Cost-Benefit Analysis for Cleaner Source Water

Project #: 388-2007

Submitted to:

Canadian Council of Ministers of the Environment

Submitted by:

Marbek Resource Consultants
David Sawyer
Laureen Chung

In association with:

Dr. Steven Renzetti, Brock University

Disclaimer
This report was prepared by Marbek Resource Consultants Ltd., under contract with the Canadian Council of Ministers of the Environment (CCME). It contains information which has been prepared for, but not approved by, CCME. CCME is not responsible for the accuracy of the information contained herein and does not warrant, or necessarily share or affirm, in any way, any opinions expressed therein.

PN 1396

Marbek Resource Consultants Ltd.
300-222 Somerset Street West, Ottawa, ON K2P 2G3
Tel: 613.523.0784 ⬩ Fax: 613.523.0717 ⬩ www.marbek.ca

EXECUTIVE SUMMARY

INTRODUCTION

With water management a growing social concern, much attention is placed on implementing solutions to improve surface water quality through improved wastewater treatment. One area of on-going focus is the role of municipal wastewater treatment in surface water protection. CCME's development of a *Canada-wide Strategy for the Management of Municipal Waste Water Effluent* (*Strategy*) is one response to the need to improve surface water quality nationally. In this Report, we provide insight and analysis on the economic implications of implementing the *Strategy*.

This focus is important since in the past the basis for investing in *municipal sewage treatment plants* (STPs) was an informal assessment of the costs and benefits. In effect, it could be argued that investment was justified on a conceptual basis where investments were made on the presumption that they were "socially-beneficial', meaning the benefits likely exceeded the costs. Indeed, it was enough to assume that by limiting the discharge of deleterious substances to surface waters, adverse impacts on ecosystem and human receptors were avoided. It could then be assumed that the benefits of the investments were avoided on-going costs to sensitive human and ecosystem receptors costs which were then balanced, at least on a conceptual basis, with the very real treatment plant costs.

In times of competing resources, and when alternative technical options have differing costs and environmental effectiveness, there is a need to take this reasoning farther. The policy objective becomes to not only improve surface water quality *per se* but rather to improve surface water quality in an economically efficient manner. Thus, there is a need for information on not just treatment costs, but also more information on the environmental and economic benefits that can be expected to flow from investments in municipal wastewater treatment.

It is this need for more succinct information that this project fulfills – to provide a tool and insight to decision-makers to help them reveal and understand the full range of environmental and economic implications that can be expected from MWWE investments.

SCOPE AND OBJECTIVES

The **objective** of this project is to examine various treatment and discharge scenarios proposed under the *Municipal Wastewater Effluent National Strategy (MWWE Strategy)* and study the associated costs and benefits for selected uses of the receiving environment. We develop a cost-benefit analysis framework that can be used to assess the economic viability of implementing a *MWWE National Strategy (Strategy)* as well as on a plant by plant basis. The framework is then applied to two case study provinces and a discussion provided about the economic efficiency implications of the proposed *Strategy,* meaning do the benefits likely exceed the costs. Information is also provided on the environmental benefits that can be attributed to STP investments under the *Strategy*.

Importantly, this report is designed to aid wastewater managers at all levels of government to better understand, estimate and communicate the benefits and costs of investments in sewage treatment. While the report seems to adopt a provincial perspective on the benefits and costs of the *National Strategy,* the method is in fact based on an aggregation of municipal results. This bottom-up approach means that any municipality can use the tools and methods presented in this report to better understand the costs and benefits of their particular investment options, for a province to understand the aggregate results of the *Strategy*, and for results to be rolled up at the National level.

Other issues of scope include:

- **Releases to surface waters**. While it is recognized that there are a number of releases from treatment facilities that can trigger costs and benefits this report is focused on surface water impacts only where air emission and biosolids disposal on land are not considered.
- **Jurisdictions**. While the approach and methods are directly transferable to all Canadian provinces, due to data availability we use two jurisdictions to illustrate the application of the method, namely Newfoundland and Labrador and New Brunswick.
- **Quantification and Monetization**. The wide range of outcomes associated with wastewater treatment means that it is a *challenge* to develop a fulsome range of quantified and monetized estimates for decision-makers to assess the merits of upgrading and installing wastewater facilities. Therefore, the expectations need to be made clear. At best, we develop a mix of qualitative and quantitative information that is useful for decision-making but stops short of comprehensive quantification and valuation of all outcomes.

THE CONCEPTUAL FRAMEWORK

Investments in sewage treatment plants, such as those contemplated under the *National Strategy*, ultimately have positive and negative implications on a range of environmental and economic outcomes. In Exhibit ES-1, the conceptual framework used to explore this range of outcomes is presented. The framework starts with the proposed MWWE options that will achieve the environmental objective, such as an effluent release limit, as in the case of the *Strategy*. To achieve the release limit, real resources must be committed. These are the costs of the *Strategy*, including capital and operating and maintenance costs, which are comprised of financial and human capital components. These resources can't be used elsewhere, and thus we should insure that our "investment" achieves some desired outcomes. What outcomes would we expect from investment in MWWE facilities? Assuming that the preferred technical option achieves the release limit:

1. We would first expect that the investments are *environmentally effective*, which is to say that the environmental benefits include:
    - A reduced mass of pollutants released into receiving waters;
    - An improved ambient environmental quality, leading to a reduction in ongoing damages to sensitive human and ecosystems receptors.
2. We would also expect the investments to *increase economic efficiency*, which would mean that it is plausible that the costs of the investments would be less than the monetized benefits. A major focus here is that societal benefits are real and verifiable, and can be credibly compared to the treatment costs.
3. Finally, we would expect that the investments would trigger *economic impacts* that are real and verifiable. Expenditures related to the *Strategy* should therefore result in increased employment and income at the provincial level.

Exhibit ES-1 presents each of these three "outcome accounts" within one overall conceptual framework, which is really a summary report card of the beneficial outcomes of the proposed *Strategy* or investment. This conceptual framework also guides the analysis, the approach, and is used to frame this report.

Exhibit ES-1
Conceptual Framework for Assessing MWWE Treatment Outcomes
What we would expect from MWWE investments?

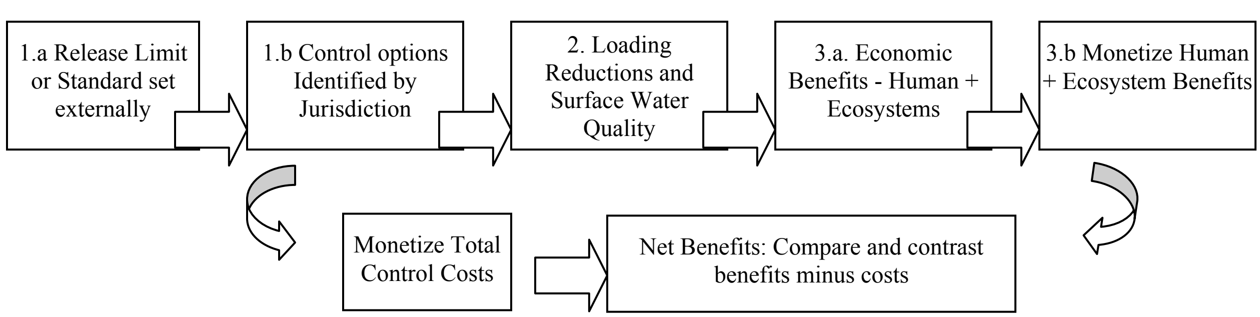
Investments are cost-effective	**→ Environmental Benefits of the *Strategy***	**→ Economic benefits likely exceeding costs**
Least-cost wastewater treatment investments have capital and operating costs that span the lifespan of the facility. These costs reduce emissions to surface water resulting in →	→ *Reduced Total Loading is plausible* • Reduced quantities of BOD, TSS, Ammonia and Phosphorous discharged into receiving waters • Reduced pathogens when disinfection is employed	*Economic benefits are real and verifiable* • Increased value placed on ecosystem and water quality by individuals / households • Willingness-to-pay by households to maintain or improve water services • Higher property values • Increased recreational use • Reduced health risk from recreational contact and consumption of fish • Increased commercial fisheries use
	→ *Reduced Impact on Sensitive Ecosystem Components is plausible* • Higher dissolved oxygen • Lower water temperature • Lower levels of toxic chemicals • Lower nutrient levels • Lower turbidity • Increased fauna and flora abundance • Lower pathogen counts	
	→	**→ Economic impacts benefit local communities**
		• Infrastructure spending generates a flow of jobs, income, GDP and tax revenue.

While the main focus of this report is on conducting a cost-benefit analysis of the *Strategy,* Exhibit ES-1 clearly indicates there is a wide range of possible benefits that are of interest for decision-makers. Further, in adequately scoping the cost-benefit analysis, we must first reveal the environmental benefits that are triggered by the *Strategy* before any credible valuation of the benefits can be conducted.

THE ANALYTICAL APPROACH

In implementing the conceptual framework, a number of steps we followed, as outlined in Exhibit ES-2, the analytical approach.

Exhibit ES-2
Analytical Approach



The basic elements of this approach include:

1. *Define control options that achieve the release limit*. The *Strategy* objective is a release limit of 25/25 mg/l BOD and TSS, plus disinfection. Based on these release limits, jurisdictions self-identify using the CBCL Costing Template the communities that will require STP investments to attain the

standard. It is this list of communities and the identified treatment upgrade investments that begin the analysis.

2. *Environmental Benefits - loading reductions and surface water quality*. The next step is to quantify the expected reductions in pollutant loading. This is a change case, where the status quo emissions are reduced to a lower level consistent with the attainment of the release limit. Next, impacts on surface water are quantified. While it is difficult to quantify under a high level analysis, generalizations can be made about the impact on surface water quality when treatment facilities are upgraded from a low level to a higher level of treatment.
3. *Economic Costs - Monetize the Total Costs*. This step uses the CBCL Costing Template, and thus is already been completed for most jurisdictions.
4. *Economic Benefits - Human uses and ecosystems*. In a sense, this is a distributional assessment that identifies who benefits from the improved surface water quality. The beneficiaries of the *Strategy* include both ecosystem components, which are valued by humans, and human uses from extractive and non-extractive uses. A monetary value is placed on a partial suite of beneficiaries for which credible monetary values can be estimated. Other non-quantified benefits are also qualitatively ranked with respect to the size of the benefit.
5. *Net Benefits - Compare and contrast benefits minus costs.* In this step we calculate the net benefit, which involves subtracting the monetized costs of the *Strategy* from the monetized benefits. Since we are conducting a partial analysis of the benefits, it is also important to discuss the significance of the non-monetized benefits.
6. *Economic Impacts - Trigger by the Strategy expenditures*. Economic impact multipliers are used to translate the *Strategy* spending into economic impacts in terms of employment, gross domestic product and employment income.
7. *Recommendations and Observations.* The final step is to determine if it is likely that the *Strategy* will result in an economic efficient outcome, where it is likely that society will be better off with the *Strategy* than without the *Strategy*.

Ultimately, this framework qualitatively and quantitatively assesses the environmental and economic cost and benefits of investments that reduce the loading of harmful substances into receiving waters.

THE RESULTS: SUMMARY OF THE *STRATEGY* IMPLICATIONS

Given the wide array of costs, environmental and economic benefits and economic impacts that have been identified, it is important to unify these into one reporting template. The summary tables below complete this for each of the two case study jurisdictions (Newfoundland and Labrador and New Brunswick) and use the conceptual framework as the basis for reporting framework.

Exhibit ES-3
Summary of the Implications of the *Strategy* in Newfoundland and Labrador

Investments in Wastewater Facilities that Achieve the National Performance Standard would result in the following implications:

Actions and Costs	→ Environmental Benefits of the *Strategy* are Important	→ Economic benefits exceed the costs
185 facilities that currently do not have treatment will move to the Standard. One large facility will upgrade from primary treatment to the Standard. The total cost over the 25-year life of the facilities would be in the order of *$506 million*, discounted at 4% in 2005 dollars	→ ***Reduced Total Loading in the order of*** Annually, • 6,980 tonnes of BOD • 8,391 of tonnes of TSS • 335 tonnes of Ammonia • 1,000 tonnes of Phosphorous discharged into receiving waters • Reduced pathogens such as *e. coli* in the order of 100% → There are *reduced Impacts on Sensitive Ecosystem Components including:* Lower BOD would result in: • A higher level of improved dissolved oxygen for fish and other aquatic species; and, • A medium level of improved biodiversity in the aquatic environment. Lower TSS would result in a *high*: • Reduction in the blanketing of spawning grounds, improved species growth and survival, and improved migration routes; • Level of improved photosynthesis of plant growth. Lower Ammonia would result in a *medium* level of improvement in: • Health risks associated with fish and shellfish; • Health risks associated with drinking water, as well as reduced taste and odour problems; • Dissolved oxygen levels for fish and other aquatic species; • Improved biodiversity in the aquatic environment; and, • Interference with shorelines and water intakes by algae and weeds. Lower Nitrogen and Phosphorous would result in a *medium* level of • Nutrient loading • Dissolved oxygen levels for fish and other aquatic species; • Improved biodiversity in the aquatic environment; and, • Interference with shorelines and water intakes by algae and weeds. On a scale of one to 10, with 10 indicating surface water that is drinking water quality, the *Strategy* would improve surface waters in 185 communities from a one to a seven. These scores imply a high level of improved surface water quality as a result of the *Strategy*.	***Economic benefits are real and verifiable.*** Based on the high improvement in surface water quality, it can be expected that a wide range of economic benefits will accrue to households, commercial fishers and ecosystems. These benefits likely have a real and significant economic value and are categorized as "*important*". Important economic benefits for which positive dollar values are likely include: • Reduced human health risks associated with contact recreation such as swimming and fishing, and commercial fishing such as shellfish harvesting and aquaculture; • Improved recreational opportunities and enjoyment; • Improved property values • Improved biodiversity and ecosystem functioning, including a current and future value placed on this improvement. Given that most of the facilities discharge to marine environments, benefits from reduced human health risks associated with safer drinking water, water suitable for industrial production and irrigation and stock watering would be less important. Due to data limitations, only a small sub-set of these benefits are estimated in dollar terms. For Newfoundland and Labrador the *Strategy* is expected to, *as a minimum,* generate: • $300 million in value to households that value safer water, improved recreational opportunities and more intrinsic values such as improved biodiversity, for now and for future generations; • Another $345 million in property value increases attributable to improvements when adjacent surface waters are improved from raw sewage quality to a higher cleaner level under the *Strategy*. **The Net Benefit of the *Strategy* is likely positive**, indicating that the monetized benefits likely exceed the costs. The net benefit for all communities impacted by the *Strategy* is in the order of $204 million. Since we have monetized only a small fraction of the overall benefits, we are confident that the *Strategy* would be an economically efficient use of resources. That said, some small and very small communities show a negative net benefit, and care should be taken to implement treatment options that minimize costs and consider local environmental circumstances, such as tolerance for high loading associated with lower levels of treatment. → **Economic impacts trigger employment and income** The spending from the *Strategy* would produce ripple or multiplier effects in the provincial economy. For Newfoundland and Labrador, the *Strategy* would likely create during the construction phase $35 million in labour income, would increase the GDP in the order of $95 million and create 1,200 direct and indirect jobs. Once the sewage plants were in operation they would have small, but an on-going impact on jobs, employment income and GDP.

Exhibit ES-4
Summary of the Implications of the *Strategy* in New Brunswick

Investments in Wastewater Facilities that Achieve the National Performance Standard would result in the following implications:

Actions and Costs	→ Environmental Benefits of the *Strategy* are Important	→ Economic benefits exceed the costs
43 facilities would be impacted by the *Strategy*. Of these, 24 are currently at a secondary level, while one is at the enhanced primary level and eight have no treatment whatsoever. The **total cost** over the 25-year life of the facilities would be in the order of *$275 million*, discounted at 4% in 2005 dollars	→ ***Reduced Total Loading*** Annually, • 3,000 tonnes of BOD • 3,620 of tonnes of TSS • 126 tonnes of Ammonia • 542 tonnes of Phosphorous discharged into receiving waters • Reduced pathogens such as *e. coli* in the order of 100% → There are *reduced Impact on Sensitive Ecosystem Components:* Lower BOD would result in: • A high level of improved dissolved oxygen for fish and other aquatic species; and, • A medium level of improved biodiversity in the aquatic environment. Lower TSS would result in a *high*: • Reduction in the blanketing of spawning grounds, improved species growth and survival, and improved migration routes; • Level of improved photosynthesis of plants growth. Lower Ammonia would result in a *medium* level of improvement in: • Health risks associated with fish and shellfish; • Health risks associated with drinking water, as well as reduced taste and odour problems; • Dissolved oxygen levels for fish and other aquatic species; • Improved biodiversity in the aquatic environment; and, • Interference with shorelines and water intakes by algae and weeds. Lower Nitrogen and Phosphorous would result in a *medium* level of • Nutrient loading • Dissolved oxygen level for fish and other aquatic species; • Improved biodiversity in the aquatic environment; and, • Interference with shorelines and water intakes by algae and weeds. On a scale of one to 10, with 10 indicting surface water that is drinking water quality, the *Strategy* would improve surface waters in 34 communities from a 5 to a 7. One community would improve from a 3 to a 7, while eight other communities would improve from a 2 to a 7. These scores indicate moderate surface water quality improvements.	***Economic benefits are real and verifiable*** Based on the high improvement in surface water quality, it can be expected that a wide range of economic benefits will accrue to households, industry, agriculture, commercial fishers and ecosystems. The benefits listed below likely have a positive economic value and are categorized as a mix of *important* monetary benefits for the eight communities upgrading from primary to the standard, as a mix of *important* and *some* monetary benefit for the one community upgrading from enhanced primary, and a lower score of "*some*" and "*negligible*" *monetary* benefit for the 34 facilities upgrading from secondary to the standard: • Reduced human health risks associated with safer drinking water, water suitable for industrial production and irrigation and stock watering; • Reduced human health risks associated with contact recreation such as swimming and fishing, and commercial fishing such as shellfish harvesting and aquaculture; • Improved recreational opportunities and enjoyment; • Improved property values • Improved biodiversity and ecosystem functioning, including a current and future value placed on this improvement. Due to data limitations, only a small sub-set of these benefits are estimated in dollar terms. For New Brunswick, the *Strategy* is expected to *as a minimum* generate: • $440 million in value to households that value safer water, improved recreational opportunities and more intrinsic values such as improved biodiversity, for now and for future generations; • Another $255 million in property value increases attributable to improvements when adjacent surface waters are improved from raw sewage quality to a higher cleaner level under the *Strategy*. **The Net Benefit of the *Strategy* is likely positive**, indicating that the monetized benefits likely exceed the costs. The net benefit for all communities impacted by the *Strategy* is in the order of $450 million. Since we have monetized only a small fraction of the overall benefits, we are confident that the *Strategy* would be an economically efficient use of resources. → ***Economic impacts trigger employment and income*** The spending from the *Strategy* would produce ripple or multiplier effects in the provincial economy. For New Brunswick, the *Strategy* would likely create $64 million in labour income during the construction phase, would increase GDP in the order of $138 million and create 2,290 direct and indirect jobs. Once the sewage plants were operation they would have small but on-going impact on jobs, employment income and GDP.

OBSERVATIONS AND RECOMMENDATIONS

This final section provides a number of observations and recommendations formulated in the course of developing this paper:

- First, the *Strategy* will be environmental effective given that the mass of pollutant loading will decrease and that there will be positive environmental benefits associated with improved surface water quality.
- Second, the *Strategy* is likely economically efficient, meaning that the dollar value of the benefits exceeds the dollar value of the costs. This result occurs even though we only assigned a dollar value to a partial sub-set of the benefits. That said, in some cases, notably very small communities, the high costs of new and upgraded treatment facilities coupled with the small benefits associated with small human populations means that it is likely that the net benefit could be negative. Hence, it is recommended that efforts be made to implement cost-effective treatment solutions that consider the capacity of the receiving environment to absorb sewage from a treatment system that emits below the proposed standard. The flip side of this is that in sensitive receiving waters, the non-monetized benefits will likely be large, and therefore more costly treatment options could be contemplated.
- Third, the *Strategy* will generate local jobs, income and GDP. Some portion of this positive effect on the economy will likely accrue in rural areas, and thus regional development objectives will also be accomplished under the *Strategy*.

Additional insights include:

- Upgrading small treatment plants is very expensive on a cost per tonne removed basis. Thus, efforts should be made to determine if cheaper alternatives can be used to achieve the standard or if that the receiving environment could tolerate emissions from lower cost treatment options. Given the high cost, especially for the small and very small plants, the second track EDO becomes more important for setting a standard that is lower, and considers the high costs and disproportionably low economic benefits. If other costs such as biosolid handling are included, this point becomes even more important.
- A related point is that since the costs are so high in the small and very small categories, it would be prudent to adopt a watershed based approach to seek alternative sources of cost-effective reductions from other point and non-point sources impacting surface water quality;
- In many cases significant BOD and TSS reductions are already in place, and the marginal costs of achieving the proposed standard are very high and are not highly valued by households, thus the marginal damages should be assessed to see if in fact they are cost-effective.
- We observe that there are a high number of facilities that are already at a secondary level and are at their end-of-life. This leads us to postulate that there may be some “free-riders” that would be upgrading regardless of the presence of the *Strategy*. If this is the case, then attributing the costs to the *Strategy* may not be appropriate.
- We also observe that the costs of upgrading are high, and therefore a phased approach to implementation may be required so that financial resources are not strained. If this is the case, adopting a mass loading approach would dictate that investments are targeted at large communities first. The economic analysis also supports this targeting where the monetary benefits tend to be higher in large communities since the costs are proportionally lower (due to plant economies of scale) and the benefits higher (due to income and population).
- For Newfoundland and Labrador, if a phased approach to compliance with the national standards was adopted, it is recommended that the 15 medium, large, and very large facilities be targeted first, to achieve the most significant impact in terms of loading reductions to the receiving water.
- For New Brunswick, if a phased approach to compliance with the national standards was desired, it is recommended that the 3 very large/large facilities be targeted first, to achieve the most significant impact in terms of loading reductions to the receiving water. On average, approximately 90% of the

loading reductions for each of the parameters considered (BOD5, TSS, TP, and total ammonia) are expected to be attributed to these facilities.

TABLE OF CONTENTS

1. INTRODUCTION

With water management a growing social concern, much attention is placed on implementing solutions to improve surface water quality through improved wastewater treatment. One area of on-going focus is the role of municipal wastewater treatment in surface water protection. CCME's development of a *Canada-wide Strategy for the Management of Municipal Waste Water Effluent* (*Strategy*) is one response to the need to improve surface water quality nationally. In this Report, we provide insight and analysis on the economic implications of implementing the *Strategy*.

This focus is important since in the past the basis for investing in *municipal sewage treatment plants* (STPs) was an informal assessment of the costs and benefits. In effect, it could be argued that investment was justified on a conceptual basis where investments were made on the presumption that they were "socially-beneficial', meaning the benefits likely exceeded the costs. Indeed, it was enough to assume that by limiting the discharge of deleterious substances to surface waters, adverse impacts on ecosystem and human receptors were avoided. It could then be assumed that the benefits of the investments were avoided on-going costs to sensitive human and ecosystem receptors costs which were then balanced, at least on a conceptual basis, with the very real treatment plant costs.

In times of competing resources, and when alternative technical options have differing costs and environmental effectiveness, there is a need to take this reasoning farther. The policy objective becomes to not only improve surface water quality *per se* but rather to improve surface water quality in an economically efficient manner. Thus, there is a need for information on not just treatment costs, but also more information on the environmental and economic benefits that can be expected to flow from investments in municipal wastewater treatment.

It is this need for more succinct information that this project fulfills – to provide a tool and insight to decision-makers to help them reveal and understand the full range of environmental and economic implications that can be expected from MWWE investments.

1.1 SCOPE AND OBJECTIVES

The **objective** of this project is to examine various treatment and discharge scenarios proposed under the *Municipal Wastewater Effluent National Strategy (MWWE Strategy)* and study the associated costs and benefits for selected uses of the receiving environment.

We develop a cost-benefit analysis framework that can be used to assess the economic viability of implementing a *MWWE National Strategy (Strategy)* as well as on a plant by plant basis. The framework is then applied to two case study provinces and a discussion provided about the economic efficiency implications of the proposed *Strategy,* meaning do the benefits likely exceed the costs. Information is also provided on the environmental benefits that can be attributed to STP investments under the *Strategy*.

Issues of scope include:

- **Releases to surface waters**. While it is recognized that there are a number of releases from treatment facilities that can trigger costs and benefits, at the direction of the Development Committee, this report is focused on surface water impacts only. Thus impacts related to air emission and biosolids disposal on land are not considered.

- **Jurisdictions**. While the approach and methods are directly transferable to all Canadian provinces, due to data availability we use two jurisdictions to illustrate the application of the method, namely Newfoundland and Labrador and New Brunswick.

- **Quantification and Monetization**. The wide range of outcomes associated with wastewater treatment dictates that it is a *challenge* to develop a fulsome range of quantified and monetized estimates for decision-makers to assess the merits of upgrading and installing wastewater facilities. Therefore, the expectations need to be made clear. At best, we develop a mix of qualitative and quantitative information that is useful for decision-making but stops short of comprehensive quantification and valuation of all outcomes. Instead, the conceptual framework we present aids in thinking about the fulsome range of costs and benefits of municipal wastewater investments, provides advice and examples on developing alternative indicators of the types of outcomes that can be expected to flow from the investment costs, and shifts the focus from monetizing and comparing the costs and benefits to developing a more comprehensive "report card" focused on environmental and economic outcomes.

1.2 ABOUT THIS REPORT

In addition to this introduction, the Report is presented in five sections

- Section 2 outlines and introduces the conceptual *framework*;
- Section 3 presents the environmental benefits of the *Strategy*;
- Section 4 presents the costs and benefits of the *Strategy*;
- Section 5 identifies the economic impacts and benefits of the *Strategy;*
- Section 6 provides a summary of the results; and,
- Section 7 concludes with observations and conclusions.

Each section is presented below.

1.3 HOW TO USE THIS REPORT

This report is designed to aid wastewater managers at all levels of government to better understand, estimate and communicate the benefits and costs of investments in sewage treatment. While the report seems to adopt a provincial perspective on the benefits and costs of the *National Strategy,* the method is in fact based on an aggregation of municipal results. This bottom-up approach means that any municipality can use the tools and methods presented in this report to better understand the costs and benefits of their particular investment options, for a province to understand the aggregate results of the *Strategy*, and for results to be rolled up at the National level.

2. THE COSTS AND BENEFITS OF MWWE INVESTMENTS

2.1 INTRODUCTION TO THE CONCEPTUAL FRAMEWORK

Investments in sewage treatment plants, such as those contemplated under the *National Strategy,* ultimately have positive and negative implications on a range of environmental and economic outcomes. In Exhibit 0-1, the conceptual framework used to explore this range of outcomes is presented. The framework starts with the proposed MWWE options that will achieve the environmental objective, such as an effluent release limit, as in the case of the *Strategy*. To achieve the release limit, real resources must be committed. These are the costs of the *Strategy*, including capital and operating and maintenance costs, which are comprised of financial and human capital components. These resources can't be used elsewhere, and thus we should insure that our "investment" achieves some desired outcomes. What outcomes would we expect from investment in MWWE facilities? Assuming that the preferred technical option achieves the release limit:

1. We would first expect that the investments are *environmentally effective*, which is to say that the environmental benefits include:
   - A reduced mass of pollutants released into receiving waters;
   - An improved ambient environmental quality, leading to a reduction in ongoing damages to sensitive human and ecosystems receptors.

2. We would also expect the investments to *increase economic efficiency*, which would mean that it is plausible that the costs of the investments would be less than the monetized benefits. A major focus here is that societal benefits are real and verifiable, and can be credibly compared to the treatment costs.

3. Finally, we would expect that the investments would trigger *economic impacts* that are real and verifiable. Expenditures related to the *Strategy* should therefore result in increased employment and income at the provincial level.

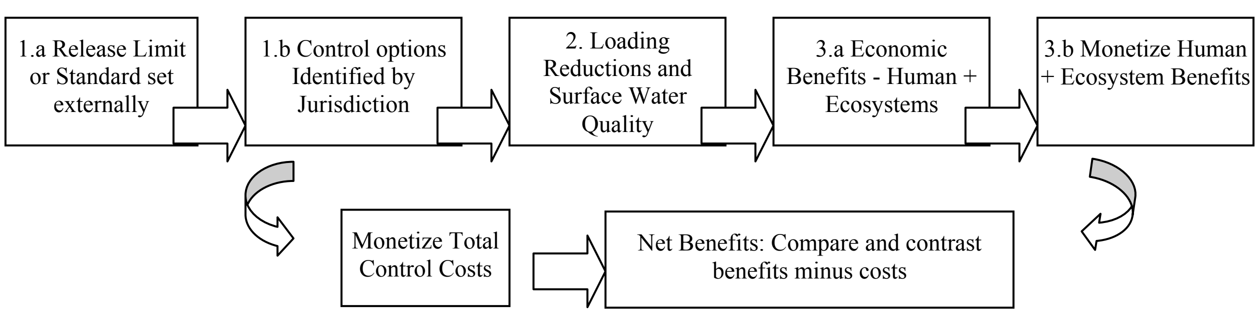
Exhibit 0-1 presents each of these three "outcome accounts" within one overall conceptual framework, which is really a summary report card of the beneficial outcomes of the proposed *Strategy*. This conceptual framework also guides the analysis, the approach, and is used to frame this report.

Exhibit 0-1
Conceptual Framework for Assessing MWWE Treatment Outcomes
What we would expect from MWWE investments?

Investments are cost-effective	**→ Environmental Benefits of the *Strategy***	**→ Economic benefits likely exceeding costs**
Least-cost wastewater treatment investments have capital and operating costs that span the lifespan of the facility. These costs reduce emissions to surface water resulting in →	→ *Reduced Total Loading is plausible* • Reduced quantities of BOD, TSS, Ammonia and Phosphorous discharged into receiving waters • Reduced pathogens when disinfection is employed	*Economic benefits are real and verifiable* • Increased value placed on ecosystem and water quality by individuals / households • Willingness-to-pay by households to maintain or improve water services • Higher property values • Increased recreational use • Reduced health risk from recreational contact and consumption of fish • Increased commercial fisheries use
	→ *Reduced Impact on Sensitive Ecosystem Components is plausible* • Higher dissolved oxygen • Lower water temperature • Lower levels of toxic chemicals • Lower nutrient levels • Lower turbidity • Increased fauna and flora abundance • Lower pathogen counts	
	→	**→ Economic impacts benefit local communities**
		• Infrastructure spending generates a flow of jobs, income, GDP and tax revenue.

While the main focus of this report is on conducting a cost-benefit analysis of the *Strategy*, Exhibit 2-1 clearly indicates there is a wide range of possible benefits that are of interest for decision-makers. Further, in adequately scoping the cost-benefit analysis, we must first reveal the environmental benefits that are triggered by the *Strategy* before any credible valuation of the benefits can be conducted. Thus, in implementing the conceptual framework, we must follow a number of steps, as outlined in Exhibit 2-2, the analytical approach.

Exhibit 0-2
Analytical Approach



The basic elements of this approach include:

1. *Define control options that achieve the release limit*. The *Strategy* objective is a release limit of 25/25 mg/l BOD and TSS, plus disinfection. Based on these release limits, jurisdictions self-identify using the CBCL Costing Template the communities that will require STP investments to attain the standard. It is this list of communities and the identified treatment upgrade investments that begin the analysis.
2. *Environmental Benefits - loading reductions and surface water quality*. The next step is to quantify the expected reductions in pollutant loading. This is a change case, where the status quo emissions are reduced to a lower level consistent with the attainment of the release limit. Next, impacts on surface water are quantified. While it is difficult to quantify under a high level analysis, generalizations can be made about the impact on surface water quality when treatment facilities are upgraded from a low level to a higher level of treatment.
3. *Economic Costs - Monetize the Total Costs*. This step uses the CBCL Costing Template, and thus is already been completed for most jurisdictions.
4. *Economic Benefits - Human uses and ecosystems*. In a sense, this is a distributional assessment that identifies who benefits from the improved surface water quality. The beneficiaries of the *Strategy* include both ecosystem components, which are valued by humans, and human uses from extractive and non-extractive uses. A monetary value is placed on a partial suite of beneficiaries for which credible monetary values can be estimated. Other non-quantified benefits are also qualitatively ranked with respect to the size of the benefit.
5. *Net Benefits - Compare and contrast benefits minus costs.* In this step we calculate the net benefit, which involves subtracting the monetized costs of the *Strategy* from the monetized benefits. Since we are conducting a partial analysis of the benefits, it is also important to discuss the significance of the non-monetized benefits.
6. *Economic Impacts - Trigger by the Strategy expenditures*. Economic impact multipliers are used to translate the *Strategy* spending into economic impacts in terms of employment, gross domestic product and employment income.
7. *Recommendations and Observations.* The final step is to determine if it is likely that the *Strategy* will result in an economic efficient outcome, where it is likely that society will be better off with the *Strategy* than without the *Strategy*.

Ultimately, this framework qualitatively and quantitatively assesses the environmental and economic cost and benefits of investments that reduce the loading of harmful substances into receiving waters.

3. THE ENVIRONMENTAL BENEFITS OF THE NATIONAL *STRATEGY*

As presented in the conceptual framework, we would first expect that the investments are *environmentally effective*, which is to say that they would reduce the mass of pollutants released into receiving waters. This is an important pre-condition to demonstrate that societal outcomes are positive and linked to the investments in MWWE treatment. If it is plausible that the reduction in pollutant loading improves ambient environmental quality, then we would expect ongoing damages to sensitive ecosystem and human receptors to be reduced. If this is the case, we can move on to monetizing the benefits in terms of avoided or reduced damages.

To assess environmental effectiveness, we have a two-part analysis that first identifies an *estimate of pollutant loading* attributable to the *Strategy* and then links this loading to *plausible changes in environmental quality*. Hence, the treatment options contemplated under the *Strategy* would be environmentally effective if it is plausible that they reduce emissions and improve environmental quality.

3.1 ESTIMATE OF LOADING REDUCTION BENEFITS

A national standard of secondary treatment or equivalent for facilities across Canada will reduce pollutant loading, which is a positive benefit of the *Strategy*. Specifically, since the proposed national standards pertain to biochemical oxygen demand (typically measured as the 5-day oxygen demand, or BOD_5) and total suspended solids (TSS), loading reductions to these two parameters are a certainty, in addition to loadings reductions in other parameters such as total phosphorus and total ammonia loading. Faecal coliform reductions are also likely, as it was assumed that all new facilities will have a UV disinfection unit, as per the CBCL Limited Costing (March 2006) report. While some of the existing treatment facilities to be upgraded likely already have disinfection, it was assumed that disinfection would be added in the majority of cases. The method to determine the pollutant reduction under the *Strategy* is straightforward:

- Without *Strategy* pollutant loading is estimated based on current levels of treatment (“Existing” portion of equation (1) below);
- With *Strategy* pollutant loading is a change case attributable to the *Strategy* where the proposed treatment achieves a performance standard (“Planned” portion of equation (1)); and,
- The difference in pollutant loading before and after (with and without) the *Strategy* is the reduction in pollutant loading (mass loading reduction) that can be attributed to the *Strategy*.

Formally, equation (1) is used to estimate the mass loading reduction, in terms of metric tonnes per year, for a range of pollutants for each community within each province:

Equation 1

$$\text{Mass Loading Reduction } (i) = Existing\left[Pe\frac{mg}{L}\ x\,Q\frac{m^3}{day}\,x\,\frac{1000\,L}{m3}x\,\frac{g}{1000\,mg}\,x\,\frac{kg}{1000\,g}\,x\,\frac{tonne}{1000\,kg}\,x\,365\,\frac{days}{year}\right]$$
$$-\,Planned\left[Pp\ \frac{mg}{L}\ x\ Q\frac{m^3}{day}\,x\,\frac{1000\,L}{m^3}\,\frac{g}{1000\,mg}\,x\,\frac{kg}{1000\,g}\,x\,\frac{tonne}{1000\,kg}\,x\,365\,\frac{days}{year}\right]$$

Where *Pe* is the existing concentration for pollutant *i*, which may or may not be treated depending on the existing level of treatment, *Q* is wastewater flow treated and *Pp* is the planned concentration for pollutant *i* with the standard in place.

The pollutant concentrations for *Pe* are provided in Exhibit 3-1. The following logic was used to guide the development of the concentrations for each level of treatment:

- For plants with no existing wastewater treatment, the parameters for untreated wastewater were used to determine the pre-*Strategy* pollutant loadings.

- For plants with existing primary treatment only, the effluent quality concentrations are considered to be a conservative 'high-level' guideline; existing effluent quality may be better than the values, depending on how well the facility is operated. Primary treatment removes only contaminants that can be settled without chemical enhancement.

- For plants with existing enhanced primary treatment (i.e. with chemical addition), total phosphorus levels are reduced through the use of chemicals such as alum, and some improvement in total ammonia levels are expected to occur as well.

- In the case of existing secondary treatment facilities, where the proposed upgrade is another form of secondary treatment, estimations for existing effluent quality were made, to account for anticipated effluent quality improvements to the National Performance Standards for BOD_5 and TSS, as well as some improvement in total phosphorus and total ammonia levels.

- Pathogen reduction was also considered for facilities, assuming that in the majority of cases, disinfection will be incorporated into the new and upgraded treatment plants. In many cases, the existing secondary treatment plants are at the end of their operating life, and require upgrading. These plants would likely have been upgraded regardless of the National Performance Standards; however, it is assumed at this stage that the loading reductions can be attributed to the *Strategy*.

Exhibit 0-1
Influent Concentrations (*Pe*) for All Facility Sizes
Wastewater Quality Concentrations used for Existing Treatment Levels

Wastewater Quality	Discharge (m^3/day)	BOD_5 (mg/L)	TSS (mg/L)	Total P (mg/L)	Total Ammonia (mg/L)	Faecal Coliform (No./100 mL)
Untreated wastewater	<= 500 to >50,000	165	192	6	25	10^6 counts/100 mL
Primary	<= 500 to >50,000	83 (50% removal)	96 (50% removal)	6 (no removal)	25 (no removal)	10^6 counts/100 mL (no reduction)
Enhanced Primary	<= 500 to >50,000	66 (60% removal)	77 (60% removal)	3 (50% removal)	20 (20% removal)	-
Secondary	<= 500 to >50,000	30 (~80% removal)	30 (~80% removal)	2 (67% removal)	15 (40% removal)	10^5 counts/100 mL (10 times reduction)
Secondary with Disinfection	<= 500 to >50,000	-	-	-	-	100 counts/100 mL (10,000 times reduction)

Notes:

- We note that site and province specific circumstances may make some of these assumptions invalid or at least will alter the conclusions. That said, the following does provide a good indication of the types of loading benefits that can be anticipated.
- BOD_5 – 5-day biochemical oxygen demand; TSS – total suspended solids; Total P – total phosphorus
- Approximations for existing, end-of-life secondary plants, based on consultations with New Brunswick.
- Untreated wastewater characteristics for BOD_5, TSS, and Total Phosphorus were taken from the “National Survey of Wastewater Treatment Plants – Final Report” (CWWA, June 2001), as presented in the “Comparative Cost Template for Various Levels of Municipal Wastewater Treatment” (CBCL Limited, March 2006). The untreated wastewater quality estimate for total ammonia and faecal coliforms was based on Metcalf & Eddy (2003). Wastewater Engineering. McGraw Hill.
- Estimates for % removal reductions were based on “Developing a Conceptual Framework for Estimating the Benefits of MWWE and Toxics Substances Control”. Final Report. Prepared for Environment Canada. Prepared by Gardner Pinfold Consulting Economists Ltd.

The concentrations for *Pp* are provided in Exhibit 0-2, where the National Performance Standards for BOD_5 and TSS were used and since no standards are proposed for total phosphorus, total ammonia, or pathogens (faecal coliforms used as the indicator) an estimate of loading reduction for these nutrients was provided to account for these expected co-benefits.

Exhibit 0-2
“Planned” Concentrations (*Pp*)
Treatment Effluent Wastewater Quality

Facility Size	Discharge (m^3/day)	BOD_5 (mg/L) (1)	TSS (mg/L) (1)	Total P (mg/L) (2)	Total Ammonia (mg/L) (2)	Faecal Coliforms (no./100 mL)
Very Small – Very Large	<= 500 to >50,000	25	25	1	10	100

Notes:

(1) Based on proposed National Performance Standards.
(2) Based on typical achievable levels for secondary treatment, without additional treatment add-ons such as filters. Total ammonia levels will vary significantly between seasons (e.g. 20-25 mg/L during the winter; 5-10 mg/L during the summer for lagoons), so the concentration used is an average annual estimate.

How are these concentrations used? To illustrate the method, assume a community with primary treatment has an average daily flow rate of 24,500 m^3/day. The average BOD_5 influent concentration would then be 83 mg/L (*Pe* in (1)), while the effluent concentration under the *Standard* would result in loading of 25 mg/L (*Pp* in (1)). Applying these values to equation (1) produces the following:

Change in Mass Loading = Existing (83*24,500 *1000*365/1000/1000/1000) – Planned (25*24,500 *1000*365/1000/1000/1000)

= 738 - 224

= 514 metric tonnes BOD per year or a 70% reduction

The percent reduction in loading between the existing and the planned case for BOD_5, TSS, total phosphorus, and total ammonia is calculated by the equation below:

Equation 2

$$\% \, reduced = \frac{Existing\,(mg\,/\,L) - Planned\,(mg\,/\,L)}{Existing\,(mg\,/\,L)} \; x\,100$$

For pathogens, the mass loading method is not applied. Instead, an estimation of the percent reduction of pathogens that the facility could expect (faecal coliforms taken as the indicator) is calculated by the equation below:

Equation 3

$$\% \;\; reduction = \frac{Existing\,(No./100\;mL) - Planned\,(No./100\;mL)}{Existing\,(No./100\;mL)} \; x\,100$$

Using the example above, where an existing primary treatment facility would be upgraded to a secondary treatment facility under the *Strategy*, the estimated percent reduction of pathogens would be:

$$\% \;\; reduction = \frac{10^6 \;\; coliforms\,/100\;mL - 100\;coliforms\,/100\;mL}{10^6\;coliforms\,/100\;mL)} \; x\,100$$

= 99.99% reduction

The following section provides this methodology to the two case study provinces.

3.2 LOADING REDUCTION BENEFITS BY CASE STUDY PROVINCE

Equation (1) (on page 7) and the concentrations in Exhibit 3-1 and Exhibit 0-2 (page 8) were used in combination with the *CBCL Costing Template Summary* sheets provided by Newfoundland and Labrador and New Brunswick. The costing template includes data on number of facilities requiring upgrades in each province, existing treatment levels, proposed treatment levels, and wastewater flow rates. We can therefore apply the above noted equations to the provincial data to estimate total loading reductions per province, and reflecting the anticipated new plants and upgrades within each province due to the *Strategy*.

3.2.1 Loading Reduction Benefits for Newfoundland and Labrador

Projected upgrades and new facilities by facility size and pollutant are provided in Exhibit 0-3. A total of 186 facilities are expected to require upgrades as a result of the *Strategy*:

- 185 of these facilities will move from no treatment to secondary treatment;
- 76% of these facilities are in the very small facility size;
- 21% (39 facilities) of these plants are in the small facility size category; and,
- St. John's is the only existing treatment facility that may be required to be upgraded from primary to secondary treatment to meet the national performance standards.

Pollutant reduction benefits include:

- **BOD_5**. A total reduction of approximately 6,980 metric tonnes per year is estimated. Approximately 75% of this reduction can be achieved through the provision of secondary treatment for the 46 very large, medium, and small facilities. The remaining 25% reduction in loading would be derived from the creation of the 140 very small secondary treatment facilities;

- **TSS**. A total reduction of approximately 8,390 metric tonnes per year. Approximately 75% of this reduction could be achieved through the upgrade (or new facilities) of the 46 very large, medium, and small treatment facilities;

- **Total phosphorus**. Approximately 330 metric tonnes per year reduction, where approximately 80% of the reduction could be achieved with secondary treatment at the 46 very large, medium, and small treatment facilities;

- **Total ammonia**. A total reduction of approximately 1,000 metric tonnes per year is also estimated, with approximately 80% of the reduction expected to be achieved by the 46 very large, medium, and small-sized treatment facilities;

- **Pathogens.** Newfoundland and Labrador currently has regulations for total coliform and faecal coliforms, and it is assumed that disinfection would likely be employed in the majority of new and upgraded facilities. The Newfoundland and Labrador municipalities potentially impacted by the *Strategy* have either no existing wastewater treatment or primary treatment, and thus, the faecal coliform reduction from disinfection would be in the order of 99.99% reduction, the highest reduction possible; and,

- **Other Impacts**. Additional reductions in metals and toxic pollutant loadings would be expected. Although pollutants will be reduced from the liquid stream via secondary treatment, there is still a solids stream to consider. Biosolids could be land-applied, landfilled, or re-utilized in other applications.

Exhibit 0-3
Loading Reductions Benefits for Newfoundland and Labrador
By Pollutant and Facility Size

Facility Size	Discharge (m^3/day)	No. of treatment facilities	Faecal coliforms	BOD5		TSS		Total P		Total Ammonia	
			% reduced/ inactivated	metric tonnes year	% total reduced	metric tonnes year	% total reduced	metric tonnes year	% total reduced	metric tonnes year	% total reduced
Very Small	<= 500	140	99.99%	1,743	85%	2,079	87%	62	83%	187	60%
Small	500 - 2,500	39	99.99%	2,131	85%	2,542	87%	76	83%	228	60%
Medium	> 2,500 - 17,500	6	99.99%	1,423	85%	1,698	87%	51	83%	152	60%
Large	> 17,500 - 50,000	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Very Large	> 50,000	1	99.99%	1,679	70%	2,073	74%	146	83%	438	60%
	TOTALS:	**186**	**-**	**6,976**	**81%**	**8,391**	**83%**	**335**	**83%**	**1,005**	**60%**

3.2.3 Loading Reduction Benefits for New Brunswick

Results for loading reductions attributable to the *Strategy* are provided in Exhibit 0-4 as well as the following summary observations. Forty-three (43) facilities in total are identified for upgrade:

- 8 of these will upgrade from no treatment to secondary treatment;
- 1 facility will upgrade from enhanced primary to secondary treatment;
- the remaining 34 facilities are existing secondary treatment plants requiring upgrades because they are at the end of their operating life and would likely not meet the proposed national treatment standards; and,[1]
- Interestingly, while close to 90% of these facilities are either small or very small facilities, the pollutant loading reductions will largely result from the 1 very large facility (Moncton) and 2 large facilities (Saint John and Fredericton).

Pollutant reduction benefits include:

- **BOD_5**. A reduction in BOD_5 loading of approximately 3,000 metric tonnes per year is estimated for the 43 facilities; over 90% of this reduction is expected to come from the 3 very large/large facilities (Moncton, Saint John, and Fredericton). The remaining 10% will result from the remaining 40 medium, small, and very small facilities requiring treatment upgrades or a new plant (if no treatment exists);
- **TSS.** A reduction in total loading of approximately 3,620 metric tonnes TSS per year is estimated, with the bulk of the savings (94%) derived from the 3 very large/large facilities;
- **Total phosphorus.** A reduction in total loading of approximately 130 metric tonnes per year of total phosphorus is estimated. As with the other parameters considered, the bulk of the savings (92%) is expected to be achieved through the upgrading of the Moncton and Fredericton treatment facilities, and the construction of the new Saint John – Hazen Creek secondary treatment plant;
- **Total ammonia**. Loading reduction is estimated to be approximately 540 metric tonnes per year, with a significant percentage of this reduction (87%) attributed to the Moncton, Fredericton, and Saint John upgrades;
- **Pathogens.** New Brunswick has a universal criteria for faecal coliforms. Seven of the 43 facilities (16%) reviewed use disinfection prior to discharge. The majority (84%) of facilities reviewed do not have disinfection. It is assumed that UV disinfection will be included for these facilities. The pathogen loading reduction benefits are noted in Exhibit 3-5 below; and,

[1] Based on communication with Tim LeBlanc. CCME Committee. Province of New Brunswick. June 2006.

- **Other Impacts.** Additional reductions in metals and toxic pollutant loadings would be expected, however, these were not estimated in the scope of this project, and would be more site-specific, as the influent quality to the treatment facilities would vary depending on the commercial and industrial sectors discharging to the sewer.

Exhibit 0-4
Loading Reductions Benefits
New Brunswick, by Pollutant and Facility Size

Facility Size	Discharge (m3/day)	No. of treatment facilities	Faecal coliforms % reduced/ Inactivated (1) (2)	BOD5		TSS		Total P		Total Ammonia	
				metric tonnes year	% total reduced	metric tonnes year	% total reduced	metric tonnes year	% total reduced	metric tonnes year	% total reduced
Very Small	<= 500	18	99.99%	39	55%	45	59%	2	57%	9	41%
Small	500 - 2,500	20	99.9%	133	43%	153	47%	7	49%	42	38%
Medium	> 2,500 - 17,500	2	99.9%	21	17%	21	17%	2	33%	21	33%
Large	> 17,500 - 50,000	2	-	1,830	78%	2,175	81%	68	76%	233	53%
Very Large	> 50,000	1	99.9%	973	62%	1,229	67%	47	67%	237	50%
	TOTALS:	**43**	**-**	**2,996**	**68%**	**3,623**	**72%**	**126**	**69%**	**542**	**49%**

(1) Maximum reduction possible noted. Faecal coliform reduction based on the maximum reduction scenario (e.g. no treatment to secondary treatment and disinfection for "very small" facilities; existing secondary treatment without disinfection to upgraded secondary treatment with disinfection for "small" and "medium" facilities; enhanced primary treatment without disinfection to secondary treatment with disinfection for the "very large" facility).
(2) Both large facilities reviewed already have existing disinfection facilities.

Conclusion. Based on the above analysis, it is likely that significant pollutant reductions are attributable to the *Strategy*. In the next section we explore if these loading reductions will trigger environmental quality benefits.

3.3 ENVIRONMENTAL QUALITY BENEFITS

3.3.1 Benefits to Human and Ecosystem Receptors

As outlined above, municipal wastewater treatment plants are designed to remove a range of "conventional" pollutants, represented as biochemical oxygen demand (BOD_5), suspended solids, nutrients (nitrogen and phosphorus) and pathogenic organisms. The risk assessment literature shows that these pollutants have wide ranging impacts on both human and ecosystem receptors. Notably, we reviewed a series of Environment Canada risk assessment documents on municipal waste water effluent.

Based on information contained in the risk assessment documents, Exhibit 0-5 was developed to provide a summary of the impact on environmental ambient quality by pollutant controlled under the *Strategy*, controlled both directly through the proposed standards and indirectly through co-pollutant reductions associated with the treatment facilities required to achieve the standards. Exhibit 0-5 identifies the types of environmental and human health impacts caused by the constituents of municipal wastewater we are considering. As can be seen, there are wide ranging and important environmental benefits that can be linked to the *Strategy*.

Exhibit 0-5 also links the ambient water quality change to sensitive human and ecosystem receptors, which is important since impacts will ultimately trigger economic benefits. To aid in understanding the importance of these linkages, a qualitative ranking was developed based on a subjective judgment of low, medium or high impact of the environmental benefit that is likely to stem from the *Strategy*. In effect, the ranking allows us to identify priority areas from which we can link environmental benefits, their significance and the likely implications for economic benefits.

Clearly, the Exhibit indicates that there are important and significant benefits to both human and ecosystems receptors. While this information is useful for decision-making, to conduct the economic benefit estimation we also need to more precisely relate these environmental benefits to the water quality conditions that the *Strategy* will trigger. This is completed in the section following the Exhibit.

Exhibit 0-5
Pollutant Removed and their impacts on Human and Ecosystem Receptors[2]

A movement to secondary treatment under the *Strategy* would result in:			
Pollutants Removed	**A Change in Ambient Environmental Quality:**	**Avoided Damages to Sensitive Human and Ecosystem Receptors of the Magnitude:**	
Total suspended solids [3]	A reduction in high levels of suspended solids can reduce excessive turbidity and the blanketing of spawning grounds. This in turn results in a beneficial increased growth or survival of species. Increased photosynthesis and plant growth is permitted due to improved water quality and reduced sedimentation. This in turn improves benthic habitats and promotes healthier aerobic conditions at the sea bottom. A reduction in total suspended solids also reduces fine particles that may be associated with toxic organics, metals, and pathogens that adhere to these solids.	High	Reduction in the blanketing of spawning grounds; improved growth or survival of species
		High	Improved photosynthesis and plant growth due to improved water quality
		High	Reduction in the blockage of migration routes
BOD [4]	Biological degradation of organic matter requires oxygen and can deplete available dissolved oxygen. The strength of wastewater is commonly expressed in terms of the biochemical oxygen demand (BOD) parameter. An improvement in BOD levels in natural waters increases the concentrations of dissolved oxygen, especially in shallow and enclosed aquatic systems. Higher dissolved oxygen concentrations are beneficial in reducing fish deaths, which occur when insufficient oxygen is available. Reductions in BOD also promote aerobic conditions (i.e. sufficient oxygen), which increases ecosystem biodiversity and reduces or eliminates the release of bad odours, from the formation of hydrogen sulphide (i.e. characteristic rotten egg odour).	High	Improved dissolved oxygen levels for fish and other aquatic life
		Medium	Improved biodiversity in the aquatic environment
	Nutrients, like nitrogen and phosphorous, are also reduced in the course of secondary wastewater treatment or equivalent, through biological means and/or chemical addition. A reduction	Medium	Reduction in nutrient loading
		Medium	Increase in dissolved oxygen levels available for aquatic ecosystem

[2] Gardner Pinfold. Developing a Conceptual Framework for Estimating the Benefits of MWWE and Toxics Substances Control. Report prepared for: Environment Canada – Environmental Economics Branch. March 28, 2002.
[3] Environment Canada, 2001. *The State of Municipal Wastewater Effluents in Canada*. Ottawa
[4] *Ibid.*

A movement to secondary treatment under the *Strategy* would result in:			
Pollutants Removed	**A Change in Ambient Environmental Quality:**	**Avoided Damages to Sensitive Human and Ecosystem Receptors of the Magnitude:**	
Nitrogen and phosphorus	in nutrient loading reduces the growth of nuisance algal blooms (including toxic algae blooms), dieback of coral and sea grasses, and eutrophication that can lead to insufficient dissolved oxygen levels, suffocating living resources (fish). Reductions in loading of nutrients from point sources such as municipal wastewater treatment plants, and other sources improves the overall water quality of inland streams, rivers, and bays. An increase in oxygen levels promotes ecosystem biodiversity, as a wider variety of flora and fauna can thrive in an environment with adequate dissolved oxygen levels.	Medium	Improved biodiversity in the aquatic environment
		Medium	Interference with shorelines and water intakes by algae and weeds
Ammonia[5]	Ammonia (a nitrogen compound) is present in two forms in the aquatic environment, NH_3 (un-ionized ammonia) and NH_4 (ionized ammonia or ammonium). It is the un-ionized form of ammonia that is most harmful to aquatic life, and it is the most frequent cause of toxicity in municipal wastewater effluents. The level of ammonia reduction achieved in secondary treatment will vary depending on the secondary treatment processes employed. Reductions in total ammonia discharged to the receiving stream are beneficial in improving the dissolved oxygen levels in the water available for aquatic life. In addition, the accompanying reductions in un-ionized ammonia reduces the toxic effects of the wastewater discharge on fish and shellfish. Among the more sensitive species are rainbow trout, freshwater scud, walleye, mountain whitefish, and fingernail clams.	Medium	Reduced health risk from contaminated shellfish
		Medium	Reduced toxic effects on fish and shellfish
		Medium	Reduced health risk from contaminated drinking water; reduced taste and odour problems
		Medium	Increase in dissolved oxygen levels available for aquatic ecosystem
		Medium	Improved biodiversity in the aquatic environment
		Medium	Reduced interference with shorelines and water intakes by algae and weeds
Pathogenic organisms[6]	Disinfection of the treated wastewater will reduce pathogen levels discharged into the receiving water body. This reduction would be expected to result in some reduction of contamination to shellfish and an overall improvement in water quality.	High	Reduced health risk from recreational exposure to contaminated water and sediments.
		High	Reduced risk of pathogens in drinking water supply
		High	Reduced contamination of shellfish thereby reducing health risk.

3.3.2 Water Quality Benefits

The improvements in surface quality anticipated under the *Strategy* now need to be translated into a measure that indicates the significance of the improvement. Studies that seek to assess the significance of improvements in surface water quality routinely characterize the improvement using the Resources for the Future Water Quality Ladder (RFF WQL).[7] The RFF WQL represents poor to excellent water quality on a scale of 1 to 10, and links specific pollutant levels to the impacts on aquatic species and to the suitability for human uses. Exhibit 0-6 provides an overview of the WQL and the qualitative description that corresponds to the WQL index value. The left hand columns identify the expected incremental improvement in the WQL that can be expected with movement from various "baseline" treatment levels to the standard.

This linking of water quality to human uses and ecosystem receptors allows for a non-technical characterization of the water quality change that is easily understood. The

[5] Environment Canada, 2001. *Priority Substances List Assessment Report: Ammonia in the Aquatic Environment*. Ottawa.
[6] Environment Canada, 2001. *The State of Municipal Wastewater Effluents in Canada*. Ottawa
[7] Mitchell and Carson, 1989, first formulated this approach.

WQL has been used in numerous studies and provides a common approach to valuing in dollar terms the benefits of surface water quality improvement.[8] Thus the WQL not only provides a good approach to characterizing surface water quality improvements and impacts on aquatic species but more importantly can be used as the basis for monetizing the benefits of the *Strategy*. Using the RFF WQL in this step thereby provides continuity for valuation in the cost-benefit analysis in the following sections.

So how do we use the WQL? First, for each community affected by the *Strategy* we must reference on the WQL both the current level of water quality and the resulting water quality under the *Strategy*. Using the CBCL Costing Template, a score can be developed for the pre-*Strategy* water quality based on the existing level of treatment. So, if a community has no treatment, they score a 1 as per Exhibit 3-7. Under the *Strategy* scenario, the achievement of secondary treatment is benchmarked as a '7' on the RFF WQL in Exhibit 0-6. The difference or incremental improvement is then the water quality improvement for the community under the *Strategy*, which in our example is a 6 (i.e. 7 – 1 = 6).

Prior to proceeding, we need to justify the benchmark for the *Strategy* at the level 7 on the WQL. This rating signifies that fishing is possible in the near vicinity of the wastewater discharge outfall, and that swimming is also possible in mid-proximity downstream of the wastewater treatment plant discharge (e.g. say 50 metres downstream to allow for some dispersion of effluent). To be considered safe for swimming, disinfection of the effluent is required. As is indicated in the CBCL Report, disinfection to the required local level is a standard assumption in the treatment train.

Disinfection requirements vary across the country, but we assume that adequate disinfection would be provided to meet the applicable standards. It is also plausible that with secondary treatment and disinfection, shellfishing would become acceptable in mid-proximity downstream of the effluent discharge. For example, if secondary treatment with disinfection achieved a level of 100 counts/100 mL for faecal coliform (as assumed earlier), and if the receiving water allowed for approximately 10 times dilution, it is possible that the water quality would meet the Environment Canada Shellfish Water Quality Protection Program standard of 14 counts/100 ml for faecal coliform.[9] This assumes that the impacts from other discharge sources (e.g. agriculture) do not significantly change the pathogen counts in the receiving water.

The lower nutrient levels which typically occur through the course of secondary treatment of chemical and biological processes would contribute to a reduction in eutrophication. Overloading of nutrients and eutrophication (excessive algae and weed growth and reduced dissolved oxygen conditions) may be an issue in a particular inland river, stream, or coastal bay. In very sensitive receiving water bodies, more stringent effluent criteria may be required than can be achieved through standard secondary treatment, but in general, secondary treatment would be expected to at least improve the water quality to a level where it is supportive of some fish habitats.

[8] Johnston *et al*, 2005 reviews in the order of 80 such studies
[9] http://www.pyr.ec.gc.ca/EN/Shellfish/index.shtml (accessed July 6, 2006)

It is reasonable to anticipate that a BOD_5 and TSS effluent concentrations of 25 mg/L and 25 mg/L would create a healthy enough environment with adequate dissolved oxygen levels and areas for spawning to allow for a fish population to thrive. The area directly around the effluent discharge pipe may still be unsuitable for fish habitat for a short downstream distance, depending on the effluent concentrations of toxics such as un-ionized ammonia; however, this can be mitigated with more stringent effluent criteria for ammonia, where required.

Secondary treatment effluent quality would not be considered "clean" enough for water reuse opportunities such as irrigation or greywater uses such as toilet flushing. As a point of comparison, tertiary treatment effluent quality of 10 mg/L each for BOD_5 and TSS, respectively, would likely be suitable for irrigation or greywater reuse applications. These types of reuse applications are actively being pursued in parts of the United States in particular.

Given this discussion, and the likelihood that both secondary and tertiary treatment effluent would not be suitable for potable water consumption (highest rating of '10' on the scale), we settled on a score of 7. Using this benchmark and setting pre-*Strategy* values based on the level of treatment in the CBCL Template, we can quantitatively score the upgraded treatment options for each jurisdiction in terms of the incremental level of surface water quality improvement. This is completed in the next section for the two case study provinces.

Exhibit 0-6
RFF WQL Ladder and Incremental Improvements with Treatment to Proposed Standard –

RFF Surface Water Quality Index		Surface Quality Benefit with Standard	
WQL Index	**Description of Human Use and Ecosystem Impacts**	**Your Starting Level of Treatment**	**Your WQ Increment to the Standard**
Best Possible Water Quality			
10 →	**Drinkable** • Meets drinking water quality guidelines		
9 →			
8 →	**Greywater uses** • Suitable for irrigation, greywater applications • Supports wide diversity of plants, fish, shellfish, and other aquatic life • Swimmable in near proximity		
7 →	**Swimmable and Shellfish acceptable – Mid-proximity** • Is a safe place to swim in mid-proximity of discharge (~50 m downstream) • Fish are safe to eat; • Shellfish are safe to eat (~50 m downstream) • Supports many plants, fish, shellfish, and other aquatic life.	At Standard 25/25 BOD/TSS with disinfection	0
6 →			
5 →	**Fishable** • Is an unsafe place to swim due to pollution, • Fish are safe to eat, • Supports plants, fish, and other aquatic life.	At Secondary but not meeting standard	2
4 →			
3 →	**Boatable** • Is an unsafe place to swim due to pollution • Has fish unsafe to eat • Supports only a small number of plants, fish, and other aquatic life	At Enhanced Primary	4
2 →		At Primary	5
1 →	**No Use**	At Raw Untreated Effluent	6
Worst Possible Water Quality			

It is also critical to note that this generic WQL approach should be tailored to local receiving waters to better reflect the impact of the investment on actual water quality. These water quality benefits, for example, may be differentiated by marine versus freshwater and large versus small rivers with differentiated flow rates.

3.3.3 Surface Water Quality Improvements by Province

Using the RFF WQL and the CBCL Cost template summaries provided by the provinces we characterize the incremental water quality improvements in Exhibit 0-7. The index clearly indicates a polarity in the likely surface water quality benefits in the jurisdictions: Newfoundland and Labrador can expect important gains because the majority of municipalities have no existing wastewater treatment, while the surface water quality gains seem to be less pronounced in New Brunswick because the majority of municipalities have at least primary treatment. That said, these gains are likely equally important when the receiving water body is considered in greater detail (beyond the scope of this study). In many cases, the New Brunswick facilities would be discharging into sensitive inland rivers and streams, and lakes used for drinking water sources. Therefore, an upgrade from primary to secondary treatment with disinfection, or a higher secondary treatment level than existing, can have a significant impact on the health of a local receiving water body, thereby reducing health risks, an important benefit of the *Strategy*.

This method for characterizing the incremental water quality improvement is carried forward in this paper to the economic benefits section below. Table 3-8 is also useful information for decision-makers and is therefore retained as an indicator of the environmental benefits of the *Strategy*.

Exhibit 0-7
Surface Water Quality Improvement by Province

	RFF WQL Incremental Improvement	RFF Water Quality Ladder (RFF WQL) Qualitative Description	NFLD	NB
At Secondary but not Standard	2 Step	Reduces nutrient loadings further; maintains biodiversity and aquatic health; decreases pathogens; allows swimming and harvesting of shellfish in mid-vicinity	0	34
At Enhanced Primary	4 Steps	Reduces nutrient loadings; significantly improved ecosystem health; decreases pathogens; fish are safe to eat, swimming and harvesting of shellfish in mid-vicinity	0	1
At Primary	5 Steps	Nutrient loading is significantly reduced; high improvement in ecosystem health; decreases pathogens; fish are safe to eat; swimming and harvesting of shellfish in mid-vicinity	1	0
At Untreated Effluent	6 Steps	Important improvement in all aspects of water quality - boating, fishing, pathogen reduction, harvesting of shellfish, swimming, biodiversity restored.	185	8

Conclusion: Based on the above outlined methodology and results, we conclude that it is plausible that significant reductions in pollutant loadings to surface waters could be attributed to the *Strategy*. It is also plausible that significant improvements in surface water quality are likely. It is therefore plausible that the *Strategy* will be environmentally effective.

4. THE SOCIETAL BENEFITS AND COSTS OF THE NATIONAL *STRATEGY*

The third outcome in the conceptual framework is that we would expect the MWWE investments to lead to increased *economic efficiency*, which would mean that it is plausible that the costs of the investments would be less than the monetized benefits. A major focus here is that societal benefits are real and verifiable, and can be credibly compared to the costs of the treatment options. Under this outcome, we use a cost-benefit analysis framework to compare the costs with the benefits. Cost-benefit analysis (CBA) is a widely used public policy decision-making tool to assess projects in terms of their potential change in the well-being of society. Cost-benefit analysis evolved based on the need for governments to assess and prioritize projects, and to allocate limited budgets and resources so that social well-being or welfare is increased with the minimum amount of resources spent or costs incurred. Thus CBA aims to guide decision-making and project selection so that scarce resources are used, or in economic jargon, allocated efficiently, where they provide the highest increase in social welfare or social return. CBA, therefore, is an approach which makes clear the advantages and disadvantages of a certain decision in terms of improving societal well-being.

A CBA applied to the *Strategy* first links "scenarios" under the *Strategy* to treatment options and incremental costs, pollutant discharge changes and then the incremental benefits attributable to the scenarios. This analysis chain is explored in three sections:

1. The Costs of the *National Strategy*, which are the capital and operating costs of achieving National Performance Standards aggregated over the operating life of the project and discounted back to a common base year dollar value;
2. The Benefits of the *National Strategy*. We first identify the range of economic benefits that can be expected to flow from the loading reductions and surface water quality improvements. Next, the benefits that can be credibly monetized are discussed and finally, benefits are estimated and monetized for the two case study provinces. Challenges to monetizing some outcomes are also discussed below, but these challenges become less important if credible estimates for a *partial set of benefits* can be shown to outweigh the costs; and
3. The Net Benefits of the *Strategy*, which aggregates the costs and the benefits in a cost-benefit analysis framework and assess if the benefits are greater than the costs, and thus if the *Strategy* is economically efficient.

The costs and benefits of implementing the *National Strategy* are highlighted using two case study jurisdictions, namely Newfoundland and Labrador and New Brunswick. These jurisdictions were selected since cost data was provided by the Development Committee.

4.1 THE COSTS OF CONTROL OPTIONS UNDER THE NATIONAL *STRATEGY*

As discussed in Section 3.1 and 3.2, the *Strategy* objective is a release limit of 25/25 mg/l BOD and TSS. Using this limit, jurisdictions use the CBCL Costing Template to identify their STP investment requirements. In this section we demonstrate how these control options and the associated costs are aggregated into an overall measure of the *Strategy* cost that can be used in a cost-benefit analysis framework.

4.1.1 Accounting for the Costs of the National *Strategy*

Accounting for the costs within a cost-benefit analysis of the *Strategy* requires a number of rather simple manipulations to the CBCL Costing Template data. These manipulations are discussed below and an example is provided in Exhibit 0-1:

- **Costs are totaled and discounted for the lifespan of the facility.** CBA takes a long-term planning view and therefore an assumption must be made about the life-span of the facility, and the distribution of operation and maintenance costs over the entire life of the facility. The operating life of the plants in the CBCL Costing Template assumes a range of 20 to 30 years. A prudent assumption would therefore be that the facility would operate for 25 years. The sum of the construction and operating costs over the life of the plant would then be discounted using a net present value formula (a function in excel) to some common base year. For this analysis, we discount costs back to 2005 dollars using a range of discount rates from 2% to 6%.[10]

- **Account for capital and operating costs in the year they occur**. This means that some assumption must be made about the distribution of costs over time. Thus, anticipated construction start and end dates are required to account for the capital costs over time as well as operating costs. We assume that the construction and therefore capital costs occur over an eighteen month period while operating costs occur in each year that the plant is in operation, starting with the half year following construction.

- **Capital and operating costs are incremental**. This is important since we are assuming a societal perspective, and thus need to account only those costs that are above and beyond current costs. That is, we are only interested in costs that are additional to existing and on-going costs. For capital costs, this requirement implies that some components of the upgraded treatment facility are in place and thus the overall capital cost will be lower than for a new facility. Similarly, for operating costs, the yearly costs are simply the new costs for the upgraded plant minus the current and on-going cost under the old plant (or annual O&M Costs Lagoon – O&M Costs Primary). Again, we are only interested in the incremental costs that will be above and beyond current and on-going plant costs.

- **Costs are uncertain**. A range of costs is assumed to account for uncertainty in the cost estimates. To bound this uncertainty, we use the facility level cost estimates before and after contingency to define the upper and lower bounds of uncertainty. This assumption implies that the actual cost estimate most likely falls within the range of contingency provided in the CBCL template.

A working example of these assumptions is provided in Exhibit 0-1, where upper and lower capital and O&M costs are calculated from the CBCL Cost template. As can be seen, upper and lower estimates are calculated that reflect the assumed uncertainty in the CBCL Template. Incremental capital costs are calculated in the Cost Template whereas

[10] Newell & Prizer (2003) provide a discussion as to why discount rates, which are in this range, are appropriate for environmental policy analysis.

incremental O&M costs are not, and thus must be estimated by subtracting the predicted current operating costs from the predicted upgraded costs. Of course, this incremental analysis only applies to facilities that are to be upgraded.

Exhibit 0-1
Upgrade for Very Large Urban Facility from Primary to Secondary- BOD (CAS)
ADF 80,000 m3/day

	Estimated Costs		Contingency	Location Factor	Estimated Project Costs	
	Existing Facility	New Facility			Capital	Annual O&M
	$ million				$ million	
Capital Cost "Upper" (from CBCL)	$12.54	$52.36	40%	10%	$61.32	
Capital Cost "Lower" (estimated)			0%	10%	$52.36	
O&M "Upper" (From CBCL)	$1.60	$2.33	20%			$0.734
O&M "Lower" (80% of Upper)						$0.587

These costs are then streamed out over the expected life of the project (25-years), and are accounted for in the year in which they occur. The corresponding stream of costs is provided in Exhibit 0-2, which assumes construction for the representative plant will commence in 2010 with the construction expenditure spread out evenly over the eighteen-month construction period followed by six months of operation in 2011 (thus the reduced operating costs in 2011). Notice that since we are reporting costs in 2005 dollars, we account for no costs between 2006 and 2009 so that we accurately account for the time value of money, where all costs are expressed in 2005 dollars. In Exhibit 0-2 the "upper" costs are presented, and thus the same accounting would need to be conducted for the "lower" bound cost estimates as well. Finally, at the direction of the Development Committee these estimates do not include biosolid control or effluent and environmental monitoring.

Exhibit 0-2
Accounting for Costs of the STP Over Time ($ Millions)
Very Large Urban Facility from Primary to Secondary- BOD (CAS)
ADF 80,000 m^3/day

		Year							
	Total	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012…**	**2036**
Capital	**$61.32**	$0.00	$0.00	$0.00	$0.00	$40.88	$20.44		
Operating	**$0.734**	$0.00	$0.00	$0.00	$0.00	$0.00	0.367	$0.782	$0.782
Undiscounted Total		$0.00	$0.00	$0.00	$0.00	$40.88	$20.81	$0.782	$0.782
Discounted Total Cost (4% discount rate)	**$52.19**					**$33.60**	**$16.44**	**$0.59**	**$0.23**

4.1.2 Provincial Costs of the National *Strategy* and the Rural/Urban Split

This same procedure was followed for the two case study provinces and all facilities that were affected by the *Strategy*. Costs were provided by the two jurisdictions, New Brunswick and Newfoundland and Labrador. Exhibit 0-3 provides the Total Cost summaries for all communities affected in each jurisdiction assuming a central discount rate (4%) for the 25-years of operating life plus the eighteen-month construction period. Total costs are for the life of the facility and include all foreseeable capital and operating costs. In the Exhibit, the total costs are grouped according to community size and rural versus urban.

Exhibit 0-3
Total Costs (incremental capital and O&M)
Newfoundland and Labrador and New Brunswick
25 Year plant life @ 4% Discount Rate (Millions 2005$)

		Newfoundland and Labrador	New Brunswick
Very Small	Rural	$223.57	$30.74
	Urban	$0.00	$0.00
Small	Rural	$142.08	$66.07
	Urban	$21.39	$0.00
Medium	Rural	$31.13	$25.86
	Urban	$36.44	$0.00
Large	Rural	$0.00	$0.00
	Urban	$0.00	$54.10
Very Large	Rural	$0.00	$0.00
	Urban	$52.19	$45.30
	Total	**$506.80**	**$222.07**

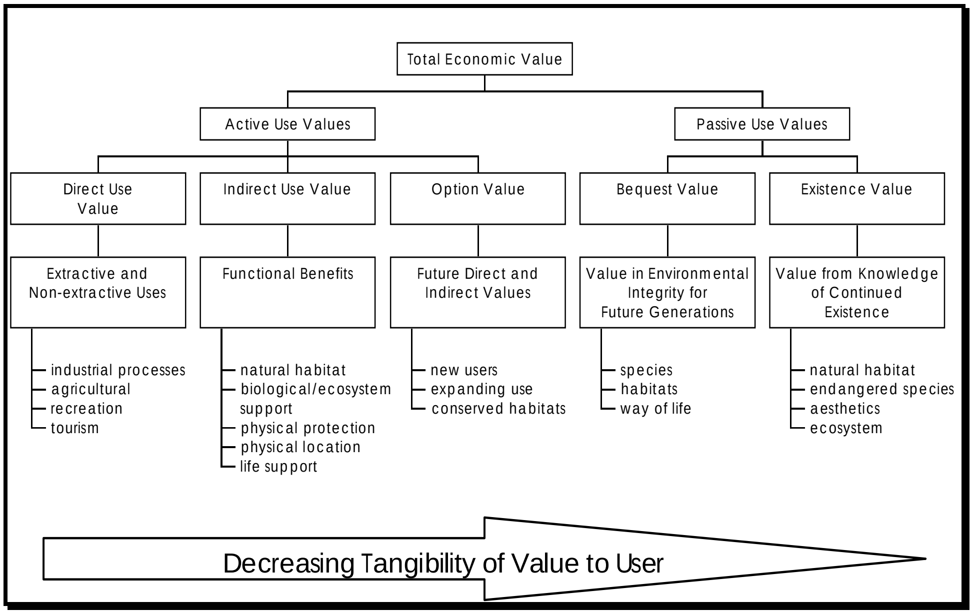
These costs do not include biosolids handling and treatment since we are focused exclusively on the benefits and costs associated with surface water quality improvements.

4.2 THE BENEFITS OF THE *NATIONAL STRATEGY*

Since we have established that environmental and health benefits can be expected from improvements in surface water quality under the *Strategy*, the next logical question is who benefits and how much? The Total Economic Value (TEV) framework is a taxonomy commonly used to link changes in environmental quality to societal benefits.[11] The Total Economic Value framework is standard practice for benefit's identification and valuation. The TEV taxonomy is presented in Exhibit 0-5, and is split under the categories "Active Use" and "Passive Use". This taxonomy is the starting point for benefits identification, quantification and sometimes monetization.

[11] See Pearce, et. al. 1989.

Exhibit 0-4
Total Economic Value Framework



From this framework we can be more precise with respect to who benefits and how much. Exhibit 0-5 identifies the range of possible beneficiaries of the *Strategy* associated with the TEV framework (left most columns). Moving right we first match a surface water "*use*" with the *water quality requirement* and the corresponding *beneficiary*, or who benefits from improved surface water quality. For example, municipal water supply needs surface water quality that can be treated to a level safe for consumption using conventional technologies. If surface water quality is improved, rate payers (households) benefit from a reduced risk associated with drinking water. Thus, the type of benefit is also identified, where three main benefits can be associated with surface water quality improvements, namely, reduced human health risk; improved recreational opportunities and aesthetics; and improved environmental quality. Finally, we can differentiate these benefits as accruing to either freshwater or marine receiving waters or to both.

For each of these areas of use under the TEV framework, we then provide a qualitative judgement of the magnitude of the likely benefit under the *Strategy* related to the starting point (or current) level of treatment. The magnitude of the benefits primarily relates to the number of RFF WQL steps achieved from the existing case to the *Strategy* level (as outlined in Exhibit 0-6) and are classified as:

- Important, meaning that significant benefits are likely;
- Some, meaning that benefits are positive and somewhat important; and
- Negligible, indicating that benefits are positive and likely small.

These subjective rankings are another indicator of the benefits of the *Strategy*, where we can judge the likely impact on a range of beneficial outcomes associated with the current level of treatment and the attainment of the standard under the *Strategy*. These benefits can be grouped in four main areas of use under the TEV framework:

Exhibit 0-5
Total Economic Value (TEV) and the Economic Benefits of Surface Water Quality Improvements

Uses under (TEV)	Water Quality Requirement	Beneficiary	Type of benefit	Fresh?	Marine?	Importance of benefit with movement to Standard from Your Current Level of Treatment			
Active Use						**None**	**Primary**	**Enhanced Primary**	**Secondary not to Standard**
Extractive Water Uses									
Municipal Water Supply	Safe drinking water and use with conventional treatment	Rate payers	Reduced human health risk	✓		Important	Important	Important	Some
Industrial	Water suitable for production with conventional treatment	Industrial	Reduced human health risk	✓		Important	Important	Some	Negligible
Agriculture	Suitable water for irrigation and stock watering	Agriculture	Improved irrigation and stock watering (reduce health risk)	✓		Important	Important	Important	Some
Nonextractive Water Use									
Swimming	Allow for primary contact without health risk	Households	Improved opportunities for swimming (reduced health risk)	✓	✓	Important	Important	Important	Important
Boating	Allow for secondary contact without health risk	Households	Improved opportunities for boating	✓	✓	Important	Important	Some	Negligible
Recreational Fishing	Support fish free from health risk and increase stock	Households	Increased catchability, some reduced human health risk	✓	✓	Important	Important	Some	Some
Commercial Fishing	Support fish free from health risk and increase stock	Commercial Fishers	Increased productivity and some reduced human health risk		✓	Important	Important	Some	Some
Land-based viewing	Suitable for Aesthetic Viewing	Households	Increased property value and recreational enjoyment	✓	✓	Important	Important	Important	Some
Shellfishing	Support shellfish populations free from health risk	Commercial fishers	Increased productivity and reduced human health risk		✓	Important	Important	Important	Important
Ecosystem Functions and Services									
Life support and biodiversity maintenance	Suitable habitat for protection and propagation of aquatic and terrestrial organisms	Households, ecosystem	Improved biodiversity and ecosystem functioning.	✓	✓	Important	Important	Important	Some
Passive Use (or Intrinsic)									
Bequest	Suitable for future use generations	Households, ecosystem	Avoidance of biodiversity loss and impairments to functions.	✓	✓	Important	Important	Important	Important
Existence	Maintenance of future ecosystem functions	Households, ecosystem		✓	✓	Important	Important	Important	Important

1. **Extractive Water Uses**. The main benefit of the *Strategy* to extractive water users is a reduction in health risk. The magnitude of this reduction is scored as "important". Under the existing situation (without the *Strategy*) extractive water users are probably already treating their water to reduce the health risk associated with poor surface water quality. Lower operational treatment costs would be expected, as a result of the reduced chemical needs involved in treating cleaner source water. These benefits would accrue to municipal water supply systems, industry and agriculture. In addition, it is reasonable to expect that the cleaner source water would reduce the health risks for the extractive water users. For example, a cleaner water quality may require less disinfection, and result in fewer disinfection by-products (some of which are considered suspected carcinogenic) in the municipal water supply. Thus, we would expect to see some sort of value related to a reduction in health risk associated with improved surface water quality accruing to extractive water users. Usually individuals and businesses place a value on a reduction in risk.

2. **Non-extractive Water Use.** The benefits of the *Strategy* are more diverse to non-extractive water users. Importantly there are the reduced health risks that accrue primarily to recreational users such as swimmers and boaters. Also important are the reduced health risks to commercial and recreational fisheries as well as shellfisheries in marine areas. Fisheries may also benefit from an increase in stock associated with cleaner surface water quality. Finally, less tangible, but nevertheless important are the benefits associated with cleaner surface water to aesthetic "users" such as shore-based recreation and adjacent property owners. For example, secondary treatment with disinfection would be expected to reduce undesirable algae and odour issues, which may be problematic along the shoreline. These non-extractive users all value clean water and therefore benefit under the *Strategy*.

3. **Ecosystem Functions and Services.** Improved surface water quality reduces impacts on sensitive ecosystem components and ensures a suitable habitat for protection and propagation of aquatic and terrestrial organisms. While reducing impacts on ecosystem functions and services, and maintaining biodiversity are inherently important, humans also place a positive value on the improved surface water quality. Humans benefit from a healthy ecosystem through the decrease in eutrophication and odour issues, which allow for increased enjoyment of the aquatic and shoreline environment. As noted above, a healthy ecosystem results in part from the presence of adequate dissolved oxygen levels. Dissolved oxygen levels are increased in a receiving water body as effluent quality increases.

4. **Intrinsic Uses.** Closely allied to ecosystem services and functions is the current value placed on their continued existence. This is a pre-cautionary factor and forward-looking benefit that is anthropocentric and related to the value people place on future uses and life support. At the root of this benefit is the value placed on an avoidance of future biodiversity loss and impairments to ecosystem functions

Based on these four categories, we see that the benefits of the *Strategy* are many and varied, tangible and intangible. In theory the full range of benefits could be valued in money terms using market and non-market valuation techniques within a welfare economics framework.[12] However, in practice the full range of benefits are quite hard to monetize and therefore most cost-benefit analyses (or valuation studies) tend focused on a sub-set of benefits and are therefore

[12] i.e. benefit cost framework

a partial analysis of the monetary benefits. In the next section, we discuss the specific benefits that can be credibly expressed in monetary terms.

4.3 MONETIZING THE BENEFITS OF SURFACE WATER QUALITY IMPROVEMENTS

In this section we present an approach to develop a *partial* estimate of a sub-set of monetized benefits for the communities affected by the *Strategy*. That is, we significantly underestimate the actual full range of monetized benefits. While we take a partial approach, we note that even detailed and site-specific economic analysis of water quality improvements tend to focus almost exclusively on the value households place on cleaner surface water. Indeed, this focus makes sense since Exhibit 0-5 indicates that households are the primary beneficiaries of improved surface water quality either directly, through reduced risk reduction or increased recreational opportunities, or indirectly, through environmental quality improvements and biodiversity maintenance. We note that our focus on partial benefits is necessary given data limitations.

Based on a literature review and our experience in benefits estimation, we focus on two important benefits to households that for which credible estimates can be developed for the broad range of communities affected by the *Strategy*:

- *Households willingness to pay for surface water quality improvements*, where households directly and indirectly benefit from surface water quality benefits and therefore value improvements in dollar terms; and,

- *Property value increases*, where property values have been observed to increase with improved surface water quality; and,

Each of these benefits and the approach to monetizing them within the context of the *CBCL Costing Template* and the *Strategy* are discussed in detail below.

Prior to exploring these two benefits, we note that Exhibit 0-5 clearly indicates a range of benefits that can be important. As noted, we could not provide credible values for these benefits in this report. Instead, Appendix A provides an overview of how benefits can be expressed in dollar values for drinking water, industrial, agricultural and commercial fisheries impacts. To value these benefits, local information will be required to fully articulate a credible estimate.

4.3.1 Households Willingness to Pay for Water Quality Improvements

Studies from both Canada and abroad reveal that people value improved surface water quality. Canadian evidence that supports this assertion includes:

- A national survey conducted in all regions of Canada in 1997 found that most respondents indicated that there was no choice but to pay higher prices for water service, or that water was essential for their activities, or that there was a need to preserve water for the future.[13]

[13] Rollins et. al., 1997

Exhibit 0-5 indicates that economic value under the *Strategy* (or sewage investment) originates from changes in health risk, recreational opportunities, aesthetics and intrinsic values associated with ecosystem improvements. In practice, however, it has been difficult to disentangle all of these benefits and thus studies generally develop one overall aggregate value estimate, usually referred to as willingness-to-pay *(WTP)* for improved surface water quality. While these valuation studies can be quite complex to design and implement, the findings can be "mined", simplified and then expressed as a function of both the surface water quality improvement from some existing situation and family income. Expressing the benefit as a function of water quality improvement and income allows results from a range of studies to be transferred for use in other applications, including estimating the benefits of the *Strategy*. How?

Essentially, information is collected from households that elicit the value placed on improved water quality and recreational opportunities and then statistical analysis (regression) is used to estimate a mathematical relationship between the dollar value for water quality improvements and a range of socio-economic variables such as income. Since many studies follow this common approach, relationships can be inferred which have a broad application in other study areas. Referred to as meta-analysis, these broadly applicable relationships between water quality improvements and income are then applied in studies where the development of site-specific information is not feasible.

We use meta-analysis to value the benefits individuals will place on the water quality and other benefits that are plausible under the *Strategy*. This is completed by first characterizing the anticipated water quality improvement under the RFF WQL and then adjusting for the local income. The resulting value is then somewhat representative of the value local communities place on the water quality improvement. Of course there is some uncertainty here, so we adopted a risk-based approached where two strategies were employed: first, we both developed a meta-analysis and then we used a meta-analysis from the literature. This two-pronged approach developed a range of monetary values, which has the bonus of minimizing some of the uncertainty inherent in transferring values from US and Canadian studies to a local or provincial context.

For our meta-analysis we identified 9 studies that value water quality improvements in a number of Canadian provinces from which we were able to glean 40 observations.[14] For each study, the RFF WQL as presented in Exhibit 0-6 was used to standardize the surface water quality improvement for each study area and then Statistics Canada household income data from the 2001 Census was used to compensate for local income.[15] This is a similar approach followed by Johnson *et al* (2005). We then applied a regression to the data set so that a predictive relationship would be available that has broad applications to the communities affected by the *Strategy*. The regression results are as follows:

$$\text{WTP per household} = -93.66 + 14.574833(\text{RFF WQL improvement}) + 0.0023476(\text{median household income in \$2005}) \qquad (2)$$

[14] We reviewed peer review journals, Environment Canada's EVRI (www.EVRI.ca) and searched the Net.

[15] 2001 income was adjusted to 2005 by dividing the 2005 consumer price index (CPI) by the 2001 CPI. See http://www40.statcan.ca/l01/cst01/econ150a.htm

This produces the dollar value per household (in 2005$) for a predicted water quality improvements, from one to six on the RFF WQL, adjusted for the local median household income. This equation can be used for each community affected under the *Strategy*, once the median income and the WQL improvement are identified.

As mentioned above, we adopt a risk-based approach, implying that it is prudent to use a number of approaches to value the surface water quality improvements. Johnson *et al. (2005)* conducted a meta-analysis of 80 US studies that value surface water quality improvements. A series of regression coefficients are estimated, including coefficients for water quality improvements using the RFF WQL and income.[16] Using these coefficients, we estimated a dataset based on alternative income and water quality improvements using Exhibit 0-6. This produced a workable equation similar to equation (2) above:

$$\text{WTP per household} = 43.88657 + 0.330389\ (\text{RFF WQL improvement}) + 0.000132\ (\text{median household income in \$2005}) \qquad (3)$$

We then tested and compared these two equations using the scored water quality ladder (WQL) results for a number of communities identified in the provincial CBCL Costing Template (i.e. the values in Exhibit 0-6 corresponding to the upgrade requirements in the Costing Template). We find that equation (2) based on Canadian studies produces higher values than equation (3), and thus we have lower and upper bounds for the value individuals place on improved surface water quality.

Since these equations measure surface quality improvements on an individual basis, we need to aggregate the individual values across the local population. Two approaches are possible here. First, we can use the CBCL flow rates (expressed in m^3/day) and divide by an average flow per person assumed in the CBCL report, which is 0.5 m^3/day. This approach likely underestimates the benefit since presumably there will be people outside of the wastewater service area that value the improvement in water quality. That said, studies have shown that value drops significantly with distance from the cleaner source water and thus we would expect the majority of the benefits to accrue locally. An alternative approach is to use the Statistics Canada population estimates[17] for the community as the basis for aggregating the individual WTP across the entire human population.

In either approach, equations (2) and (3) are multiplied by the population to give the annual benefit. Another requirement is to forecast the population over the life-span of the wastewater equipment (say 25-years) to ensure that we capture the long-term benefits that are expected. This streaming of benefits (and costs) out into the future is a basic requirement of cost-benefit analysis. To do this, we simply need a population change expressed as an annual percent. Again, the Statistics Canada Census data will provide a five-year population change between 1996 and 2001 for each community in Canada.

[16] We used the used the purchasing power parity method to transfer these US values to 2005 Canadian dollars. See http://www.evri.ca/dwnld/Int_Health_BT.pdf

[17] See http://www12.statcan.ca/english/census01/Products/standard/themes/DataProducts.cfm?S=2 for population and income statistics for your community.

To illustrate, for each community we must:

1. Use Exhibit 0-6 to "score" the WQL improvement under the *Strategy*;
2. Determine the average income in 2001 for the community and use a consumer price index to express in constant 2005 dollars (http://www40.statcan.ca/l01/cst01/econ150a.htm - divide 2005 by 2001 and then multiply by the 2001 income for the community)
3. Equations (2) and (3) are then used to estimate the per individual benefit which then must be aggregated across the population in the community; and,
4. Forecast the community population from the year that the facility will become operational. We can use the 2001 Census population for the community or the wastewater flow rate from the CBCL Costing Template in m^3/day divided by 0.5 m^3/day to estimate the base population that is served by the facility. In our tests, either approach produces very similar population estimates. We then forecast this to the year we anticipate the facility will become operational by determining the annual population growth rate for the community from the 1996 and 2001 Census.

This analysis chain is demonstrated in Exhibit 0-6.

Exhibit 0-6
Demonstration of How to Estimate the Value of Individuals for Improved Surface Water Quality

WTP for WQ Improvement						
	No Treatment to Standard	Average income	Equation (2) and (3) Coefficients			Estimated Per Individual Benefit (2005$)
			Intercept	WQ Coefficient	Income Coefficient	
Equation (2) (High)	6	$53,000	-93.66	14.574	0.002347	$ 118.21
Equation (3) (Low)	6	$53,000	43.886	0.3303	0.000132	$ 52.87
Population Assumptions						
CBCL Flow Rate m^3/day	Population in 2001	Annual Growth Rate				
500	1,000	1.2%				
Stream of Benefits						
	Year 1 2011	Year 2 2012	Year 3 2013	Year 4 2014	Year 5… 2015…	Year 25 2035
Population growth	1,074	1,087	1,100	1,113	1,127	1,140
Aggregate Annual Benefit (Low)	$56,794	$57,476	$58,165	$58,863	$59,570	$60,285
Aggregate Annual Benefit (High)	$126,986	$128,509	$130,052	$131,612	$133,191	$134,790

A third check is to reference these values against what people actually pay for sewage services in a jurisdiction as indicated in Environment Canada's Municipal Water Pricing Databases (MUP).[18] What people are actually paying for wastewater services is not a great indicator of what they would be willing to pay for improved surface water quality but rather is the fee paid for sewage removal and disposal services.[19] So, at best the value is a proxy that should not be used in isolation but instead as a complement to the WTP values in equations 2 and 3. Further, the sewage price in the MUP database is specific to provinces, and therefore adds provincial specificity to the benefits estimates. Our logic here is to provide a plausible range of values, and including the sewage "price" strengthens the analysis.

For each province, we estimated a relationship between the sewage price paid and the population served, which provides a predictive relationship that can estimate a sewage price paid for different community sizes (see Exhibit 0-7). One significant limitation is that we were unable to link the sewage treatment level to the price paid, and thus only have one overall sewage price regardless of the WQL increase under the *Strategy*. The assumption is that what people are paying is a good indictor of what they would pay for any surface water quality improvement. This is not that far fetched an assumption since both equations (2) and (3) are somewhat insensitive to surface water quality changes, meaning that there are small marginal gains associated with increasing levels on the WQL index. Again, taken in isolation the sewage price approach may not be that credible for estimating the value placed on surface water quality, but when combined with the other two approaches is a good complementary measure.

To use the equations in Exhibit 0-7, we simply plug in the community size as the x variable and the sewage price for the jurisdiction is predicted in 2005 dollars. The factor "1.8" is a scaling factor to reflect the amount of sewage services households actually use, and is included to transform the data in the EC MUP to reflect the sewer flow from households.[20] For example, a community of 1,000 people in British Columbia would pay in the order of $276 per household for sewage services. The resulting value is then a proxy for the value placed on improved surface water quality. It also acts as a point of reference for equations (2) and (3) where we would expect that the sewage price would be comparable to the value placed on improved water quality. That said, there are all kinds of distortions in the sewage price and therefore there is a much lower estimate than the actual long-term cost of sewage services supply.

---

[18] http://www.ec.gc.ca/water/en/manage/use/e_data.htm

[19] A study conducted by Corporate Research Associates for the Halifax Regional Municipality found that 71% of households would be WTP at least $100 for improved surface water quality. The people surveyed were those who are currently serviced by HRM water services and would be experiencing increased water and sewage payments for a new plant. The study results indicated that the incremental willingness to pay of Halifax residents was somewhere between $100-$150/household/year

[20] CBCL assumes 500 litres per day per individual, which is 1,500 litres per day per household assuming 3 people per household. This equates to 45 cubic metres per month for a 30-day period. Since the MUP is expressed as a price per 25 m^3/month, the scaling factor is therefore 45/25 = 1.8. For each community, the average number of individuals per household (from the Census) can be substituted for the 3 persons per households to add more geographic specificity. This is completed in the two provincial case studies.

Exhibit 0-7
Provincial Equations that Predict Sewage Price
as a Function of Community Population
Annual per household in 2005$

Province	Equation ($2005)	R^2 (fit)
British Columbia	y= (5.8335Ln(x) + 113.22)*1.8	0.02
Alberta	y = (14.812Ln(x) + 69.109)*1.8	0.07
Saskatchewan	y = (22.831Ln(x) - 23.828)*1.8	0.14
Manitoba	y = (-3.225Ln(x) + 164.51)*1.8	0.03
Ontario	y = (-8.1813Ln(x) + 304.33)*1.8	0.03
Quebec	y = (-2.0498Ln(x) + 139.53)*1.8	0.01
Nova Scotia	y = (475.43x-0.1321)*1.8	0.37
New Brunswick	y = (33.552Ln(x) - 82.803)*1.8	0.25
PEI	y = (-109.25Ln(x) + 1306.7)*1.8	0.59
Newfoundland and Labrador	y = (-9.0264Ln(x) + 177.87)*1.8	0.15

4.3.2 Provincial Benefits: Households Willingness to Pay for Water Quality Improvements

In this section we estimate the benefits to households of the *Strategy* for the two case study provinces. Recall that the households are significant beneficiaries of the *Strategy*, and thus the monetization of this benefit is important. Recall also that we first scored on the WQL index the surface water quality improvements and then we used equations (2) and (3) to estimate a range of benefits, and then compared this to the sewage price benefit. This three-pronged approach provides us with a range of benefits to households in which the actual benefit estimate is most likely to be found.

To estimate the benefits over time and accurately reflect the time value of money through discounting, we must assume a start date for the operation of the wastewater facilities leading to the water quality improvement and then the time period in which the benefit stream will continue. As assumed above in Section 4.1 (costs), plant operations commence in the second half of the 2011 reflecting a one and a half year construction period starting in 2010. Benefits then commence for 25 and a half years.

Again to recap, for each community impacted by the *Strategy*, equations (2) and (3) are estimated for a forecast population in 2011, and reflecting the 2001 medium income (expressed in 2005 dollars and constant over time) and the WQL benefit as indicated in the CBCL Costing Template. The stream of benefits for each province is included in Exhibit 0-8 and Exhibit 0-9. An average of the three methods is presented in the last column to highlight the central value of the three estimation techniques. These results clearly indicate that there are positive and significant benefits of the *Strategy* that accrue to households.

Exhibit 0-8
Newfoundland and Labrador - Estimate of Household Benefit
Millions 2005$ @ 4% discount rate for 2011 to 2035

Facility Size	Discharge (m^3/day)	Treatment facilities	Benefit Estimate			
			Equation (2)	Equation (3)	WTP Sewage price	Average of three
Very Small	<= 500	140	$56.57	$62.24	$83.38	$67.40
Small	500-2,500	39	$69.34	$67.89	$101.17	$79.46
Medium	> 2,500-17,500	6	$42.75	$35.70	$73.37	$50.60
Large	> 17,500-50,000	0	$0.00	$0.00	$0.00	$0.00
Very Large	> 50,000	1	$161.63	$99.52	$272.71	$177.96
	Total	**186**	**$273.72**	**$203.11**	**$447.24**	**$308.02**

Exhibit 0-9
New Brunswick - Estimate of Household Benefit
Millions 2005$ @ 4% discount rate for 2011 to 2035

Facility Size	Discharge (m^3/day)	Treatment facilities	Benefit Estimate			
			Equation (2)	Equation (3)	WTP Sewage price	Average of three
Very Small	<= 500	15	$4.34	$4.96	$3.51	$4.27
Small	500-2,500	21	$28.96	$45.45	$21.02	$31.81
Medium	> 2,500-17,500	2	$22.60	$48.34	$22.07	$31.00
Large	> 17,500-50,000	4	$100.31	$255.02	$95.18	$150.17
Very Large	> 50,000	0	$128.56	$357.65	$190.27	$225.49
	Total	**42**	**$284.77**	**$711.43**	**$332.05**	**$442.75**

4.3.3 Property Value Increases from Water Quality Improvements

Studies dating back to the 1970s have shown a positive relationship between surface water quality and housing prices. A notable 1998 study of Hamilton Harbour found that sewage and park investments increased housing prices by 18% within one km of the Harbour.[21] The strongest influence on housing prices was found to be improved water quality rather than increased park land. A report by GPI Atlantic also assessed the value of improved surface water quality in Halifax Harbour and concluded that the benefits of improved surface water quality on property values could be potentially significant.[22] Thus it seems reasonable to conclude that the proximity to the improved surface water is a strong determinant of property value. Improved property value is therefore a theoretically acceptable societal benefit that can be attributed to the *Strategy*. The question is can we credibly develop a method that can be applied to the *Strategy*?

As a starting point, it seems intuitive that assigning a zero value to increased property values may be inappropriate since we could omit a significant source of benefit. Indeed,

[21]Muir, Tom (Environment Canada). 1998. "Rising Property Values on Hamilton's West Harbourfront: Effects of Environmental Restoration on Real Estate Prices". http://www.cciw.ca/glimr/data/prop-values-hamharb/intro.html
[22] http://www.gpiatlantic.org/pdf/water/halharbour.pdf

given the base value of housing stocks in most communities, even small increases in property values that are attributable to the *Strategy* would result in large and significant societal benefits. Let us illustrate this point. Assuming,

- The average housing price in the community is $100,000;
- The number of houses within 1 Km of an improved water body is 100; and
- The property value increase is 5% due to surface water quality improvement; or,

= 100,000 * 100 * 0.05
=$500,000

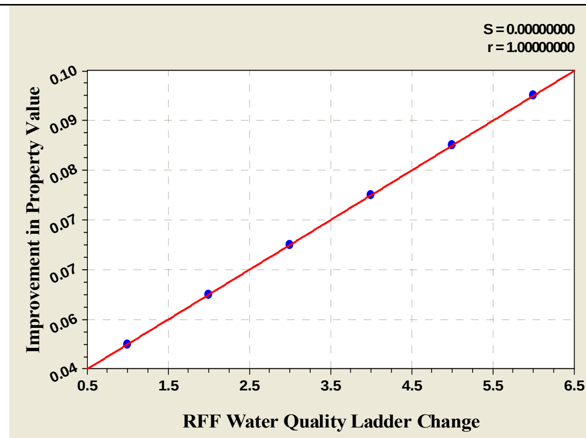
This $500,000 would be the initial one time increase in property values, and then over time this value would increase incrementally at the normal market appreciation rate. So, in year one that the surface water quality was improved the value would be $500,000, and if housing prices were rising at 6% annually, the year two benefit would be $30,000 and increasing at 6% compounded annually over the life of the municipal wastewater plant.

So, we see that there is a potential for significant value and therefore we should consider this benefit. How? Using the 2001 Census data we can determine the average housing price for most communities in Canada. Next, we can use GIS software to estimate the proportion of houses within close proximity to water courses.[23] We then need to assign some increase in property value that can be attributed to the *Strategy*. Applying the 18% increase observed in the Hamilton Harbour case to the *Strategy* may not be appropriate given that the value is attributable to a basket of improved amenities such as surface water quality and parks. And thus a lower rate is likely more appropriate. The GPI Atlantic Halifax Harbour Study assumed a “conservative” increase in property value in the 5% to 10% range for an upgrade in water quality from no treatment to a primary treatment level. While the rate is conservative relative to the Hamilton study, it does not link marginal improvements in surface water quality to marginal improvements in property value. That is we would expect larger property value increases with larger improvements in surface water quality. Thus, to be more realistic, we use the 5% to 10% range of the GPI Study and relate these to the RFF water quality ladder, where the 5% corresponds to a 1% jump in the RFF WQL and the 10% indicates a 6% jump. Inputting the value in between gives us the following function:

[23] PCensus by www.tetrad.com has a geographically based software program that enables users to estimate both the average property value and the number of dwellings is a user defined area such as 1 km from a water body.

RFF WQL	% Increase in Property Value
6	10%
5	9%
4	8%
3	7%
2	6%
1	5%

Linear Fit: y=a+bx
Coefficient Data:
a = 0.04
b = 0.01



While somewhat uncertain, this approach is likely more realistic than assigning a zero value. To recap, we estimated the property value increases attributable to the *Strategy* by:

1. For each community, estimating the increase in property value for adjacent residential properties by using the equation: y = 0.04+0.01x, where x is the RFF WQL score;
2. Determining the median value of the homes using the 1996 Census; and
3. Multiplying this estimate of the number of homes located within a ~1km range of improved water body

This approach is demonstrated in Exhibit 0-10 and is followed for the provincial case studies presented below.

Exhibit 0-10
Demonstration of How to Estimate the Property Value Increase from Improved Surface Water Quality

a. Number of dwellings			10,000				
b. Houses within 1Km			15%				
c. Houses impacted by *Strategy* (a*b)			=	**1500**	c.		
d. Average value of dwellings			=	**$50,000**	d.		
e. Increase in property value from WQ		(y=a+bx)					
x, Community RFF WQL improvement		a	b				
	3	0.04	0.01 =	**7%**	e.		
f. Initial Increase in value				(c*d*e) =	**5,250,000**	f.	
g. Annual property value growth rate				**5%**		g.	
h. Starting residual value in 2012					(f*g)	= $262,500	…@5%
	Year 1 2007	Year 2 2008	Year 3 2009	Year 4 2010	Year 5 2011	Year 6… 2012	Year 25 2035
Initial Value	$0	$0	$0	$0	$5,250,000		$0
On-going Residual Value (5%)	$0	$0	$0	$0	$0	$262,500	$1,263,478
Undiscounted Value	$0	$0	$0	$0	$5,250,000	$262,500	$1,263,478

4.3.4 Provincial Benefits: Property Value Increases from Water Quality Improvements

Given the large number of communities in each provincial jurisdiction, we sampled a subset of communities using GIS software (PCensus) and then developed a ratio between the number of homes within a 1km zone of the improved water body relative to the total number of houses. The sampling method was to sample two communities for each category size and then extrapolate the results across the rest of the communities in the size category. For large communities we used the actual values so that the results would be more accurate. For,

- *Newfoundland and Labrador, w*e sampled ten communities representing 60% of the population. The average was 29% and ranging between 8% and 68%;
- *New Brunswick*, we sampled eight communities representing 67% of the population. The average was 13% and ranging between 4 and 24%; and,

The first observation from these findings is that a small proportion of houses in each community could plausibly be impacted by improved water quality. Next, there is variation between communities in the proportion of housing in close proximity to impacted water bodies, and thus we should reflect this uncertainty in our calculations. This implies that for each jurisdiction the range of values should be used to calculate the proportion of housing located in close proximity to the cleaner surface water. Exhibit 0-11 provides the provincial results for the two case study provinces using the average value, whereas the range of values is used in net benefit calculations, presented below. As can be seen the property value increase can be significant even when a conservative property value increase is assumed.

Exhibit 0-11
Estimate of Property Value Benefit
Millions 2005$ @ 4% discount rate for 2011 to 2035

Facility Size	Discharge (m^3/day)	Benefit Estimate	
		Newfoundland and Labrador	New Brunswick
Very Small	<= 500	$68.05	$96.67
Small	500-2,500	$116.83	$51.72
Medium	> 2,500-17,500	$80.14	$6.72
Large	> 17,500-50,000	$0.00	$40.22
Very Large	> 50,000	$69.82	$59.89
	Total	**$334.84**	**$255.21**

4.4 NET BENEFITS OF THE *STRATEGY*

The net benefit compares the costs of the treatment to achieve the national performance standard with the monetized benefits over the life of the treatment facilities. In order for the *Strategy* to increase economic efficiency, we would expect that the net benefit would be positive, meaning that the benefits are larger than the costs. However, **since not all benefits are monetized** due to significant data uncertainties, at best we would expect that the benefits would overlap with the costs. This means that over the range of assumptions employed, such as households WTP for water quality improvement, discount rates, population growth rates, property values etc., we would expect that the net benefit would at least, some of the time, be equal to the costs. If this "overlap" of the partial benefits and full costs is observed, it is likely that if all of the benefits were monetized a positive net benefit would be highly probable. So, our decision rule to determine if the *Strategy* is economically efficient is that the net benefit should be positive *some of the time*.

To operationalize this notion of "*some of the time"*, we use a statistical technique called Monte Carlo sampling.[24] This probabilistic approach allows us to simultaneously alter within our Excel model the input assumptions to reflect our uncertainties and then track the impact of these uncertainties on the net benefit. A large number of iterations or samples, say 5,000, select one number from each input range and then calculates and records the resulting net benefit. Over the large number of samples, a large number of input value combinations produce a probability density function of all of the net benefit possibilities. The resulting output, expressed as the probability of a positive net benefit, then provides us with the notion of how often the net benefit is likely positive.

4.4.1 Net Benefit for Newfoundland and Labrador

The results for Newfoundland and Labrador indicate that overall the *Strategy* provides a large and significant net benefit to society, even when only a partial valuation of the benefits is conducted. The most likely or central value of the net benefit is in the order of $200 million over the 25-year life of the wastewater facilities.

That being said, the large overall net benefit masks the variation for small and very small communities which discharge to marine environments. We find that the net benefit for these communities has a large probability of being negative, and for very small communities, is always negative across the range of assumptions employed. If biosolids handling were included, the net benefit for the small and very small communities would be even smaller. The negative net benefit is explained through the high costs of treatment for very small communities and the low overall benefit associated with a small population – meaning on a per capita basis the costs are very high and the benefits are very low.

However, in all cases, the water quality improvement is large, with the jump in the RFF WQL equal to six points indicating that water quality will improve from a level of raw

[24]http://www.google.ca/search?hl=en&hs=6f6&lr=&client=firefox-a&rls=org.mozilla:en-US:official&defl=en&q=define:Monte+Carlo+simulation&sa=X&oi=glossary_definition&ct=title
http://www.poultryscience.org/pba/1952-2003/2002/2002%20Kachman.pdf
http://www.palisade.com/risk/default.asp

sewage to a fairly high level under the national performance standard. Given that all but one of the communities affected by the *Strategy* discharge to marine waters, the commercial fisheries benefit stemming from reduced bacterial contamination would be important. Conversely extractive water benefits to industry, drinking water supply and agriculture are not present. Finally, there would be ecosystem benefits that could be categorized as important given the large improvement in water quality from the existing level, where no treatment is in place. The size of these benefits would be highly dependent on the impact on marine receiving waters.

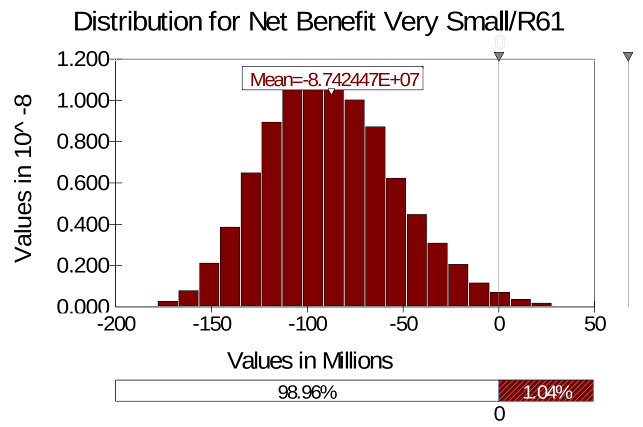
Another observation is that there are very expensive treatment options identified for very small rural communities. Given that the total mass of pollutant loading would be minute for small communities, and that many of these would be discharging into marine environments that are less sensitive than freshwater, it may be advisable to contemplate treatment options that are not as stringent as those envisioned under the *Strategy*.

Thus, it would be likely that the majority of investments would increase economic efficiency. However, in some cases, especially for very small and small communities, effort should be made to contemplate less stringent and expensive treatment options that consider local receiving environments.

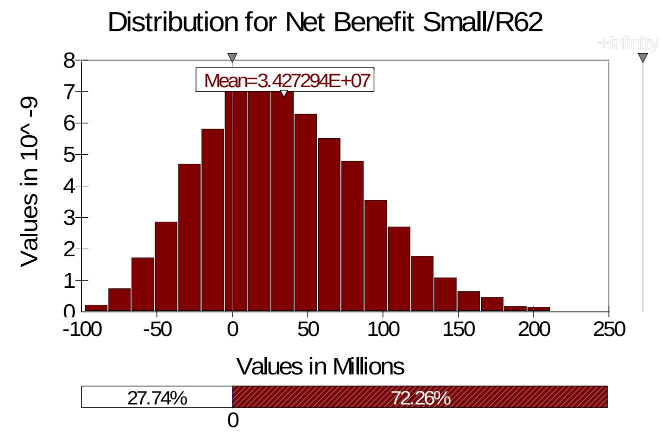
Exhibit 0-12
Estimate of Net Benefit for Newfoundland and Labrador
Millions 2005$ for 2011 to 2035 (discounted using 2%, 4% and 6%)

Facility Size	Discharge (m^3/day)	Net Benefit range		
		Low (10th Percentile)	Most Likely (50th Percentile)	High (90th Percentile)
Very Small	<= 500	-$130.65	-$89.81	-$41.12
Small	500 - 2,500	-$32.37	$30.30	$106.07
Medium	> 2,500 - 17,500	$16.53	$61.35	$116.89
Large	> 17,500 - 50,000	$0.00	$0.00	$0.00
Very Large	> 50,000	$81.73	$196.50	$310.23
	Total	**-$25.74**	**$204.51**	**$438.86**

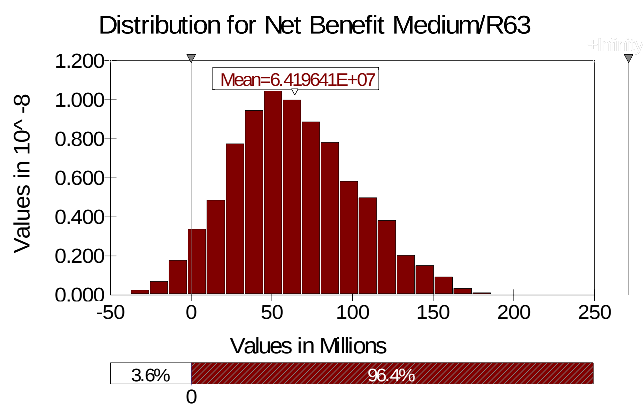
Exhibit 0-13
Net Benefit Results for Newfoundland and Labrador



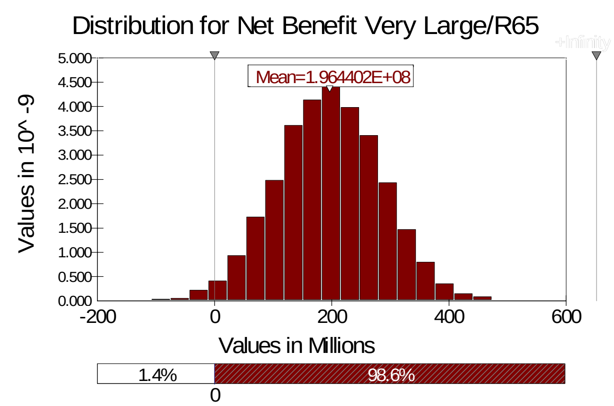
For very small communities, the net benefit is negative 99% of the time with a median value of $-87 million.



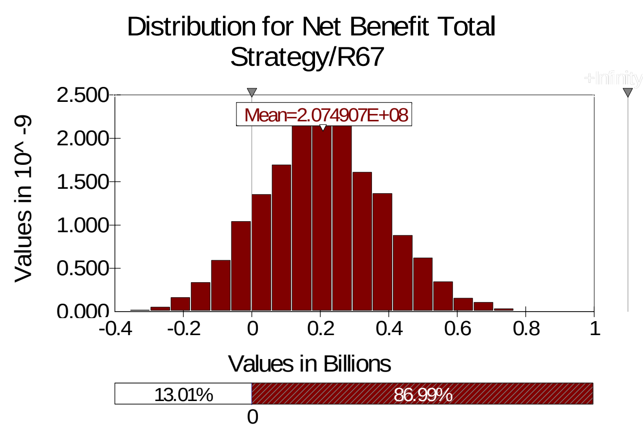
For small communities, the net benefit is negative 28% of the time with a median value of $34 million.



For medium communities, the net benefit is negative 4% of the time with a median value of $64 million.



For Very Large communities, the net benefit is negative 7% of the time with a median value of $119 million.



For all communities, the net benefit is negative 13% of the time with a median value of $207 million.

4.4.3 Net Benefit for New Brunswick

The net benefit for New Brunswick is likely large and positive. Exhibit 0-14 indicates that overall the net benefit is also positive with a central value in the range of $445 million over the 25-year period. In all cases the median value is positive, indicating that the *Strategy* would likely be economically efficient.

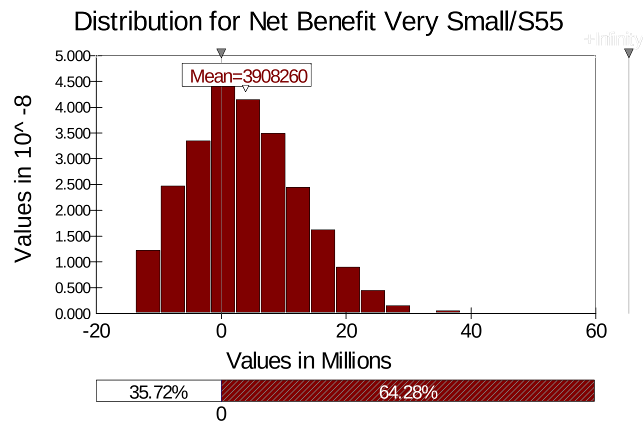
However, as with the other provinces, the overall positive net benefit masks a high likelihood of a negative net benefit for the very small and small communities. In the analysis, a negative net benefit results in 35% of the simulations, indicating that the positive net benefit for the small and very small communities could be negative. This again indicates that both the non-quantified benefits are important to the overall economic efficiency of the *Strategy* and that there is a need to implement cost-effective treatment options that are appropriate for local receiving waters.

Thus, it would be likely that the investments would increase economic efficiency, but that it can't be assumed that a positive net benefit would occur in all communities.

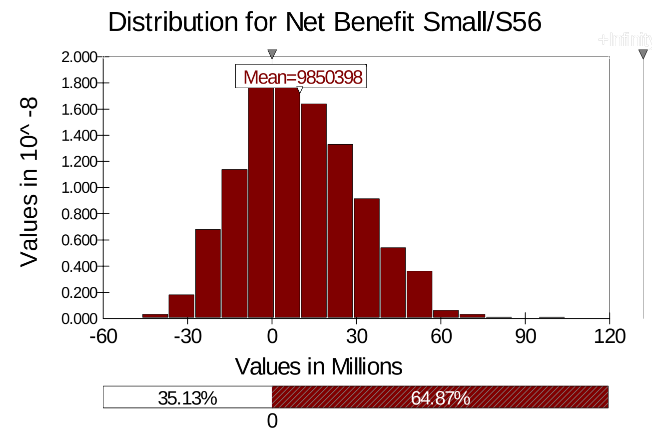
Exhibit 0-14
Estimate of Net Benefit for New Brunswick
Millions 2005$ for 2011 to 2035 (discounted at 2%, 4% and 6%)

Facility Size	Discharge (m^3/day)	Net Benefit range		
		Low (10th Percentile)	Most Likely (50th Percentile)	High (90th Percentile)
Very Small	<= 500	-$7.43	$3.91	$15.54
Small	500 - 2,500	-$15.55	$9.85	$38.03
Medium	> 2,500 - 17,500	-$12.78	$7.85	$27.35
Large	> 17,500 - 50,000	$97.12	$211.93	$325.24
Very Large	> 50,000	$61.48	$216.03	$383.02
	Total	**$130.90**	**$449.30**	**$758.53**

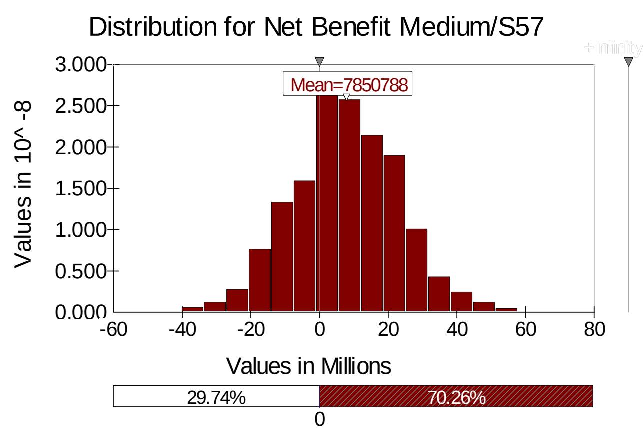
Exhibit 0-15
Net Benefit Results for New Brunswick



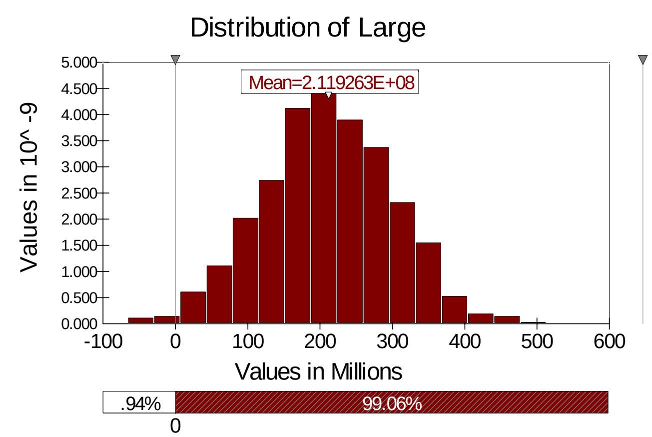
For very small communities, the net benefit is negative 36% of the time with a median value of $3.9 million.



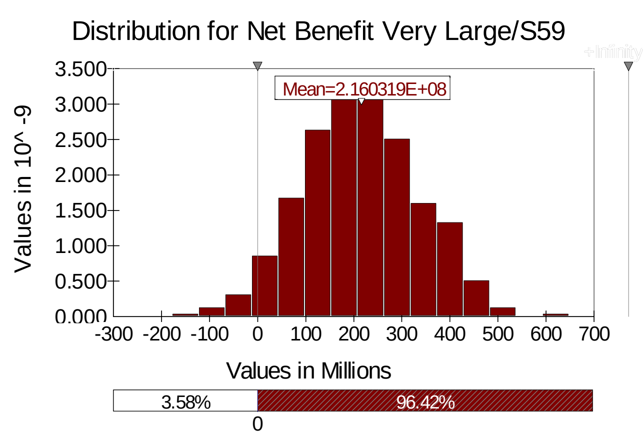
For small communities, the net benefit is negative 35% of the time with a median value of $9.8 million.



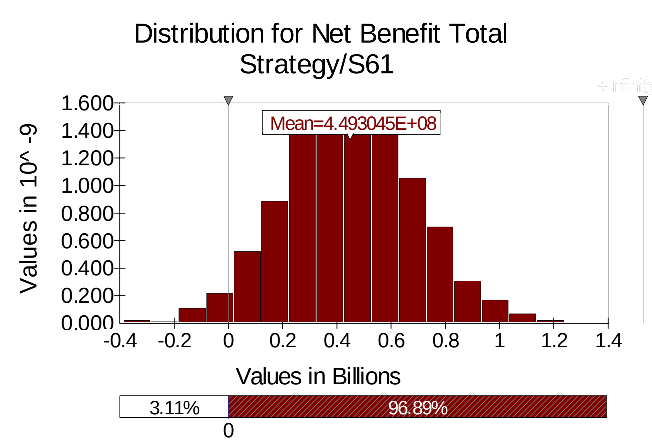
For medium communities, the net benefit is negative 30% of the time with a median value of $7.8 million.



For large communities, the net benefit is negative 1% of the time with a median value of $211 million.



For all communities, the net benefit is negative 4% of the time with a median value of $216 million.



For all communities, the net benefit is negative 3% of the time with a median value of $449 million.

5. ECONOMIC IMPACT OF THE *STRATEGY*

As well as the environmental and economic benefits, there can be positive or "ripple" effects on the provincial economies associated with the expenditures to implement the *Strategy*. Notably, income and employment will result from expenditures on the wastewater plants. These expenditure effects can be estimated quite simply by multiplying the total dollar value of the expenditures to comply with the *Strategy* by provincial economic impact multipliers available from Statistics Canada.[25] These economic impact multipliers are in effect intensity ratios, which predict changes in economic activity per dollar of expenditure within each province. While there are a number of economic impact multipliers, we suggest three important indicators:

(i) *Wages and salaries*, which is a measure of the labour income from spending;

(ii) *Gross Domestic Product*, which indicates the overall level of economic activity that occurs as a result of the spending; and,

(iii) *Total employment*, which estimates the total number of full time equivalent jobs created.

The provincial multipliers for the Water and Sewage Sector (NAICS 221300) are presented in Exhibit 0-1. For each jurisdiction there is a provincial impact and then an additive impact that occurs outside the jurisdiction (in the rest of Canada). To use these multipliers we simply apply the appropriate ratios to the CBCL cost estimates for both construction spending and the on-going annual operating and maintenance. So, if we have $1 million in construction spending in Newfoundland and Labrador and $100,000 annual operating costs, the economic impacts would be:

	Impact in the Province:			***Plus Impact in the Rest of Canada:***		
	Wages and Salaries per dollar expenditure	**GDP per dollar expenditure**	**Employment per millions dollars**	**Wages and Salaries per dollar expenditure**	**GDP per dollar expenditure**	**Employment per millions dollars**
N&L Multiplier	0.13	0.34	4.59	0.10	0.19	2.72
times $1 million in Construction =	$126,000	$340,000	5	$98,000	$187,000	3
times $100,000 in O&M =	$13,000	$34,000	0.5	$10,000	$19,000	0.3

We see from the above example that we have provincial impacts and then impacts on the rest of Canada. These two impacts are additive, and give an overall national estimate of the economic impact of the provincial spending. Note that we did not discount these values over time, but rather express the impact as a one time event (or shock) attributable to the *Strategy* and then as an annual operating impact for future years. We recommend this approach since the natural temptation for some will be to add the economic impacts with the economic benefits given that they are both expressed in dollar terms. Strictly speaking this is inappropriate since both are measures of two very different outcomes of the *Strategy*.

The multipliers in Exhibit 0-1 are applied to the case study provinces in the next section.

[25] Statistics Canada Catalogue No. 15F0046XDB. 2002 National and Provincial Input-Output Multipliers. www.statcan.ca

Exhibit 0-1
2002 Provincial Input-Output Multipliers (direct and indirect)
NAICS 221300 Water, Sewage and Other Systems

	Impact in the Province			***Plus Impact in the Rest of Canada***		
	Wages and Salary per dollar expenditure	**GDP per dollar expenditure**	**Employment per millions dollars**	**Wages and Salary per dollar expenditure**	**GDP per dollar expenditure**	**Employment per millions dollars**
Newfoundland and Labrador	0.13	0.34	4.59	0.10	0.19	2.72
PEI	0.17	0.83	5.06	0.05	0.09	1.41
Nova Scotia	0.30	0.79	9.39	0.04	0.08	1.07
New Brunswick	0.25	0.54	8.94	0.09	0.16	2.48
Quebec	0.21	0.53	6.25	0.05	0.10	1.29
Ontario	0.43	0.67	10.88	0.02	0.05	0.61
Manitoba	0.16	0.60	7.05	0.07	0.16	1.69
Saskatchewan	0.13	0.46	7.79	0.10	0.18	2.70
Alberta	0.23	0.75	5.68	0.04	0.08	1.10
British Columbia	0.42	0.40	12.32	0.07	0.13	1.74
Territories	0.24	0.65	5.75	0.13	0.23	4.09

5.1 THE PROVINCIAL ECONOMIC IMPACTS OF THE *STRATEGY*

In this section we estimate the economic impacts of the *Strategy* for the two case study provinces. As discussed above the construction and operating costs are simply multiplied by the relevant multipliers to estimate the provincial and additional national economic impact of the *Strategy*.

For **Newfoundland and Labrador**, the *Strategy* would likely create during the construction phase $35 million in labour income, would increase the GDP in the order of $95 million and create 1,200 direct and indirect jobs. Once the sewage plants were in operation they would have small but on-going impact on jobs, employment income and GDP.

Exhibit 0-2
Economic Impact of the *Strategy*
Newfoundland and Labrador

	Impact in Newfoundland and Labrador			***Plus Impact in the Rest of Canada***		
	Wages and Salary (million)	**GDP (million)**	**Employment (FTEs)**	**Wages and Salary (million)**	**GDP (million)**	**Employment (FTEs)**
Construction	$35.15	$94.97	1,280	$27.42	$52.30	35
Operation and Maintenance	$0.80	$2.15	29	$0.62	$1.18	1

For **New Brunswick**, the *Strategy* would likely create $64 million in labour income during the construction phase, would increase GDP in the order of $138 million and create 2,290 direct and indirect jobs. Significant jobs and GDP would also be generated during the 25-year life of the plants.

Exhibit 0-3
Economic Impact of the *Strategy*
New Brunswick

	Impact in New Brunswick			***Plus Impact in the Rest of Canada***		
	Wages and Salary (million)	**GDP (million)**	**Employment (FTEs)**	**Wages and Salaries (million)**	**GDP (million)**	**Employment (FTEs)**
Construction	$64.12	$138.49	2,290	$23.08	$41.04	640
Operation and Maintenance	$1.92	$4.15	69	$0.69	$1.23	19

Overall, we see that the spending associated with the *Strategy* will generate important and significant employment, income and GDP benefits to the provincial economies, with additional benefits to the national economy.

6. SUMMARY OF IMPLICATIONS OF THE *STRATEGY* FOR THE TWO CASE STUDY PROVINCES

Given the wide array of costs, environmental and economic benefits and economic impacts that have been identified, it is important to unify these into one reporting template. This section completes this for each of the two case study jurisdictions and uses the conceptual framework to guide the reporting framework (See Exhibit 0-1 on page 4).

Exhibit 0-1
Summary of the Implications of the *Strategy* in Newfoundland and Labrador

Investments in Wastewater Facilities that Achieve the National Performance Standard would result in the following implications:

Actions and Costs	**→ Environmental Benefits of the *Strategy* are Important**	**→ Economic benefits exceed the costs**
185 facilities that currently do not have treatment will move to the Standard. One large facility will upgrade from primary treatment to the Standard. The total cost over the 25-year life of the facilities would be in the order of *$506 million*, discounted at 4% in 2005 dollars	***→ Reduced Total Loading in the order of*** Annually, • 6,980 tonnes of BOD • 8,391 of tonnes of TSS • 335 tonnes of Ammonia • 1,000 tonnes of Phosphorous discharged into receiving waters • Reduced pathogens such as *e. coli* in the order of 100% → There are *reduced Impacts on Sensitive Ecosystem Components including:* Lower BOD would result in: • A higher level of improved dissolved oxygen for fish and other aquatic species; and, • A medium level of improved biodiversity in the aquatic environment. Lower TSS would result in a *high*: • Reduction in the blanketing of spawning grounds, improved species growth and survival, and improved migration routes; • Level of improved photosynthesis of plant growth. Lower Ammonia would result in a *medium* level of improvement in: • Health risks associated with fish and shellfish; • Health risks associated with drinking water, as well as reduced taste and odour problems; • Dissolved oxygen levels for fish and other aquatic species; • Improved biodiversity in the aquatic environment; and, • Interference with shorelines and water intakes by algae and weeds. Lower Nitrogen and Phosphorous would result in a *medium* level of • Nutrient loading • Dissolved oxygen levels for fish and other aquatic species; • Improved biodiversity in the aquatic environment; and, • Interference with shorelines and water intakes by algae and weeds. On a scale of one to 10, with 10 indicating surface water that is drinking water quality, the *Strategy* would improve surface waters in 185 communities from a one to a seven. These scores imply a high level of improved surface water quality as a result of the *Strategy*.	***Economic benefits are real and verifiable.*** Based on the high improvement in surface water quality, it can be expected that a wide range of economic benefits will accrue to households, commercial fishers and ecosystems. These benefits likely have a real and significant economic value and are categorized as "*important*". Important economic benefits for which positive dollar values are likely include: • Reduced human health risks associated with contact recreation such as swimming and fishing, and commercial fishing such as shellfish harvesting and aquaculture; • Improved recreational opportunities and enjoyment; • Improved property values • Improved biodiversity and ecosystem functioning, including a current and future value placed on this improvement. Given that most of the facilities discharge to marine environments, benefits from reduced human health risks associated with safer drinking water, water suitable for industrial production and irrigation and stock watering would be less important. Due to data limitations, only a small sub-set of these benefits are estimated in dollar terms. For Newfoundland and Labrador the *Strategy* is expected to, *as a minimum,* generate: • $300 million in value to households that value safer water, improved recreational opportunities and more intrinsic values such as improved biodiversity, for now and for future generations; • Another $345 million in property value increases attributable to improvements when adjacent surface waters are improved from raw sewage quality to a higher cleaner level under the *Strategy*. **The Net Benefit of the *Strategy* is likely positive**, indicating that the monetized benefits likely exceed the costs. The net benefit for all communities impacted by the *Strategy* is in the order of $204 million. Since we have monetized only a small fraction of the overall benefits, we are confident that the *Strategy* would be an economically efficient use of resources. That said, some small and very small communities show a negative net benefit, and care should be taken to implement treatment options that minimize costs and consider local environmental circumstances, such as tolerance for high loading associated with lower levels of treatment. **→ Economic impacts trigger employment and income** The spending from the *Strategy* would produce ripple or multiplier effects in the provincial economy. For Newfoundland and Labrador, the *Strategy* would likely create during the construction phase $35 million in labour income, would increase the GDP in the order of $95 million and create 1,200 direct and indirect jobs. Once the sewage plants were in operation they would have small, but an on-going impact on jobs, employment income and GDP.

Exhibit 0-2
Summary of the Implications of the *Strategy* in New Brunswick

Investments in Wastewater Facilities that Achieve the National Performance Standard would result in the following implications:

Actions and Costs	→ Environmental Benefits of the *Strategy* are Important	→ Economic benefits exceed the costs
43 facilities would be impacted by the *Strategy*. Of these, 24 are currently at a secondary level, while one is at the enhanced primary level and eight have no treatment whatsoever. The **total cost** over the 25-year life of the facilities would be in the order of *$275 million*, discounted at 4% in 2005 dollars	→ ***Reduced Total Loading*** Annually, • 3,000 tonnes of BOD • 3,620 of tonnes of TSS • 126 tonnes of Ammonia • 542 tonnes of Phosphorous discharged into receiving waters • Reduced pathogens such as *e. coli* in the order of 100% → There are *reduced Impact on Sensitive Ecosystem Components:* Lower BOD would result in: • A high level of improved dissolved oxygen for fish and other aquatic species; and, • A medium level of improved biodiversity in the aquatic environment. Lower TSS would result in a *high*: • Reduction in the blanketing of spawning grounds, improved species growth and survival, and improved migration routes; • Level of improved photosynthesis of plants growth. Lower Ammonia would result in a *medium* level of improvement in: • Health risks associated with fish and shellfish; • Health risks associated with drinking water, as well as reduced taste and odour problems; • Dissolved oxygen levels for fish and other aquatic species; • Improved biodiversity in the aquatic environment; and, • Interference with shorelines and water intakes by algae and weeds. Lower Nitrogen and Phosphorous would result in a *medium* level of • Nutrient loading • Dissolved oxygen level for fish and other aquatic species; • Improved biodiversity in the aquatic environment; and, • Interference with shorelines and water intakes by algae and weeds.	***Economic benefits are real and verifiable*** Based on the high improvement in surface water quality, it can be expected that a wide range of economic benefits will accrue to households, industry, agriculture, commercial fishers and ecosystems. The benefits listed below likely have a positive economic value and are categorized as a mix of *important* monetary benefits for the eight communities upgrading from primary to the standard, as a mix of *important* and *some* monetary benefit for the one community upgrading from enhanced primary, and a lower score of "*some*" and "*negligible*" *monetary* benefit for the 34 facilities upgrading from secondary to the standard: • Reduced human health risks associated with safer drinking water, water suitable for industrial production and irrigation and stock watering; • Reduced human health risks associated with contact recreation such as swimming and fishing, and commercial fishing such as shellfish harvesting and aquaculture; • Improved recreational opportunities and enjoyment; • Improved property values • Improved biodiversity and ecosystem functioning, including a current and future value placed on this improvement. Due to data limitations, only a small sub-set of these benefits are estimated in dollar terms. For New Brunswick, the *Strategy* is expected to *as a minimum* generate: • $440 million in value to households that value safer water, improved recreational opportunities and more intrinsic values such as improved biodiversity, for now and for future generations; • Another $255 million in property value increases attributable to improvements when adjacent surface waters are improved from raw sewage quality to a higher cleaner level under the *Strategy*. **The Net Benefit of the *Strategy* is likely positive**, indicating that the monetized benefits likely exceed the costs. The net benefit for all communities impacted by the *Strategy* is in the order of $450 million. Since we have monetized only a small fraction of the overall benefits, we are confident that the *Strategy* would be an economically efficient use of resources.

	On a scale of one to 10, with 10 indicting surface water that is drinking water quality, the *Strategy* would improve surface waters in 34 communities from a 5 to a 7. One community would improve from a 3 to a 7, while eight other communities would improve from a 2 to a 7. These scores indicate moderate surface water quality improvements.	→ ***Economic impacts trigger employment and income*** The spending from the *Strategy* would produce ripple or multiplier effects in the provincial economy. For New Brunswick, the *Strategy* would likely create $64 million in labour income during the construction phase, would increase GDP in the order of $138 million and create 2,290 direct and indirect jobs. Once the sewage plants were operation they would have small but on-going impact on jobs, employment income and GDP.

7. OBSERVATIONS AND RECOMMENDATIONS

This final section provides a number of observations and recommendations formulated in the course of developing this paper:

- First, the *Strategy* will be environmental effective given that the mass of pollutant loading will decrease and that there will be positive environmental benefits associated with improved surface water quality.

- Second, the *Strategy* is likely economically efficient, meaning that the dollar value of the benefits exceeds the dollar value of the costs. This result occurs even though we only assigned a dollar value to a partial sub-set of the benefits. That said, in some cases, notably very small communities, the high costs of new and upgraded treatment facilities coupled with the small benefits associated with small human populations means that it is likely that the net benefit could be negative. Hence, it is recommended that efforts be made to implement cost-effective treatment solutions that consider the capacity of the receiving environment to absorb sewage from a treatment system that emits below the proposed standard. The flip side of this is that in sensitive receiving waters, the non-monetized benefits will likely be large, and therefore more costly treatment options could be contemplated.

- Third, the *Strategy* will generate local jobs, income and GDP. Some portion of this positive effect on the economy will likely accrue in rural areas, and thus regional development objectives will also be accomplished under the *Strategy*.

Additional insights include:

- Upgrading small treatment plants is very expensive on a cost per tonne removed basis. Thus, efforts should be made to determine if cheaper alternatives can be used to achieve the standard or if that the receiving environment could tolerate emissions from lower cost treatment options. Given the high cost, especially for the small and very small plants, the second track EDO becomes more important for setting a standard that is lower, and considers the high costs and disproportionably low economic benefits. If other costs such as biosolid handling are included, this point becomes even more important.

- A related point is that since the costs are so high in the small and very small categories, it would be prudent to adopt a watershed based approach to seek alternative sources of cost-effective reductions from other point and non-point sources impacting surface water quality;

- In many cases significant BOD and TSS reductions are already in place, and the marginal costs of achieving the proposed standard are very high and are not highly valued by households, thus the marginal damages should be assessed to see if in fact they are cost-effective.

- We observe that there are a high number of facilities that are already at a secondary level and are at their end-of-life. This leads us to postulate that there may be some "free-riders" that would be upgrading regardless of the presence of the *Strategy*. If this is the case, then attributing the costs to the *Strategy* may not be appropriate.

- We also observe that the costs of upgrading are high, and therefore a phased approach to implementation may be required so that financial resources are not strained. If this is the case, adopting a mass loading approach would dictate that investments are targeted at large communities first. The economic analysis also supports this targeting where the monetary benefits tend to be higher in large communities since the costs are proportionally lower (due to plant economies of scale) and the benefits higher (due to income and population).

- For Newfoundland and Labrador, if a phased approach to compliance with the national standards was adopted, it is recommended that the 15 medium, large, and very large facilities be targeted first, to achieve the most significant impact in terms of loading reductions to the receiving water.

- For New Brunswick, if a phased approach to compliance with the national standards was desired, it is recommended that the 3 very large/large facilities be targeted first, to achieve the most significant impact in terms of loading reductions to the receiving water. On average, approximately 90% of the loading reductions for each of the parameters considered (BOD5, TSS, TP, and total ammonia) are expected to be attributed to these facilities.

8. BIBLIOGRAPHY

Brox, J.A., R.C. Kumar, and K.R. Stollery, *"Estimating Willingness to Pay for Improved Water Quality in the Presence of Item Nonresponse Bias"*, American Journal of Agricultural Economics, 2003, 85(2), 414-428 , 2003

Burke D, L Leigh, and V Sexton (2001) *Municipal Water Pricing 1991-1999*. Environment Canada, Environmental Economics Branch.

Dupont, D.P., *"CVM Embedding Effects When there Are Active, Potentially Active and Passive Users of Environmental Goods"*, Environmental and Resource Economics, 25, 319-341 , 2003

Environment Canada, 2001. Priority Substances List Assessment Report: Ammonia in the Aquatic Environment. Ottawa.

Environment Canada, 2001. *The State of Municipal Wastewater Effluents in Canada*. Ottawa

Sawyer, David and Gardner Pinfold (2002). "Developing a Conceptual Framework for Estimating the Benefits of MWWE and Toxics Substances Control." Report prepared for: Environment Canada – Environmental Economics Branch. March 28, 2002.

Gardner Pinfold Consulting Economists Ltd., *"Valuing the Benefits of Improving Municipal Wastewater Treatment in Canada"*, Environment Canada Dartmouth, Nova Scotia , 2005

GPI Atlantic. *The Costs and Benefits of Sewage Treatment and Source Control for Halifax Harbour*. March 2000, 62. http://www.gpiatlantic.org/pdf/water/halharbour.pdf

Johnston, Robert J., Elena Y. Besedin, Richard Iovanna, Christopher J. Miller, Ryan F. Wardwell and Matthew H. Ranson. (2005) *Systematic Variation in Willingness to Pay for Aquatic Resource Improvements and Implications for Benefit Transfer: A Meta-Analysis*, Canadian Journal of Agricultural Economics. Volume 53, Page 221 - June 2005.

Metcalf & Eddy (2003) "Wastewater Engineering". Fourth Edition. McGraw Hill.

Pearce, David, Anil Markandya and Edward B. Barbier. *Blueprint for a Green Economy*. Earthscan, London, Great Britain, 1989. 192 pp.,

Phillips, T.P. and B.A. Forster (1987). "Economic Impacts of Acid Rain on Forest, Aquatic, and Agricultural Ecosystems in Canada". American Journal of Agricultural Economics 69, no. 5, 963-969

Foster, R., *"Applying Contingent Valuation To The Saint John Harbour"*, Thesis, University of New Brunswick , 2002

Rollins, K., J. Frehs, D. Tate and O. Zachariah (1997) "Resource Valuation and Public Policy: The Case of Water Pricing", *Canadian Water Resources Journal*, 22(2), 185-196

Subhrendu, K.P., Wing, J., Depro, B., Van Houtven, G.L., De Civita, P. Steib, D. and Hubbell, B., 2002, "International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indices,"report prepared for the Economic Analysis and Evaluation Division, Health Canada

Mitchell, R.C and R.T. Carson, "Willingness to Pay for National Freshwater Quality Improvements.", Resources for the Future, Washington, D.C. 1984. , 1984

Muir, Tom (Environment Canada). 1998. "Rising Property Values on Hamilton's West Harbourfront: Effects of Environmental Restoration on Real Estate Prices". http://www.cciw.ca/glimr/data/prop-values-hamharb/intro.html

Newell, Richard G. and William A. Pizer. (2003). *Uncertain Discount Rates in Climate Policy Analysis*. *Energy Policy*, Vol. 32, No. 4. pp. 519-529. www.rff.org

Wood, K. Scott, Donald Waller, Michael Foster, June Hall and Mohammed Salah. 1996. Economic Instruments for Community-Based Water Quality Management: A Case Study of Pictou County, Nova Scotia. Environment Canada, Dartmouth, NS.

Appendix A: Valuation Approaches

ADDITIONAL REVEALLED VALUE APPLICABLE TO LOCAL WATERSHEDS

This appendix further helps to reveal the benefits story. In addition to the overall benefits listed above, there may be instances where quantification and monetization of additional benefit is possible with more site-specific information. In this section, we provide a basic overview of how to quantify and value a number of these important benefits that may be relevant in particular local cases. These benefits would be additive to the household and property value benefits discussed in the main text of the report. Exhibit A-1 provides an overview of important benefits for which it may be possible to develop localized monetary values. For each type of benefit under the total economic value framework, there are three types of valuation approaches: the Damage Function Approach, Avoided Cost, and Increased Productivity. Each is discussed in this Appendix.

Exhibit A-1
Valuation Approaches for Important Local Benefits

Uses under Total Economic Value	Valuation Approach	Valuation Concept
Drinking Water Supply	Damage Function Approach for Health	Value individuals place on reduced risk of contracting fatal and non-fatal cancer if reduced organics decreases THM in drinking water.
	Avoided Cost for Drinking Water Treatment	If chlorination can be reduced due to decreased inflow of organic matter, then chlorine cost savings can be attributed to the sewage investment.
Industrial	Avoided Cost for Water Supply	If water treatment costs can be reduced due to improved surface water quality, the value of the savings can be attributed to the sewage investment.
Agriculture	Avoided Cost for Water Supply (stock watering and irrigation)	With cleaner surface water, stock watering and irrigation may be less costly. If this is the case, where cost-savings can be demonstrated, the value of the cleaner water equals to the incremental cost of the next best alternative supply versus the new (cleaner) supply
Commercial Fishing	Increased Productivity Approach for aquaculture and shellfish harvesting	The value of improved surface water quality is equal to the value added from new opportunities. Essentially, the new areas open to harvesting or aquaculture are valued based on the new revenue less the new cost, or the value-added.

Damage Function Approach for Drinking Water

Chlorine combined with the organic matter in drinking water can produce harmful chlorination by-products[26]. A number of epidemiologic studies, including a 1995 study sponsored by Health Canada, have found a modest increase in the risk of bladder cancer among people who had drinking water that included high levels of chlorination by-products (Mills et. al. 2000). A more recent study by Villanueva et. al. (2003) observes that the best available epidemiological evidence indicates that long term consumption of chlorinated drinking water is associated with bladder cancer, particularly in men. The study also observes that the relative risk is only moderately high, but the population attributable risk could be important as the vast majority of the population of industrialised countries is potentially exposed to chlorination by-products for long time periods.

Organic matter is naturally present in raw water supplies, and is also released from industrial sources and non-point sources, such as agriculture and municipal sewage (Health Canada, 2006). While the standard practice in drinking water treatment is to use filters to reduce the concentration of organic matter prior to chlorination (and thereby reduce the precursor), health risks clearly remain. Thus, if reduced surface water contamination can be credibly linked to a reduction in chlorinated by-products, either through less organic matter in the raw water or through a reduction in the level of chlorination, then it is likely that health benefits ca be attributed to investments in STPS.

But, can this benefit be credibly quantified and monetized? Probably not, but still, there may be reason for decision-makers to be aware of this potential health benefit when contemplating sewage plant investments. Given this possible need to factor this benefit into decision-making, the following discussion provides an indication of the direction and significance of the benefit.

There appears to be a high degree of uncertainty with respect to the causal relationship between bacterial contamination, chlorination and fatal and nonfatal cancers. That said, the US EPA assessed its *1998 National Primary Drinking Water Regulations* and concluded that a monetary value associated with a reduced risk of contracting cancer could be attributed to reduced chlorinated by-products in drinking water. The following assumptions were employed in the damage function approach used in the USEPA's Regulations:

- The population at risk (or exposed) are those served by systems that disinfect drinking water with chlorine;
- 0% to 17% of all national bladder cancer cases can be attributed to chlorination in the US, which implies a per capita bladder cancer incidence rate between 0 and 3.45725E-05;
- A linear relationship exists between a reduction in chlorinated by-product concentrations and a reduction in cancer risk;
- Fatal and non-fatal cancers would be reduced and the risk reduction would be valued by individuals as the willingness-to-pay to avoid contracting fatal and non-fatal cancers.

[26] Included in this are Trihalomethanes, which are A class of chemical organic compounds that are chlorination by-products formed when organic matter naturally present in surface water reacts with the chlorine added during the disinfection process (chlorine treatment of drinking water) (Health Canada, http://www.hc-sc.gc.ca/ewh-semt/pubs/eval/handbook-guide/vol_1/appendix-annexe_e.html) .

Formally, this damage function approach can be expressed as follows:

$$B_h = P_i \cdot i_c \cdot r_r \cdot wtp_r \qquad (1)$$

Where B_h is the dollar value of risk reduction, P_i is the population exposed, i_c is the incidence rate of fatal or non fatal cancer, r_r is the risk reduction and wtp_r is the willingness to pay for the risk reduction.

Using the damage cost approach to estimate benefits associated with reduced chlorinated by-products that can be attributed to STP investments is very uncertain. That said, we will endeavour to develop a method that can be used to assess the significance of the benefit. Applying the damage function approach to the *Strategy* would require a number of assumptions such as:

- P_i *is the population exposed*. To attribute this possible benefit to investments in STPS, there is a need to first link the sewage outfall to the drinking water intake. If this can be credibly demonstrated, then it is likely that some health risk may be present. If this is the case, then the population incidence rate can be attributed to the local population served by the drinking water supply;

- i_c *is the incidence rate of fatal or non fatal cancer*. The Canadian Cancer Society (2006) forecasts 6,400 new bladder cancer cases and 1,700 bladder cancers deaths in Canada in 2006. Using the incident rate attributable to chlorinated by-products in drinking water from the USEPA study (0% to 17%) implies new cancer cases could be in the range of 0 to 1,088 per year. Alternatively, applying the incidence rates from the US (0 and 3.45725E-05) to the Canadian population in 2006 (32,422,919) implies a population impact of 0 to 1,121 new cancer cases;

- r_r *is the risk reduction*. Some assumed risk reduction in the incidence rate would have to be made with respect to exposure to THM. In general, it can be expected that the THM concentration in finished water will decrease with decreased chlorine dosage and colour. Since we are demonstrating that there may be value in reducing THM exposure, we can assume some ranges for illustrative purposes. For example, assuming a 25% reduction would imply a 25% reduction in the number of fatal (deaths) and non-fatal cancer cases.

- wtp_r is the willingness to pay for the risk reduction. Studies in Canada have shown that Canadians value a reduction in the risk of fatal cancer to be in the order of $5.1 million per year, with the risk of non-fatal cancer cases being in the order of 10% of this value.[27]

To illustrate this benefit, assume a community that has a drinking water supply system serving 10,000 people. Further assume that it can be shown that the new or upgraded facility can reduce the THM concentrations in the order of 25%. This implies the following:

---

[27] See the Air Quality Valuation Model report by the Royal Society of Canada for detailed elaboration on these values an the associated background. http://www.rsc.ca//index.php?lang_id=1&page_id=118

			With Reduced Organics	
		Logic	Low	High
a.	Population (assumed)		10,000	
b.	Incidence Rate for Population		0	3.45725E-05
c.	Population exposed =	a * b	0	0.345725
d.	25% Reduction in THM Exposure on Population with Strategy (assumed) =	c * d (25%)	0	0.086431
e.	Fatal Cases (1,700/6,400)		0	0.022958
f.	Non Fatal Cases (4,700/6,400)		0	0.063473
g.	Annual Value Fatal Case (millions$)		$5.1 million	
h.	Annual Value Non-fatal (millions$)		$0.51 million	
i.	Estimated Annual Value Fatal Case (millions$) =	e * g	$0	$117,087
j.	Estimated Annual Value Non-fatal (millions$) =	f * h	$0	$32,371
k.	Resulting Annual Value @ 25% reduction in THM =	I + j	$0	$149,458

We can then say that the annual benefit of a 25% reduction in THM could be in the order of zero to 150,000 annually, with a central average of $75,000. While this example is purely hypothetical it does demonstrate that there may be an important source of benefit available to communities that have improved surface water quality leading to reduced organics in drinking water supplies.

Avoided Costs for Industrial and Agriculture

If an enterprise is paying for water as an input into a production process, the cost of water intake can be used as an estimate of the value of water. This implies that if cleaner surface water lowers water treatment and supply costs, then a benefit is available for attribution to the *Strategy* (or the sewage investment). This indicator measures the lower bound of water since the value of water must be at least equal to its cost. Even if the price of water was accurately estimated using this method, the cost of water only represents what the user does pay, and not what the user would be *willing to pay*.[28]

To measure this benefit, water supply and treatment production costs must first be benchmarked before the sewage investment and then the reduction in costs established with the *Strategy*. The value is simply the cost difference before and after the investment.

Increased Productivity for Commercial Fisheries

There are two types of commercial fisheries' benefits that are possible: commercial fin-fisheries and shellfisheries. In both cases it is the disinfection of wastewater that will likely result in improved conditions for commercial activities where reduced faecal counts will enable shellfish harvesting or open new areas to finfish culture.

[28] Gardner Pinfold Consulting Economists. *Monitoring the Value of Natural Capital: Water*. Environment Canada and Statistics Canada. 2001. Contract K0821-1-0023.

In both cases if it can be shown that the Strategy improves surface water quality and improves finfish or shellfish opportunities, it is plausible that a positive economic benefit will result. How is value quantified?

- **Shellfish**: First use information on shellfish closures, which can be attributed to municipal sewage to estimate costs of sewage (potential benefits of control). Critical variables required are an estimate of the closed area (i.e. ha) due to sewage and the productivity of the closed areas (i.e. standing stock per ha). Then, the market value of the harvest would be calculated as the harvest opened due to the *Strategy*, multiplied by the sustainable harvest rate (some portion of the standing stock), multiplied by the market price of the harvested catch. We then need to net out the costs of harvest, given that to obtain the value of the "with *Strategy*" allowable harvest required, we must expend resources (labour and materials) to gain a benefit (shellfish) harvest. So, the costs of harvesting must be obtained and then subtracted from the overall harvest so that an accurate estimation of the shellfish value is obtained.

- **Aquaculture Potential**: A value here is triggered if the reduced faecal loading attributable to the *Strategy* results in additional aquaculture potential. If it is determined that new aquaculture opportunities could result from the new or upgraded wastewater plant, the estimation of value is fairly simple. First, the new area of aquaculture potential is first determined using information that assesses suitable habitat (depth being the primary criterion). The estimate of new potential should be made on a unit basis such as the number of hectares of increased potential. Then a value-added estimate would be developed and assigned to the number of units of new potential. As with shellfish the value-added would simply be revenues minus costs. The total value of the new potential would then be the units of new potential (number of hectares) multiplied by the average value-added on a per unit basis (value-added per hectare of production)