoff. | 1. Municipal water supply customers—Reduce risk of water supply contamination.<br>2. Recreational users—Reduce risk of exposure to water borne pathogens, reduce risk of beach closures, improve quality of experience.<br>3. Rural residents—Less frequent clean out of sediment from municipal drains, reduced risk of private water supply contamination.<br>4. Farm operators—Lower farm costs and improve net farm income.<br>5. Broad public—Enhance aquatic and riparian ecosystems. |
| **Upgrade wastewater treatment**:<br>Upgrades include measures to improve the performance of existing operations and investments in new treatment processes. These improve the quality of treated effluent and/or reduce the frequency of untreated wastewater bypasses. | 1. Municipal water supply customers—Reduce risk of water supply contamination.<br>2. Broad public—Enhance valued aquatic ecosystems.<br>3. Municipal wastewater customers—Certain measures may reduce cost of wastewater treatment.<br>4. Recreational users—Reduce risk of exposure to water borne pathogens, reduce risk of beach closures, improve quality of experience. |
| **Urban storm water management**:<br>Measures include combined sewer separations, disconnection of roof leaders, street and catch basin cleaning, storm water ponds, other end-of-pipe treatments, and so on. These measures are designed to keep the pollutants in storm water out of surface waters, to reduce erosive flows and/or to attenuate peak flow volumes. | 1. Municipal water supply customers—Reduce risk of water supply contamination.<br>2. Recreational users—Reduce risk of exposure to water borne pathogens, reduce risk of beach closures, improve quality of experience.<br>3. Urban residents—Reduce expected damages from local flooding and erosion, enhance the aesthetic quality of the urban environment.<br>4. Broad public—Enhance aquatic and riparian ecosystems. |
| **Operation of reservoirs**:<br>Manage the storage and release of water in a reservoir for various purposes including augmenting low downstream flows during dry periods, preventing damage during flood events, maintaining reservoir levels within limits required for recreation, and generating hydroelectric power. | 1. Municipal water supply customers—Improve the security of supply for withdrawal uses, improve the quality of water for withdrawal uses.<br>2. Broad public—Enhance downstream aquatic ecosystems.<br>3. Land owners and residents—Reduce damage from local flooding and erosion.<br>4. Recreational users—Provide opportunities for water-based recreation.<br>5. Reservoir operator—Generate a profit from power sales. |

**TABLE 1 – SOME EXAMPLES SHOWING HOW WATERSHED MANAGEMENT ACTIONS CREATE BENEFITS**

| WATERSHED MANAGEMENT ACTION | BENEFICIARIES AND BENEFITS OF WATERSHED PLANNING ACTIVITIES |
|---|---|
| **Protect natural areas**: Measures such as municipal zoning, regulations, land acquisition or education can be used to alter or restrict land uses in wetlands, flood plains, upland forests, etc. Such measures prevent contaminants in overland flows from reaching streams, may increase infiltration of precipitation, and preserve species and ecosystems. | 1. Municipal water supply customers—Reduce risk of water supply contamination, improved yield of ground water for water supply.<br>2. Recreational users—Reduce risk of exposure to water borne pathogens, create opportunities for and improve quality of recreation experience.<br>3. Rural residents—Less frequent clean out of sediment from municipal drains, reduced risk of private water supply contamination.<br>4. Broad public—Enhance aquatic and terrestrial ecosystems. |
| **Water conservation**: Various measures, including: optimise urban and agricultural irrigation practices, retrofit or replace water use appliances, restrict municipal water use, modify water use habits, reuse wastewater, etc. These reduce water withdrawals and can also improve the performance of wastewater treatment plants. | 1. Municipal water supply customers—Reduce the costs of water and wastewater.<br>2. Community—Increase the available capacity to service new customers<br>3. Rural residents—Reduce the cost of water supply and wastewater systems.<br>4. Broad public—Enhance aquatic and riparian ecosystems. |

## VALUATION CASE STUDIES

This section provides a number of case studies that demonstrate, directly or indirectly, the values created by watershed management. Case studies included here are well documented and were readily available. They demonstrate different aspects of watershed management, not all related to the safety of drinking water.

**Case Study 1: Value of Water Quality Enhancements in the Grand River Watershed, Ontario**

**OVERVIEW**: The Grand River watershed in Southern Ontario has been the focus of ongoing research and planning efforts for several decades. The watershed has an area of about 7,000 square kilometres and a population of about 730,000 persons. Water resource issues in the watershed include rapid urbanisation relying on limited ground water resources for water supply and surface water flows for waste assimilation, intensive agricultural operations, and the protection and enhancement of valued natural environments and a popular sport fishery. This study involved a household willingness-to-pay survey to determine the magnitude of benefits associated with potential improvements in water resources. Factors motivating the study cited here include a concern for the availability of potable water in the future, human health, and the maintenance of green areas, wetlands, and aquatic ecosystems.

**VALUATION**: Estimated annual values are summarised below:

| TOTAL VALUE OF BENEFIT (million 2001 Cdn $/yr) | High | Medium | Low |
|---|---|---|---|
| Improving the quality of tap water | $347.78 | $34.81 | $4.35 |
| Improving water quality for recreation | $34.78 | $6.02 | $0.23 |
| Total | $382.56 | $40.83 | $4.62 |

| | | | |
|---|---|---|---|
| Total Benefits per Capita ($'s/person) | $1476 | $158 | $18 |

**COMMENTS**: Results are based on an empirical study of households in communities in the Grand River watershed in 1994. A high response rate to a household survey assured a representative sample of the community, while the design of the survey instrument helped to minimise the risk of biased responses.

Such studies typically focus on a single benefit. The broad scope of benefits addressed in this study is commendable and supports a watershed-based approach to resource management.

**REFERENCE**: Brox, Kumar and Stollery, 1996

**Case Study 2: Value of Groundwater in Caledon, Ontario**

**OVERVIEW**: Caledon is situated in the headwater area of four river systems in Southern Ontario. This area, in the northern end of the Regional Municipality of Peel, is also on the junction of the Oak Ridges Moraine and the Niagara Escarpment. This community was selected by the study authors to demonstrate the economic, social and ecological values of groundwater in the Oak Ridges Moraine. Factors that motivated their work included the local reliance on groundwater as a source of supply, the stress of rapid urbanisation on the Oak Ridges Moraine and the lack of a comprehensive set of policies and programs to protect groundwater.

**VALUATION**: Values estimated in this report were for uses of groundwater within the study area that were amenable to valuation. Estimated annual groundwater values are summarised below:

| TOTAL VALUE OF BENEFIT (millions 2001 Cdn $/yr) | High | Low |
|---|---|---|
| Benefits for residential water user | $15.92 | $2.88 |
| Benefits for non-residential water user | $14.64 | $4.47 |
| Benefits for the agricultural user | $2.34 | $1.20 |
| Wastewater assimilation (cost savings for treatment) | $2.78 | $0.72 |
| Recreational benefits | $1.50 | $1.50 |
| Total | $37.17 | $10.77 |

| | | |
|---|---|---|
| Groundwater value per capita ($'s/person) | $946 | $275 |

Values that were not estimated in this study include any water-based recreation other than cold-water fishing, non-use ecosystem values, the willingness of residents to pay to assure that groundwater resources would be protected for future use and any values accruing to neighbouring jurisdictions.

**COMMENTS**: This is part of ongoing efforts in Ontario to focus attention on the value of groundwater resources in the Oak Ridges Moraine. Current development activities on the Moraine "may result in reduction or elimination of base flow to streams, drying of wetlands and shallow wells, depletion of groundwater resources and deterioration of water quality". The objective of this and related work is to establish a comprehensive approach to manage and protect groundwater. Such an approach is equivalent to the watershed management approach.

**REFERENCE**: Troyak, 1996

**Case Study 3: Giardiasis Outbreak in Luzerne County, Pennsylvania**

**OVERVIEW**: An epidemic of giardiasis occurred in 1983 in Luzerne County, Pennsylvania. The outbreak was caused by contamination of the municipal water system with *Giardia lamblia*. It was one of the largest such outbreaks ever observed in the US, causing 6,000 people to fall ill. Boil water advisories lasting up to 9 months were issued to 75,000 people and to numerous businesses and institutions in the affected area. Beavers resident in the Spring Brook Intake Reservoir, the area's source of supply, were the immediate source of Giardia cysts in the water supply. These animals carried the infection from upstream tributaries. A malfunctioning wastewater treatment plant and improperly constructed septic systems on these tributaries were the primary source of the infection.

**VALUATION**: An exhaustive study was launched to estimate the value of losses caused by this epidemic. Estimated losses are summarised below:

| TOTAL VALUE OF LOSS (millions 2001 Cdn $'s) | High | Medium | Low |
|---|---|---|---|
| Loss due to illness | $27.29 | $21.62 | $17.60 |
| Cost of averting action – residential | $98.20 | $33.00 | $30.91 |
| Cost of averting action – non-res. | $15.96 | $14.92 | $10.84 |
| Total losses | $141.45 | $69.54 | $59.34 |

| | | | |
|---|---|---|---|
| Losses per capita ($'s/person) | $1,890 | $929 | $793 |

Losses due to illness include medical costs and lost wages but not the emotional costs associated with pain and discomfort. Averting actions are defensive actions that were taken to avoid contracting the illness once a boil water advisory was issued. Valuation methods used in the study likely underestimate the actual losses experienced by individuals in the community.

The total annualised cost of a filtration plant to eliminate giardia cysts from the drinking water was estimated to be $3.4 to $3.9 million. A benefit cost analysis comparing the cost of a filtration plant to the benefit associated with avoiding future outbreaks produced benefit cost ratios that exceeded 1.0 for most scenarios. The option of using watershed management activities was not evaluated by the authors.

**COMMENTS**: The principal value of this case study is to demonstrate the high cost associated with the outbreak of water borne disease in a community. While the report authors do not consider a watershed management perspective, the underlying cause of the epidemic suggests that a relatively modest level of management of upstream sources of contamination would have been worth consideration.

**REFERENCE**: Harrington, Krupnick and Spofford, 1991

**Case Study 4: Value of the South Saskatchewan River to Residents of Saskatoon, Saskatchewan**

**OVERVIEW**: A three-part study of the value of the Saskatchewan River to residents of Saskatoon was published in the Canadian Water Resources Journal. The motivation for this study was a desire to foster an understanding of the value of the river to various user groups. This understanding, it is argued, is needed in order to develop an optimal watershed management strategy for current conditions and for a future in which climate change and ongoing development will make water allocation decisions all the more difficult.

**VALUATION**: Reported values are for uses of the river within the City. Estimated annual values are summarised below:

| TOTAL VALUE OF BENEFIT (millions 2001 Cdn $/yr) | High | Low |
|---|---|---|
| Benefits for residential water user | $7.06 | $5.18 |
| Benefits for non-residential water user | $8.32 | $6.10 |
| Benefits reflecting enjoyment of river view: aesthetic value | $1.58 | $1.58 |
| Wastewater assimilation (cost savings for treatment) | $21.95 | $16.10 |
| Recreational benefits | $3.75 | $3.75 |
| Hydroelectric power (commercial benefit) | $0.24 | $0.24 |
| Total | $42.90 | $32.95 |

| | | |
|---|---|---|
| Total value per capita ($'s/person) | $233 | $179 |

A supplementary analysis of lower and higher flow conditions revealed that lowering mean flows by 50% would cause a loss in use value of $3.04 million while doubling the flow would not have a significant impact on use values. Values that were not estimated in this study include any non-use ecosystem values and the willingness of residents to pay to assure that water resources would be protected for future use.

**COMMENTS**: This relatively comprehensive assessment of use values supports a watershed-based approach to management of water resources in the River.

**REFERENCE**: Kulshreshtha and Gillies, 1993(A), 1993(B), 1994

**Case Study 5: Watershed Based Aquatic Emission Trading – Bay of Quinte, Ontario**

**OVERVIEW**: The Bay of Quinte is a narrow shallow bay on the eastern portion of Lake Ontario. It receives large inputs of nutrients, particularly phosphorus, from urban centres in the watershed and from agricultural sources. These loads have caused excessive algae blooms and impaired a number of water related values. Controlling phosphorus from point source discharges was expensive and largely ineffective since tertiary treatment was already widely used. A study was completed in 1997 evaluating the opportunity to achieve greater loading reductions by allowing municipalities to use phosphorus reduction credits purchased from agricultural operations as a means of complying with their discharge permits. This approach allows them to allocate money to cost-effective rural non-point source control programs rather than building ever more advanced wastewater treatment plants.

**VALUATION**: The focus of this study was the cost savings that could be achieved by implementing an aquatic emissions trading program for phosphorus. Existing urban point source discharges could achieve compliance with their discharge permits at an annual cost of $2.34 million (2001$'s). This would reduce phosphorus loads to the Bay by 12 tonnes. In contrast to this, the cost of achieving compliance through emissions trading was estimated to be $0.53 million, a 77% reduction in cost. This cost included the transactions costs associated with implementing a trading program. Moreover, trading would reduce loadings by 16 tonnes, a 33% improvement.

Values that were not considered in this report were those associated with the reduction of contaminant loadings to the Bay and its tributaries. The non-point source measures considered in the analysis included conservation tillage, best management practices for manure and milkhouse wastewater, remediation of faulty septic systems, and controlling access of cattle to streams. These measures reduce loadings of a number of other contaminants including biochemical oxygen demand, suspended solids and pathogens. A non-point source control program can therefore be expected to reduce risks to livestock and human health, and to increase both use and non-use benefits.

**COMMENTS**: Aquatic emissions trading requires a level of co-ordination and planning that calls for a watershed based management agency.

**REFERENCE**: Draper, Fortin and Bos Engineering, 1997.

**Case Study 6: Catskill/Delaware Watershed Management for the New York City Water Supply System, New York**

**OVERVIEW**: In 1997, the New York City Watershed Memorandum of Agreement (MOA) was reached. It outlined a watershed strategy to protect the drinking water supply for nine million residents located primarily in New York City. Disinfection is the only treatment currently used for the water supply system that was the subject of this agreement. With this agreement, New York City obtained a waiver until April 2002 under EPA's Surface Water Treatment Rule of the filtration requirement for its Catskill/Delaware supply system. Conditions of the waiver include compliance with drinking water quality standards, maintenance of a watershed protection program, and prevention of episodes of waterborne disease. The MOA has three main provisions: (1) land acquisition in the Catskill/Delaware watershed, (2) regulation of watershed activities, and (3) financial support to watershed communities for economic development and watershed protection.

**VALUATION**: Under the MOA, commitments were made to undertake a multifaceted watershed management program. Important program elements include:

Acquisition of up to 355,000 acres of sensitive lands using purchases or conservation easements;

Disease surveillance for giardiasis and cryptosporidiosis;

A phosphorus (P) offset pilot program to allow for new P discharges from wastewater treatment plants provided that they are offset by non-point source reductions elsewhere in the watershed;

Agricultural, forestry and storm water pollution control programs; and

Land use regulations including requirements for setbacks and buffer zones.

Planned investments to 2007 under the program amount to $2.25 billion (US$1.5 billion). Program proponents justify the program based on the opportunity it provides to avoid investing $12 billion (US$8 billion) in a conventional filtration plant.

**COMMENTS**: Program reviewers commented that treatment plant costs were too high and that the program did not necessarily guarantee that a filtration plant would never be required.

If we assume that costs reported above are accurate and that the program manages only to delay the requirement for a filtration plant, then the program is cost effective provided that the treatment plant can be delayed by at least 5 years (based on a discount rate of 6%). This assessment ignores all other benefits of watershed management and the benefit or cost of any differential in the risk of a disease outbreak between the watershed approach and an approach relying on a conventional treatment plant.

**REFERENCES**: Committee to Review the New York City Watershed Management Strategy, National Research Council, 1999. www.nap.edu/watershed_mgmt.html; Okun, Craun, Edzwald, Gilbert and Rose, 1997; Ashendorff, Principe, Seeley, LaDuca, Beckhardt, Faber Jr., Mantis, 1997.

## DISCUSSION

The 6 case studies presented above demonstrate that the benefits of watershed management are diverse in form and potentially substantial in magnitude. The same conclusion can be drawn from the tabulated estimates of value for specific types of benefit on Table A of Appendix A.

Efforts to assign value to watershed management benefits can be used for several purposes. In reports such as this, estimates of value are used to promote the development of policy in support of watershed management by verifying that watershed management can make a significant contribution to our well being.

In a planning and management context, benefit valuation fulfils a very different role. It is used to help determine optimal management programs. This involves comparing benefits to costs to ensure that program elements yield a positive return and then comparing the estimated returns across different combinations of program elements to find the most beneficial combination. In this type of analysis, the valuation of benefits must be specific to the watershed under study and must be sufficiently detailed to support reliable management decisions.

When benefits are valued in detail for a specific watershed, the resulting information can be used to help develop cost recovery programs to finance watershed management activities. "Who pays" is a key question in developing cost recovery programs. The answer to this question will often reflect factors such as political expediency and administrative feasibility, but it may also reference notions of equity, namely "beneficiary pay' and 'polluter pay'.[1]

The use of a "beneficiary pay" principle or a "polluter pay" principle will depend on the initial allocation of rights and responsibilities with respect to water resources as established in laws and regulations. For instance, farmers in Ontario have had a right to engage in activities that can pollute watercourses provided that those activities conform to normal farming practice. In this situation, the beneficiary of a watershed management program that attempts to change farming practices to reduce pollution must compensate the farmer.

When we accept "beneficiary pay" as a reasonable basis for funding decisions, then the valuation of benefits can be used to make informed decisions regarding the allocation of costs among groups of beneficiaries. A well-designed funding formula for government activities such as watershed management assures sustainable, full-cost recovery while avoiding unintended cross subsidies between groups of beneficiaries.[2] Benefit valuations are useful in designing funding formula because they call for the identification of beneficiaries and the description and quantification of expected benefits (e.g. type of benefit, scope, magnitude, coverage, duration, etc.). When this is done for each benefiting group, then it is possible to allocate costs to those groups in proportion to benefits received. An analysis of benefits for this purpose must be comprehensive in scope, encompassing all significant use and non-use benefits.

The sketch of a sustainable funding framework for watershed management based on a beneficiary pay principle is provided in Table 2. This framework separates broader public environmental benefits from specific user benefits.

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[1] Affordability or 'ability to pay' is also an important consideration in developing cost recovery programs. The discussion of affordability is beyond the scope of this report.

[2] A cross subsidy occurs when one group pays more than its fair share of costs while another pays less. A cross subsidy may at times be desirable for instance to support low-income households. The graduated income tax is a case of broad cross subsidisation of low-income households by higher income households.

**TABLE 2: A BENEFICIARY-PAY FRAMEWORK FOR RECOVERING WATERSHED MANAGEMENT COSTS**

| BENEFIT | BENEFICIARY | FUNDING MECHANISM |
|---|---|---|
| Improved municipal water supply | Urban water supply customers (enjoy better quality, quantity and safety, lower cost) | Municipal water bill or property taxes if customers are not billed separately |
| Improved assimilative capacity for municipal wastewater effluent | Urban wastewater customers (benefit from treatment cost savings) | Municipal wastewater bill or property taxes if customers are not billed separately |
| Improved water quality and quantity for private water and wastewater systems | Industry, farms, rural residents | Large users—volumetric charges attached to water taking permits or to certificates of approval for effluent discharges, property taxes if user charges are not feasible<br>Small users—charges for permitting of septic systems, property taxes if user charges are not feasible |
| Water-based recreation | Recreational users of parks and public access rivers and lakes | Park entry fees, license fees for boating or fishing, property and income taxes* |
| Protection from flood and erosion damages | Owners and residents of private property, general public using public property (e.g. roads, parks, utilities) | property and income taxes* |
| Aesthetic values | General public | property and income taxes* |
| Ecosystem values | General public | property and income taxes* |

* Property taxes for benefits that are local in nature, income taxes for benefits that are regional or provincial in scope.

# APPENDIX – OVERVIEW OF VALUATION METHODS[3]

## INTRODUCTION

Valuation methods are used to assign value to benefits. Prices measure value for goods and services that are bought and sold in markets. But there are many things that can not be valued using market prices (eg. aesthetic impacts, health, safety, ecosystem impacts). Methods are available to assign either monetary or non-monetary values to these. Monetary methods rely on public surveys or indirect evidence related to market values. Non-monetary methods involve ranking and weighting exercises to develop indices that represent value. This appendix reviews commonly used methods used to value the benefits arising from watershed management. Table A, at the end of the Appendix, summarises the findings of selected studies to value specific types of benefits.

## BENEFITS FROM WATERSHED MANAGEMENT

In watershed management, benefits and costs are used to understand and compare the relative merits of alternative courses of action. The net benefits generated through an action depend on the magnitude of the impacts and the value assigned to these impacts by affected people. Good watershed management increases the expected benefits experienced by domestic and non-domestic water supply customers, farm operators, other rural self-supplied residents, people participating in water-based recreation and those who value aquatic ecosystems and environmental amenities.

Watershed management increases the expected benefits experienced by water supply customers by reducing the risk of a water supply system failure, and, in certain cases, by reducing the occurrence of objectionable colours and odours in treated water (Freeman, 1993). System failures can expose the customer to unsafe drinking water and potential impairment of health. Unpalatable water reduces the customer's level of satisfaction. Watershed management, by improving the quality of ground and surface water, increases the customer’s expected benefit from consuming tap water by reducing both the risk of system failure and the risk of receiving unpalatable water.

An improvement in raw water quality may also reduce the customer’s water bill by reducing the cost of producing treated water and the cost of treating wastewater. The reduction in the expected price of water services increases the expected benefits the consumer derives from the consumption of various goods/services including tap water (Boardman et al, 1996).

Changes in both the quality and quantity of surface waters that occur through watershed management can often generate recreational benefits. This is done by increasing the likelihood that an individual will frequent a recreational site, and by modifying, in certain cases, the quality of the recreational experience (personal communication, K. Rollins; Desvouges et al., 1986).

Benefits of watershed management are also experienced in agricultural, commercial and industrial operations. These benefits are produced by increases in the expected income generated by the operations. Watershed management increases expected income by either reducing production costs or increasing productivity (Freeman, 1993; Boardman et al, 1996). For example, watershed management can modify the expected quantity or quality of water that is available for irrigation. Resulting reductions in the cost of producing irrigated crops or in the yield or quality of these crops will benefit the farm operator by increasing net farm revenues.

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[3] This appendix is based, in part, on ESSA Technologies and M. Fortin, 1994 and J. Donnan, M. Fortin and R. Gaghadar, 1993. Dr. K. Rollins is acknowledged for her guidance in drafting portions of this appendix.

The preceding examples of benefit are all user benefits. These are benefits experienced by people who use the water resource in some way. But individuals also experience "non-use benefits" from watershed planning. These are individuals who value the environment for reasons other than their direct use of environmental amenities. Economists identify a number of distinct non-use values that can be magnified through watershed management (Boardman et al, 1996):

- Pure existence benefits: the satisfaction derived from just knowing, talking, or thinking about the existence of healthy ecosystems for fauna and flora;

- Altruistic existence benefits: the satisfaction derived from just knowing, talking, or thinking about the opportunity that other persons have or will have to benefit from healthy ecosystems, where other persons include either existing or future generations.

Certain non-use values come into play when there is uncertainty about future outcomes:

- Option value: the additional satisfaction experienced by an individual when an anticipated future benefit, that would normally be uncertain, is guaranteed. Option value can be compared to the amount of money an individual would be willing to pay, say as an insurance premium, to guarantee that opportunities to experience use or non-use benefits associated with a water resource will be provided in the future. Option value is a relatively small amount relative to the total use and non-use value of an environmental amenity.

- Quasi-option value: the satisfaction experienced by an individual when an irreversible action that may have an uncertain adverse impact is delayed in order to allow for the development of more knowledge about the consequences of the action thus permitting better decisions about the action to be taken.

## A FRAMEWORK FOR VALUING BENEFITS

The preceding section identifies the means by which watershed planning increases the benefits individuals derive from consuming various goods/services. In watershed management, significant expenditures in capital works and operations are at times required to increase the benefits individuals derive from consuming various goods/services. The merit of making such expenditures is often questioned because the benefits they generate are unknown and cannot be directly compared to the costs. Economists have developed a number of valuation tools to address this concern. These tools are based on the economic behaviour of households and firms

Consider, for example, a household trying to fulfill a number of needs and wants for goods and services, including the need for water and wastewater services, while trying to meet the constraint of a limited income. The household's problem involves figuring out how to maximize the level of satisfaction derived from the basket of purchased goods and services. The manager of a firm faces a similar problem—how to organize the firm's activities in order to maximize profits. Economists assume that households and firms are reasonably effective at solving the maximization problem given that they must function in an environment of limited income, limited information and considerable uncertainty. In other words, they are generally satisfied with decisions that they make about their use of goods and services including water and wastewater services—their decisions are the best that they can make in their circumstances in the sense that their decisions yield the greatest benefit to them.

How does this view of economic decision-making by households and firms help us in valuing the benefits of watershed management? The question can be answered using an example: a household uses municipally supplied water that has an unpleasant taste in the summer due to excessive algal growth in waters that are the town's source of supply. Since algae need phosphorus to grow, the town can eliminate the taste problem by reducing phosphorus loadings to the water from upstream farms and factories. This would benefit our household by increasing its satisfaction with the water service. To find out what dollar value the household places on the benefit, economists argue that you must determine the amount that the household's income must fall to just offset the satisfaction gained from the improvement in water quality. This amount is the maximum that the household would willingly pay for the improvement in drinking water quality and represents the tradeoff that the household would make between the improvement and the purchase of other goods and services. The reduction in income is therefore a measure of value that they place on the improvement.

The value of any benefit from watershed management is revealed by the dollar amounts that people willingly pay to experience that benefit or the compensation they require to give it up if they already have it. **Willingness to pay** (WTP) and **compensation requirement**, also known as **willingness to accept compensation** (WAC), are measures of the values that people assign to benefits.

WTP is the maximum cost that someone is willing to incur rather than go without a benefit. The cost may be a price paid to a supplier and it may also include indirect costs such as travel costs to a recreation site or the costs of equipment required to participate in an activity. But WTP can not be directly equated to the actual cost or cash outlay that a person makes because this amount isn't necessarily the maximum amount that they would willingly pay. The difference between their actual costs and their WTP is called **consumer's surplus** (see example in the text box).

WAC is the minimum amount that an individual will accept to willingly do without a benefit. Both WTP and WAC can be used to determine the value of any watershed management benefit. WAC and WTP assume different reference points. With WTP, we assume that the persons who benefit from an amenity do not have a right to the amenity and start from the position that they must pay to secure it. WAC starts from the opposite position: beneficiaries do have a right to the amenity and if they do not get the improvement, they should be compensated.

Producers of economic goods and services can also benefit from ecosystem improvements, and measures of WTP and WAC can be used to value these benefits. As with consumers, the economic measure of net value for an ecosystem improvement is **producer's surplus**. This is measured as total WTP or WAC less actual costs incurred to attain the improvement.

CONSUMER'S SURPLUS

I spend $5 in entry fees and $20 in travel costs to go to a park where I can hike escarpment trails. I might still go to the park if the entry fee is $7 or even $20. If $20 was the most that I would pay, then my WTP for this activity is $40 ($20 fee plus $20 travel costs). My consumer's surplus is $15, my WTP of $40 less my actual cost of $25.

PRODUCER'S SURPLUS

Improved water quality means that a manufacturer no longer has to pre-treat cooling water. This reduces manufacturing costs by $50,000/yr. The company did not spend anything to help improve water quality but it would presumably pay up to $50,000 for the improvement. It's WTP is $50,000, and, since its actual costs are zero, producer's surplus in this case is also $50,000

Consumer and producer surplus and willingness to pay are basic concepts that underlie methods used to assign value to impacts caused by watershed management activities.

## ECONOMIC ACTIVITY AND VALUE

It is important to distinguish between values that measure benefits and values that measure levels of **economic activity**. Benefits are created either by the production of new public and private goods or by measures that save valued resources. Economic activity in a region is measured by statistics such as employment, income, and tax revenues. Economic activity tends to increase in response to increases in government expenditures on things like watershed management. The increase occurs because the new expenditures generate direct and indirect sales for enterprises within the affected region. Such increases are called spin-off or multiplier effects. Many people like to identify these increases in economic activity as a benefit arising from the government expenditure. But these increases are often offset by decreases in economic activity elsewhere in the economy since financing the public expenditure means increasing taxes or reducing some other public expenditure. For this reason, increases in economic activity levels brought about by public sector expenditures should not be automatically interpreted as a benefit without careful assessment of underlying conditions. In this paper we do not address the impact of watershed management activities on regional economic activity.

## VALUATION METHODS

### Travel Cost

The travel cost method is used to determine the value to users of a facility such as a park or a body of water. It can be used to determine the total value of the facility or of an attribute of the facility such as water quality. This method is based on a demand curve model for a recreational site. A demand curve is a mathematical expression showing the relationship between the quantity demanded for a good or service and the price of the service, the income of the buyer, and various other determinants of demand. The distinguishing feature of the demand curve in a travel cost model is the interpretation of price as the total cost incurred to visit the facility. The value of an attribute of the site is determined from an analysis of the extra cost incurred to access sites where that attribute is provided in greater quantity or quality. The extra cost usually takes the form of a higher travel cost; for instance, people are willing to travel further to get to a clean beach. The demand curve is higher for a beach with better water quality. This simply means that willingness to pay to access the site is higher and this translates into a higher consumer surplus for the beach with better water. The increase in consumer surplus for a beach with better water measures the value of the water quality to beach users.

This method has been used to value a wide range of recreational uses including swimming, boating, fishing, hunting, camping and general park use.

### Hedonic Model

The hedonic method relies on the link between the price of a good and its attributes. Unlike the travel cost model, the hedonic model is applied to marketed commodities where price data for the commodity are available. In the case of real estate, environmental and resources amenities can be significant determinants of demand and thus of price. For the hedonic model a quantitative relationship between observed market prices for properties and the attributes of properties is developed using statistical techniques. Important attributes for a residential property might include numbers of rooms, location and size of the lot, ambient air quality, proximity to a body of water, and so on. The resulting relationship identifies how price varies in response to improved environmental amenities. From this, the implicit, or hedonic, demand curve for the environmental amenity can be inferred.

The hedonic price is an aggregate measure of value reflecting all of the householder's reasons for valuing an environmental attribute, including both use and non-use values.

### Contingent Value

The contingent value method is a survey technique used to determine the value that individuals place on environmental amenities and other things. Statements about value are elicited from survey respondents by questions that reveal their willingness to pay for the environmental amenity in question. Both use and non-use values can be determined with this method. It is the only tool available for the monetary assessment of non-use values.

The valuation question in a contingent value survey can take various forms. The simplest form of questions asks respondents to state the maximum that they would be willing to pay for something such as an improvement in water quality. Because responses to such questions are prone to error and bias, alternative question formats have been developed, for instance, asking respondents to identify which of several options they prefer, where the options provide differing levels of cost and environmental amenity. Contingent value surveys have been used in the valuation of a variety of things including the preservation of species and ecosystems, environmental improvements, water supply services and health.

### Benefits Transfer

Benefits transfer is a method for estimation of benefits at the site of a planning study, the "policy" site, using measures of benefit or benefit functions developed from the published results of primary valuation research at other study sites using travel cost, contingent value or hedonic methods. The approach is promising because it creates the possibility of effective benefit assessment without the cost and time requirements of primary valuation research in every planning study.

At its simplest, benefits transfer involves the use of published unit values, for instance the value per user day of recreation, to the policy site. Unit values may be adjusted to account for local conditions. The simple application of unadjusted unit values in evaluations is a long standing practice, but more methodical benefits transfer is relatively new.

### Valuing Impacts on Health

A variety of methods have been used to determine values associated with morbidity and mortality. The purpose of these approaches is not to assign an absolute value to life but to determine the individual WTP to avoid episodes of ill health and to reduce the risk of death. A number of methods, based on market prices, are listed below:

COST OF ILLNESS - Data on lost earnings and medical expenditures are used to estimate a lower bound on the individual's WTP to avoid a non-fatal episode of illness. This approach provides a lower bound on WTP because it does not capture any value associated with the individual's desire to avoid discomfort or the loss of leisure and work time.

HUMAN CAPITAL - This approach is used to measure the value of a life. It assumes that the value of a person's life corresponds to the value of that person's economic productivity as measured by discounted lifetime earnings. While the simplicity of this technique is appealing, it is not consistent with a WTP approach to valuation and should not be used.

AVERTING BEHAVIOUR - WTP to reduce the risk of morbidity or mortality is inferred from voluntary expenditures to prevent illness (e.g. purchases of UV sun screens, water filters, bottled water). This approach measures actual expenditure rather than maximum WTP. In applications addressing the risk of potentially fatal diseases such as cancers it has produced estimates of the value of life that are lower than other WTP approaches. This approach is also called a defensive expenditures approach.

COMPENSATING WAGES - The value of life is inferred from wage premiums paid to workers in dangerous jobs. The analysis requires data on wages, job attributes and worker attributes to construct a statistical wage function. It assumes that workers are informed about job risk and are able to negotiate wage differentials based on this risk.

In addition to these methods, impacts on health can be valued using the contingent value method described above.

### Valuing Impacts on Production

Productive activities encompass activities in both the public and private sectors. Examples of impacts on production are changes in the cost of water treatment and the loss of a commercial fishery. Such impacts are normally valued on the basis of market prices using one of the following approaches:

CHANGE IN COSTS – In this case, the inputs to produce a given level of output increase or decrease leading to a cost increase or decrease. The affected inputs are valued at their market prices and the value of the total change is just the change in total cost.

CHANGE IN NET INCOME – When the level of output changes, the appropriate measure of value is the change in net income. This is estimated as the value of the output in question at market prices less the cost of production in the case of increased output or cost savings in the case of a reduction in output.

CHANGE IN PROPERTY VALUE – A change in output can at times be measured using the associated change in property value. Property in this case may be land, a business or any other asset. For instance, consider a commercial fishing license on a water body that is closed to fishing due to contamination of the fish stock. The loss can be valued as the change in net fishing income over the period of the closure or alternatively, using a property value approach, as the change in the value of the fishing license.

**REPRESENTATIVE VALUES FOR COMMON WATERSHED BENEFITS**

Potential benefits created by watershed management are identified in the following table and sample estimates are provided of values that have been measured for each one. The values shown in this table are unit values such as dollars per household or dollars per day. They are used in conjunction with descriptive information about the magnitude of benefits to determine total value of benefits at a watershed scale. Many of the total values for case studies in the main body of the report are estimated from unit values such as these.

**TABLE A: THE VALUE OF POTENTIAL BENEFITS FROM WATERSHED MANAGEMENT**

| CATEGORY OF BENEFIT | ESTIMATED VALUES (2001 $Cdn) | REF. |
|---|---|---|
| Municipal water supply and human health: losses due to infection by giardia via a municipal water supply system in Pennsylvania, the avoidance of such losses represents a benefit. | Individual loss due to a confirmed case of giardiasis - $3,800/case<br>Total cost of actions to avoid giardiasis during an episode of contaminated water supply - $1,300/household<br>Loss of business income due to an outbreak of Giardiasis (restaurants and bars) - $18,000/establishment | c |
| Municipal water supply quality: prevent tastes and odours in water by controlling precursor contaminants in Georgia. | Annual willingness to pay to improve water quality - $190 per serviced urban household, $250 per rural household on a private well | f |
| Municipal water supply treatment cost: impact of poor source water quality on the water treatment cost for 430 of the 600 largest water supply utilities in the United States | Increased costs associated with treating raw water with higher turbidity levels - $0.0035 to $0.14 per cubic meter of treated water | m |
| Rural residential water supply quality: delay nitrate contamination of groundwater by controlling waste from factory farm hog facilities in Iowa. | Annual willingness to pay to delay nitrate contamination of groundwater by 20 years - $143 per household | k |
| Municipal water supply quantity: Improve the security of supply to avoid water use restrictions in California | Annual willingness to pay to avoid water shortages - $250 to $365 per household<br>Average loss to industrial enterprises due to a 15% summer seasonal and 30% year long reduction in water supplies - $120 and $230 per cubic meter of water respectively | d<br>e |
| Agricultural water supply quality: livestock exposure to pathogens by direct contact with contaminated surface waters | Cost incurred when animal contracts illness through water contaminated with M. avium subsp. Paratuberculosis - $3871 per bovine | l |

**TABLE A: THE VALUE OF POTENTIAL BENEFITS FROM WATERSHED MANAGEMENT**

| | | |
|---|---|---|
| Water-contact recreation: prevent loss of recreation opportunities due to contamination of water at beaches in Ontario | Annual willingness to pay to eliminate beach postings - $25 to $80 per household | h |
| Water-contact recreation and human health: avoid episodes of illness | Willingness to pay to avoid one day of nausea - $87/person<br>Willingness to pay to avoid one day of eye irritation - $48/person | g |
| Water-based recreation: provide individuals with opportunities for water related recreation (e.g. boating, swimming, fishing, nature appreciation, aesthetics) | Willingness to pay for recreation days:<br>Boating - $23 to $30 per user day<br>Fishing - $33 to $95 per user day<br>Waterfowl hunting - $57 per user day<br>Swimming, water sports - $28 per user day<br>nature viewing - $25 to $63 per user day<br>Hiking, camping, picnicking - $20 to $45 per user day | a, b |
| Non-use benefits: restore and protect species and ecosystems that are valued by households even though they are not used | Water quality improvement - $125 to $500 per household per year<br>Wildlife/wilderness protection - $18 to $110 per household per year | a<br><br>j |

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