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Canadian Water Sustainability Index (CWSI)

Project Report

February 2007

PRI Project
Sustainable Development

Canada

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- Environment Canada; and
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- Tsuu T'ina First Nation, Alberta;
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- Rural Municipality of Gimli, Manitoba; and
- Moose Cree Nation, Ontario.

About this Report

The PRI contributes to the Government of Canada's medium-term policy planning by conducting cross-cutting research projects, and by harnessing knowledge and expertise from within the federal government and from universities and research organizations. However, conclusions and proposals contained in PRI reports do not necessarily represent the views of the Government of Canada or participating departments and agencies.

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1. Executive Summary

The Policy Research Initiative (PRI) has developed and tested a composite water index for evaluating the well-being of Canadian communities with respect to fresh water. This index, known as the Canadian Water Sustainability Index (CWSI), integrates a range of water-related data and information into a series of indicators. Together the indicators provide a holistic profile of a community's key water issues, allowing for intra-community and inter-community comparison and analysis.

To evaluate a community's water well-being using the CWSI, scores ranging from 0 to 100 are calculated for each indicator. The fifteen indicators are evenly grouped into five policy-based components:

- Resource;
- Ecosystem Health;
- Infrastructure;
- Human Health and Well-being; and
- Capacity.

The five component scores are determined by averaging the three indicators under each component. The composite CWSI score is the average of the five component scores. The higher a community's CWSI score, the better positioned it is to enjoy and maintain the ecological, socio-economic, and health benefits associated with fresh water.

The CWSI was field tested in six community case studies. These case studies and the community workshop that followed them were very successful in gauging the usefulness and practicality of the index, in particular the fifteen indicators. Overall, the communities expressed interest in the CWSI and in seeing the tool being further developed and implemented. They also suggested further refinements to certain elements of the index.

The field testing process and results allowed us to identify challenges related to data availability, the geographic scale of some existing data, such as watershed level or community level, and the relevance of certain indicators. In response to these challenges, the consultants and, in particular, the communities provided valuable feedback and suggestions to improve the CWSI. The communities also provided feedback on the process of populating and calculating the index, specifically on the commitment of time and personnel.

In general, communities were very receptive to the CWSI and identified a number of uses and applications for the index:

- to inform planning decisions and activities related to water and waste water infrastructure, such as exploring water storage options and training operators;
- to inform land-use planning, particularly zoning for water-intensive industries;
- in approaching governments for funding;
- as a communications tool to verify or discredit existing speculation in the community on a number of water issues, particularly quality and quantity;
- to educate residents on the state of water well-being in their communities and comparisons to other communities across the country;
- to market the community's potential to prospective developers and industries, including water intensive industries; and
- to identify areas for research.

Participants also felt that the index could be extremely useful if applied by communities in the same region or relying on the same water source. Communities could then compare their scores, simultaneously acquiring a general understanding of the state of their area and their collective ability to address water sustainability on a regional level.

Federal departments have indicated that they could foresee using such a tool to inform funding decisions.

The CWSI needs further refinement and development, but holds clear potential for use by all levels of government in Canada.

2. Introduction

Canada relies on fresh water to safeguard the health and well-being of its citizens, sustain healthy aquatic and terrestrial environments, provide ecological services, and support a competitive economy. Canada is fortunate to have an abundance of fresh water resources with 20 per cent of the world's fresh water, almost half of which is renewable.[1] Nevertheless, parts of the country are threatened by poor water quality, water shortages, and accessibility issues due to some shortcoming in the overall water system.

The community is the appropriate scale to assess key water issues. A clean and plentiful fresh water resource is a vital contributor to the well-being of Canadians and many of the health, ecological, economic, and cultural benefits fresh water can provide are directly experienced in our communities. The water we use in our homes comes from the ground water beneath us or from the rivers and lakes nearby. Many rural and remote communities depend on farms and industries that rely on water to prosper. Our aquatic ecosystems also provide places to recreate and sustain species that are both culturally and economically important. When these benefits are compromised, most often, it is the community that suffers and actions required to address shortcomings, whether locally, provincially, or nationally instigated, are often implemented at the community level.

The Canadian Water Sustainability Index (CWSI) is a composite index that evaluates the well-being of Canadian communities with respect to fresh water. It integrates a range of water-related data and information into a series of indicators that together provide a holistic profile of a community's key water issues, allowing analysis both in a community and between communities. The key water issues addressed by the indicators fall into the following broad policy categories:

- Fresh Water Resources;
- Ecosystem Health;
- Water Infrastructure;
- Human Health and Well-being; and
- Community Capacity.

CWSI results reflect the community's water sustainability. The higher a community's CWSI score, the better positioned it is to enjoy and maintain the ecological, socio-economic, and health benefits associated with fresh water. The results have a range of applications and practical uses for different groups, including the general public, community leaders, policy makers, water managers, and other interested stakeholders. The CWSI can contribute to:

- Raising awareness of the overall state of fresh water in Canadian communities;
- A transparent and standardized means of comparing the state of fresh water in different types of communities (e.g., First Nation and non-First Nation communities);
- Monitoring progress towards integrated water resources management;
- Identifying priority communities where well-being is compromised by fresh water issues;
- Setting fresh water priorities in a community (e.g., drinking water, infrastructure);
- Targeting investments to specific communities or specific needs in a community;
- Focusing efforts and attention on areas in need of improvement; and
- Compiling community-based data and information on a range of fresh water issues.

This report provides a detailed look at the CWSI framework and the methodology by which communities are evaluated in the framework. The report also presents case study results, their implications for future development of the CWSI, and considerations regarding the use of this index as a policy tool. Background is also provided to outline the history of the CWSI project and its different phases of development.

Although the Policy Research Initiative has no plans to conduct further work on the CWSI at this time, this report points to the way for others to further develop and implement the Index.

3. Background

The Policy Research Initiative (PRI) began working on the Canadian Water Sustainability Index (CWSI) project in the summer of 2005 with the purpose of developing a composite water index that captures a multitude of fresh water indicators reflecting water well-being at the community level. Inspired by the Water Poverty Index (WPI), the CWSI attempts to integrate physical, environmental, and socio-economic aspects of water and water management in a relevant context for Canadians and Canada's natural circumstances.

The WPI was developed by the Centre for Ecology and Hydrology (CEH) in the United Kingdom to provide an integrated assessment of water stress and scarcity, linking physical estimates of water availability with socio-economic variables reflecting poverty.[2] The index was partly developed in response to the United Nations Millennium Development Goals addressing poverty and water access[3] as a means for monitoring progress and prioritizing water needs. In addition to allowing comparisons between nations and communities, the WPI can provide a better understanding of the relationship between the status of water issues and community welfare by examining theme-based sub-indices. Although designed for use at the community level, national WPIs were estimated for a preliminary international comparison.[4] In this study, out of 147 countries,[5] Canada had the second best WPI after Finland.

Canada clearly does not face the same water poverty challenges as the rest of the world, particularly developing countries in Africa and parts of Asia, and the implications of poor water access and availability are not nearly as severe. Nevertheless, Canada does experience regional and community level disparities in water sustainability that can compromise a community's welfare. The term 'water sustainability' is used here to express the sustainability of fresh water benefits in a community, including essential services such as clean drinking water, for ecological, cultural, and economic benefits. It is used, in part, to emphasize the future-oriented nature of the tool.

The CWSI is offered as a modified WPI to examine water-related issues relevant to Canada with particular emphasis on rural and remote communities, including Aboriginal communities, where many of the water concerns in Canada occur.

Water Poverty in Canada?

Many of the water concerns in Canada occur in rural and remote communities, including First Nation and Inuit communities, where the benefits associated with water quality, access, and availability are threatened. For example:

- Agricultural regions in southern Alberta, Saskatchewan and Manitoba, where irrigation is the largest consumer of water, are experiencing high levels of water stress, with more than 40 per cent of the available renewable water in the watershed consumed for industrial, agricultural, or personal uses.[6]
- Health Canada conservatively estimates the health costs associated with waterborne illness to be about $200 million per year.[7]
- The 1999 reported rate of shigellosis among First Nations communities was almost 20 times that of the overall Canadian rate. Sustained transmission occurs in many communities, either person to person by the fecal-oral route, or indirectly from ingestion of contaminated food or water. Transmission is amplified when water supply is inadequate for regular daily hand washing with soap or if housing is overcrowded.[8]
- Only 41.4 per cent of First Nations and Inuit communities reported that at least 90 per cent of their homes had piping to centralized water treatment plants in 1999.[9]
- In 1999, 65 First Nations and Inuit communities were under boil water advisories for varying lengths of time, an average of 183 days of boil water advisory per affected community per year.[10]

The CWSI project consisted of several iterative elements, described below:

Discussion Document

A preliminary discussion document intended to initiate research and discussion was prepared early in the project.[11] The paper outlined the key elements of the water poverty index to provide a context for the type of tool to be designed. The paper also discussed considerations for building a composite index as well as a draft conceptual framework for a Canadian water index. The proposed CWSI was similar in structure to the WPI but modified to be more suited to the Canadian context.

Data Study

The draft framework presented in the discussion paper was used to support a data study conducted by Tri-Star Environmental Consulting.[12] The purpose of the data study was to assess the availability of data for several variables under consideration for incorporation into a composite water index. The study focused primarily on national data sets as well as some data collected by the provinces. In addition to identifying issue-based data gaps, the report also indicated geographical data gaps.

Expert Workshop

In November 2005, a two-day workshop was held to discuss the CWSI (see Appendix 1). Informed by the discussion document, the data study and a handful of presentations, water and indicator experts weighed in on elements to be incorporated in a composite water index. Opinions differed to some degree on the scope of variables to be addressed by the CWSI. While many felt it was important to have a range of indicators that reflect the integrated nature of water resources, some felt it important to "keep it simple", that the index should be restricted to the quality and quantity indicators likely to be the most critical in the largest number of communities.

Index Development

Outcomes from the data study, expert workshop, and other sources were used to revise the index framework and develop an evaluation methodology wherein calculations were formulated for a series of indicators. The framework and methodology presented chapters 4 and 5 were developed to field test the index.

Field Testing

The Centre for Indigenous Environmental Resources (CIER) was hired to conduct a field test of the CWSI to assess its applicability and usefulness in a range of Canadian communities.[13] Six case studies were conducted as part of this field test. The six communities, three of which were First Nations communities, spanned five provinces and each had a population of less than roughly 5,000 people or less. Findings from the field test are presented and discussed in this report.

Community Workshop

A small workshop was held in Ottawa in August 2006 to allow for the communities participating in the field testing exercise to meet with officials from partnering federal departments. The workshop gave officials a chance to receive feedback from the communities on the CWSI process and framework and to address some of the issues that came up during the field test (see Appendix 2).

4. CWSI Framework

The CWSI is a composite index consisting of five theme-based components. The score for the final index is equal to the average score of the five components, wherein a component score is equal to the average of the three indicators in that specific policy category. This nesting structure, typical of composite indices, is illustrated in the table below.

Each of the fifteen indicators is assigned a score between 0 and 100. The higher the score, the closer the community is to having the ideal conditions for that given indicator. The scores are based on a standardized evaluation scheme presented in the following chapter wherein the indicators are measured against a benchmark or target. This varies from some other composite index models where scores are determined based on the relative rankings of the administrative units being assessed.

The benchmark/target approach increases the relevancy of the results, as a community's score is not linked to the performance of other communities, but rather to its status relative to acceptable conditions and standards for water well-being. This also makes the CWSI results more meaningful from year to year. Although inter-community comparisons will be an important application of the CWSI, the benchmark approach adds to the tool's flexibility as it allows for individual community assessments to be conducted independently of a provincial or national level study.

The individual indicator scores form the basis for the broader CWSI and need to be carefully selected. There were several considerations associated with index selection and the development of a CWSI framework suitable for initial field testing. Among the main considerations were scope, scale, applicability, relevancy, data, and scoring.

	Component	Indicator	Description
Canadian Water Sustainability Index	Resource	Availability	The amount of renewable fresh water that is available per person
		Supply	The vulnerability of the supply as caused by seasonal variations and/or depleting ground water resources
		Demand	The level of demand for water use based on water license allocations
	Ecosystem Health	Stress	The amount of water that is removed from the ecosystem
		Quality	The Water Quality Index score for the protection of aquatic life
		Fish	Population trends for economically and culturally significant fish species
	Infrastructure	Demand	How long before the capacity of water and waste water services will be exceeded due to population growth
		Condition	The physical condition of water mains and sewers as reflected by system losses
		Treatment	The level of waste water treatment
	Human Health	Access	The amount of potable water that is accessible per person
		Reliability	The number of service disruption days per person
		Impact	The number of waterborne illness incidences
	Capacity	Financial	The financial capacity of the community to manage water resources and respond to local challenges
		Education	The human capacity of the community to manage water resources and address local water issues
		Training	The level of training that water and waste water operators have received

Scope

The nature of a composite index allows for a broad spectrum of issues to be addressed in one measure. A composite water index incorporates a wide range of potential variables given the many dimensions of water and water-related activities that are of interest to communities. In defining the reach of a composite water index, it is therefore important to negotiate the tradeoffs between narrowing and broadening the scope. For example, an index that is limited to physical measures of quantity and quality would exclude many of the socioeconomic and municipal service concerns of interest to communities and would, largely, go against the integrated nature of water resources. Conversely, an index that attempts to capture too much information could increase complexity and create problems in meeting excessive data requirements. Much of the discussion at the expert workshop focused on the debate between these two opposing perspectives. The CWSI is believed to fall somewhere in the middle of the debate with a framework that reflects the integrated nature of water resources while restricting the number of indicators and data requirements to a manageable level.

Scale

When assessing water indicators, the issue of scale is always an important consideration because it is difficult to assess elements at the community level in isolation from the broader river basin or watershed where the community is located. Often, the condition of the resource at one location is affected by or affects conditions elsewhere. In order to address the issues associated with scale, indicators dealing with matters that do not fall within the control of the community, specifically indicators relating to the physical availability of the resource and ecosystem health, are assessed at the river basin scale. That means the data needs for such indicators are collected at the scale of the river basin. All remaining indicators that measure elements unique to the community are based on community-level data.

Applicability

Applicability refers to the extent to which the index indicators apply to a wide range of Canadian communities. Ideally, all of the indicators will be generic enough to be measurable in all communities yet specific enough to be meaningful. As an example, indicators relating to specific uses of water, such as irrigation and beach closures, should be avoided as they may not be meaningful to most communities. The challenge, then, is to incorporate the concerns associated with such uses as consumption and safety into other indicators that are more widely applicable.

Relevancy

One of the primary objectives in populating the CWSI was to select indicators that would be relevant and meaningful to communities and community planners. Community feedback provided crucial insight into the usefulness of each indicator.

Data

The ability to obtain and/or collect data for the indicators is perhaps the most important consideration and ultimately decides the make-up of the index. Even if an indicator is considered to be very meaningful and important, its use is limited by data availability. In developing the trial index, several indicators have been constructed to rely on data collected by federal agencies, such as Statistics Canada and the Water Survey of Canada. Other indicators are designed to use data that is assumed to be collected and/or obtainable in the communities. The field testing provided insight into whether the assumptions were correct.

Scoring

In order to determine a value or measure for a community using the index, a means of scoring for each indicator and, in turn, the final index is required. With respect to the CWSI, each indicator is scored on a scale of 0 to 100. Therefore, it is necessary to have benchmarks or baseline data to establish a context in which to allocate a score for each indicator. Data and/or information for which there is no context to evaluate is thus not appropriate for inclusion into a composite index of this nature.

5. CWSI Evaluation Methodology

This chapter presents the methodology used in the field test for evaluating water sustainability and well-being in Canadian communities. The methodology consists of calculations for each of the 15 indicators that form the basis of the CWSI. The calculations are grouped according to their respective issue-based components.

5.1 Resource

The Resource component is evaluated at the scale of the river basin and scores the natural endowment of fresh water, whether the resource can reliably meet the needs of the community. The three indicators assess the amount of renewable fresh water available (AVAILABILITY), how variable the supply is (SUPPLY), and the current level of demand for the resource (DEMAND). Both surface water and ground water can be considered depending on the sources of water that are used or could be used in serving the community. For the Resource component, variables will be measured at the river basin scale.

5.1.1 Availability

This indicator looks at the annual amount of renewable fresh water available on a per capita basis (m^3/cap/yr). Depending on the community, renewable water can be measured using the average annual stream flow and/or the sustainable ground water yield. The Falkenmark water stress indicator is used as a benchmark for whether domestic, economic and ecosystem water needs can be met from a quantitative perspective.[14]

According to Falkenmark, 1700 m^3/cap/yr can meet the water requirements of the community whereas anything less than this amount can cause problems in reliability, economic development, and meeting basic human needs as seen below:

> 1700	Water shortages occur only irregularly or locally
1000 – 1700	Water stress appears regularly
500 – 1000	Water scarcity is a limitation to economic development and human health and well-being
< 500	Water availability is a main constraint to life

The parameters outlined by Falkenmark are used as benchmarks for evaluating the availability of renewable fresh water where a score of 100 is assigned to any value over 1700 m^3/cap/yr and a score of 0 is assigned to any value below 500 m^3/cap/yr. A community score for this indicator (R_A) is thus calculated using the following equation:

Indicator Score (R_A):

$$R_A = \frac{(T_{cap} - 500)}{(1700 - 500)} \times 100$$

Where: T_{cap} = total renewable water resources per capita (m^3/cap/year)

If $T_{cap} > 1700$, then $R_A = 100$
If $T_{cap} < 500$, then $R_A = 0$

To determine the total renewable water resource, use the average annual stream flow, the sustainable ground water yield or both, depending on the water resources in the river basin.

5.1.2 Supply

This indicator serves as a proxy for the vulnerability of the community's fresh water supply by looking at the variability of surface water flows and/or the trends in ground water reserves. Highly variable surface flows can have implications for the reliability of the water supply for both economic and domestic uses. Gleick (1990) established the water run-off ratio to assess the extent to which surface flows vary.[15] This ratio can also act as an indication of the community's vulnerability to drought and flood. The ratio is calculated by dividing the run-off that is exceeded 5 per cent of the year by the run-off exceeded 95 per cent of the year. The lower the ratio, the less variability there is in surface flows. According to Gleick, a value greater than 3 indicates vulnerability. To evaluate surface flow variability (R_{SS}) for the CWSI, a run-off ratio (x) of 1 is equal to a score of 100, 3 is equal to a score of 50, and 5 is equal to a score of 0. The community's score is calculated using the following equation:

$$R_{SS} = \left(1 - \frac{(x-1)}{(5-1)}\right) \times 100$$

Where: x = run-off ratio

If $x < 1$, then $R_{SS} = 100$
If $x > 5$, then $R_{SS} = 0$
If $5 > x > 1$, then calculate R_{SS} using above formula

If run-off data is unavailable, then stream flow data can be used as a surrogate.

The vulnerability of the ground water supply (R_{SG}) is based on the general trends observed in community wells. The Government of Alberta uses ground water trends as a water indicator by determining how many wells are exhibiting rising levels, how many are exhibiting no change, and how many are exhibiting declining levels.[16] The same approach is used for the CWSI. To calculate a score, factors of 1, 0.5, and 0 are assigned to rising, no change, and declining observations respectively using the following equation:

$$R_{SG} = (r + 0.5n) \times 100$$

Where: r = % of wells with rising water levels
n = % of wells with no change in water level

Water levels will change from day to day so this equation should consider the overall trend over a period of a year or longer.

If a community depends entirely or primarily on surface water (or ground water), R_{SS} (or R_{SG}) is used as a resource indicator for supply. If both sources of water are important, a weighted average is used to arrive at a final score based on the percentage of supply derived from surface or ground water sources. For example if 60 per cent of a community's water supply is derived from surface water and the rest from ground water, the supply score (R_S) can be calculated as follows:

$$R_S = 0.6R_{SS} + 0.4R_{SG}$$

5.1.3 Demand

This indicator assesses the demand for water in the river basin by looking at the amount of water allocated through water licenses. Water licenses are issued for a variety of water uses, including irrigation, industrial processing, and municipal uses. The amount of allocated water is the maximum amount of water that can be used but does not necessarily reflect the actual amount of water use. High levels of demand can have implications for the sustainable use of water for economic purposes and uses in growing municipalities.

To evaluate the demand on the resource (R_D), the amount of water annually allocated is evaluated relative to the total amount of renewable fresh water (T), where 100 per cent allocation is equal to a score of 0 and 0 per cent allocation is equal to a score of 100. The following equation is therefore used to calculate R_D:

$$R_D = \left(1 - \frac{a}{T}\right) \times 100$$

Where: a = amount of water allocated (m^3/year)
T = total renewable water resources (m^3/year)

If $a/T \geq 1$, then $R_D = 0$

If T consists of both surface and ground water, then allocations of both surface and ground water are considered. If information is only available for surface water (or ground water) allocations, then T should only consider surface water (or ground water).

5.2 Ecosystem Health

This component is evaluated at the river basin scale, examining the health of the river basin's aquatic ecosystems with indicators of the pressures imposed on the ecosystem (STRESS), its current condition for the protection of aquatic life (QUALITY), and the resulting impacts, if any, on the fish species that are economically and/or culturally important to the community (FISH).

5.2.1 Stress

The STRESS indicator is intended to reflect the types of pressures imposed on the ecosystem. An ecosystem can become stressed from pollution as well as excessive water use. The QUALITY indicator addressed below measures the state of the water quality, focusing on water quantity by measuring the amount of surface water removed and consumed from the system.

To score this indicator, the annual amount of water consumed is assessed relative to the total annual renewable surface flows. According to the OECD, 60 per cent of renewable water flows is required to maintain a healthy, functioning ecosystem[17] and, thus, in scoring this ecosystem stress indicator (E_S), a rate of consumption greater or equal to 40 per cent is assigned a score of 0.

$$E_S = \frac{0.4 - c/T_{sur}}{0.4} \times 100$$

Where: c = annual amount of water consumed (m^3·year)
T_{sur} = total annual renewable surface flow (m^3/year)

If $c/T_{sur} > 0.4$, then $E_S = 0$
If $c/T_{sur} = 0$, then $E_S = 100$
If $0.4 > c/T_{sur} > 0$, then use the above equation to solve for E_S

This indicator is not only relevant for the health of the ecosystem but for the sustainable use of water in the community.

5.2.2 Water Quality

For this indicator, the CWSI relies on the Water Quality Index (WQI), an existing tool that assesses the quality of the water with respect to the protection of aquatic life. The WQI assesses surface water quality based on the scope, frequency, and amplitude of water quality observations relative to the guidelines for protecting aquatic life. Quality guidelines for a range of nutrients, metals, physical characteristics, ions, and organic compounds are incorporated into the WQI calculations.

The WQI has been calculated for 345 sites in Canada, 19 on lakes and 326 on rivers, across the country where extensive water quality monitoring occurs. More monitoring sites are to be added over the next four years to generate the data necessary for determining the WQI. The WQI is quantified on a scale of 0, indicating poor quality, to 100, indicating excellent quality, and thus the WQI results can be directly integrated into the CWSI scoring scheme. Please refer to the Canadian Council of Ministers of the Environment web site for further information on the WQI.[18]

5.2.3 Fish

Many Canadian communities are engaged in fishing activities be it for commercial sales, recreation, or subsistence. Such activities are highly dependent on a healthy ecosystem that can support strong fish populations. This indicator reflects the health of native fish species that are economically and culturally important to a community. Thus, those species that are commercially harvested, fished recreationally, and/or represent a significant portion of a traditional diet are accounted.

This indicator could also reflect ecosystem health and the sustainability of the fishing activities. For example, if the STRESS and QUALITY scores are high yet fish populations are declining, the problems may be associated with poor stock management.

The score for this indicator (E_F) is calculated by assigning factors of 1, 0.5, or 0 to the percentage of economic and/or culturally significant species whose populations are believed to be increasing, stable or declining respectively. Exact population numbers are not required for this indicator; anecdotal observations are sufficient.

$$E_F = (i + 0.5s) \times 100$$

Where: i = % of culturally or economically significant fish populations that are increasing
s = % of culturally or economically significant fish populations that are stable

5.3 Infrastructure

The Infrastructure component looks at the state of the water and waste water infrastructure in the community by measuring its ability to meet future demand (DEMAND), its condition (CONDITION), and the level of treatment that it provides (TREATMENT).

5.3.1 Demand

This indicator assesses the ability of the community's water infrastructure to meet future demand by measuring the number of years before 100 per cent system capacity is reached (t_{100}). A change in demand is an important consideration as it can provide an indication of when, and if, system upgrades or new facilities are needed. To solve for t_{100}, the following equation can be used:

$$t_{100} = \frac{\log FV - \log PV}{\log(1 + r)}$$

Where: FV = number of people that can be served at 100% capacity of existing system*
PV = number of people currently being served by existing system
r = annual rate of population growth

**A constant per capita water use is assumed; however, significant known trends can be factored in.*

The value of t_{100} is calculated for both the water and waste water systems. If population growth is negative, the score for infrastructure demand (I_D) is 100, as the demand on the system will be decreasing. When population growth is positive, any community that has a value for t_{100} equal to or greater than 50 (i.e., 50 or more years until 100 per cent capacity is reached) has a score of 100 and a community with a t_{100} of 0 (i.e., system is already operating at 100 per cent capacity) receives a score of 0. The following equation can therefore be used to calculate I_D:

$$I_D = \frac{t_{100}}{50} \times 100$$

If $t_{100} \geq 50$, then $I_D = 100$
If $t_{100} = 0$, then $I_D = 0$
If $50 > t_{100} > 0$, then calculate I_D using the above equation

I_D is calculated for both water and waste water systems and the lowest score is used.

5.3.2 Condition

This indicator measures the condition of the water and waste water infrastructure by looking at the percentage of system losses in the water and/or waste water mains. This not only provides a measure of system inefficiencies but also an indication of the level of repair needed and, in the case of waste water losses, the extent to which untreated effluent is released to the environment.

The following equation is used to calculate a score for the infrastructure condition indicator (I_C), where 25 per cent system loss or greater receives a score of 0 and 0 per cent system loss receives a score of 100.[19]

$$I_C = 100 - \left(\frac{L}{25} \times 100\right)$$

Where: L = % system losses

If $L \geq 25$, then $I_C = 0$
If $L = 0$, then $I_C = 100$

System losses (L) are determined for both water mains and sewers. The system with the highest percentage of losses is used to calculate I_C.

5.3.3 Treatment

The TREATMENT indicator focuses solely on waste water treatment plants. The quality of drinking water is addressed in the Human Health component. The degree to which waste water will affect receiving waters depends on the level of treatment it receives prior to discharge. There are three levels of waste water treatment: primary, secondary and tertiary. Primary treatment only removes insoluble matter. Secondary treatment removes insoluble matter and biological impurities. Tertiary treatment is the highest level of treatment where nutrients and chemical contaminants are removed after secondary treatment.

To determine a score for the infrastructure treatment indicator (I_T), the population connected to municipal sewers is assessed depending on the level of waste water treatment it receives. The percent of the population served by sewers without treatment, primary treatment, secondary treatment, or tertiary treatment is multiplied by the following factors:

None	0
Primary	1/3
Secondary*	2/3
Tertiary	1

**Waste stabilization ponds and sewage lagoons fall in this category as well.*

The equation below is used to determine a community's I_T score:

$$I_T = (1/3P + 2/3S + T) \times 100$$

Where: P equals % of population connected to sewers that receive primary treatment
S equals % of population connected to sewers that receive secondary treatment
T equals % of population connected to sewers that receive tertiary treatment

People who use septic tanks or are otherwise not serviced by municipal sewers are not accounted for in this measure.

5.4 Human Health

The Human Health component of the CWSI looks at three issues directly related to the health and well-being of Canadians. Specifically, the component looks at the amount of potable water available per person (ACCESS), how reliable the water supply is (RELIABILITY), and to what extent the health of Canadians is compromised by poor drinking water quality (IMPACT).

5.4.1 Access

This indicator looks at how much potable water is normally available per person, with the exception of service disruptions, as a measure of whether basic domestic needs are being met. The amount of potable water people can access provides an indicator of how much water is available for potential use, whereas actual use is, in many cases, dependant on behaviour and can capture wasteful use in excess of basic human needs. Water supplied by municipal infrastructure, water trucks, and domestic wells can be included.

There are several assessments in the literature regarding adequate amounts of water for daily personal use, all of which fall well below average daily water use for Canada. There are, however, some Canadian communities that record average daily uses below some of the recognized benchmarks.

According to Shiklomanov (1997), 150-250L per capita per day satisfies all personal requirements such as drinking, cleaning, and bathing.[20] This benchmark, one of the highest, will be used here as it represents a range that complements Canada's position as a developed nation with a high quality of life. Thus, to evaluate the access indicator (H_A), the amount of accessible potable water available for domestic use is compared to this benchmark, where communities that have access to at least 150L/cap/day receive a score of 100. At the lower end, anything equal to or below 50L/cap/day receives a score of 0. The following equation can therefore be used to calculate H_A:

$$H_A = 100 - \left(\frac{150 - y}{150 - 50} \times 100 \right)$$

Where: y = amount of accessible potable water available per person per day (L/cap/day)

If $y \geq 150$, then $H_A = 100$
If $y \leq 50$, then $H_A = 0$
If $150 > y > 50$, the calculate H_A using the above equation

5.4.2 Reliability

When a community is subject to service disruptions, the supply is considered to be unreliable. This indicator is intended to reflect the reliability of a community's water supply by looking at the number of days water service is interrupted by a loss of service, a boil water advisory, or other form of drinking water ban or warning. Loss of service, boil water advisories, or other drinking water warnings are typically issued when there is a concern about water quality brought on by any number of reasons, including contamination, infrastructure problems, or even human error.

To determine a score for this indicator, the number of service disruption days per capita per year is assessed. The total number of service disruption days (*SDD*) per capita is calculated using the following equation. The maximum value for *SDD* is 365, meaning that every person in the community is subject to a service disruption for the entire year.

$$SDD = \frac{\sum_{i=1}^{N} (p_i + d_i)}{pop}$$

Where: SDD = service disruption days measured per capita
N = number of service disruptions experienced in a year
p_i = the number of people affected by service disruption
d_i = the duration of the service disruption i in days
pop = total population

To arrive at a score for the reliability indicator (H_R), the following equation is used:

$$H_R = \left(1 - \frac{SDD}{365}\right)^3 \times 100$$

Although 365 is the maximum value for *SDD*, 50 service disruption days is still considered to be a very significant problem, despite 315 days with reliable water. For this reason, the inverse percentage is cubed so *SDD* values that pose a significant concern are not rewarded with high scores.

5.4.3 Impacts

This indicator assesses the health impacts associated with insufficient water quality and/or quantity. Waterborne diseases such as Giardiasis, Campylobacteriosis, Shigellosis, and illnesses caused by *Escherichia coli*, affect thousands of Canadians each year.[21] To evaluate this Human Health Impact indicator (H_I), the number of reported cases of waterborne diseases and illnesses (w) is used.

To determine an H_I score, the number of water disease and illness incidents per 1000 people is factored into the following equation, where a score of 100 corresponds to 0 incidents and a score of 0 corresponds to 1 or more incidents occurring for every 1000 people.

$$H_I = (1 - w) \times 100$$

Where: w = number of reported waterborne disease and illness cases/1000 people.

If $w = 0$, then $H_I = 100$
If $w \geq 1$, then $H_I = 0$

5.5 Capacity

This component measures the capacity of the community to manage their water resources safely and effectively by looking at financial capacity (FINANCIAL), education (EDUCATION), and the number of trained operators working in water and waste water treatment plants (TRAINING). This component is important because it outlines the socioeconomic resources available in the community to manage their fresh water resources on a daily basis, respond to issues that arise, implement policies and programs, and recognize potential or existing problems.

5.5.1 Financial

To examine the financial capacity of a community, the local government's per capita surplus or excess of revenues over expenditures is assessed relative to minimum and maximum levels across the country. Statistics Canada collects and compiles this data at the provincial/territorial level.[22] In 2002, local governments in Saskatchewan averaged the highest per capita surplus of $863 per person (+863). Conversely, local governments in Quebec averaged the greatest debt of $2177 per person (-2177). These maximum and minimum values are used as benchmarks to calculate a score for the community's financial indicator (C_F), where a value greater or equal to +863 will have a score of 100 and a value of less than or equal to –2177 will be have a score of 0. For values that fall between the benchmarks the following equation can be used:

$$C_F = 100 - \left(\frac{\max - s}{\max - \min} \times 100\right)$$

Where: max = maximum provincial average for local government per capita surplus (+863)
min = minimum provincial average for local government per capita surplus(-2177)
s = community's per capita surplus

5.5.2 Education

This indicator looks at the level of education in the community. Education can provide individuals with practical and analytical skills that, when applied locally, can positively serve the community in a variety of functions. Education can also serve as a proxy for awareness of health and environmental issues. It is an important consideration for the CWSI as education provides an indication of human capacity available to manage the water resource independently and sustainably.

The EDUCATION indicator (C_E) is evaluated by measuring the percentage of the population aged 20 to 64 with a high school education or higher.[23] In 2001, 65.9 per cent of Canadians aged 20 to 64 had attained at least a high school certificate.[24] The highest provincial or territorial value was recorded in Yukon Territory where 83.5 per cent of people aged 20 to 64 had attained a high school certificate or higher. The lowest value was recorded in Nunavut Territory where 59 per cent of people had a high school certificate or higher for the same age group.[25] These maximum and minimum values are used as benchmarks for C_E scores where a value greater or equal to 83.5 per cent has a score of 100 and a value less than or equal to 59 per cent has a score of 0. For those values in between, the C_E score can be calculated using the following equation:

$$C_E = 100 - \left(\frac{\max - e}{\max - \min} \times 100 \right)$$

Where: max = maximum provincial/territorial % of pop aged 20-64 with a high school education or higher (83.5%)
min = minimum provincial/territorial % of pop aged 20-64 with a high school education or higher (59%)
e = community's % of pop aged 20-64 with a high school education or higher

If $e \geq$ 83.5%, then $C_E = 100$
If $e \leq$ 59%, then $C_E = 0$
If 83.5% > C_E > 59%, then calculate C_E using the above equation

5.5.3 Training

This indicator specifically addresses the community's capacity to operate water and waste water treatment plants by looking at the level of training water and waste water plant operators have received. Adequately trained operators ensure the reliability and effectiveness of the water and waste water infrastructure and the safety of community members and the environment. To evaluate this capacity, the percentage of operators with the forms of training listed below is recorded for each plant. The percentage of operators in each training category is multiplied by the corresponding factors listed below.

Industry certified	1
Other training	0.5
No training	0

Thus for each plant, the following calculation is required to determine an operator training value:

$$OTV = (c + 0.5t) \times 100$$

Where: c = % of operators per plant that are industry certified
t = % of operators per plant that have some other form of training

To calculate a final score for the community (C_O), the results from the various water and waste water treatment plants are aggregated using the following equation.

$$C_O = \frac{\sum_{i=1}^{N} w_i OTV_i}{\sum_{i=1}^{N} w_i}$$

Where: OTV_i refers to the operator training value for water or waste water plant i
w_i is the weight applied to each plant based on the percentage of the population the plant serves

5.6 Final Index Calculation

Once the indicator scores are calculated, component-level scores are determined by taking the average score of the three indicators that make up that component. The final index score for a given community is determined using the following equation:

$$CWSI = \frac{\sum_{i=1}^{N} w_i X_i}{\sum_{i=1}^{N} w_i}$$

Where: X_i refers to component i of the index for a particular community
w_i is the weight applied to that component.

In the standardized evaluation of the CWSI, each component is equally weighted and is therefore equal to the average of all fifteen indicators. Should a community decide one component is more important than another, weights can be adjusted accordingly for internal analysis, although such results would not be used for inter-community comparisons.

6. Overview of the CWSI Case Studies

To test the applicability and usefulness of the CWSI, the Centre for Indigenous Environmental Resources (CIER) was contracted to conduct a series of CWSI case studies. This section presents a synthesis of the field testing exercise. Community descriptions and a thorough review of the methodology are documented in a separate working paper.[26]

The initial phase of the field testing exercise identified the participating communities. Several factors were considered in selecting the communities to test the CWSI. First, a good range in circumstances was sought in the perceived water challenges, primary industries, activities, and geography of the communities to better test the broad applicability of the index. The scope of the field testing exercise was limited to rural and/or remote communities with populations ranging from 1,000 to 5,000 inhabitants.

Another consideration was the objectives of the CWSI project partners to assess the use of the tool in examining the water well-being in First Nation and agricultural communities relative to non-First Nation and non-agricultural communities. Finally, the interest of community officials was necessary for participation. With these considerations in mind, the six communities listed in the following table were selected from across the country.

The primary tool for obtaining data from the communities was a detailed 33 page questionnaire developed by CIER in consultation with community representatives. Other sources of data included federal and provincial government personnel and on-line government databases.

Once available data was obtained, the consultants calculated the individual indicator scores and the final component and index scores using the PRI methodology presented in the preceding chapter. Results were analyzed for each community and comparative analyses conducted between First Nation and non-Aboriginal communities and between all communities based on their primary economic activities.

The final phase of the field testing contract was follow-up interviews with community representatives to get their feedback on their respective community's results. These interviews and other factors resulted in revisions to some scores. The community workshop held in August provided communities with an opportunity to react to the revised results and provide additional input on the field testing process, the usefulness of the CWSI indicators, and the tool in general. This feedback and input is discussed in the following chapter.

	Agricultural	Resource-Based	Other
First Nation	**Pelican Lake First Nation, Saskatchewan** Rural community Population = ~2200 Hay crops, bison and cattle ranching Water issue = water quality	**Tsuu T'ina Nation, Alberta** Rural, but adjacent to Calgary Population = ~1900 Gas development Water issues = water quality and quantity	**Moose Cree, Ontario** Remote Population = ~1700 Tourism (ecotourism) Water issues = water quantity and jurisdictional issues regarding water responsibility
Non-Aboriginal	**Three Hills, Alberta** Rural community Population = ~3500 Primary industry is agriculture, followed by oil and gas production Water issue = water quantity	**Chetwynd, British Columbia** Rural community Population = ~2800 Numerous industries as the area is rich in oil, gas, coal, and timber Water issue = water quality	**Gimli, Manitoba** Rural community Population = ~3500 Tourism Water issue = water quality

7. Case Study Results and Discussion

This section presents an overview of the results and discusses the implications for further index development. The discussion is based on feedback from the consultants and, more importantly, feedback and input obtained from community representatives during follow-up interviews and a one-day workshop held in August 2006.

7.1 Overview

The table below is a summary of the component and final index results for the six surveyed communities. As will be discussed, many of the component scores are not based on the average of the three corresponding indicators due to missing data. Thus, the final index scores are not based on the average of all fifteen indicators. Consequently, the analysis of component and final CWSI scores is limited.

The examination of results, therefore, concentrates on individual indicators and focuses on the usefulness and effectiveness of the evaluation methodology, issues of data availability and quality, and the relevancy of results in the context of index improvement and refinement.

7.2 Discussion of Indicator Results

Analyzing results by indicators is the most useful format as any revisions and improvements to the CWSI will initially occur at the indicator level in terms of making changes to data requirements, scoring benchmarks, or elimination or replacement of entire indicators. At the component level, any revisions or improvements will be less technical, involving a reorganization or regrouping of indicators. This section will not focus on specific community results. Refer to the case study working paper for a more complete discussion of the evaluation outcomes in individual communities and inter-community comparisons.[27]

	Resource	Ecosystem	Infrastructure	Human Health	Capacity	Final CWSI
Tsuu T'ina	50	n/a	12	100	50	53
Pelican Lake	100	n/a	67	65	25	64
Moose Cree	33	100	56	60	80	66
Chetwynd	67	100	86	100	41	79
Three Hills	67	100	70	100	100	87
Gimli	100	n/a	52	100	67	80

7.2.1 Resource – Availability

Tsuu T'ina	100
Pelican Lake	No data
Moose Cree	100
Chetwynd	100
Three Hills	100
Gimli	100

Communities that had data to contribute to scoring of the indicator received a score of 100, indicating a sufficient amount of fresh water to meet basic community health and economic needs. Such results are not surprising as many parts of Canada are water rich and a limit of 1700m^3/cap is likely to be achieved in most areas across the country.

Despite the fact that the results are likely to be accurate when using the Falkenmark water stress index as a benchmark (section 5.1.1), scoring in the field test was not based on data for the respective river basins, as was intended. Rather, per capita calculations were based on the community's population, as opposed to the population in the entire basin. This could be an important factor in densely populated areas, such as the region surrounding the Tsuu T'ina First Nation near Calgary. Stream flow data was based on results from the closest monitoring station. Although it is very positive that such data is readily available, it is not known if results from one monitoring station are representative of the basin.

Other concerns with this indicator are the lack of information on ground water, specifically sustainable yield, and the inability to address renewable fresh water from lakes. Research to identify appropriate indicators for fresh water availability is ongoing and, perhaps, outcomes from such work can be integrated into the CWSI. It is widely acknowledged that such an indicator is relevant to communities and community planners.

7.2.2 Resource – Supply

Tsuu T'ina	0
Pelican Lake	0[28]
Moose Cree	0
Chetwynd	0
Three Hills	0
Gimli	No data

This indicator is intended to reflect the vulnerability of fresh water supply and combines measures of both the surface water and the ground water. Preliminary results suggest that all the surveyed communities have serious supply issues. Surface water vulnerability is based on the ratio between extremes of stream flow throughout the year. It is also referenced against an international benchmark that, in retrospect, is likely to be inappropriate for Canadian rivers, due to the range in temperatures through the year that often result in highly variable stream flows with winter freezing and quick thaws in the spring. Furthermore, the benchmark is intended for runoff data which was not obtained and stream flow data was used as a surrogate.

The supply scores for all but Gimli and Pelican Lake are based solely on the stream flow ratio. Those communities consulted do not feel these results reflect the true vulnerability of supply in the community. If this indicator were to remain in the CWSI, more appropriate benchmarks for supply vulnerability need to be sought and the issue of community versus river basin scale resolved. Another consideration is to incorporate any provisions for water storage in the community.

The other component of this indicator was ground water vulnerability for which the indicator calculation required non-quantitative information on the overall trend of well water levels. Communities have indicated that this type of information is readily available but, unfortunately, the wrong questions were posed during the field testing process. Thus, the results do not account for ground water. With more clarity, however, the method for evaluating ground water vulnerability is likely to be appropriate.

In general, communities feel that the issue of supply vulnerability is important and such an indicator is relevant. When refined, this indicator could help with respect to planning, specifically for exploring options for off-stream storage.

7.2.3 Resource – Demand

Tsuu T'ina	No data
Pelican Lake	No data
Moose Cree	0*
Chetwynd	100
Three Hills	100
Gimli	No data

Data requirements for this indicator are renewable surface water which was collected for the first indicator and the amount of water allocated through water licenses, where the percentage of renewable flows allocated reflect the demand for the resource. Given that provinces or appointed water boards are tasked with issuing water licenses, data on the amount of allocated water is available for at least all non-Aboriginal communities.[29]

This case study revealed that complications could arise in some Aboriginal communities on questions surrounding water rights. In some cases, it is not felt that a water license is required by Aboriginals to remove surface water so the allocation data may underestimate the amount of water that is or could be used.

Again, data for this indicator was not obtained at the appropriate scale. This may have produced artificially high scores for Chetwynd and Three Hills. For these communities, only local allocation amounts were used for calculating the score as opposed to the amount allocated in the basin. Nevertheless, it is felt that this is a useful indicator for planning and should remain an element of the CWSI.

7.2.4 Ecosystem – Stress

Tsuu T'ina	No data
Pelican Lake	No data
Moose Cree	100
Chetwynd	100
Three Hills	100
Gimli	No data

This indicator centers on how much of the renewable surface water is removed from the system and consumed, where the greater the consumption, the more stress is placed on the fresh water ecosystem. This data was available or applicable for half of the communities surveyed. In these three cases, the scores were very high, as only a marginal amount of surface water is consumed. Again, these values may be artificially high as the amount of water consumed is for the community itself as opposed to the basin.

In general, communities felt that the health of the ecosystem is important but may not have direct implications or relevance for planning. Although this particular indicator is referred to as a proxy for ecosystem stress, the level of consumption is very much a quantity/supply issue and could be "reclassified" into another component if it is thought to be more appropriate from a community planning perspective.

7.2.5 Ecosystem – Quality

Tsuu T'ina	No data
Pelican Lake	No data
Moose Cree	No data
Chetwynd	No data
Three Hills	No data
Gimli	No data

No results were obtained for this indicator as it was intended to be populated with Water Quality Index results for the protection of aquatic life. The WQI is a composite water quality index relying on a range of ambient water quality data that was simply not available in the surveyed communities. This was anticipated. The use of WQI was considered to be a long-term application requiring a significant increase in monitoring.

Communities did confirm, however, that raw water quality was analyzed for certain parameters. They stressed that water quality has important implications for socioeconomic activities such as fishing, recreation, and tourism as well as for human health. It was suggested that framing the issue of quality differently could increase its relevancy to the community. Among the suggestions were to look at differences between upstream and downstream water quality to assess the impact of the community or to look at levels of harmful bacteria, such as *E.coli*, and incidences of fish consumption advisories or beach closures. Looking at the human dimensions of ambient water quality as opposed to ecosystem or aquatic life dimensions may give such an indicator more significance from a community planning or policy perspective.

7.2.6 Ecosystem – Fish

Tsuu T'ina	No data
Pelican Lake	No data
Moose Cree	No data
Chetwynd	No data
Three Hills	No data
Gimli	No data

Unfortunately, the data survey compiled by CIER did not ask the questions that would have allowed scores for this indicator to be calculated. To calculate the score, an opinion on the population trends of culturally and/or economically significant fish species was needed, likely based on observations over time. The survey requested detailed information on population numbers whereas only a general sense of population trends, whether increasing or decreasing, was needed. In the follow-up workshop, communities indicated that such information could have been provided.

Although results are not available, the surveyed communities feel that this is an important and relevant indicator to community members. The only concern is whether the indicator should be limited to native fish species. While the presence of foreign species has negative implications for ecosystem health, it is suggested that many sport fisheries and perhaps even commercial fisheries are based on non-native species. Should foreign species be integrated into such an indicator, it may not be well suited as an indicator of ecosystem health.

7.2.7 Infrastructure – Demand

Tsuu T'ina	9
Pelican Lake	No data
Moose Cree	100
Chetwynd	100
Three Hills	100
Gimli	47

With the exception of one community, the necessary data was available to calculate the number of years before water and waste water services were to reach full capacity due to increasing demand. The only concern was that the most recent population data were not used to calculate the annual rate of population growth. Census data from 1996 and 2001 were used and many communities feel that did not reflect the current population dynamic. Should the most recent data be used, the communities agree it is a useful indicator that will allow planners to anticipate upgrades and/or new construction. A score of 100 is achieved if the plant will serve the population for 50 or more years. These benchmarks are felt to be appropriate. It was also pointed out that existing plants can become obsolete due to changes in quality standards but such changes are independent of demand and cannot be predicted.

Scores for the demand and condition indicators are calculated for both water and waste water systems and the lower of the two is used. During follow-up interviews, it was suggested that the water and waste water systems be addressed separately as opposed to being combined in the Infrastructure indicators. If the two systems were separated into components, for example, community results would include individual indicator scores for water and waste water systems.

7.2.8 Infrastructure – Condition

Tsuu T'ina	No data
Pelican Lake	No data
Moose Cree	0
Chetwynd	92
Three Hills	44
Gimli	No data

This indicator is intended to reflect the condition of water mains and sewers, where the score is based on the amount of water or waste water that is lost from the system. Scores for both water and waste water systems are determined and the lower of the two scores is used. The communities were only surveyed for losses to the water mains, not sewers, thus any results are based on the condition of water mains. System loss data for the water mains was available for four out of the six communities, although it was not obtained for Gimli. It is not known if system data for sewers is available.

The surveyed communities consider this indicator to be useful and feel that the benchmarks and results are appropriate. Consequently, there were no suggestions for improvement.

7.2.9 Infrastructure – Treatment

Tsuu T'ina	15
Pelican Lake	67
Moose Cree	67
Chetwynd	67
Three Hills	67
Gimli	57

This indicator evaluated the level of waste water treatment provided by the community, where the more people serviced by tertiary treatment plants, the higher was the score. The data acquisition survey did not ask the appropriate questions, thus results were not calculated using the intended method. However, the necessary data would have been available.

More importantly, the surveyed communities did not feel that this was a relevant or useful indicator 'as is'. Communities observed that waste water is not typically treated beyond the level needed to ensure quality standards are met. It was suggested that this indicator focus on compliance. A score would be based on the frequency of effluent standards met. It was agreed that such an indicator would be very useful.

7.2.10 Human Health and Well-being – Access

Tsuu T'ina	No data
Pelican Lake	100
Moose Cree	100
Chetwynd	100
Three Hills	100
Gimli	100

All of the communities that had the necessary data scored 100 for this indicator. These results are not entirely unexpected as the benchmark of 150L/cap/day is well below the average amount of water Canadians use in a day. It has been documented, however, that some Canadians, particularly those in the North, use less than 100L/cap/day, presumably due to limited access.[30] It is in such communities that this indicator would be most important as scores below 100 would indicate that basic human needs are not being met due to insufficient provision of water.

7.2.11 Human Health and Well-being – Reliability

Tsuu T'ina	100
Pelican Lake	96
Moose Cree	19
Chetwynd	No data
Three Hills	100
Gimli	100

The purpose of this indicator is to measure the reliability of the distribution system by looking at the number of service disruption days. The score is based on the frequency and duration of service disruptions as well as the number of people affected by disrupted service.

Unfortunately, the survey did not ask the correct questions, thus the methodology was not used in the intended manner. In the community workshop, community representatives indicated that the necessary data would have been available from either the community or the province. The communities agreed that this is important information and that such an indicator is useful.

7.2.12 Human Health and Well-being – Impacts

Tsuu T'ina	100
Pelican Lake	0
Moose Cree	No data
Chetwynd	100
Three Hills	No data
Gimli	No data

Data regarding waterborne illness was not obtained in the field test in half of the communities surveyed, although community representatives suggested that health authorities and the public health agency would have the necessary statistics.

Communities were not entirely convinced that this is a useful indicator or that the benchmarks are appropriate, as waterborne illnesses would likely have to affect a large segment of the population, such as during an outbreak, before being identified and subsequently reported. As a result, the scores for this indicator are likely to be either 0 or 100 in smaller communities from year to year based on the benchmark used (if 1/1000 people are affected then the score = 0).

It was suggested that other parameters that relate to human health and well-being could be explored, including water properties not captured by drinking water guidelines that can affect the actual or perceived quality of the water, such as minerals, taste and smell.

7.2.13 Capacity – Financial

Tsuu T'ina	No data
Pelican Lake	No data
Moose Cree	No data
Chetwynd	No data
Three Hills	No data
Gimli	No data

This indicator reflects the per capita financial surplus or deficit carried by the community. Although not obtained this field study, the data is collected by Statistics Canada.

Despite the lack of results, the surveyed communities feel that this is a useful indicator, providing an indication of the financial flexibility in the community to respond to and address water and water service shortcomings. Communities always have a number of financial obligations and competing demands and suggested that results from this type of indicator could be used to approach provinces or other funding institutions for financial assistance. A low score would reflect the limited ability of the community to maintain, replace or improve water services or to respond to any other water concern. Given that the benchmarks used to determine the indicator score are based on the average financial status of local governments across the country, a low score would also reflect how poorly a given community is situated in a national context. This could provide increased leverage to look for funding opportunities.

7.2.14 Capacity – Education

Tsuu T'ina	100
Pelican Lake	0
Moose Cree	No data
Chetwynd	49
Three Hills	100
Gimli	34

This indicator evaluates the community based on the number of high school graduates between the ages of 20 and 64. National averages are used as benchmarks in determining a score. This indicator was seen as an appealing addition to the capacity component since the required data is collected by Statistics Canada as part of the census, even though certain First Nations are not surveyed. Communities did not feel that this was a relevant indicator and concluded that its inclusion in the CWSI is not particularly useful.

7.2.15 Capacity – Training

Tsuu T'ina	0
Pelican Lake	50
Moose Cree	80
Chetwynd	33
Three Hills	100
Gimli	100

Although the necessary information was available to calculate scores for this indicator, the surveyed communities do not feel that this indicator addresses the appropriate concerns with respect to water and waste water operators. As it is, this indicator uses the level of operator training to establish a score. A score of 100 is achieved when all of the operators are certified. This is not thought to be an appropriate measure since not all communities are obligated to have all of their operators certified. It is, therefore, seen to be unfair to deduct points from a community while it is meeting the necessary requirements and standards.

Communities suggest that the main capacity concern is the lack of trained operators, a common problem in many communities, particularly those that are small and remote. It is, therefore, proposed that this indicator look at the deficit of operators in the community by the difference between the number of trained operators needed and the number of trained operators currently available. In that way, scores would reflect the extent to which labour shortages are affecting the ability of the community to operate its water and waste water services. Such an indication would be helpful for communities to make necessary plans and arrangements for dealing with capacity concerns.

8. Feedback on the CWSI Process

This section, discussing the CWSI process, is largely based on community input and other lessons learned throughout the project, especially the case study exercise.

8.1 Time Requirements and Community Involvement

For participating communities, the time commitment consisted of a one to two hour phone call and a full day consultant visit that also involved responding to the questionnaire. Following the site visit, there was an additional time commitment to obtain the data and information community representatives were unable to provide during the initial site visit. A representative from the community was also asked to participate in a follow-up interview over the phone. Should the CWSI be more broadly implemented, site visits to each community and follow-up interviews would be highly unlikely thus alleviating an aspect of demand on the community's time and personnel.

From the consultant's perspective, attempting to gather data from government departments was the most time-consuming aspect. CIER observed that the fact that it is an external research body that the government was not obligated to serve was likely a factor in this limitation. Had the communities placed information requests themselves, data acquisition would have been more successful since governments have a greater obligation to meet community requests. The communities are also likely to have better networks for obtaining data more efficiently.

In participating in the CWSI process, surveyed communities did not express an interest in actually calculating the indicators and the index themselves. In general, it was perceived that index results would have more credibility and clout within the community if scores were tabulated and presented by an external body, preferably a central government agency. Overall, the communities felt that the commitment of time and personnel was acceptable; however, they would prefer to see the questionnaire in advance in order to coordinate and prepare for the site visit and to understand the types of data required. Communities would also have benefited from more information on the CWSI project.

8.2 Considerations for Data Acquisition

There are several options for acquiring the data necessary to populate the CWSI. The consultant's primary tool for acquiring data from the community was an extensive questionnaire, often seeking data and information that was not necessary for calculating the indicators. Also, it was clear that the needed data was not always solicited by the questionnaire, even though it would have been available in many cases. To minimize unnecessary work on the part of the community, surveys and questionnaires should, where possible, be limited to collecting only essential data. Perhaps, had a separate list of data needs been provided as part of the methodology, the questionnaire would have been easier to respond to.

Rather than a separate process for the CWSI, it was suggested that additional questions be added to existing surveys, such as the Canadian water and waste water survey. The surveyed communities observed that, if they were informed that the voluntary surveys currently issued would also be used to calculate community-based CWSI scores, there would likely be a higher rate of return since the prospect of the government calculating the CWSI for their community would provide an extra incentive to complete the Canadian water and waste water survey.

In terms of frequency, communities felt that it would be beneficial to calculate the CWSI on an annual basis to keep track of changes in the community.

9. CWSI as a Policy Tool

The potential policy applications of the CWSI are discussed in previous publications.[31] This chapter focuses on the applications identified by the surveyed communities during follow-up interviews and the community workshop. Based on their understanding of the CWSI and their participation in the field testing exercise, communities believe that the CWSI can be used as a planning, communications, marketing, and education tool. Suggestions for enhancing the usefulness of the tool are also discussed.

First, communities expressed that their CWSI results could be used to inform planning decisions and activities, specifically those related to water and waste water infrastructure, such as exploring water storage options and training operators. Indicators related to issues of supply and demand could also help inform land-use planning, particularly zoning for water-intensive industries. Results could also be useful in approaching governments for funding and identifying areas for research. Federal departments have also indicated that they could foresee using such a tool to inform funding decisions.

It was also suggested that CWSI could be used as a communications tool to verify or discredit existing speculation in the community on a number of water issues, particularly around quality and quantity. Results can also be used to market the community's potential to prospective developers and industries, especially water-intensive industries.

Finally, the CWSI could be used to educate residents on the state of water well-being in their communities and how they compare to other communities across the country. Communities also felt that the index could be extremely useful if applied by communities in the same region or relying on the same water source. If used in this way, communities could compare their scores, simultaneously acquiring a general understanding of the state of their area and their collective ability to address water sustainability on a regional level.

In general, communities were very receptive to the CWSI and are looking forward to further development and implementation of the tool to be used as described above. In addition to the comments in section 7.2 providing input on the usefulness of specific indicators, many communities felt that the index would be more useful if it incorporated elements more specific to the activities in the community, such as indicators on beach closures or irrigation. That is difficult to negotiate since what is important to some communities is not relevant to others. As discussed in chapter 4, applicability was a main consideration for index development and indicators needed to be general enough to be applicable to a diverse range of communities.

10. Conclusion

Overall, the PRI's CWSI project was very successful. In a relatively short time, a composite water index was developed and field tested. Index development was guided by a review of the water index and indicator literature, work that had been done on the Water Poverty Index, and input from a number of experts participating in the PRI's two-day workshop or otherwise consulted.

As anticipated, the case studies proved to be very useful in testing the CWSI as they identified the good elements of the index and, perhaps more importantly, elements of the index that need refinement or improvement. This type of information will be very beneficial in moving forward with index development.

This report presents the results of the case studies in the context of index development by providing suggestions for modifying certain indicators. Such suggestions stem from the logistical challenges in obtaining necessary data with respect to availability and issues of scale and from the valuable input from participating communities addressing the relevancy and usefulness of the individual indicators as well as how the index could be improved. One finding that is not unique to this project is the need for monitoring to increase our understanding of water and water issues within communities and across the country.

The number of uses communities have identified for this type of tool highlights its potential value. As discussed, surveyed communities are interested in the CWSI and anticipate its implementation in the future. In terms of process, communities would be willing to commit the time and personnel to provide the data necessary to populate the index and observed that the opportunity to have CWSI results for their communities would, in fact, provide an incentive for completing voluntary surveys.

This report largely concludes the PRI's involvement in the CWSI project. It is hoped that the suggestions and findings emerging from this project can be used to further develop and implement the CWSI so governments at all levels can use the tool to inform decision-making and improve our understanding of water issues in our communities.

NOTES

1 Environment Canada Freshwater web site: <http://www.ec.gc.ca/water/en/info/pubs/wwf/e_intro.htm>

2 Sullivan, C. 2002. *"Calculating a Water Poverty Index."* World Development. Vol. 30, No.7, pp.1195-1210.

3 <http://www.un.org/millenniumgoals/>

4 Ibid.

5 The WPI ranges from 0 to 100 where the lower the score, the more severe the water poverty problem.

6 Environment Canada Freshwater web site: <http://www.ec.gc.ca/water/en/manage/use/e_ratio.htm>

7 Peterson, H. 2001. "A Tale of Two Countries – The Quality of Rural versus Urban Drinking Water in Canada." *Encompass Magazine.* <http://www.safewater.org/PublicEducation/articles/mag-enc1.htm>

8 A Statistical Profile of the Health of First Nations in Canada. Accessed at <http://www.hc-sc.gc.ca/fnihb-dgspni/fnihb/sppa/hia/publications/statistical_profile.pdf>

9 Ibid.

10 Ibid.

11 Morin, Anne. 2005. *The Canadian Water Sustainability Index (CWSI)* (PRI Working Paper Series #011). Policy Research Initiative: Ottawa.

12 Tri-Star Environmental Consulting. 2006. *Canadian Water Sustainability Index (CWSI) Data Study* (PRI Working Paper Series #013). Policy Research Initiative: Ottawa.

13 Centre for Indigenous Environmental Resources and Anne Morin. 2006. *The Canadian Water Sustainability Index (CWSI) Case Study Report* (PRI Working Paper Series #028). Policy Research Initiative: Ottawa.

14 Falkenmark, M., J. Lundqvist and C. Widstrand. 1989. "Macro-scale Water Scarcity Requires Micro-scale Approaches: Aspects of Vulnerability in Semi-arid Development." *Natural Resources Forum* 13 (4): 258-267.

15 Gleick, P. H. 1990. "Vulnerability of Water Systems." *Climate Change and the US Water Resources.* Edited by P. E. Waggoner, pp. 223-240, John Wiley and Sons, New York.

16 <http://www3.gov.ab.ca/env/soe/water.html>

17 OECD. 2004. OECD Key Environmental Indicators, 2004. Paris.

18 <http://www.ccme.ca/ourwork/water.html?category_id=102>

19 According to NRTEE, poorly maintained piping systems and sewers lose up to 25 per cent of the water they carry. From: National Roundtable on the Environment and the Economy (1996). State of the Debate on the Environment and the Economy: Water and Wastewater Services in Canada.

20 Meigh and Cobbing. 2002. "Assessment of Water Availability for the Pilot Study Sites." In: Sullivan et al. 2002. *Final Report of the Development and Testing of a Water Poverty Index.* CEH and DFID.

21 Peterson, Hans G. 2001. "Rural Drinking Water And Waterborne Illness." Accessed at <http://www.safewater.org/Publications/pressarticles/Peterson,%20CWWA,%202001.pdf>.

22 Statistics Canada, CANSIM Table 385-0003.

23 Includes high school, trades certificate or diploma, college and university (Source: 2001 Census of Population – Statistics Canada).

24 Excludes census data for one or more incompletely enumerated Indian reserves or Indian settlements (Source: 2001 Census of Population – Statistics Canada).

25 Ibid.

26 Centre for Indigenous Environmental Resources and Anne Morin. 2006. *The Canadian Water Sustainability Index (CWSI) Case Study Report* (PRI Working Paper Series #028). Policy Research Initiative: Ottawa.

27 Ibid.

28 This score is different from previously published results. The score was recalculated to account for declining well water levels in all community wells. Stream flow ratios were not available for Pelican Lake as the community obtains its surface water from Lake Chitek.

29 Data for Gimli is available but was not obtained in this field test.

30 Refer to the 2001 Municipal Water Use Database, Sustainable Water Use Branch, Environment Canada.

31 Morin, Anne. 2005. *The Canadian Water Sustainability Index (CWSI)* (PRI Working Paper Series #011). Policy Research Initiative: Ottawa.
Morin, Anne. 2006. "The Canadian Water Sustainability Index." *Horizons.* Volume 9 Number 1. Policy Research Initiative: Ottawa.

Appendix 1

Canadian Water Sustainability Index Workshop
November 17-18, 2005
Ottawa

List of Participants

Phil Adkins	Agriculture and Agri-Food Canada
Meriem Aït Ouyahia	Policy Research Initiative
Paul Allen	Natural Resources Canada
Sushma Barewal	Policy Research Initiative
Sam Bediako-Cra	Health Canada
Oliver Brandes	University of Victoria
James Bruce	Global Change Strategies International Company
Hon. Charles Caccia	University of Ottawa
Ian Campbell	Policy Research Initiative
John Cooper	Health Canada
Ian Corbin	Indian and Northern Affairs Canada
Graham Daborn	Acadia Center for Estuarine Research
Sean Douglas	Government of Alberta
Duncan Ellison	Canadian Water and Waste water Association
Kathleen Fischer	Fisheries and Oceans Canada
Elisabeth Gardiner	Mining Association of Canada
Connie Gaudet	Environment Canada
Al Howatson	The Conference Board of Canada
Derrick Kamanga	Ontario First Nations Technical Services Corporation
Haseen Khan	Department of Environment and Conservation, Government of Newfoundland & Labrador
Henry Lickers	Mohawk Council of Akwesasne
Sue Lowell	Suncor Energy Inc.
Robin MacKay	Agriculture and Agri-Food Canada
Anjela Markova	Policy Research Initiative
Elizabeth May	Sierra Club of Canada
Lynn Menard	Health Canada
Teresa Mersereau	Health Canada
Mary Jane Middelkoop	Federation of Canadian Municipalities
Anne Morin	Policy Research Initiative
Rasheda Nawaz	Assembly of First Nations
Corey Peabody	Industry Canada
Merrell-Ann Phare	Centre for Indigenous Environmental Resources
Alfonso Rivera Natural	Resources Canada
James Robinson	University of Waterloo
Michael Roy	Indian and Northern Affairs Canada
Cate Soroczan	Canada Mortgage and Housing Corporation
Caroline Sullivan	Centre for Ecology and Hydrology
Les Swain	Tri-Star Environmental Consulting
Darren Swanson	International Institute for Sustainable Development
Michel Villeneuve	Environment Canada

Appendix 2

Canadian Water Sustainability Index Community Workshop
August 30, 2006
Ottawa

List of Participants

Len Dyck	Town of Three Hills
Lee Crowchild	Tsuu T'ina First Nation
Gord Gosse	District of Chetwynd
Joann King	Rural Municipality of Gimli
Mary-Ann Wilson	Agriculture and Agri-Food Canada
Emily Austen	Environment Canada
Vincent Mercier	Environment Canada
Jackie Redmond	Health Canada
Anne Morin	Policy Research Initiative
Ian Campbell	Policy Research Initiative
Anjela Markova	Policy Research Initiative
Meriem Aït Ouyahia	Policy Research Initiative